1 Introduction

1.1 This publication, Consultant's Handbook, is designed as a concise and easily referenced handbook to outline the administrative and technical nuances involved in providing professional services to Purdue University.

1.2 This publication is referenced as both "the Guidelines" and "the Handbook". The two terms are synonymous and can be used interchangeably.

1.3 Familiarity with the Handbook is recommended prior to submission of a proposal for professional services and is to be referred to throughout the execution of the A/E contract.

1.4 Questions regarding and suggestions for improving the information in the Handbook are encouraged and should be addressed to the PM.

1.5 The information in the Handbook are not meant to replace professional design analyses and does not relieve the A/E of any professional or contractual responsibility. Consultants are expected to conduct independent evaluations and to discuss recommendations with the PM and associated professional staff.

1.6 Deviations from the materials or methods identified in the Handbook are to be submitted in writing to the PM for approval by the appropriate senior staff member prior to any such material or method being presented at any design meeting.

1.7 Upon entering into an agreement with the University you will be issued a copy of the Handbook. This copy will remain with the project documentation for reference.

2 Proprietary Items

2.1 Purdue provides for open competition to the extent reasonable on products and materials.

2.2 Use of brand names in the specifications is acceptable, but a statement should be included to indicate that this is for establishment of a general level of quality and is not intended to limit competition.

2.3 "No substitute" statements are permissible with justification.

3 Design Process

3.1 Designs must achieve an appropriate balance of quality, durability, reliability, adaptability, sustainability, and economy. The relative weights of these attributes may vary depending upon the project requirements.

3.2 All facilities should be designed for visual compatibility and context within the appropriate neighborhood of campus.

3.3 Professional due diligence, ingenuity and expertise is expected to be used to investigate various designs and develop the best approach for all elements of the project.

4 Equipment and Materials

4.1 Equipment and materials specified in the design should be carefully explored with life safety, cost, and long-term goals (projected life of facility, equipment, and systems) in mind.

4.2 Discussion with University staff on equipment and material options should begin early in the design process to allow for informed decisions in line with University experience.

5 Expectations of Design

5.1 Design of facilities and infrastructure should strive for optimum value at lowest cost. Facility use, expected design life, and life cycle cost should be considered in this evaluation.

5.2 Drawings and specification requirements must be clear, concise, and thoroughly detailed and coordinated.

5.3 Existing conditions must be adequately shown on the drawings and described in the specifications. Where existing conditions cannot be readily determined, A/E shall advise PM as to the risk associated with unknown conditions and recommend if pre-design investigation or testing is warranted.
1 Establishment of Project Manager
1.1 One individual should be designated as Project Manager to work directly with the PM.
1.2 The Project Manager is to be fully cognizant of the requirements of the A/E Contract, performance schedule, and contents of this publication.

2 Project Communication
2.1 Though the Program, RFP, and/or contract may delineate a minimum communication frequency and method additional communication regarding the project status, questions, problematic situations, etc. is encouraged.
2.2 All communication will go through the PM or as directed by the PM. Instructions or requests from a University faculty or staff member not directly approved by the Project Manager will not be valid. Verbal direction from a team member should be promptly followed by an email to the PM.
2.3 The consultant is responsible for meeting minutes and transcripts preparation and distribution.

3 Pre-Design Conference
3.1 A pre-design conference chaired by the PM may be held at the University to introduce all team members and to familiarize the team with the design process and project. The meeting may include:
- Outlining the design process
- Team Introductions
- Discussing team objectives
- Discussing project goals and objectives
- Developing the schedule of events
- Gathering available organizational, site, and other existing information; discussing the unique aspects of the project
- Determining initial site investigative work
- Familiarizing the team with the site

4 Maintenance of Project Scope, Schedule, and Budget
4.1 In general, the scope may not be exceeded without written approval of the PM; however, minor deviations in the scope of supporting items may be made to suit field conditions.

5 State Plan Review Submittal
5.1 When required, an initiated copy of the current State Release Form with the owner information will be provided to the A/E. The completed form and a check covering the applicable fees will be returned to the PM to secure the owner’s signature.
5.2 The A/E manager will send the package to the State Office.

6 Drawings
6.1 Drawings are to be complete, accurate, and explicit with all elements of the work properly coordinated to eliminate conflicts between disciplines or between drawings and specifications.
6.2 Duplication of information on the drawings and in the specifications should be avoided.

7 Specifications
7.1 Owner supplied specifications are for reference purposes to assist in design document development. The A/E is responsible for appropriate use, customization, and application of these specifications to the particular project.
8 Contractor Submittal Review

8.1 The A/E is expected to review and process shop drawings. Reviewed submittals are to be forwarded to the appropriate University personnel.

8.2 The A/E is expected to attend appropriate pre-bid and regularly scheduled construction progress meetings so as to quickly resolve questions and conflicts.

8.3 A transmittal or cover letter referencing the appropriate Division and Sections should accompany each submittal. The transmittal letter should include:
   - PID Number
   - Quantity of each Submittal item
   - Division/Section number of each Submittal item
   - Description of each Submittal item
   - Status of each Submittal item; Approved, Approved as Noted, or Reject and Resubmit
   - Notes area identifying the reason for Approved as Noted, or Reject and Resubmit

8.4 Rejected Shop Drawings are to be sent directly back to the Contractor. A copy of the transmittal letter concerning the Rejected Shop Drawing is to be sent to Purdue for our records.

8.5 Shop Drawings with the same Division/Section number can be submitted at one time under the same cover letter.

8.6 Shop Drawings with the same Division, but different Section, need to be submitted separately with separate cover letters.

8.7 A submittal log should be developed and, if required, issued shortly before Construction to facilitate processing.
1 Introduction
1.1 Following are items the University typically supplies and for which it assumes responsibility.
1.2 The items are not inclusive and do not remove the obligation for both the University and the A/E to adhere to the terms of the contract.

2 A/E Agreement
2.1 Once your proposal has been accepted the University will develop and provide an A/E agreement covering the work on this project.
2.2 The University will develop and provide Boilerplate Division 00 and 01 sections (Purdue refers to this as the “Front End”). It consists of:
   2.2.1 “Hard copy” file (PDF) containing documents (e.g., General Conditions) that don’t require editing or have already been edited by the University for this project. These should not be edited by the A/E.
   2.2.2 “Electronic portion” file (MS Word) containing documents (e.g., Principal Subcontractor Questionnaire) that the A/E should customize for the project.
   2.2.3 “Inserts” file (PDF), reference copies of the contract forms (e.g., Construction Invoice Voucher) that the contractor will be using.
   2.2.4 Campus Map (PDF) showing project and bid opening location.
2.3 The A/E shall complete and assemble the Front End in accordance with the Table of Contents.
2.4 Bid Form 96 (revised 2000) and the Standard Questionnaires and Financial Statement for Bidders (Form 96-A, revised 1949) are referenced in the Table of Contents as inserted loose. If bid documents are printed and distributed by a firm other than Xerox on West Lafayette campus, these two forms should be requested by the AE for insertion by their designated print shop. Both forms are required of all prime bidders.
2.5 In general the Front End Documents for Design-Bid-Build projects will include:
   2.5.1 Bidding Documents:
     • Bid Form (Form 96) (inserted loose)
     • Standard questionnaire and financial statement for bidders (Form 96A) (inserted loose)
     • Advertisement for Bids

3 Architectural Program
3.1 The Academic Program Statement, when required by the project, will be used in conjunction with the design professional’s Architectural Program when developing the design documents.
3.2 The Academic Program Statement will include specific program requirements for the department as well as a program narrative, mission statement, information about the department, relationships between spaces, area requirements and other project specific information that is used to develop the project’s plans.
3.3 It is the design professional’s responsibility to provide, in a tabular format, a listing of all the rooms identified in the Academic Program Statement and their associated square footage and to compare that with the developed Architectural Program. Deviations must be approved by the PM.

4 Site survey
4.1 The University will furnish, if applicable, electronic and paper copies of the most recent site plan and utility maps for the projected building location.
4.2 Once the extent of construction is clearly established, the University will arrange for a site engineering survey. Engineering surveys may include soil borings and analysis. This survey will be supplied for use in the design process and inclusion in the CD’s.

4.3 This does not remove the need to investigate the existing conditions for undocumented construction.

5 Subsurface Soils Information

5.1 Subsurface soil information, if provided, is included for informational purposes, and is not guaranteed to fully represent all subsurface conditions. The data included in the RFP are intended for proposal preparation and preliminary design only. The Consultant shall perform, at his expense, such subsurface exploration, investigation, testing, and analysis as his Designer of Record deems necessary for the design and construction of the foundation system.

5.2 Any work by the Consultant-provided Geotechnical Engineer shall be coordinated with the PM and shall not interfere with normal University operations.

5.2.1 Prior to the Foundation Work Design submittal, provide a Consultant Geotechnical Report (an editable Adobe Acrobat PDF version on CD and two printed copies). The report shall become the property of the University.

5.2.2 Geotechnical reports generated during construction, such as pile driving results and analysis, shall be provided to the project contract manager. In addition, provide an editable Adobe Acrobat PDF version and two printed copies for record keeping purposes.

5.3 Material Testing

5.3.1 Subsoil permeability testing will be the responsibility of the site contractor. This testing must be performed prior to placement of fill soils for plant materials.

5.3.2 In general, all other testing of soil, backfill, compaction, asphalt, concrete steel and masonry will be contracted by the university. Larger projects should have a separate “testing” specification to allow for separate bid package.

6 Landscape Guidelines

6.1 Description of landscaping requirements for this project will be provided in the Program and outlined in the following sections.

7 Hazardous materials testing and coordination for removal

7.1 The University will typically conduct a thorough survey of the project area prior to your development of the CD’s. The PM and A/E will review this survey allowing opportunity to inform the University of any questionable or omitted materials.

7.2 Removal of lead, asbestos and other hazardous materials will be shown on the time schedule.

8 University Coordination

8.1 Coordination of distribution of drawings for in-house reviews

8.2 Coordination of University staff reviews

8.3 Coordination of User/Occupant reviews

8.4 Coordination of User/Occupant moves (may be outsourced)

8.5 Coordination of University Approval Committee reviews (may be outsourced)

9 Room Key Schedule, Cylinders, Cores & Keys

9.1 Submit a copy of the ‘final’ floor plan. The University will develop and forward a key schedule. This key schedule is typically developed after construction has begun.

9.2 The contractor will provide cylinders and cores. The University will “key” the cores and provide keys.

10 Loose furniture and equipment

10.1 In general, loose equipment, furniture, window coverings, and occasionally carpet will be furnished and installed by the Owner for each project. Equipment and furniture is considered loose when it has no permanent connection to a utility or the structure. The PM will review University supplied equipment and the utility requirements for all loose equipment so appropriate notes can be made on the drawings.

10.2 Fixed equipment will usually be furnished and installed by the Contractor. In the event that
equipment is to be owner furnished, it will be specifically described in the Program. The A/E will be responsible to see that all utility requirements for the equipment are included in the bid documents.

### 11 Building information access

11.1 Access to existing building systems information archive (e.g., blueprints, specifications, etc.)
1 Fees
1.1 Fees are negotiated for each project. Hourly based fees will only be considered if accompanied by a not-to-exceed maximum.

2 Billing
2.1 Most firms bill the University monthly for work completed to that date. Fee billings and reimbursable billings should be on separate invoices.
2.2 All invoices should contain the following:
   - The official project title
   - The phase of the project in which work is being done
   - The degree of completion of that phase
   - The percentage of the total project that has been completed
   - The total fee on which billings are to be based
   - The amount previously billed.
2.3 Billings for additional services may be included with fees, but should be accompanied by a clear explanation of the services and the reason they are required. This justification will reference the prior approval of the project manager.

3 Reimbursable
3.1 Requests for reimbursements will be for items directly associated with the project. Unreasonable or undocumented requests will be challenged and require justification.
3.2 Reimbursable invoices must contain the following:
   - Each invoice must contain a copy of the bills, receipts, invoices, etc. referenced
   - Each receipt must list the person or persons expensed
   - Travel expenses must show the date and itinerary
3.3 No alcoholic beverages will be reimbursed
3.4 No travel expenses will be reimbursed unless the travel had been previously approved by the PM in writing
3.5 Each invoice must be on the appropriate University form
1 Introduction

1.1 This is a common sense guide to assist in identifying environmental items of concern on a Purdue project. It is not intended as a comprehensive checklist that addresses every environmental/regulatory issue requiring investigation.

1.2 It is important that environmental/regulatory issues be addressed early in the design process to allow for application for necessary permits or design modifications if needed. Some permit applications require up to six months of lead time.

1.3 Environmental/regulatory project review should focus on the following question: Does the design, process or plan include something that may impact 1) Air, 2) Water, or 3) Land

1.4 Refer questions to Purdue Project Manager; consultants or contractors are not to make direct contact with the state or federal regulatory agencies without prior Purdue approval.
<table>
<thead>
<tr>
<th>Item of Concern</th>
<th>Purdue Contact</th>
<th>Purpose for Concern</th>
<th>Min Lead Time Required</th>
<th>Governing Regulatory Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incinerators of any variety</td>
<td>Robin Ridgway</td>
<td>Need Permit from IDEM</td>
<td>6 months</td>
<td>Purdue Part 70 Permit/ “Title V”</td>
</tr>
<tr>
<td>Particulate pollution control equipment (baghouses, filters) for processes NOT directly associated with non-profit research and teaching</td>
<td>Robin Ridgway</td>
<td>Need Permit from IDEM</td>
<td>6 months</td>
<td>Purdue Part 70 Permit/ “Title V”</td>
</tr>
<tr>
<td>Paint Spray Booths</td>
<td>Robin Ridgway</td>
<td>Need Permit from IDEM</td>
<td>6 months</td>
<td>Purdue Part 70 Permit/ “Title V”</td>
</tr>
<tr>
<td>Fugitive Emissions: e.g., vapors from a manufacturing process or a for profit research activity.</td>
<td>Robin Ridgway</td>
<td>Need Permit from IDEM</td>
<td>6 months</td>
<td>Purdue Part 70 Permit/ “Title V”</td>
</tr>
<tr>
<td>Heaters/Boilers:</td>
<td>Robin Ridgway</td>
<td>Need Permit from IDEM Needs to add all boilers to inventory</td>
<td>6 months</td>
<td>Purdue Part 70 Permit/ “Title V”</td>
</tr>
<tr>
<td>Electric Generators (not able to be moved by hand):</td>
<td>Robin Ridgway</td>
<td>Construction Permit Needed Need to add to inventory for reporting and recordkeeping</td>
<td>6 months</td>
<td>326 IAC 2-1.1-3</td>
</tr>
<tr>
<td>Electric generators, any fuel any size (&gt;500 brake horsepower (373 kW) needs notification)</td>
<td>Robin Ridgway</td>
<td>Specific Design Requirements</td>
<td>na</td>
<td>Purdue Part 70 Permit/ “Title V”: RICE MACT; code requirements</td>
</tr>
<tr>
<td>No.</td>
<td>Indicate Yes or No for each Item of Concern</td>
<td>Item of Concern</td>
<td>Purdue Contact</td>
<td>Purpose for Concern</td>
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<tr>
<td>8</td>
<td>YES ☐ NO ☐</td>
<td>Electric Generators fuel storage</td>
<td>Robin Ridgway Eric Johnson</td>
<td>Possible Design Considerations for containment, update SPCC</td>
</tr>
<tr>
<td>9</td>
<td>YES ☐ NO ☐</td>
<td>Transformers containing &gt;50 gallons oil</td>
<td>Robin Ridgway Eric Johnson</td>
<td>Possible Design Considerations for containment, update SPCC,(possibly SWPPP)</td>
</tr>
<tr>
<td>10</td>
<td>YES ☐ NO ☐</td>
<td>Ventilation systems intended to remove hazardous vapors or particulate (dust) from a production process NOT associated with research and teaching. E.g., a hood in a research lab does not need a specific permit, but a hood in a maintenance area does.</td>
<td>Robin Ridgway</td>
<td>Need Permit from IDEM</td>
</tr>
<tr>
<td>11</td>
<td>YES ☐ NO ☐</td>
<td>Construction activities that generate large quantities of vapor or particulate (building implosion)</td>
<td>Robin Ridgway</td>
<td>Need Permit from IDEM, possibly SWPPP</td>
</tr>
<tr>
<td>12</td>
<td>YES ☐ NO ☐</td>
<td>Internal combustion engines &gt; 200 brake horsepower</td>
<td>Robin Ridgway</td>
<td>Specific Design and Notification Requirements</td>
</tr>
<tr>
<td>13</td>
<td>YES ☐ NO ☐</td>
<td>Internal combustion engines ≥ 500,000 BTU/hr combined</td>
<td>Robin Ridgway</td>
<td>Specific Design and Notification Requirements</td>
</tr>
<tr>
<td>Item of Concern</td>
<td>Purdue Contact</td>
<td>Purpose for Concern</td>
<td>Min Lead Time Required</td>
<td>Governing Regulatory Program</td>
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<tr>
<td>Process/chlorinated water discharged to the ground or storm sewer:</td>
<td>Robin Ridgway</td>
<td>Permit needed; specific design requirements</td>
<td>3 months</td>
<td>NPDES permitting program (Phase II); groundwater rules; wellhead protection program</td>
</tr>
<tr>
<td>• gray water,</td>
<td>Jim Knapp</td>
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<tr>
<td>• compressor blow down,</td>
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<tr>
<td>• cooling tower blow down,</td>
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<td>• vehicle cleaning water,</td>
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<td>• aircraft deicing</td>
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<tr>
<td>• filter backflush</td>
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<td>• deionized water backflush</td>
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<tr>
<td>Any discharge of chilled water must go to the sanitary sewer;</td>
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<tr>
<td>West Lafayette Waste Water Treatment Plant must be notified prior to discharge</td>
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<tr>
<td>Dry wells; French drains</td>
<td>Robin Ridgway</td>
<td>Specific Design Requirements</td>
<td>na</td>
<td>NPDES permitting program (Phase II); groundwater rules; wellhead protection program</td>
</tr>
<tr>
<td>Runoff waters from areas such as salt storage or coal storage</td>
<td>Jim Schweitzer</td>
<td>Permit needed; specific design requirements, possibly SWPPP</td>
<td>na</td>
<td>NPDES Phase II</td>
</tr>
<tr>
<td>Erosion control construction site ≥ ½ acre</td>
<td>Jim Knapp</td>
<td>Permit needed; specific design requirements</td>
<td>na</td>
<td>NPDES Phase II</td>
</tr>
<tr>
<td>Work in or near waterways or potential wetlands areas or endangered species</td>
<td>Jim Knapp</td>
<td>Permit/mitigation may be required</td>
<td>varies</td>
<td>Wetland, floodplain regulations, endangered species (IDEM, IDNR, NFWS, COE)</td>
</tr>
<tr>
<td>areas (e.g., work near Todd’s Creek, Jordan Creek, Celery Bog, Hort Park, etc.)</td>
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<tr>
<td>Wastewater treatment systems</td>
<td>Jim Knapp AND Chris</td>
<td>Permit needed; specific design requirements</td>
<td>6 months</td>
<td>NPDES, WLaf WWTP</td>
</tr>
<tr>
<td>Wastewater sewer mains</td>
<td>Marks</td>
<td></td>
<td>45 days</td>
<td>IDEM, WLaf WWTP</td>
</tr>
<tr>
<td>Item of Concern</td>
<td>Purdue Contact</td>
<td>Purpose for Concern</td>
<td>Min Lead Time Required</td>
<td>Governing Regulatory Program</td>
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<tr>
<td>21 Septic systems of ANY variety</td>
<td>Jim Knapp</td>
<td>Permit needed; specific design requirements</td>
<td>6 months</td>
<td>County Health Dept; NPDES Phase II</td>
</tr>
<tr>
<td>22 Discharges to sanitary sewer not meeting pretreatment requirements</td>
<td>Jim Knapp AND Chris Marks</td>
<td>specific design requirements</td>
<td>na</td>
<td>WLWWTP pretreatment program</td>
</tr>
<tr>
<td>23 Underground storage tanks</td>
<td>Robin Ridgway and Eric Johnson</td>
<td>specific design requirements; permit requirements</td>
<td>6 months</td>
<td>NPDES Phase II, well head protection, UST program</td>
</tr>
<tr>
<td>24 Above ground storage tanks</td>
<td>Eric Johnson AND Mike Koppes</td>
<td>Possible Design Considerations for containment, update SPCC</td>
<td>na</td>
<td>Campus SPCC Code requirements: fire code</td>
</tr>
<tr>
<td>25 Hazardous waste storage tanks</td>
<td>Eric Johnson</td>
<td>specific design requirements; permit requirements</td>
<td>varies</td>
<td>RCRA Permit</td>
</tr>
<tr>
<td>26 Work in the area of solid waste management units</td>
<td>Eric Johnson</td>
<td>Specific procedures required</td>
<td>varies</td>
<td>Closed landfill requirements</td>
</tr>
<tr>
<td>27 Land application of waste or secondary materials</td>
<td>Robin Ridgway</td>
<td>Permit required</td>
<td>na</td>
<td>Land Application Permit</td>
</tr>
<tr>
<td>28 Pesticide storage facilities</td>
<td>Eric Johnson</td>
<td>specific design requirements; permit requirements</td>
<td></td>
<td>Pesticide Program</td>
</tr>
<tr>
<td>29 Water main extension</td>
<td>Jay Schwartz AND Chris Marks</td>
<td>IDEM permit or notice of intent required for compliance</td>
<td>45 days</td>
<td>IDEM</td>
</tr>
<tr>
<td>Item of Concern</td>
<td>Purpose for Concern</td>
<td>Min Lead Time Required</td>
<td>Governing Regulatory Program</td>
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<tr>
<td>Sanitary sewer extension</td>
<td>IDEM permit or notice of intent required for compliance</td>
<td>45 days</td>
<td>IDEM</td>
<td></td>
</tr>
<tr>
<td>Well-head protection issues for location to well fields</td>
<td>Maintain safe drinking water in well head protection area</td>
<td>30 days</td>
<td>IDEM</td>
<td></td>
</tr>
<tr>
<td>Installation of geothermal (ground source heat pump) wells</td>
<td>Protection of Public Water Supply</td>
<td>6 months</td>
<td>SDWA Wellhead Protection</td>
<td></td>
</tr>
<tr>
<td>Any addition/change to Animal Science Research (ASREC) that modifies/adds to existing manure management infrastructure and current animal numbers and/or adds buildings of any sort</td>
<td>Verification of a manure management plan; permit modification</td>
<td>6 months</td>
<td>IDEM Confined Feeding Approval; possible CAFO NPDES permit</td>
<td></td>
</tr>
<tr>
<td>Work in FAA runway safety zones at airport</td>
<td>FAA regulations</td>
<td>6 months</td>
<td>FAA regulations</td>
<td></td>
</tr>
<tr>
<td>Any other work adjacent to airport that may involve wildlife hazard mitigation</td>
<td>FAA regulations</td>
<td>6 months</td>
<td>FAA regulations</td>
<td></td>
</tr>
<tr>
<td>Planned new buildings on campus</td>
<td>FAA notice of determination required</td>
<td>6 months</td>
<td>FAA regulations</td>
<td></td>
</tr>
<tr>
<td>Use of construction cranes anywhere on campus</td>
<td>FAA notice of determination required</td>
<td>60 days</td>
<td>FAA regulations</td>
<td></td>
</tr>
<tr>
<td>Demolition of structures of any sort that may contain asbestos or lead paint.</td>
<td>Permit required, licensed contractor required</td>
<td>6 months</td>
<td>IDEM asbestos program</td>
<td></td>
</tr>
<tr>
<td>Item of Concern</td>
<td>Purdue Contact</td>
<td>Purpose for Concern</td>
<td>Min Lead Time Required</td>
<td>Governing Regulatory Program</td>
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</tr>
<tr>
<td>Use of Purdue’s clean fill area for disposal of construction debris. Only materials meeting the definition at the right may be placed there; ALL OTHER MATERIALS MUST GO TO A PERMITTED C/D LANDFILL OR A SANITARY LANDFILL</td>
<td>Robin Ridgway</td>
<td>Only uncontaminated rocks, bricks, concrete, road demolition waste materials, or dirt may be placed in Purdue’s clean fill area.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Will there be a generator removed from this project that will be available for salvage/reuse/resale?</td>
<td>Robin Ridgway</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:
1 Introduction

1.1 The Instruments of Service provided under the contract are required to be delivered for all projects. These deliverables should be received within five (5) working days of the Bid Opening. Final Payment for A/E services will not be made until the Instruments of Service are received, reviewed, and approved.

1.2 This document outlines basic requirements and expectations related to the production and delivery of the Instruments of Service. Several offices at Purdue University are responsible for different aspects of building and infrastructure management. These Administrative Operations departments include Physical Facilities, Environmental Health and Public Safety, Auxiliary Services, Business Services, Asset Management, Space Management, and Campus Master Planning and Sustainability.

1.3 In order to maintain processes and systems that support ongoing university facilities planning, development, and management needs these offices depend on these records for decision making purposes. In order to facilitate meeting these needs, standards for the collection, organization, and maintenance of necessary project records have been established.

1.4 These standards exist in order to provide and maintain facilities information for the following purposes:

1.4.1 Support for facility management and long-term records management.

1.4.2 The ability to share and transfer data among departments within the University and to assist external design and construction professionals working on facilities projects.

1.4.3 Reduction of effort required in-house for drawing manipulation and modification and data creation.

1.4.4 The ability to perform asset management and geospatial and facility analysis.

2 Standards and Requirements for All Drawings

2.1 Expected Drawing format

2.1.1 Title Block

- The building name, project title, and Purdue University Project ID (PID) are required to be provided on each drawing sheet, including addenda, supplemental, and revision drawings.

- Sheet numbers will combine a discipline specific letter followed by a three (3) digit number (e.g. A101).

- Revision and addendum sheets should clearly indicate the corresponding sheet.

- Descriptions of the specific sheet number are required to be provided on each drawing sheet (e.g. “First Floor Architectural Floor Plan”).

2.1.2 Clearly indicate drawing submittal stage (Schematic, Design Development, Bid, etc.).

2.1.3 Clearly identify bid, revision, and alternate items.

2.1.4 Plans should be oriented so that architectural north is to the top or right of the sheet. If true north differs from architectural north this should be indicated. The orientation should be the same from sheet to sheet.

2.1.5 The difference between existing work and new work should be clear.

2.1.6 Legends, graphic scales, and north arrows should be provided on all sheets and provide key drawings where necessary.

2.1.7 Appropriate stamps and signatures (Architect/Engineer of Record) should be indicated on each sheet.

2.2 Expected Sheet Arrangement

2.2.1 Title and index of drawings

- Project location plans
- Existing Site Survey
- Landscape Protection Plan
- Civil and Sanitary
- Soil Boring Logs
- Landscape and Irrigation
- Architectural and Interior Design
- Structural
- Mechanical
- Electrical
- Fire Protection

2.2.2 For large or complex projects it may be necessary to provide a separate sheet for the drawing index.

2.2.3 The University Logo or other copyrighted items should not be used without permission from the University’s Marketing and Media Office.

http://www.purdue.edu/brand/visual/logos/signature.html

2.3 Legibility
2.3.1 Drawings, including plans, details, symbols, and lettering must be clear and legible.

2.3.2 Attention should be given to the amount of detail shown in a given space.

2.3.3 Poor spacing, careless lettering, weak lines and crowded drawings will not be accepted.

2.3.4 Illegible or poor quality drawings will not be accepted.

2.4 Sheet sizes

2.4.1 Hardcopy drawings shall be no smaller than D-Sized (24 x 36) and no larger than E-Sized (36x48 inch).

3 CAD Standards

3.1 This section outlines standards related to the production and delivery of computer-aided design and drafting drawings required for projects constructed on all Purdue University campuses.

3.2 All drawings and maps to be provided under the contract shall be created using computer-aided design and drafting (CAD) software.

3.3 CAD drawings will be prepared using recent versions of AutoCAD or MicroStation. Files must be delivered in AutoCAD version 2010 or later; or in MicroStation V8. Contact the PM with any questions about specific versions.

3.4 All CAD files must be organized in a clear concise manner using descriptive file names, layer/level names, and reference file attachments. All drawing elements must be on their appropriate assigned level. Purdue University uses the National CAD Standard. The AIA layer standard is also a preferred standard. Use of the Architect’s own layer standard is acceptable provided that layer names are clear and apparent to the information that is represented on that layer.

3.5 File names for sheet drawings should reference Purdue University’s Project ID (PID) and match hardcopy drawing sheet names (e.g. 10234_A101). Model or reference drawings should use the PID as a prefix to the model or reference file name (e.g. 10234_a-fp1.dwg).

3.6 Elements of the digital “drawing” file representing the work to be done will be created at their “real world” size using the appropriate unit of measurement. Civil drawings need to be created in engineering units and reference control points as outlined in survey specification documents. Civil details can be created in architectural units if desired.

3.7 Support files required to assure the drawing will appear in print form exactly as the hardcopy must be provided.

3.8 Fonts installed with the basic CAD program are the only fonts acceptable for use on the design project.

3.9 Unused information should be purged prior to delivery of files. This includes unused fonts, blocks, layers, etc.

3.10 All references should be bound to the sheet file and referenced in a manner that they are not dependent upon absolute file locations.

3.10.1 The A/E’s professional stamp & signature should be detached from the sheet files.

3.10.2 Image files (JPGs, BMPs, PNGs) must be embedded into the CAD file.

3.11 The use of PDF, TIF, DXF, or other static image formats are not considered a substitute for CAD delivery.

4 CAD Base Plans / Floor Plans

4.1 An updated base floor plan will be required for projects affecting any walls, doors, windows, and space modifications in addition to CAD files representing the contracted project deliverables. The Architect or design professional will be provided base plans at the beginning of the project upon request.

4.2 The Architect should only modify the location or assigned layer of any of the elements that are directly affected by the Project. These files are located spatially correctly to their real world location and must remain that way.

Note: Use NAD83 Indiana State Planes, Western Zone, & Vertical Datum: North_American_Vertical_Datum_1988

4.2.1 This deliverable can be accomplished by using the provided plan as a nested reference (xref) and then rotating and moving the referenced version.

4.3 For New Construction projects, the base plan delivered to the Owner should be oriented spatially correctly within the digital coordinates set as it would be constructed on site.

Note: Use NAD83 Indiana State Planes, Western Zone, & Vertical Datum: North_American_Vertical_Datum_1988

4.4 The Architect is encouraged, but not required to use the layers in the provided floor plan; however, new layers should adhere to the format of the Owner’s layers.

4.5 Use of the Architect’s own layer standard is acceptable if providing a translation table in .CSV or
4.6 Floor plans must be delivered in AutoCAD version 2004 or later; or in MicroStation V8. Files created in a BIM application such as Revit should be included as a supplement to the CAD deliverable.

4.6.1 When exporting and converting floor plans created in BIM software settings should be modified to remove or flatten any 3D information and remove any smart object association.

5 Civil, Utility, Landscape, and Survey Requirements

5.1 Civil, Utility, Landscape, and Survey references should be provided in addition to CAD files representing the contracted project deliverables. These references serve to update the University’s GIS.

5.2 Civil, Utility, Landscape, and Survey submittals should be delivered with spatially correct coordinates.

5.2.1 Projected NAD 1983 State Plane Indiana West FIPS 1302 (US Feet).

5.2.2 Vertical Datum: North_American_Vertical_Datum_1988.

5.2.3 All models submitted should contain at least 3 station points with X Y and Z coordinates either in annotated and/or table form.

5.2.4 All planning, civil, landscape, demolition, site and utility deliverables should be received in model format with all references bound.

5.3 Use of Architect’s own layer standard is acceptable providing layer names are apparent to what information is represented on that layer. National CAD Standards or AIA Standards are preferred.

Note: Also see Attachment 1 for other acceptable layer names

5.4 Image Production

5.4.1 Image files representing exactly the hardcopy instruments of service and the CAD file deliverable are to be provided. Image files may be organized by volume or by sheet depending on the size and complexity of the project.

5.4.2 PDF or TIFF file formats are the only accepted image formats.

5.4.3 Image files must be produced to match submitted hardcopy document dimensions.

5.4.4 Image files organized by volume must have file names that clearly indicate the Purdue University Project ID and volume number of total volumes (i.e., 10234_Vol1 of 4).

5.4.5 Image files organized to the sheet level must have file names that indicate the Purdue University Project ID and drawing sheet number indicated in the title block (i.e., 10234_A101).

6 Building Information Modeling

6.1 BIM requirements for deliverables must adhere to the Project’s BIM Execution Plan (BEP), if a plan was created for the Project. The existence of a BEP does not supersede the Project Document Deliverables Requirements. If there is no BEP and there are BIM related or other modeling related files they should be provided in addition to requirements outlined in this document.
7 Instruments of Service-Checklist

7.1 The table below summarizes the deliverables described above. Questions regarding specific standards and requirements can be directed to the Project Manager. Acceptable delivery methods for electronic deliverables are CD, DVD, or USB drive. Secure file transfer of the Instruments of Service is also an acceptable delivery method.

8 Table of Document Types

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Hardcopy</th>
<th>CAD</th>
<th>Model</th>
<th>Image (PDF/TIFF)</th>
<th>Delivery Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawings</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>CD/DVD/File Transfer</td>
</tr>
<tr>
<td>Specifications</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>CD/DVD/File Transfer</td>
</tr>
<tr>
<td>Base Plan/Floor plan</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>CD/DVD/File Transfer</td>
</tr>
<tr>
<td>Civil, Utility, Landscape, Survey</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>CD/DVD/File Transfer</td>
</tr>
<tr>
<td>Building Information Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CD/DVD/File Transfer</td>
</tr>
</tbody>
</table>

7.2 A transmittal should accompany these deliverables addressed to the attention of the Project Manager with a carbon copy to the Assistant Director of Facilities Information Services. The transmittal should identify the project by the Purdue University Project ID (PID) and the established Project Title.
1 Introduction

1.1 Most University projects have three distinct phases. The actual number of submittals will be outlined in the RFP.

1.1.1 Schematic Design Phase
1.1.2 Design Development Phase
1.1.3 Construction Document Phase: This phase may require up to four submittals

1.1.3.1 Intermediate Construction Documents: to verify that the University responses to the DD submittals are understood and being properly implemented

1.1.3.2 Final Review Construction Documents: a complete set of construction documents for owner review offering the last opportunity for revisions to be incorporated into the Bid Documents

1.1.3.3 Construction Documents (Bid Set): the document set initially delivered to contractors with comments to be addressed by addenda

1.1.3.4 Contract Documents: This is the complete and legally binding set of documents that includes the Bid Documents with accepted alternates delineated, and all addenda

1.2 After the expectations as outlined below are successfully met the Consultant will receive notification from the PM releasing them to proceed to the next level of submittals. If the University Project Team is not satisfied that the expectations have been met then the Consultant will be required to re-submit a corrected submittal package at a date to be determined by the University Project Manager.

2 Submittal Review

2.1 Written comments from PM should be expected within three weeks from the date of delivery of the plan submission.

2.2 Consultant will respond in writing to each of the review comments.

2.3 At each level of the design process the University will typically require submittal review meetings. Additional meetings will be covered in the RFP.

3 Requirements Common to All Projects

3.1 Construction cost estimate arranged by discipline including identification and estimated cost of any Owner-provided equipment or materials

3.2 Code review for all disciplines

3.3 Basis of Design for all disciplines

3.4 Review of University Design Standards and a list of non-compliance issues

3.5 Energy & LEED

3.5.1 Describe energy efficiency and sustainability aspects of the design approach integrated between all disciplines for all phases after SD

3.5.2 Show the energy modeling as developed for all phases after SD

3.5.3 Provide a copy of the COMcheck submittal as developed for all phases after SD

3.5.4 Provide estimate of annual energy consumption as well as a list of potential energy savings options

3.5.5 Provide LEED project checklist (if seeking certification)

3.5.6 Provide LEED Basis of Design document (if seeking certification)

3.6 Ventilation Rate Procedure:

3.6.1 Refer to Division 23 HVAC 0000 Systems 1.1 and 1.2 for submission requirements.

3.6.2 Provide a copy of the Ventilation Rate Procedure as developed for all phases after SD.
1 Introduction

1.1 Printing and distribution of the Project's Drawings and specifications are required at established stages of each Project. The Project Manager will determine those stages.

1.2 The guidelines below are the current standards for printing and distribution through PDSX. Printing and Distribution requirements relating to the Instruments of Service are located in Article 2: Section K. Maps and Records.

2 Drawings

2.1 PDSX requires one print ready PDF file containing all drawings within each volume of the Project. The drawings must be in the same order that is indicated on the Index or Cover Sheet.

   2.1.1 Each sheet file must be identified by file name and in the order the files should print (i.e. A100, and A101 etc.). File names and sheet names should match.

   2.1.2 It is recommended that a print ready PDF test file with all pen weights and colors be prepared.

2.2 Specifications (Project Manual)

   2.2.1 Provide one complete print ready PDF file of the specifications.

   2.2.2 It is recommended that a print ready PDF test file with all pen weights and colors be prepared.

3 Submitting files via Electronic File Transfer

3.1 Electronic file transfer is an acceptable delivery method for documents reflecting the planning and design review stages. Electronic file transfer is not an acceptable delivery method for the Final Instruments of Service. See Section 7.0 of the Guidelines for Instruments of Service for acceptable delivery methods for the Final Instruments of Service.

3.2 New Companies: Contact the Project Manager or FES Administrator to initiate the process.

   FES Administrator
   Office Phone: (765) 494-6359

3.3 Returning Companies: The File Exchange Services – User Documentation contains instructions and information on: How to obtain and setup “Remote Desktop Client”.

   How to connect and use the File Exchange Services offering.

3.4 Problems

   3.4.1 If you have trouble logging on or accessing the file exchange server, please contact: Physical Facilities Technical Coordinator (765) 494-7776
1 Site Survey General Specifications

1.1 Provide labor, materials, and equipment, to complete a site survey for the prescribed project.

1.2 Use appropriate instrumentation and procedures, including adequate supervision and quality control measures, which are consistent with accepted professional surveying standards and practice.

1.3 All drawings shall be done using computer-aided design and drafting (CADD) software.

1.4 The area of interest on a map to be provided by the project manager.

1.5 The site survey will be incorporated into the Purdue University Geographic information system (GIS). The GIS horizontal reference datum is NAD 83, and the vertical reference datum is NAVD 88. Be aware that previous surveys and plan drawings, provided for reference, may be referenced to other datums.

2 Site survey minimum detailed specifications

2.1 Documentation

2.1.1 A preliminary of the site survey shall be submitted for review. A pdf of each drawing is to be provided for that review. Your questions for the university’s reviewers should be submitted at this time. Presentation in an electronic word document will facilitate their response.

2.1.2 Final documents will be: 1) a CADD drawing file (.dwg or .dgn) provided on a cd, or by electronic file transfer, 2) a field point drawing file (.dwg or .dgn) provided on a cd, or by electronic file transfer, and 3) a pdf file of each drawing.

2.1.3 CADD drawing files shall be provided in AutoCAD 2000 which is compatible with MicroStation, and in AutoCAD 2006 if available.

2.1.4 CADD drawing files shall be organized in a clear and concise manner using descriptive file names, level names, and reference file attachments.

2.1.5 CADD files containing reference files (xrefs) shall be delivered with the “retain path” box unchecked. CADD files shall have extraneous graphics outside the subject area removed.

2.1.6 Each drawing shall bear the certification of the licensed land surveyor responsible for the survey.

2.1.7 It is understood that Purdue University may reproduce the drawings and distribute the prints without incurring obligation for further payment.

2.1.8 Drawing sheets shall be 24” x 36”, using an appropriate scale.

2.1.9 Show the scale with the north arrow. Include a graphic scale.

2.1.10 Include a legend, or legends, for symbols and abbreviations as necessary.

2.1.11 Include a site map to show the site survey area. For clarity when there are multiple drawing sheets, show their locations on the site map.

2.1.12 Cite the University project name in each drawing title block.

3 Control points

3.1 Site survey horizontal control points shall be referenced to NAD 83; vertical control points shall be referenced to NAVD 88. Horizontal and vertical control reference points from University archived surveys may be provided. The number of horizontal control points and the number of vertical control points to be established on the site shall be based on intervisibility; however, a minimum of 2 horizontal control points and 2 vertical control points will be established for any site survey. Control points shall be semi-permanent and set in a manner for construction layout. Provide a description of each control point. State the horizontal datum and the vertical datum used on each drawing sheet.

4 Elevations

4.1 Elevations shall be shown on a 30-foot grid, and at breaks in elevation; or closer in areas with special conditions. Grids will be reduced accordingly in areas of larger scale.

4.2 Elevations shall be to the nearest 0.01 foot on pavement or other hard surfaces and to the nearest 0.1 foot on all other surfaces. For clarity it may be necessary to provide a separate drawing, and cad drawing file, showing surface elevations without showing underground utility lines. Include control points on these separate drawings.

4.3 Show contour lines at 1-foot intervals; if impractical adjust the interval appropriately. For clarity it may be necessary to provide a separate drawing, and cad drawing file, showing contours without showing spot elevations. Be sure to
include control point information on these separate drawings.

5 Utilities, structures and features
5.1 Show utilities and their surface structures. Provide elevations on tops of valves, vaults, meters, access panels, etc. Provide ground elevations next to utility poles, utility boxes, hydrants, standpipes, etc., if there is a grade change. Show and identify overhead utility lines. Show guy wires. Provide sewer and storm drainage structure rim elevations and inverts, and indicate the type and size of pipes and their direction; structure tables are appropriate. Provide structure bottom elevations where necessary. In order to provide adequate sewer information it may be necessary to include a structure, or structures, beyond the subject site. Show the size, depth and pressure of underground utilities where possible. Show above ground markers and signs. Provide ownership information on non-Purdue utilities. Underground utility locations should be shown as accurately as possible. Purdue University GIS maps showing utilities are provided for general reference only. Copies of pertinent drawings on file with Purdue University will be provided for reference. Indicate on the site survey the drawing(s) used as a reference for utilities or structures; using a reference table is appropriate. Purdue University will arrange for above ground marking of its utilities. Contact IUPPS for marking of non-university utilities. Confined space entry is not permitted without prior approval from the University.

5.2 Show Purdue University sewer and storm sewer structure numbers as indicated on the GIS maps provided. Proprietary structure numbers can be used provided the Purdue number follows in parenthesis. This shall be done when shown and when referenced.

5.3 Show ditches and culverts. Provide center line and top of bank elevations for ditches. Provide type, size and inverts of culverts and drains. Show rights-of-way for legal drains

5.4 Show the locations and provide brief descriptions of buildings and structures. Show the first floor elevation of buildings at main and side entrances. Building entry may require coordination with the building deputy. Show downspout locations. Show locations of fire suppression systems (Siamese valves and standpipes). Show building names and building indexes.

5.5 Show or note the sanitary setback radius for wells. Purdue wells are subject to the Indiana administrative code for public water supply. Wells on campus that are located in well houses are subjected to automatic disinfection. The sanitary setback radius for those wells is 100 feet measured from the outside edge of the well casing. Setbacks for other wells vary and those setbacks will be provided.

5.6 Show roads, streets, curbs, curb cuts, driveways, and parking lots. Indicate their surface material. Note if surfaces are permeable; e.g. permeable pavers, porous asphalt, or pervious concrete. Provide cross section elevations for roads and streets at 30-foot intervals (intervals will be reduced accordingly in areas of larger scale) and at breaks in elevation. Provide elevation details at intersections.

5.7 Show walks, steps, ramps, railings, gratings, walls, benches, fences, bicycle racks, landscape features, gardens, sculptures, plaques, and other improvements. Provide necessary details. Provide critical elevations. Note if walks or ramps are permeable pavements or permeable pavers.

5.8 Show signs, parking blocks, parking meters and traffic control poles, manholes and boxes. Show traffic signal loops provide street names. Label one-way streets.

5.9 Show fire alarm boxes and emergency telephones.

5.10 Show and identify extent of surfacing material, lawns, planting areas, gardens, shrubs, bushes and hedges. Cutting of shrubs and bushes is not allowed.

5.11 Show and identify trees. If the canopy of a tree falls in the site survey limits, the tree needs to be included. Include their trunk diameter measured at 4 feet above grade. Show their canopies (drip line) to scale. Show their root zone using a dashed-line circle around each tree. The trunk diameter in inches multiplied by 1.5 equals the radius of the root zone in feet. Show grade elevation at trees. Show tree grates and enclosures. Show extent of masses of trees and high bushes. Cutting of trees or their branches is not allowed. Purdue University GIS tree maps and inventory data will be provided for reference if available. The campus arborist will provide a
tree appraisal using the preliminary site survey submitted for review.

5.12 Show location of soil borings if ascertainable, and the grade elevation at each boring.

5.13 For clarity a utility data drawing(s) and a topographic data drawing(s) is recommended. Using tables for information and data is appropriate.

5.14 Do not mark utilities, structures, or features, with paint or permanent markers.

5.15 All information provided by Purdue University to assist in the planning of, or the completion of, this site survey is subject to the following: Purdue does not assume any responsibility for damages including, but not limited to, special, incidental, punitive, or consequential damages whether arising from or in connection with the use of this information, or data, in any way. It is understood that the content may or may not contain sensitive information and discretion will be used. The only people authorized to use this information are the person to whom these specifications are submitted to and any individuals specifically involved with the identified use. Any use of this information other than that described above must be approved by an appropriate representative of the department of physical and capital planning. This information is not to be circulated to anyone without prior written communication from an appropriate representative of the department of physical and capital planning. When this information is no longer needed by the recipient it is to be destroyed.

6 Notes and Clarifications

6.1 The above specifications are comprehensive; therefore some specifications may not apply.

6.2 The University surveyor will modify the preliminary and final deliverables appropriately.

6.3 If measure downs of structures are prevented by lids or covers that are locked, or difficult to remove, the University surveyor is to be contacted.

6.4 The firm doing the survey cannot make an excavation for determining the locations of utilities, or buried structures. Necessary excavations will be coordinated by the project manager and the University surveyor. The information to be gathered in an excavation will be specified, and accomplished with appropriate University personnel on site.

6.5 Elevations inside tunnels are not required. If needed they will be coordinated by the project manager and the University surveyor; and appropriate University personnel will be present at all times to provide access and guidance.

6.6 Building floor elevations other than those mentioned in the above specifications are not required. If needed they will be specified separately, and will require coordination with the project manager and the building deputy or building manager.

6.7 Building heights are not required. If needed they will be specified separately. Confined space entry is not permitted without prior approval from the University. Once permitted, appropriate University personnel will control the entry.

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6.14 Building heights are not required. If needed they will be specified separately.
6.15 Confined space entry is not permitted without prior approval from the University. Once permitted, appropriate University personnel will control the entry.

7 Subject to:

7.1 The statutes and rules for land surveying as defined in the Indiana administrative code; and the rules, standards, and regulations of the occupational, safety and health administration, department of labor.
1 Introduction
1.1 Because of the proximity of the Purdue University Campus to the Purdue University Airport, the Federal Aviation Administration (FAA) requires that all proposed permanent structures to campus, including but not limited to antennae, antennae towers, buildings, building additions, chimneys, flagpoles, high mast illumination, landfills, light poles, monopoles, stacks, power lines, water tanks, wind turbines, etc., and all proposed temporary structures on campus, including but not limited to cranes, drilling rigs, etc., must be evaluated and approved by the FAA prior to their construction or installation.

2 Process
2.1 Consequently, the Purdue University project manager must be contacted at the earliest possible time in the planning process of permanent structures for guidance and counsel on the above requirement.

2.2 Preliminary maximum allowable structure height review, per the Purdue Airport Layout plan, should initially be evaluated by the Project Engineer of Record.

2.3 Location and design of the permanent structure is determined by the AE and the academic/administrative department, the Project Engineer of Record will submit the required structure details to the FAA on behalf of Purdue University for FAA review. https://oeaaa.faa.gov/oeaaa/external/portal.jsp (Provide the Purdue Project Manager copies of the initial and FAA review submittal as well as the FAA final determination.)

2.4 The submission of crane details to the FAA will be considered when the construction of the structure is certain and crane height and location are certain.

3 Timeline
3.1 The FAA typically takes one to four months to evaluate a structure and issue a determination.

3.2 The University has no ability to condense the time of this review period.

3.3 Even structures determined as “not a hazard to air navigation” are subject to FAA conditions and recommendations.

4 Emergencies
4.1 In an emergency, or adverse situation, where an FAA evaluation of a proposed temporary structure cannot be obtained in time, the Purdue Airport Director must be consulted immediately.

5 Evaluation
5.1 All construction and alteration activity, regardless of height, on the Purdue Airport is subject to evaluation and approval by the FAA.

6 References
6.1 Indiana Code IC 8-21-10
6.2 Code of Federal Regulations CFR Title 14 Part 77
6.3 FAA Form 7460-1 Notice of Proposed Construction or Alteration
A/E – Architect or Engineer responsible for the components being discussed

ADA – Americans with Disabilities Act

AFC — Arc Flash Consultant responsible for the arc flash study

AFF – Above Finished Floor

AHU – Air Handling Unit

APD – Air Side Pressure Drop (used with coils)

APW – Acid Proof Waste

ATS – Automatic Transfer Switch (electrical)

BDF – Building Distribution Frame

CA – Commissioning Agent

CAL – Calorie

CD – Construction Documents including drawings and specifications certified by design professional for use by construction trades.

CPU – Central Processing Unit

CWR – Chilled Water Return

CWS – Chilled Water Supply

DC – Direct Current

DD – Design Development

DDC – Direct Digital Control

EC – Electrical Contractor

ECS – Environmental Control System

EMT – Electrical Metallic Tubing

EOR – Engineer of Record

EP – Electricity Primary

EWT – Entering Water Temperature

FA – Fresh Air

FCU – Fan Coil Unit

FPS – Feet per Second

FR – Flame Resistant

HP – Horsepower

HPS – High Pressure Steam

HVAC – Heating Ventilating and Air Conditioning

IE – Incident Energy

IFB – Internal Face and Bypass

IOSHA – Indiana Occupational Safety and Health Administration

IPS – International Pipe Size

IR – Infrared

LOT – Lockout Tagout

LPS – Low Pressure Steam

LWT – Leaving Water Temperature

MCC – Motor Control Center

MER – Mechanical Equipment Room

MTS – Manual Transfer Switch

MVD – Manual Volume Damper

NEC – National Electrical Code (Latest edition as adopted by the State of Indiana)

OA – Outside Air

OCPD – Overcurrent Protective Device

OSHA – Occupational Safety and Health Administration

OPR – Owner Project Requirements

PIC – Purdue Information Connection

PM – The University Project Manager

PDSX – Purdue Print and Digital Services delivered by Xerox

PPE – Personal Protective Equipment

PRV – Steam Pressure Reducing Valve

PSI – Pounds per Square Inch

PSIG – Pounds per Square Inch – Gauge

PT Plug – Pressure & Temperature Sensing Port (‘Pete’s Plug’)

RA – Return Air

REM – The University Division of Radiological and Environmental Management

RF – Radio Frequency

RFP – Request for Proposal

SA – Supply Air

SD – Schematic Design
SRV – Steam Safety Relief Valve
TAB – Test Adjust and Balance
TCC – Temperature Control Contractor
UPS – Uninterruptible Power Supply
VAV – Variable Air Volume
VFD – Variable Frequency Drive
W – Water
WPD – Water Side Pressure Drop (used with coils)
1 Landscape Protection Plans

1.1 Prior to the start of design work, the consultant will develop a Landscape Protection Plan including information provided by Purdue.

1.2 For each existing tree, the plan will identify the:

- Location
- Tree ID number
- Canopy Size
- Root zone

1.3 The plan will include an appraisal table provided by the Campus Arborist, noting the monetary value of each tree and whether it is to be protected, relocated, spade (tree is large enough to need a tree spade to relocate it) and/or removed as part of the project.

1.4 Purdue’s standard notes will be included on the Landscape Protection Plan. An example plan can be provided.

1.5 Tree types, locations, sizes, and root zone areas may be provided as part of the project survey. Should the survey be incomplete at the start of design, the consultant will use Purdue’s archive and planimetric drawings, Arboretum data, and field verification to establish an initial draft Landscape Protection Plan.

1.6 The consultant will work with the Project Manager, Grounds Department Landscape Architect, and Campus Arborist to understand landscape protection goals impacting the project and to establish protective fence and mulch locations as the project design develops.

1.7 The Landscape Protection Plan will be located after the survey and before the demolition plan in the construction documents.

2 Landscape Protection Specifications

2.1 Contract document specifications will include the section titled “Tree Protection and Pruning” available from the Grounds Department Landscape Architect or the Project Manager.

2.1.1 This section will be included verbatim except Part 1.2.b. which the consultant will modify to coordinate with other, related sections in the project specifications booklet.

2.1.2 This section will be inserted in the appropriated section of the specifications.

2.2 The required content of the landscape protection plan has been carefully coordinated with verbiage in the tree protection specification section. Neither should be modified without prior approval of
1 Description

1.1 University standard is to redirect at least 50% of non-hazardous solid construction and demolition waste from the waste stream.

1.2 Construction and demolition waste includes products of demolition or removal, excess or unusable construction materials, packaging materials for construction products, and other materials generated during the construction process but not incorporated into the work.

1.3 In the management of waste consideration shall be given to the availability of viable markets, the condition of the material, the ability to provide the material in suitable condition and in a quantity acceptable to available markets, and time constraints imposed by internal project completion mandates.

2 University recycled material programs

2.1 The Purdue Gravel Pit coordinator manages the construction material program for Purdue.

2.1.1 Gravel Pit Coordinator contacts

- (765) 496-6650
- (765) 496-1711
- (765) 494-3089

2.2 The project budget should include a line item for Purdue Grounds personnel to manage materials from University projects.

3 Topsoil

3.1 Clean topsoil from projects will be stockpiled as directed.

4 Construction demolition debris

4.1 The Contractor may use the Owner’s Solid Fill Area for disposal of uncontaminated concrete, brick, stone, blacktop, soil, gravel, and similar types of road demolition material.

4.2 Building materials including scrap lumber, glass, wallboard, roofing, plumbing fixtures, wiring, insulation, steel, ductile iron or cast iron piping cannot be deposited in the solid disposal area.

4.3 Coordinate project needs w/ the Gravel Pit Coordinator prior to bidding.
1 Items to be Included

1.1 Certain control points and benchmarks are shown on the plans, or will be available from the Project Manager. These points must be used by the Contractor to provide as-built utility information for this project.

1.2 The Contractor must locate all existing utilities encountered during the construction of the project and record all information necessary to accurately locate that item in the future.

1.3 At a minimum all newly installed utilities must have the x-y-z coordinates (distance north-south, and east-west; and depth) referenced to the control and a written description of all points located (i.e., elevation, location, material, etc.).

1.3.1 This information should include information about the start point, end point and any change in direction of the newly installed utility.

1.3.2 Reference should also include structures, and any splices from damaged utility lines.

1.3.3 Show all changes in size, material, location, and elevation of all new, existing, and/or abandoned underground utility lines or other pertinent work.

1.3.4 Show the location (x-y-z) of all valves, manholes, etc.

2 Format and Delivery

2.1 Format and delivery requirements of as-built drawings should follow 01 GENERAL 3300.1 Submittals-Document Standards as closely as possible.

2.2 The as-built drawing sheet size will be the same as the original drawings unless otherwise authorized by the Project Manager.

2.3 Drawings will be prepared by a competent draftsman in a neat and acceptable manner to scale and fully dimensioned.

2.4 As-built information must be provided in both raster (i.e. PDF) and vector (AutoCAD, MicroStation, or ArcGIS) as well as hardcopy drawing sheets.

2.5 Vector formats should reference Section 5 of 01 GENERAL 3300.1 Submittals-Document Standards for required standards and formats.

2.6 Original contract documentation may be used as the base for the “As-Built” document.

2.7 The “As-Built” document shall be stamped “As-Built” on each drawing sheet. As-built drawings submitted in CAD format should be appropriately titled in each file name (ex. A101ab.dwg).

2.8 Upon completion of the project, the “As-Built” drawings will be delivered to the PM.
1 Introduction

1.1 All projects must have the exterior approved by the Senior Architect (SA). Any deviation to the approved exterior during construction must be approved in writing by the SA and Project Manager.

1.2 A mockup panel shall be installed by the contractor that shows the relationship of exterior building materials to include, but not limited to, masonry, caulk, windows, window sills, and other materials specific to the project. This panel will be approved by Purdue University and the Project Architect prior to the occurrence of any exterior construction of these materials. The panel will be considered for aesthetics, contractor workmanship, and color and will be kept on the job site in a safe location so that it will not be subject to damage for the duration of the project.

1.3 The design professional shall familiarize themselves with the document, “Architecture On Campus” which can be obtained from the Project Manager.

2 Roof design criteria

2.1 Building roof lines shall be carefully designed to avoid exposure of pedestrians to snow and/or ice falling from sloped roofs above pedestrian areas.

   2.1.1 Anywhere pedestrian areas exist below the edge of a sloped roof, an entry canopy or other means of protection should be provided for the safety of the pedestrians.

Note: Snow guards on the roof, by themselves, have not proven adequate.

2.2 The need for the installation of roof fall protection shall be discussed with University representatives during design.

2.3 Flat roof design shall include secondary (emergency) roof drains or scuppers where water could be entrapped if the primary drains allow buildup for any reason.

2.4 Flat roof slopes shall be a minimum of 1/8 inch/foot to the roof drain.

3 Roof Warrantees

3.1 All manufacturer roofing warranties shall be for a minimum of 20 years unless agreed upon with the project manager.

3.2 Installer warranties shall be for two years.

Note: There has been some confusion over the time period for the installer warranties. While it was determined some years ago that this would be a two year warranty, some of the associated paperwork continues to show one year as the default time period. The project specifications should make clear that this will be a two year warranty.

4 Secondary Roof Drains

4.1 Secondary roof drains shall have the end point discharge separate from the primary system and shall be above grade, in a location that could be observed by building occupants or maintenance personnel.
1 High traffic areas

1.1 Main corridor and other high traffic areas must be designed to withstand not just the traffic, but the actual occupancy of students arriving early for class, participating in impromptu discussions, and general lounging.

1.2 Surface mounted or otherwise exposed conduit should not be used in publicly accessible spaces.

2 Offices

2.1 University standards control office sizes. Strict compliance with sizes noted in the Architectural Program is required.

2.2 Typically, an office will have its long dimension perpendicular to the corridor with the door on the “end” wall. It is assumed that the desk will be located against the long wall farthest from the door.

2.3 Lighting will be designed for general distribution. Task lighting in offices and specialty labs can be used to supplement room lighting.

2.4 Offices will not be allowed within laboratories except under specific circumstances and with specific approval.

3 Entrances

3.1 Building entrances should have a vestibule with walk-off type carpet.

3.2 Vestibules should be deep enough to accommodate appropriate placement of automatic door operators, switches, and wheelchair access to those switches.

Note: The code minimum 7’ vestibule does not provide this degree of access. In addition, the deeper the vestibule, the more effective the walk-off mats.

4 Wall Construction

4.1 Unless the Program directs otherwise, all walls will be constructed tight to the underside of the structural deck above. The top of the partition must be sealed to the deck and all openings for passage of services must also be sealed.

4.2 Install fire rated blocking in frame walls for hanging items and at the base of the corridor walls for resistance to damage from floor cleaning equipment.

5 Anchors

5.1 Install no anchors in the underside of concrete joists or beams. All anchors must be set horizontally as near as possible to the neutral axis of the structural member. Drill and Set anchors in beams (not power driven).

5.2 Plastic anchors are not acceptable for securing items to walls.

5.3 Use of powder-actuated fasteners into the underside of concrete slabs is discouraged.

6 Partition Construction and Surface Table

<table>
<thead>
<tr>
<th>Location</th>
<th>Coated CMU</th>
<th>Gyp Board</th>
<th>STC level</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Traffic Corridor</td>
<td>X(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Traffic Corridor</td>
<td>X(2)</td>
<td>X(1,3)</td>
<td></td>
</tr>
<tr>
<td>Mechanical rooms</td>
<td>X(2)</td>
<td></td>
<td>60(4)</td>
</tr>
<tr>
<td>Public Areas</td>
<td>X(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restrooms</td>
<td>X(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classrooms</td>
<td>X(2)</td>
<td>X(1)</td>
<td>45(4)</td>
</tr>
<tr>
<td>Offices</td>
<td>X(2)</td>
<td>X(1)</td>
<td></td>
</tr>
<tr>
<td>Recording studios</td>
<td>X(2)</td>
<td></td>
<td>60(4)</td>
</tr>
<tr>
<td>Areas with confidential conversations</td>
<td>X(2)</td>
<td>X(1)</td>
<td>60(4)</td>
</tr>
</tbody>
</table>

(1) In general, use of gypsum board is to be approved by the University Project Manager. We use it only in areas with low traffic.

(2) CMU surface coating material needs to be chosen for the specific use but may include glazing, painting, epoxy coating etc. Ceramic tile is appropriate for most restroom finishes.

(3) If gypsum walls are used in corridors (this is discouraged), rails, corner guards, wainscot treatments, and other special treatments will be necessary. A veneer plaster finish will probably be necessary as well.

(4) These sound transmission levels will require special construction and insulation considerations.

(5) Vinyl wall covering can only be used in certain areas due to its tendency to be peeled away at corners. When it is used, the paste must be carefully specified.

7 Severe weather refuge

7.1 Specific strategies to provide a severe weather refuge must be discussed with the Project
Manager.

**Note:** In many pre-engineered steel buildings and certain other buildings of special construction techniques, it may be difficult for the occupants to find adequate refuge from flying glass and sheet metal in the event of severe weather. For this reason it is recommended that when appropriate, due to the building type, interior space(s) shall be provided that are of a more substantial construction type to withstand severe weather and large enough to house the building’s occupants.
1 Introduction

1.1 The Americans with Disabilities Act (ADA) Accessibility Guidelines (ADAAG) – current edition - shall be strictly followed.
1 Industry Design and Construction


1.1.1 All lab animal housing and care facilities must meet the standards as outlined in this Guide, used as a basis for performance of animal facilities by the Purdue University Animal Care and Use Committee and for accreditation of institutions by the Association for the Assessment and Accreditation of Laboratory Animal Care (AAALAC).

1.2 Planning and Designing Research Animal Facilities, The American College of Laboratory Medicine, First Edition, 2009

1.3 The Guide for the Care and Use of Agricultural Animals in Research and Teaching, Third Edition, January 2010

1.4 National Institute of Health (NIH), Biomedical and Animal Research Facilities Design Policies and Guidelines, Section 2.4, Design Considerations for Animal Research Facilities

1.5 ASHRAE Handbook – HVAC Applications, Chapter on “Environmental Control for Animals and Plants”

2 General Design Considerations

2.1 Corridors shall be a minimum 7'-0” wide.

2.2 Windows are generally not permitted in animal rooms.

2.3 Doors in all animal rooms shall be 42” (W) x 84” (H) and open into the animal room.

2.3.1 Doors shall be constructed of corrosion resistant materials.

2.3.2 Door closer shall have a delayed action feature.

2.3.3 Doors should be equipped with locks.

2.3.4 Provide entrance function lockset with knob trim inside room and flush ring pull to corridor side.

2.4 Walls and ceilings shall be smooth, moisture resistant, non-absorbent, and resistant to impact damage.

2.4.1 Animal room walls should be constructed of pre-glazed concrete masonry with epoxy grout with no voids in the masonry, to deter infestation of vermin.

2.4.2 Alternate wall construction may be metal stud wall framing with moisture-resistant drywall and rigid PVC wall panels.

2.5 Floors should be moisture resistant, impact resistant, seamless and monolithic with integral cove to the wall.

Note: Epoxy resins, hard-surface sealed concrete, methyl methacrylate, polyurethane, and special hardened rubber-base aggregates have proved satisfactory. Correct installation and substrate condition is essential to ensure the long-term stability of the surface.

3 Power and Lighting

3.1 In the event of a power failure, an alternative or emergency power supply should be available to maintain critical services and support functions in animal rooms, operating suites and other essential areas.

3.2 Use sealed, flush-mounted, light fixtures; pendant-mounted fixtures are not acceptable.

3.3 In general, provide 30 fc, approximately one meter above the floor for animal housing rooms.

3.3.1 Select proper illumination to meet specific and exceptional applications as required.

3.3.2 Animal room lights shall be controlled with auto-timer with switch override. Where required, provide two levels of lighting, with one level on a timer and one on the switch.

3.4 All conduit and junction boxes shall be weatherproof, sealed to deter infestation of vermin, mounted 48 inches above finished floor.

3.5 Outside each animal room, there shall be a water resistant recessed panel containing light switches, light timer for each animal cubicle, and mechanical gages for readouts for temperature and pressure, as required.

3.6 Rough-ins shall be made for card access systems to provide for secure access to animal facilities.

3.6.1 Conduit needs to be stubbed to the doorframe at the door strike pocket, run to above the doorframe and terminated at a 4x4 box.

3.6.2 Depending on the type of access control reader required, an additional wall box with conduit run up to the 4x4 doorframe box may be required.

3.6.3 In high security rooms the conduit needs to be installed in the wall.

4 Mechanical Guidelines

4.1 All penetrations shall be sealed watertight.

4.2 Where required, install a waste gutter with a sediment trap floor drain with a removable drain trap bucket to prevent material from clogging drains in animal rooms.
4.3 Minimize all exposed ductwork and piping. If ductwork must be exposed, it shall be stainless steel and have no exposed duct insulation. Provide access doors where required for equipment maintenance and to provide access for cleaning ductwork.

4.4 Exhaust grilles and supply diffusers should be corrosion resistant and able to be sanitized.

4.5 A visual indication of differential pressure should be installed close to the door of each room that has pressure requirements.

4.6 Mechanical equipment requiring maintenance should be located outside of the animal room.

4.7 If a heat recovery system is used, it should be “run around” with no means of cross contamination.

4.8 HVAC zone controls, including room temperature and humidity controls, should be housed in a corrosion resistant cabinet. Install the temperature sensor such that only a stainless steel or corrosion-resistant, waterproof plate is exposed inside the room.

4.9 In general, provide 10 to 15 fresh air changes per hours in animal housing rooms, unless a mechanical engineering evaluation indicates that more is required for a specific application.
1 Introduction

1.1 These guidelines are intended to govern all aspects of design for Purdue’s Classrooms and Learning Spaces and may be applied to classrooms, class labs, large conference rooms, gathering spaces, and any facilities that may serve an assembly function as a secondary aspect of the program.

2 Site and Spatial Relationships

2.1 Windows, quality lighting, good ventilation and excellent acoustics are healthy attributes of classrooms.

2.2 Classrooms should be located within one floor of the grade entry level.

Note: Below grade locations are not ideal for classrooms, unless daylight can be provided by means of window wells or atria.

2.3 Consider ceiling height requirements when locating classrooms within a building.

2.4 Classrooms should be protected from disruptive noise.

3 Approaching and Leaving Classrooms

3.1 Allow generous corridors and stairs to serve students arriving and leaving simultaneously and awaiting start of class.

Note: Benches and alcoves may minimize “running the gauntlet” between students lounging along the corridor walls.

3.2 Finish materials outside classrooms should be selected for durability and to control sound penetration and impact noise.

3.2.1 Impact noise may be abated by masonry or high-impact wallboard and sound insulation.

3.2.2 Glazed classroom walls should be laminated or double-pane glass to reduce sound penetration.

3.3 If provided, gathering spaces outside of classrooms should support collaboration, with seating and writing boards.

4 General Classroom Design

4.1 Station count - Verify with Purdue student station quantities required or stated in an Academic Program Statement.

Note: ‘Station’ refers to the quantity of students a classroom is designed to accommodate, not to Occupancy Load which includes students, instructor(s), and additional ADA stations.

4.1.1 Station count in classrooms

- The station count programmed or requested does not include accessible stations.
- Add the appropriate quantity of accessible or wheelchair locations.

4.2 Assignable area

4.2.1 The assignable area stated in an Academic Program Statement does not include ramps, lifts, elevators, and other means required to distribute accessible seating in classrooms.

4.2.2 Add space for ramps, lifts, elevators, etc., as needed, to give disabled students access to the locations provided to meet their needs.

4.3 Room proportions

4.3.1 Classroom dimensions are critical and must be protected throughout the design phases.

4.3.2 Tiered Classrooms

- Large lecture halls should be wedge or fan shaped.

Note: Wedge/fan shapes stagger seats for better views and sit more students closer to the instructor and images.

- Stadium lecture halls, those spanning 2 floors, are discouraged.

Note: Stadium rooms sit students far away from and far above the Instructor, hampering engagement.

4.3.3 Flat floor classrooms

- Flat floor rectangular classrooms with a 1:1 or 2:3 ratio are often ideal.
- Longer, narrower classrooms may be preferable for active learning where every table has access to a side wall display.

4.4 Classroom Service

4.4.1 Classroom Service spaces are provided as directed by Owner and should never be entered only through the classroom.

4.4.2 Classroom Service may include demonstration prep, lecture prep, breakout rooms, video conferencing control, a performance area (stage), laptop storage, etc.

4.4.3 Projection booths - No longer needed and being removed during renovations.

4.4.4 Closets

- General Storage, e.g. closets, are not permitted inside of General Purpose Classrooms.

- Class Labs may have General Storage if
4.5 Sightlines

4.5.1 Good sight lines must be maintained in all classrooms.

4.5.2 No permanent impediments should interrupt sight lines.
- No columns are permitted in classrooms.
- Inboard pilasters are strongly discouraged.
- Deeply recessed doorways are discouraged depending on placement in the room.

4.5.3 Student distance from projected images
- No student should be closer to a projected image than 2 times the image height.
- No student should be farther from a projected image than 7 times the image height.

4.5.4 Vertical sight lines
- Students should not have to tilt their head more than 45° to view the horizontal centerline of the image.

4.5.5 Horizontal sight lines
- Projected images - All students should be seated within a viewing triangle that is a 90° arc from the center of the projection screens.
- Flat panel displays - All students should be seated within a viewing triangle that is a 130° arc from the center of the flat panel.

4.6 Deliverables

4.6.1 Early in the design, the A/E shall provide Cross Sections and Plan Diagrams indicating that every seat meets vertical and horizontal sight line requirements.

4.6.2 Loose furniture - provide at least one code-compliant layout where every seat meets sight line requirements.

4.6.3 Plan all classroom layouts using actual dimensions of Purdue standard furniture and equipment.

4.7 Doors and doorways

4.7.1 In classrooms with a single door, the door is typically located at the front of the room at the Instructor Area, where the open space provides queueing for exit and entrance.

Note: Departments may prefer that Class Labs have rear entrances for late arriving students.

4.7.2 Out-swinging classroom doors along busy corridors should be recessed in shallow alcoves (18” deep).

Note: Deeply recessed door alcoves (36” deep) may cause sight line and furniture layout issues within the classroom.

4.8 Accessibility

4.8.1 Purdue addresses some ADA issues “administratively” by tracking students needing accommodation and providing services on a case-by-case basis. Examples:
- Moving an entire class to a more accessible classroom.
- Placing special furniture for disabled students.
- Reducing enrollment to free up a companion seat.

4.8.2 New classrooms must meet all requirements of the Americans with Disabilities Act Accessibility Guidelines (ADAAG). Renovations must meet the highest level of accommodation feasible, as determined by Purdue.

4.8.3 There are a few areas of accessibility that arise often in classroom renovations
- Accessible entrances - Owner will determine if a renovation requires all entrances to be rebuilt or if any entrance may be grandfathered.
- Protruding elements - The A/E must provide a detectable element below any flat panel display that is not mounted with its bottom edge at 80”AFF and protrudes more than 4” from the wall.
- Wheelchair stations and companion seats - Purdue will determine the quantity of wheelchair stations to be permanent and the remainder may be added as needed.

Note: Unlike movie theaters and other public venues, Purdue is aware of every student needing accommodation and meets those needs administratively on a case-by-case basis.

4.9 Ceiling height

4.9.1 Small classrooms should have a 10 foot minimum ceiling height. Renovations should strive for 9 feet minimum.

4.9.2 Ceiling height at projection wall(s) is calculated based on the size and placement of
projection screens.

- Projection screens that pull down in front of writing boards must maintain 5 foot minimum clear from bottom edge to finish floor.
- Projection screens above writing boards are preferred if student setback is adequate to maintain vertical sight lines - 7 foot minimum clear from bottom edge to finish floor.

4.9.3 Ceiling height in the rear of tiered classrooms must be 8 foot minimum (7 feet in renovations).

4.10 Lighting and controls

4.10.1 Light fixtures

- Recessed ceiling fixtures are preferred in classrooms.
- Supplementary light is required on chalkboards while typically good general room lighting will serve for whiteboards.
- Chalkboard lights, if needed, shall be linear and project no more than 10 inches from the wall. Avoid glare by using white blade diffusers. Avoid ceiling reflections.
- Relamping - Provide easy access in tiered classrooms for relamping light fixtures and projectors.

4.10.2 Lighting controls

- Lighting should be controlled in a consistent manner from classroom to classroom, as directed by Owner.
- Larger classrooms have lighting controls in more than one location and on/off switches at secondary entrance door(s).
- Small classrooms (<50 seats) have simple lighting controls by the door.
- Occupancy sensors - All classrooms require sensors for safety and energy efficiency.

4.11 Speech intelligibility

4.11.1 Classrooms must have good acoustical properties.

- A/V/E should engage an acoustician to vet the design of any classroom over 60 students.

4.11.2 Acoustical considerations

- Classroom size, proportion, shape, and volume.
- Sound and unwanted sound (aka noise) including background noise from inside and outside the room, e.g. mechanical noise, or pass-through noise from adjacent spaces.

5 Technical Guidelines

5.1 Ceilings

5.1.1 Ceilings shall be white, lay-in acoustical tile systems.

- Active Learning Classrooms require high-performance fiberglass ceiling pads.

Note: Unlike older, more formal pedagogies, many students (teams) may be talking simultaneously in Active Learning Classrooms, causing a need for better sound attenuation.

- Longevity and appearance benefit from fiberglass ceiling pads.

Note: Fiberglass ceiling tiles are less susceptible to breakage from repeated access to interstitial spaces (above ceilings) and to water damage from unexpected leaks.

5.1.2 Limited areas of ceiling may be other materials, including wood, drywall, or exposed structure with floating ceiling areas.

- Acoustics must not suffer.
- Access to interstitial space must not be hampered.

5.2 Walls

5.2.1 Finishes should be highly durable.

- Use semi-gloss paint for improved scrub resistance.

5.2.2 Color schemes must be Purdue approved.

- Most walls should be Purdue standard classroom field color.
- An accent color wall is encouraged, unless acoustical panels provide accent color.

5.3 Wall and corner protection

5.3.1 Wall and corner protection

- Shall be mechanically-fastened, not adhesive-adhered.
- Rooms with masonry walls do not require corner or wall protection.
5.3.2 Corner guards
- Should be provided at protruding corners within a classroom.
- Should be provided at protruding corners just outside a classroom.

5.3.3 Wainscot
- Wainscot below the primary writing board protects the wall from damage.

Note: Walls below boards may be damaged by ‘storking’ - instructors who lounge against the chalk tray with a foot resting on the wall.

- In classrooms with fixed seating next to a side wall or against a rear wall, protect walls with wainscot to above head height.

Note: Use wainscot that can be easily cleaned of graffiti and cannot be soiled by hair products.

5.3.4 Chair rail
- Chair rail is required in all classrooms with mobile furniture. Position the rail to prevent wall damage by chair backs and table edges.

5.4 Flooring and trims
5.4.1 Flooring
- Non-slip floors - Sloped aisles should have non-slip flooring such as recycled rubber.
- Quiet floors are required in Active Learning Classrooms - Linoleum and recycled rubber products are durable and reduce impact noise.
- Finished concrete (ground, polished, stained, etc.) is permitted on the tiers in lecture halls, but all aisles and instructor area(s) should have finish flooring.
- Vinyl Composition Tile (VCT) is not preferred and requires Owner approval, but if existing and in excellent condition, it may be permitted to remain.

5.4.2 Straight edging
- High traffic areas demand cast aluminum, mechanically fastened edging.
- Aisle stairs.
- Straight tiers.

Note: Purdue has had great success with Wooster aluminum edging and will often retain old edging in renovations.

5.4.3 Curved edging
- Curved tier edging of vinyl or rubber may be used only where no one can step or pry up the edging with a foot (under strip tables or behind fixed tablet arm chairs).
- Curved tier edging must be fully-adhered.

5.4.4 Vinyl base
- Base 4” high is required adjacent to moppable floors.
- Never place wooden base next to a moppable floor.
- Stepped base - Use 1 of 2 approved base conditions: preferred step-blocks (HAMP 1252) or Z turn-downs (PHYS 223).

5.4.5 Transition strips
- Transitions at classroom entrances should be metal and mechanically fastened.
- Transition strips at aisles or other flooring changes may be fully adhered vinyl or rubber.

5.5 Doors and hardware
5.5.1 Solid flush wood doors are preferred by Owner.

5.5.2 Vision lights
- Classroom doors must have vision lights with one-way glass.
- Size vision lights to be ADA compliant.
- Assure that the mirror-side faces into the classroom to reduce visual distractions from outside the room.

5.5.3 Doors in renovations
- Always replace or refinish damaged doors.
- Use ‘building standard’ wood species, grain match, and stain.
- Never paint doors unless directed by Owner (seldom used doors, closets, etc.)

5.5.4 Door hardware
- Hardware finish shall match the building standard.
- The Purdue Lock Shop will provide guidance and support regarding door
hardware, such as specifying panic hardware, mortise locks, electronic locks or card swipes, security locks, and keying.

6 Classroom Audio Visual Equipment

6.1 Every classroom will have:
- AV cart/lectern with a floor or wall box
- Image devices
- Wireless internet access
- Four data jacks in the floor box or lectern wall box
- Four data jacks in the rack closet

6.2 Some classrooms will have additional AV equipment:
- AV Rack
- Additional floor boxes
- Amplified sound systems
- Power to the desktop
- Assistive listening systems
- Distance teaching & learning equipment
- Student response systems
- Sidewall flat panel displays
- Crestron switching matrices

6.3 Purdue AV Services will assist the A/E in planning.

6.3.1 Some AV items are furnished and installed by AV Services from project funds with little or no prep from the General Contractor (GC).

6.3.2 Some AV items require prep by the General Contractor and are furnished and installed by AV Services, e.g. AV racks, flat panel display infrastructure, and ceiling mounted projector infrastructure.

6.3.3 Some AV items require prep by the General Contractor and are furnished and installed by the General Contractor, e.g. projection screens, AV rack niches, and lay-in ceiling speakers.

6.4 Prep for projection screen(s) - AV Services will work with the A/E to determine the type and size of screen for each room.

6.4.1 Blocking and framing is required to support screens from wall or deck.

6.4.2 Permanent screens
- Stretched, wall-mounted projection screens are preferred.
- There must be adequate ceiling height and set-back from the first row.

6.4.3 Drop-down screens
- Motorized drop-down projection screens require Owner approval.
- Dual motorized screens have motors at opposite ends so the images are close together.
- Assure that any wall-mounted raise/lower switch is outside the lowered position.
- Manual drop-down projection screens are preferred in small classrooms.
- In rooms with low ceilings (<10’), drop-down screens should be pocketed to elevate the upper edge of the image.

6.5 Prep for ceiling mounted projector(s)

6.5.1 Conduit, power, and structure for ceiling mounted projectors will be by the GC. The A/E should plan infrastructure as directed by AV Services.

6.5.2 Projectors are furnished, installed, and wired by AV Services.

6.6 Prep for flat panel displays

6.6.1 Prep for flat panel displays will be by the GC as directed by AV Services. The A/E should plan infrastructure including:
- Blocking in the walls to support large flat panel displays.
- Built-in Flat Panel Interface Box (with attractive cover-plate) requires dedicated 120 VAC 20-amp circuit, network PIC, and a 2” conduit to the video head end.
- AV Services will furnish and install both the mounting bracket and flat panel display.
- Detectable element for ADA compliance.

6.7 Prep for AV equipment rack

6.7.1 GC will build a custom niche for the AV rack. The A/E should plan a niche 84”H x 20”-22”W x 30’-36”D as directed by AV Services.

6.7.2 AV rack is furnished and installed by Owner.

6.8 Prep for Assistive Listening Systems (ALS)

6.8.1 All large classrooms, or any with sound amplification, should have Assistive Listening Systems (ALS). Smaller classrooms will have ALS if directed by Owner.
- Preferred ALS is the Induction Hearing Loop.
• Alternate systems if/when available may be considered.

6.8.2 Audiology specialists, as a consultant to the A/E, will design, specify, provide, install, and commission hearing loop systems.
• Contact Owner for the names of qualified firms.

6.9 Prep for sound amplification

6.9.1 Larger classrooms, or any classrooms with an Assistive Listening System, will be equipped with sound amplification systems.

Note: Rule of thumb for classrooms with sound amplification over 64 stations or 37 feet in length.

6.9.2 All classrooms with ‘front’ projected image(s) will include ‘point-source’ speakers.
• GC shall prep for point-source speakers to be furnished and installed by AV Services.
• Point-source sound is not advised when there are images in multiple locations in the room.

6.9.3 Larger rooms will also have distributed sound by means of ceiling speakers.
• Ceiling speakers will be specified by AV Services and installed by the General Contractor.

6.10 Prep for floor boxes

6.10.1 Floor boxes are provided at the AV lectern and in other locations, if directed by Owner, such as:
• At the instructor table.
• At designated secondary teaching location(s).
• At student tables.

6.10.2 Provide floor boxes where directed and with services as directed during design:
• 120 VAC 20-amp dedicated circuit,
• Data connection (PIC),
• 2” conduit video path to the AV rack, with pull string.

6.10.3 AV Cart/Lectern floor box
• Typically located 5’ from front wall and 6’ from side wall on the side opposite the door.
• In large lecture halls, the AV cart/lectern may be centrally located, not off-center as in smaller classrooms.

6.11 Prep for Distance Learning as directed during design.

6.11.1 Additional side wall lighting is needed to improve video production.

6.11.2 A typical 2-camera setup is the standard using wall-mounted tilt/pan/zoom cameras.
• Locate a camera above the presenter to capture the audience.
• Locate a camera diagonally across from the presenter to capture the presenter.
• Each camera requires a 120 VAC 15-amp circuit within 6” of a single- gang video J-box at 84” min. AFF with a 1” conduit home-run to AV rack or designated ‘head-end’ noted by Owner.

6.12 Prep for Student Response Systems not required.

6.12.1 A state-of-the-art Student Response System will be provided by AV Services in all tiered classrooms and flat floor classrooms over 60 seats.

7 Classroom Fixtures

7.1 Writing boards - All classrooms will be equipped with writing boards except those so large that ordinary writing is not legible from the back rows. Purdue will work with the A/E to determine what boards are needed in each classroom.

7.1.1 Size: Writing boards are at least 16 feet long and 4 feet or 5 feet tall, maximize length on front wall.

7.1.2 Style: Butt-jointed with concealed splines, wide anodized aluminum frame, boxed-end trays, top rail with cork insert, and map clips.

7.1.2.1 Do not use H-splines to join multiple panels.

7.1.3 Installation: All wall mounted boards shall be mechanically fastened to the wall with the top at 7 feet AFF.

7.1.4 Writing surface:
• Chalkboard - Purdue still has many faculty who prefer chalkboards.
• Dry Marker Board (DMB) writing surface – Use only PolyVision e3 Environmental CeramicSteel™ with lifetime warranty.

Note: No substitutions are permitted to PolyVision e3 writing surface, but the material may be bid by any frame manufacturer. GC is to provide e3 documentation from the vendor for each installation.
• Non-glare glass writing boards are
phys. facilities
2018 consultant’s handbook
division 01 general
8813.2 special requirements – instructional spaces

8 permitted and have excellent longevity and ease of cleaning.

Note: to date purdue has found the initial cost of glass boards prohibitive.

- dry marker paint or wallcovering may be used in class labs, if requested.

7.1.5 sizes of writing boards:

- instructor board - typically 4’ high by at least 16’ wide, mounted on the front wall or where it can be seen by all students.
- teaming boards - may be multiple 5’H x 4’W boards spaced around the room or several continuous 5’ high boards on long walls.

Note: polyvision 5’ high boards are made of 4’ wide stock used vertically with butt joints every 48”.

Note: polyvision 5’ wide stock is not preferred because it requires H-splines every 8’-10’ and has an uneven spray-on surface.

- personal boards - small, portable DMBs are carried to the tables for collaboration and then hung on wall track or set on an easel-cart. Manufacturer and model must be approved.

8 miscellaneous classroom items

8.1 telephone and alert system

8.1.1 provide a wall-mounted campus telephone near the AV cart/lectern. provide phone mounting plate. owner will furnish and install phone.

8.1.2 provide for an emergency notification device, typically adjacent to or near the wall phone. owner will furnish and install device.

Note: where feasible, locate emergency notification device on a side wall, as students should not face the glowing alert screen while trying to see projected images.

8.2 recycling and waste containers

8.2.1 plan a designated space for containers near all entrances, including multiple locations in rooms with multiple exits.

8.2.2 owner will furnish and install containers.

8.3 clock

8.3.1 a/e shall assure that appropriate mounting space is available on a side wall near the front of the room.

8.3.2 owner will furnish and install a battery operated GIS clock.

8.4 pencil sharpener(s)

8.4.1 GC to furnish and install a stained wood or other approved mounting block for the pencil sharpener(s).

- 1 in small classrooms.
- More, as directed, in large classrooms.

8.4.2 owner will furnish and install pencil sharpeners.

8.5 signage

8.5.1 international hearing loop signs must be posted for any classroom with an induction hearing loop, including:

- outside each door (approx. 5’W x 7”H) above or included within room-number sign.
- high on the side wall or front wall (approx. 8.5”W x 11”H in small classrooms, larger in large classrooms) with lettering visible from the back row.

8.5.2 occupancy rating

- all classrooms over 50 stations must have maximum occupancy posted.
- owner will determine occupancy rating for each room based on area.

8.5.3 classroom sign

- a small editable frame is wall-mounted near the phone to indicate critical phone numbers and the furniture type and station count.
- paper insert is provided by owner.

8.5.4 seat numbers

- permanent seat number plaques shall be provided and installed on all fixed seating.
- owner must approve seat numbering scheme.

8.5.5 other - active learning classrooms with fixed tables and technology hubs may need:

- table numbers,
- flat panel display numbers,
- writing board numbers.

8.6 coat hooks

- not required in general purpose class rooms.
- departments may have coat hooks in class labs.
If provided, coat hooks are seldom needed for every occupant.

8.7 Bulletin boards
- Not permitted in General Purpose Classrooms.
- Departments may have bulletin boards in Class Labs.

8.8 Writing board cleaning supplies
- Purdue may provide paper towel dispenser and spray water bottles in General Purpose Classrooms with marker boards.
- Departments may have cleaning supplies in Class Labs.

8.9 Hand sanitizer
- Not provided in General Purpose Classrooms.
- Departments may have hand sanitizer in Class Labs.

8.10 Artwork
- Artwork is occasionally provided by the University Visual Arts Committee ‘Art in the Classroom’ project.
- Artwork in existing classrooms must be carefully removed and reinstalled when the room is renovated.
- Departments may have artwork in Class Labs.

9 Classroom Furniture

9.1 All furniture must be Purdue Standard makes and models. Contact Purdue.

9.1.1 All classroom furniture shall have standard finishes, unless directed by Owner.

9.2 Tables
9.2.1 Tables - Built-in
- Built-in strip tables in lecture halls have cantilever bases and tops of varying widths.

9.2.2 Tables - Anchored or mobile
9.2.2.1 SCALE-UP - 120 degree tables (for 3)
- May be anchored in groups of 3 around a technology/power Tri-hub.
- May be provided loose to allow teaming for 6 or 9 students.

9.2.2.2 Media-sharing - Wedge-shaped or D-shaped tables
- May have an enclosed compartment for matrix devices.
- May have legs when only power is provided.

9.2.3 Rectangular mobile tables (for 2)
- Are typically 24”x54” or 24”x60” with casters on one end for ‘wheelbarrowing’.

9.2.4 60” round tables (for 6)
- May be anchored and provide power to the tabletop.
- May be made up of loose pairs of half-round tables (for 3).

9.2.5 Other tables
- Instructor tables.
- Laptop credenzas anchored below flat panel displays.

9.3 Chairs
9.3.1 Chairs - Built-in
- Pedestal based chairs with jury swivel are used at strip tables.
- Theater seats with anti-panic folding tablets are used in some lecture halls.
- Beam-based or pedestal-based tablet-chairs are used in older lecture halls.

Note: Beam-based tablet-chairs offer the opportunity to replace seats in the future without re-drilling the floor.

9.3.2 Chairs - Loose
- Star-based task chairs with caster and swivel seats are preferred in Active Learning Classrooms.
- Instructor stools - All future classrooms will have a height adjustable stool/chair for the instructor.
- Modern mobile tablet-chairs with casters and large tablets are used for Active Learning Classrooms.
- Small-form 4-leg tablet-chairs with casters may be used in renovations where a smaller footprint is required to maintain capacity.
- 4-leg side chairs with casters may be used in Active Learning Classrooms where budget or space is an issue.
Chairs in Seminar Classrooms may have arms and may or may not have casters.

Sled-based side chairs are used in many small classrooms.

Note: Sled-bases can tolerate tilting better than 4-leg chairs.

9.4 Instructor furniture

9.4.1 AV cart/lectern
- AV cart/lectern shall have standard finishes.
- Selected, furnished, and installed by AV Services from AV budget.
- ADA accessible by side approach. Front approach models should be considered when budget permits.

9.4.2 Instructor table
- Loose tables have standard finishes.
- A 24” x 54” table is provided for the instructor in addition to the lectern.

9.4.3 Instructor chair or stool
- In all new classrooms, a height adjustable chair/stool is provided.
- A sled-based or task-based chair may have been provided in older classrooms.
1 Applicable Industry Design Guidelines, Standards, and References:
1.1 ANSI/AIHA Z9.5-2012 (or latest version), American Industrial Hygiene Association
1.2 2011 ASHRAE Handbook (or latest version), HVAC Applications, Chapter 16, Laboratories
1.3 ASHRAE Energy (90.1) and Ventilation (62.1) Standards – latest versions
1.4 The National Institute of Health (NIH) Design Requirements Manual for Biomedical Laboratories and Animal Research Facilities (DRM)
1.5 ACGIH Industrial Ventilation, A Manual of Recommended Practice for Design – latest edition
1.6 ANSI Z358.1-2004 Compliance Checklist for Emergency Eyewash and Shower Equipment
1.7 Center for Disease Control (CDC) Biosafety in Microbiological and Biomedical Laboratories

2 Room Layout
2.1 Wall-mounted bench depth is 30”.
   2.1.1 For the standard 22” deep base cabinet, this leaves a 1” overhang in front and a 7” space behind that is used as a utility chase.
2.2 Aisle width is 5’-0” minimum where knee spaces occur back to back.
2.3 Occupant-provided equipment lists should be obtained early in the design process, so that accurate size, electrical, and HVAC requirements can be factored into the design. When possible, plan shared equipment space for energy and space efficiency.
2.4 Service sinks are normally 21” to 24” long, 15” to 18” wide, and 7” to 10” deep with a hot and cold mixing faucet and an RO water faucet.
   2.4.1 Pegboards are provided at service sink locations above the backsplash with a drip trough.
2.5 If the lab requires a higher degree of water purification than is provided by the building RO system, then provide space for a polisher (Millipore-type unit) at a central service sink along with a 120v outlet located at 7’-0” AFF and a stubbed RO water line.
2.6 At least one door into the lab should provide a 48” wide opening filled with a 36” active leaf and a 12” inactive leaf. This provides adequate space to get large equipment into and out of the lab.
2.7 Desks and extended work spaces should be separated from lab hazards. When provided within the lab, give close attention to egress and air quality.

3 Laboratory Room Finishes
3.1 Room finishes are intended to provide long life and low maintenance.
3.2 Floors are typically sealed concrete, sheet vinyl with welded seams, quartz epoxy, or 12” x 12” vinyl composition tile. Vinyl base is installed at all walls and in toe spaces of base cabinets.
3.3 Ceilings, when installed, are 24” x 48” lay-in acoustical tile. When no ceiling is installed, everything above 8’-0” - the building structure, ductwork, conduit, and wall surface - is painted white.
3.4 Walls, whether block, drywall, or plaster, are painted with a color that has a light reflectance value of 70+.

4 Laboratory Furniture
4.1 Base and wall cabinets are to be either oak or metal, and certified by Scientific Equipment and Furniture Association (SEFA).
   4.1.1 Base cabinets have removable back panel to provide access to the utility chase.
   4.1.2 Minimum 24” wide knee spaces with finished back panels and electrical outlet are provided where requested by the lab occupant.
   4.1.3 The lab occupant determines the proportional mix of drawers and doors provided by the cabinets.
   4.1.4 Knee space is sometimes provided for under-counter refrigerators, ice machines or glassware washers.
4.2 Countertops are 1” thick chemical resistant material (e.g. modified epoxy, Trespa “TopLab”) in grey, taupe, or black. Consider higher light reflectance values to improve the illumination.
4.3 A 4” backsplash occurs at peninsula end-sink and at all wall-mounted locations. Countertops are continuously flat surfaces at peninsulas penetrated only by shelving support systems, utility lines and cup sinks.
4.4 Shelving above countertops should be flexible and adjustable to accommodate changes in countertop equipment. Task lighting under lower shelf is recommended, and should also be adjustable with the shelf.

5 Power Distribution
5.1 Electrical power and data is provided at the counter and perimeter as needed.
5.2 Emergency power requirements need to be
identified prior to beginning design work. Generators may need to be sized to accommodate building needs.

6 Laboratory Ventilation

6.1 The laboratory ventilation system should remove, dilute, and control the buildup of air contaminants and odors in the laboratory. The ventilation rate must satisfy the general codes and standards that apply to the occupancy class. Minimum air changes per hour (ACH) must be at least 6 ACH occupied and 4 ACH unoccupied.

6.1.1 Higher ventilation rates and dilution may be required.

6.1.2 Lower ventilation rates may be possible with central Demand Controlled Ventilation (cDCV) and air quality sensing.

6.2 Control of temperature variations, humidity, air velocity, noise, and other environmental factors shall be designed to meet the critical laboratory environmental requirements of lab processes, equipment, and specific applications.

6.3 Follow industry best practices and criteria for fume hood and biological safety cabinet (BSC) placement with respect to occupant traffic, walls, doors, benches, structural details, airflow diffusers and grilles, and other hoods.

6.4 A ‘low air flow zone’ is required at each hood and BSC. Supply air diffusers shall be selected and located so to have no deleterious effect on fume hood aerodynamics.

6.5 Select appropriate lab controls and offset between the laboratory supply and exhaust airflow to maintain the required pressure differential to the corridor and adjacent spaces.

7 Laboratory Fume Hoods: Selection, Testing, & Operation

7.1 Complete the Fume Hood Selection form, section 13, for each fume hood as the basis of design, defining the location, application, usage, type, size, utilities, expected chemical use, and sash type.

7.2 All new fume hoods shall be “High Performance, Low Velocity” type, engineered, manufactured, and tested to safely contain hazards at a minimum face velocity of less than or equal to 60 fpm with the sash in the fully open, set-up position.

7.3 Specified fume hood models must provide third-party, independent ASHRAE 110 - “As Manufactured” (AM) testing for the widest fume hood planned for the project.

7.3.1 Containment tests must demonstrate passing performance and include flow visualization, smoke testing, face velocity measurements, and tracer gas containment testing with as-used challenges representing sash movement effect, walk-by tests, and cross draft conditions of at least 30 fpm.

7.3.2 ASHRAE 110 – (AM) test reports must be pre-approved by the Purdue University Radiological and Environmental Management (REM) department and Physical Facilities Engineering Services to qualify for specification.

7.4 All new fume hood installations must be tested and pass the ASHRAE 110 - “As Installed” (AI) test as determined per project requirements for the most challenging sash operating configuration.

7.4.1 For small fume hood installations, testing may be provided in-house by the Purdue University REM department.

7.5 The fume hood exhaust volume used as the basis-of-design must include the hood bypass and duct leakage airflow.

7.6 Constant air volume (CAV) fume hoods shall have bypass grilles/openings of adequate size to maintain an acceptable face velocity over the entire range of sash movement.

7.7 Variable air volume (VAV) fume hoods shall have a restricted bypass to allow for exhaust airflow reduction as sash closes.

7.8 Fume hoods shall have access ports for cords, tubes, wires, etc. to be run through the side sills or front airfoil to the interior of the hood.

7.9 Fume hoods must have a visual and audible face velocity indicator to be installed and calibrated by a representative of the manufacturer.

7.10 Training on the calibration, operation, and maintenance of the fume hood controls must be provided by the manufacturer.

7.11 Sash sensors shall not deleteriously affect fume hood aerodynamics.

7.12 For traditional or existing fume hoods that were engineered and tested for 80 to 120 FPM, the design operating face velocity is 100 FPM. For high performance fume hoods that are engineered and tested to 60 FPM, the design operating face velocity is 80 FPM, providing a margin for safety.

7.13 The maximum fume hood exhaust (CFM) is determined by the greater of the following two conditions:

7.13.1 The fume hood operating at the design operating face velocity with the sash open to
working area (height x width). The vertical sash working height is 18”.

7.13.2 The fume hood operating at the manufacturers recommended minimum face velocity with the sash fully open.

7.14 The minimum fume hood exhaust (CFM) with the sash closed is defined by ANSI/AIHA Z9.5 Lab Ventilation Standard Z9.5 - latest version and risk assessment by REM, but not less than 15 CFM/SF fume hood worktop.

7.15 Perchloric acid and Radio-isotope fume hoods and exhaust fans must be specifically designed for that use.

7.15.1 Ducts may not be more than 45 degrees off vertical with no more than four offsets (two to get into a chase, and two to get out of the chase).

7.15.2 Perchloric acid systems are to have a water wash down (see “Laboratories – Plumbing Guidelines”).

7.15.3 Perchloric acid hoods must be attached to a dedicated exhaust system using FRP, PVC or welded stainless steel ductwork.

7.15.4 Radio-isotope hoods must be attached to a dedicated exhaust system using welded stainless steel ductwork.

8 Laboratory and Fume Hood Exhaust Fan Systems

8.1 Lab air control valves which impact the fan static pressure requirement should have a pressure drop less than or equal to 0.3” water gauge at design flow.

8.2 For energy efficiency and safe dispersion of laboratory and fume hood exhaust, a Variable Air Volume (VAV) central Manifold Hood Exhaust Roof (MHER) system is required for multiple fume hoods and labs.

8.3 CAV fume hoods are acceptable where hood exhaust is less than the minimum lab ventilation rate or if VAV is not feasible with existing infrastructure.

8.4 Where cost effective with a life cycle analysis, consider energy efficiency approaches such as heat recovery and lab exhaust optimization (wind engineering and dispersion model testing).

8.5 The exhaust stack must discharge vertically at least 10’ above the roof with no rain cap. Exhaust stack exit air velocity shall be determined by an approved engineering approach, generally at least 3,000 fpm unless a lower velocity is justified.

8.6 Fume hood exhaust ducts should be designed with a velocity of 1,000 to 2,000 fpm. For VAV fume hood systems, an exhaust diversity factor may be used for the maximum duct velocity. Assume no diversity factor when sizing exhaust fan capacity and total static pressure.

8.7 General purpose fume hood exhaust duct material is typically galvanized steel with a chemical resistant coating from the hood discharge to the point of significant dilution (manifold exhaust system main duct).

8.7.1 Uncoated galvanized steel may be used on manifold exhaust systems where enough fume hood and lab exhaust combine to provide adequate dilution.

8.7.2 Stainless Steel is rarely used for general fume exhaust and will require justification.

Note: The exceptions to this are the welded stainless steel systems for perchloric or radioisotope hoods. PVC is acid resistant but has poor solvent resistance. PVC may be used only when exhaust system is being specifically designed and marked for acid only use.

9 Fume Hood Plumbing Considerations:

9.1 Fume hoods should be purchased pre-plumbed and with all pipes pre-insulated.

9.2 Laboratory water in fume hoods must have a reduced pressure backflow preventer or a vacuum breaker.

9.2.1 Vacuum breakers must be located out of the contaminated air and mounted high on the exterior face of the hood, with forward extended piping so that leakage that may occur under normal operation does not damage equipment below.

9.2.2 Do not locate vacuum breakers in inaccessible or concealed space.

10 Plumbing for Perchloric and Radio-Isotope Hoods

10.1 The exhaust system must include a backflow protected wash-down system. This system must be carefully designed to guarantee the proper flow to each of the spray nozzles. It may require multiple risers and/or pump(s).

10.2 The system will be designed using the following parameters:

- Spray head nozzles should be installed below and after each elbow, and every five feet in straight duct runs.

- Nozzles and components should be made of stainless steel and/or fluorocarbon plastic.
• Nozzles and components must be accessible for maintenance.

• Each hood enclosure should be equipped with a minimum of two spray heads.

• Flow from spray heads should be allowed to drain back to hood. Verify acceptance flow for drains in hoods. For flow greater than hood drain acceptance wash down spray heads should be sequenced to prevent overflow.

• A timed, field adjustable wash down sequence must occur after each perchloric acid hood usage, at least daily. Show timer location on the drawings.

10.3 Flow to spray nozzles must have a means of testing, adjusting, and balancing.

11 Laboratory Water Systems

11.1 Laboratories shall utilize a segregated laboratory water distribution system, independent of the building’s domestic potable water.

Note: The intent of the separated water distribution approach is to minimize the need for point of use backflow preventers, while still maintaining potable water supplies to required areas and sufficiently clean water for laboratory research and general non-potable demand purposes. The laboratory water system shall not serve any outlets intended for ingestion, bathing, or pharmaceutical applications for humans or animals; however, the system shall still be protected to ensure a clean water supply. This includes the use of reduced-pressure principal devices or vacuum breakers at equipment outlets of particularly high hazard or probability of cross connection.

11.2 In general, reverse osmosis quality purified water (> 0.05 Mohm-cm) is to be made available in laboratories.

Note: It is the responsibility of the researcher to provide water purification equipment if higher quality water is required.

12 Emergency Eyewash and Safety Shower Equipment

12.1 Each lab unit must be equipped with an eyewash station. Each lab unit where the use of hazardous chemicals is anticipated must be equipped with a combination eyewash/safety shower.

12.2 The eyewash must have a face wash feature and hands-free operation. Once activated it should continue to provide water flow until manually shut off.

12.3 Safety showers shall be located in an immediately accessible area within the laboratory unit or other work areas where the user shall not have to pass through a corridor door to reach the unit.

12.4 Eyewash and safety showers should be located near the door. If the door location is not practical, an alternate location is at the end of a peninsula bench next to a 3'-0" wide sink unit.

12.5 For laboratories sharing a common suite or area not separated by closed doors one emergency shower may be sufficient.

12.6 All emergency eyewashes and safety showers shall be tied into the potable water system.

12.7 The water supply line in the lab must have a manual shutoff valve below the ceiling within 48” of each eyewash or safety shower.

12.8 For new construction, all emergency eyewashes and safety showers will be supplied with tepid (60°F to 100°F) water using a mixing valve specifically designed for this use. A typical set point is 75°F. For renovation projects where difficult to attain, discuss the options with the PM for direction to proceed.

12.9 All new eyewash stations are to be hard-piped to a waste line.

12.10 All new safety showers are to have a floor drain in the vicinity of the shower discharge area, but located away from chemical spill risk.
### Fume Hood Selection Guide - General Information

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### Contact Information for Faculty & Staff Responsible For Hood Operation

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### Hood Use information

**Application (describe expected use of hood):**

**Apparatus (describe anticipated equipment use):**

**Hood usage (circle):** CAV / VAV (Constant or Variable Air Volume) 24/7 continuous Occasional/intermittent

**Utilities (circle each):** Vac. Nat. Gas Nit. Air RO DI CW / HW Cup sink(s) Other:

**Storage Cabinet type:** General Acid Flammable vacuum pump Other

### Chemicals Expected to be Used

(Attach additional pages as needed)

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<td>*example: room temperature, betw. #° C to #° C, liquid N2 boiling point</td>
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### Hood Type

(Check all that apply. Physical Facilities may select based on above info.)

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</table>
1 O&M Considerations for MERs

1.1 To the extent possible, all mechanical equipment should be located within the Mechanical Equipment Room (MER).

1.2 Equipment must be located so as to allow room for servicing and maintenance, including room to pull HVAC coils and heat exchanger tube bundles.

   1.2.1 Adjoining pieces of equipment need to be separated by a minimum of 36”.

1.3 Water Softener brine tank(s) must be located to allow salt to be delivered to the tank by pallet jack with an unobstructed path from MER entrance to brine tank.

   1.3.1 Salt placed in the brine must be lifted no higher than 46” from the standing surface.

2 MER Design Considerations

2.1 MER must be accessible by a standard stair or elevator. Ship’s ladders are NOT acceptable.

2.2 MER is to be well lit with lamps located in such a manner that equipment may be serviced without requiring additional portable lighting.

2.3 MER should not be adjacent to classrooms or offices if possible.

2.4 MER shall be thermally, vibrationally, and acoustically isolated from occupied areas.

   2.4.1 MER walls designed to meet STC 60.

   2.4.2 MER doors should meet STC 45.

2.5 Provide space to store two changes of air filters, lubricants, etc.

2.6 Provide locally controlled thermostatic ventilation.

2.7 Provide separate concrete housekeeping pads under each mechanical equipment item.

2.8 Floor drains are required for each piece of equipment requiring drainage. Floor drain shall be laid out to prevent drain pipe floor obstructions.

   Note: Do not let cooling coils drain condensate across MER floor. When there is condensate drain piping that is not buried or running along the floor it must be insulated.

2.9 Oil or petroleum storage containers with a capacity of 55 gallons or greater, will have secondary containment.

   2.9.1 Containment will have a capacity of 110% of the largest single container

   2.9.2 Containment will have a means for manual drainage of secondary containment areas.

2.10 MER above the lowest floor shall be curbed or have condensation/drip pans under all equipment.

2.11 All floor penetrations must be sleeved. MER floor sleeves to be a minimum of 6” diameter extend 4” above the floor and have a water tight material (that may have to be fire stopping as well) to create a water tight compartment system.
PHYSICAL FACILITIES

2018 Consultant’s Handbook
Division 01 General
8813.5 Special Requirements — Restrooms and Lactation Rooms

1 Flooring
- Tile no smaller than 4”x4” with dark grout
- Slip resistant surface, but not overly abrasive
- Through-color
- Easy to clean
- Neutral Color (not white), accent colors in smaller quantities

2 Walls
- Tile, especially adjacent to toilet fixtures
- Epoxy painted stacked-bond CMU
- Painted gypsum or plaster walls permitted when not near fixtures, and in areas less populated by students.
- Easy to clean
- Neutral color, with accent bands, dots, fields, accent walls, etc.

3 Ceilings
- Painted gypsum board
- Acoustical lay-in for larger toilet areas (but not over WCs)
- Easy to clean
- White

4 Stall Partitions & Urinal Screens

4.1 The following acceptable partitions
- Solid Plastic High Density Polyethylene
- Solid Surface (Corian)
- Stainless Steel (never use for urinal screens)
- Solid Phenolic Core

4.2 Description
- Graffiti Resistant
- Through-color, or highly scratch resistant (as in solid phenolic)
- Easy to clean
- Long life expectancy
- Color to be approved by PM (dark colors in some product show fingerprints)
- Coat hooks at 48”

4.3 Partition Brackets

4.3.1 Brackets provided to anchor toilet partitions to the wall must be large enough to allow two anchor points through the panel and two points vertical into the wall.

Note: This is critical as two vertical anchor points will cause the weight of the partition to be in shear

4.3.2 Water closet screens are to be floor-mounted and wall braced. The bottom of the screen is to be 12” A.F.F.

5 Doors

5.1 All restrooms are to have doors – not simply sight restrictive entrances

5.2 Where possible doors are to be hinged so as to be pushed open from the restroom side

5.3 Small restrooms (1 person may have thumb-turn privacy locking hardware, which may be unlocked by building custodian’s key from the outside.

5.4 All other restrooms may have push-pull hardware unless fire code requires latching hardware.

5.5 Restroom entrance doors shall have double-cylinder deadbolt locks that may be unlocked by building custodian’s key from the outside (for use to take restroom out of commission).

6 Wall mounted items

6.1 Mirrors shall be individual and shall extend down to the backsplash.

6.2 Soap dispensers will be provided and installed by the owner. Space shall be allowed between mirrors for this equipment.

6.3 Towel dispensers will be provided and installed by the owner. Since these project 10” from the wall, it is important that locations be designated that will not create ADA violations. Whenever accessories must be mounted on a frame wall, blocking shall be provided.

6.4 Toilet paper dispensers shall be Royce Rolls Ringer 2, 3, or 4 roll. Verify size with Project Manager. In accessible stalls, mount toilet paper dispenser above handrail.

6.5 Sanitary products dispensers and disposers will be provided and installed by the owner.

6.6 Where more than one lavatory is required, it is preferred that a solid surface counter with integral sinks and backsplash be installed rather than individual sinks.

7 Family Restrooms

7.1 Each floor of each building shall have at least three restrooms, one assigned to each gender and one “single-occupancy” family-friendly facility with baby changing station.
8 Lactation Facilities

8.1 Every building should have at least one space that can be used as a lactation room with:

- Privacy (lockable)
- Comfortable seating
- A work counter with an electrical outlet and a sink within arm's length.

8.2 Refrigerated storage does not need to be provided in this room.

8.3 Lactation facilities may be adjacent to, but not be within, restrooms.

**Note:** It is not essential that this be a dedicated room. It could be a small conference room that is centrally scheduled for use by anyone in the building.
1 **Receiving room**

1.1 Provide a platform lift for transfer of bulk supplies from freight vehicles.

1.2 Adjacent to the platform lift provide a covered receiving area approximately 10'-0" deep and 20'-0" long and minimum 14' clear height for semi-truck access.

2 **Mail room**

2.1 Approximate size required is 100 SF with a secured storage closet for packages.

- Locate near the receiving dock.
- Locate near an elevator.
- Locate within easy access to a corridor.
- Provide for a desk, chair, shelving, and file cabinet for an attendant.

3 **“Wet” custodian closet**

3.1 No area in the building should be more than 150' from a "wet" custodian closet.

3.2 At least one closet should be on each floor.

- Provide a 42” door that swings out from, not into, the room.
- Provide a 20 amp electrical wall duplex outlet in an accessible area of the closet.
- Finish walls and floors with an impervious, easily cleaned surface.
- Provide a floor type mop sink supplied with hot and cold running water. The water outlets shall have a threaded end and shall be not less than 30” above the mop sinks. The mop sink curb should be at least 4” above the floor.
- Provide self-gripping wall hangers and space for dust mop and brooms.
- Provide self-gripping wall hangers with at least four holders located over the mop sink for wet mops.
- Provide at least two adjustable wire shelves (approximately 12"x84” each), with the lower shelf mounted about 48" AFF and the upper 66”.
- If hazardous gases or chemicals are present in this closet (i.e., typical liquid cleaning products) the construction of the closet must meet the following criteria:
  - Exhaust rate of at least 0.5 cfm/sf
  - Self-closing door
  - Deck-to-deck partitions or a hard ceiling, for example gypsum board, instead of acoustic ceiling tile.

4 **Custodian equipment storage room**

4.1 A central storage area for custodian equipment (automatic scrubbers, floor machines, vacations, etc.) and bulk supplies (toilet paper, hand towels, floor cleaners and finishes) should be accessible from both the service dock and elevator.

- The storage room should be approximately 120 square feet.
- The minimum required door width is 42”.
- Provide a floor type mop sink supplied with hot and cold running water.
- Provide as much shelving as possible for storage of supplies.
- Provide floor drain.

5 **Recycling closet**

5.1 Provide a closet for a minimum of (3) 64 gal recycling containers near the dock.

5.2 The minimum required door width is 36”.

6 **Battery charging room**

6.1 At least one custodial room per building should have an exhaust system for battery operated equipment storage and recharging.
1 Refuse and Recycling Containers

1.1 Table of refuse container sizes

<table>
<thead>
<tr>
<th>Container Size</th>
<th>Footprint Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CuYd</td>
<td>80” x 32”</td>
</tr>
<tr>
<td>1.5 CuYd</td>
<td>80” x 40”</td>
</tr>
<tr>
<td>2 CuYd</td>
<td>80” x 60”</td>
</tr>
<tr>
<td>4 CuYd</td>
<td>80” x 90”</td>
</tr>
<tr>
<td>6 CuYd</td>
<td>80” x 128”</td>
</tr>
</tbody>
</table>

1.2 Large buildings with significant output of refuse might require compactors, which vary in size.

1.3 Table of recycling container sizes

<table>
<thead>
<tr>
<th>Container Size</th>
<th>Footprint Dimensions</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>64 gallon</td>
<td>28¾”x23”</td>
<td>42¼”</td>
</tr>
<tr>
<td>68 gallon</td>
<td>26¾”x25½”</td>
<td>42¼”</td>
</tr>
</tbody>
</table>

1.4 The quantity of refuse containers required at each building depends on the refuse output of the departments housed in each building.

2 Locating & Accessing Refuse Containers

2.1 Refuse containers must be located adjacent to service/loading docks and as close as possible to loading dock entry doors for safe and convenient access by building services personnel.

2.2 Adequate lighting is essential since most access to containers is during nighttime hours. Any screen walls surrounding containers must be semi-transparent.

2.3 Containers should be screened from view.

2.4 Covered access to the containers is desirable for transporting refuse to containers in inclement weather.

2.5 A minimum of three feet clearance is required around all sides of the refuse container.

2.6 Vehicular-grade concrete pads are required under all refuse containers (asphalt, compacted stone/gravel are not acceptable surfaces).

2.7 If more than one 4 or 6 cubic yard container is required, then containers must be situated side by side.

2.8 Containers must be oriented appropriately for a refuse truck to approach the container squarely and in reverse with adequate drive space available for the truck to pull forward and back-up to the container.

2.9 Curbs or walls are required around storage areas for 1.0, 1.5, and 2.0 cubic yard containers to prevent accidental rolling.

2.10 A concrete apron must extend beyond the pad so containers can be rolled to the proper position for pick-up at the back of the refuse truck. (Asphalt, compacted stone/gravel are not acceptable surfaces for this purpose.)

3 Refuse Truck Considerations

3.1 Minimum inside turning radius for the refuse truck is 35 feet; minimum outside radius is 40 feet.

3.2 Maximum ground clearance of the refuse truck is 10.5 inches. Paths to and from the container must not have dips or humps that will impede access or cause the truck to scrape the grade.

3.3 Overall truck length is 30 feet -10.5 inches.

3.4 Overall truck width is 8 feet -7.5 inches.

3.5 Overall truck height is 12 feet -3 inches; however, minimum overhead clearance required for the container to be lifted and emptied is 14 feet.

4 Building Recycling Carts

4.1 Recycling carts must be located on or adjacent to service/loading docks and as close as possible to loading dock entry doors for safe and convenient access by building services personnel.

4.2 All recycling carts are wheeled for easy maneuvering.

4.3 Typically, a minimum of four recycling carts is required at each building. Actual quantity depends on the paper output of the departments housed in each building.

4.4 Covered access to the carts from the door is desirable.
1 General

1.1 Commissioning scope and requirements will be determined for each individual project.

1.2 Projects involving the installation or modification of mechanical, electrical, or building envelope systems may require some level of commissioning.

1.3 The expectation of the commissioning process throughout the project design, construction, and occupancy phases is to provide or verify the following for the commissioned systems:

   1.3.1 Consistency with the Owner Project Requirements, Basis of Design, and other design concept documents
   1.3.2 Coordination between systems and building components
   1.3.3 Energy saving goals
   1.3.4 Maintainability, constructability, accessibility, flexibility, and reliability
   1.3.5 Completeness of the design phase as is commensurate with the corresponding phase

1.4 The commissioning scope for each project will be provided as detailed in the A/E request for proposal (RFP).
1 Introduction
1.1 The work under this Section consists of furnishing all labor, equipment, and materials required for mixing, transport, conveyance, placement, and finishing of all cast-in-place concrete as required by the Drawings and Specifications.

2 Quality Assurance
2.1 Concrete: Designed in accordance with the latest edition of ACI 301, ACI 318 and all other Codes and Standards as adopted by State of Indiana.
2.2 Reinforcement: Designed in accordance with ACI 315, ACI 318, CRSI manual of Standard Practice, and ACI "Manual of Standard Practice for Detailing Reinforced Concrete Structures" and all other Codes and Standards as adopted by State of Indiana.

3 Submittals
3.1 All submittals pertaining to this Section shall be delivered to the Structural Engineer of record for review with sufficient time for review.
3.2 Concrete Mix Designs: Submit a mix design for each class of concrete to be utilized on the project in accordance with Part 6 of this Section
3.3 Reinforcement: Submit shop drawings indicating bending diagrams, deformed bars, plain steel bars and wire, and welded wire fabric of the sizes shown or noted on the drawings.

4 Concrete Materials
4.1 Cement: Cement shall conform to the Specifications for Portland Cement (ASTM Designation: C150), Type I and Type IA or Type III and Type IIIA.
4.2 Water: Water shall be clear and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substances.
4.3 Normal Weight Course Aggregate: Normal Weight Course Aggregate shall conform to ASTM C33 and Table 1 of this Section.
4.4 Admixtures: The use of any material added to the concrete mix shall be approved by the Structural Engineer of Record.
4.5 Synthetic Fiber Reinforcement: Synthetic Fiber reinforcement shall be 100% virgin polypropylene fibers. Fibers may be used to enhance concrete performance in regard to plastic shrinkage or settlement crack resistance, abrasion and impact resistance, and residual strength, but in no case shall fibers be used as a substitute for structural reinforcement.

5 Sampling & Testing:
5.1 Contractor shall furnish all material and shall provide such labor as may be required for sampling the concrete for test specimens.
5.2 Concrete materials and operations will be tested and inspected as the work progresses. Failure to detect any defective work or material shall not in any way prevent later rejection when such defect is discovered nor shall it obligate the Architect/Engineer for final acceptance.
5.3 Sampling procedures as outlined in ASTM Designation C 172, Sampling Fresh Concrete, shall be followed.
5.4 The procedures outlined in ASTM Designation C 31, Standard Method of Making and Curing Concrete Compressions and Flexural Test Specimens in the Field, shall be followed.
5.5 Every class of concrete shall be represented by a minimum of one test for slump, air content and compressive strength.
5.6 Tests may be made at any time during a pour and additional determinations of slump and air content shall be made whenever any change is observed in the consistency or workability of the concrete.
5.7 One strength test shall consist of six (6) specimens tested in compression; two (2) at seven (7) days, two (2) at twenty-eight (28) days and one (2) spares. Test specimens shall be molded in plastic cylinders consistent with ASTM requirements.

6 Quality of Concrete:
6.1 Concrete for any portion of the structure or appurtenant construction shall be of the Class indicated on the plans or in Table 3. The general requirements for each class of concrete are shown on Table 1. Within these general guidelines and ranges specified, the Contractor shall establish the:
   A. Amount of fine aggregate to be used. The aggregates shall be proportioned to use the maximum amount of coarse aggregate that will produce a workable mix.
   B. Slump (+/- 1")
C. Quantity of mixing water to be used. This will be the minimum quantity of water consistent with the required workability.

D. Air content

E. Admixtures

6.2 These Guidelines indicate a minimum cement factor and a maximum permissible water content in addition to limitations on coarse aggregate size and grading, percentage of fine aggregate, etc.

6.3 In no case will concrete be acceptable in the structure if the 28 day compressive strength as determined by test cylinders is less than that stated in Table 1 of this Handbook or as specified by the Structural Engineer of Record.

6.4 All concrete shall be ready mixed and delivered to the project site. Site mixed concrete is prohibited.
### Table 1: General Requirements for Various Classes of Concrete

<table>
<thead>
<tr>
<th>Description</th>
<th>Class Of Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Cement factor, bags per cubic yard minimum</td>
<td>5.5</td>
</tr>
<tr>
<td>Coarse aggregate size designation per INDOT Standard Specifications, unless otherwise noted</td>
<td>8</td>
</tr>
<tr>
<td>Slump, inches</td>
<td>3-5</td>
</tr>
<tr>
<td>Maximum permissible water content, gal. per bag of cement for Gravel <strong>(1)</strong></td>
<td>6.25</td>
</tr>
<tr>
<td>Maximum permissible water content, gal. per bag of cement for Stone crushed <strong>(1)</strong></td>
<td>7.0</td>
</tr>
<tr>
<td>Entrained Air % by volume <strong>(2)</strong></td>
<td>2-4</td>
</tr>
<tr>
<td>Fine aggregate content, % total weight of aggregate</td>
<td>35-45</td>
</tr>
<tr>
<td>Minimum 28 day Compressive Strength (psi)</td>
<td>3000</td>
</tr>
</tbody>
</table>

**(1)** Water Content based on dry aggregate  
**(2)** Air entraining admixture is not permitted for interior slabs to receive a smooth trowel finish.

### Table 2: Course Aggregate Size Distribution Requirements

<table>
<thead>
<tr>
<th>Size No.</th>
<th>1-1/2</th>
<th>1”</th>
<th>3/4”</th>
<th>1/2”</th>
<th>No. 4</th>
<th>No. 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>#8</td>
<td>100</td>
<td>85-100</td>
<td>20-60</td>
<td>0-5</td>
<td>0-2</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3: Class of Concrete for Various Parts of the Structure

<table>
<thead>
<tr>
<th>Structure Component</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall &amp; Isolated Footings, trench footings, Auger-Cast Piles</td>
<td>Class 2 <strong>(2)</strong></td>
</tr>
<tr>
<td>Interior Floors on Fill</td>
<td>Class 2 <strong>(2)</strong></td>
</tr>
<tr>
<td>Walls and slabs of tunnels, manholes, etc. <strong>(1)</strong></td>
<td>Class 4 <strong>(2)</strong></td>
</tr>
<tr>
<td>Interior shear walls, elevator shafts, and stairwell walls</td>
<td>Class 4 <strong>(2)</strong></td>
</tr>
<tr>
<td>Floor and roof slabs, joists, beams, girders, and stairs</td>
<td>Class 4 <strong>(2)</strong></td>
</tr>
<tr>
<td>Exterior walls, grade beams, etc.</td>
<td>Class 4A <strong>(2)</strong></td>
</tr>
<tr>
<td>Exterior walks, steps, slabs, platforms, etc.</td>
<td>Class 4A L.S.</td>
</tr>
<tr>
<td>Curb and gutter, lamp bases, etc.</td>
<td>Class 4A L.S.</td>
</tr>
<tr>
<td>Parking Garage slabs on fill</td>
<td>Class 4A L.S.</td>
</tr>
</tbody>
</table>

**(1)** Crystalline waterproofing admixture require  
**(2)** Minimum or as required by the Structural Engineer of Record
1  **Face Brick**

1.1  Face Brick is typically included in the bid package as an allowance, with the actual brick selection to be made by the owner during construction.

1.2  Brick will be Grade SW and Type FBX or FBS as appropriate.

1.3  Exterior brick will normally be selected to blend and be compatible with surrounding and adjacent structures.

1.4  The project manager will be responsible for facilitating the final brick selection with the Senior Architect.

2  **Mortar**

2.1  Mortar should be non-staining Portland Cement and Lime with clean washed masonry sand.

     2.1.1  Lime should be plastic hydrate Type S. No admixtures will be allowed without written approval.

     2.1.2  Water shall be clean and free from deleterious amounts of acids, alkalis, or organic materials.

3  **Mock-Up Panels**

3.1  Mock up panels are required for selection and approval of brick, stone, & mortar by the Senior Architect. Workmanship panel will be demonstrated by “wall assembly” panel noted in Section 8300 “Shell Exterior Performance Requirements”.

3.2  Panels should be at least 4’x6’.

4  **Winter Construction**

4.1  No masonry will be constructed in temperatures below freezing. No antifreeze will be allowed.

5  **Joints**

5.1  All joints in exterior masonry will be tooled unless specifically approved by the Project Manager and the Senior Architect.

6  **Expansion Joints**

6.1  Vertical expansion joints receive a sealant that will approximate the color of the adjacent brick.

6.2  Horizontal “moving” joints receive a sealant that will approximate the color of the adjacent mortar.
1 General
1.1 The name of metal building manufacturer is to be submitted with the bid.
1.2 Metal building manufacturer’s proof of AISC Certification Category MB is to be submitted with the Materials and Subcontractor Questionnaire.
1.3 Contractor’s Certificate certifying that the Contractor complies with specified requirements and is a manufacturer’s currently authorized dealer of the system to be furnished shall be submitted with the Materials and Subcontractor Questionnaire.
1.4 Letter of Design Certification shall be submitted with the shop drawings. Letter of Design Certification shall include:
   1.4.1 Signature of the Designer of Record who shall be a Registered Professional Engineer licensed in the State of Indiana
   1.4.2 Building dimensions and elevations
   1.4.3 Governing Building Code
   1.4.4 Lateral Design procedure used
   1.4.5 Design Criteria including dead, live, snow, seismic, collateral, wind, and concentrated loads; load combinations; methods of load application; and load path

2 Design Criteria
2.1 A minimum collateral load of 10 PSF shall be applied to the entire structure to account for the weight of additional materials, systems, and/or equipment.
   2.1.1 Collateral load shall not be included when considering load combination of (Dead + Wind Uplift)
   2.1.2 Additional Collateral load shall be included in the roof design for mechanical rooms, laboratories, corridors, etc. or any other space that may experience hanging loads beyond the normal collateral dead load. Minimum 20 psf or as required by the design intent of the space.
2.2 Additional framing considerations shall be made for anticipated concentrated loads
2.3 The live load deflection of roof elements shall not exceed the following where L is the span of the element considered:
   2.3.1 Exposed structure (no ceilings) shall not exceed L/180

2.3.2 Supporting plaster ceilings shall not exceed L/360
2.3.3 Supporting other ceilings shall not exceed L/240

2.4 Lateral deflections, or drift, at the roof level in relation to the slab-on-grade shall be calculated based on a 50-year mean recurrence interval and shall not exceed the following:
   2.4.1 H/125 for buildings with exterior metal panel walls,
   2.4.2 H/500 for buildings with masonry or concrete exterior walls.
   2.4.3 H/600 for masonry walls with steel stud backup walls

2.5 Maximum deflection for wall and roof panels under full dead and live and/or wind loads shall not exceed L/180.
2.6 Frost Wall: The building foundation shall include a continuous perimeter reinforced concrete frost wall which is founded at or below the minimum frost depth prescribed by the building code.
2.7 Minimum 18 gage steel to be used for steel stud backup walls of masonry/steel stud walls.
2.8 Minimum slope for a mechanically seamed metal roof shall be 1:12.
2.9 Minimum slope for a manual snap-in seamed roof shall be 3:12.
2.10 Aluminum roofing and siding shall not be acceptable unless approved by Owner.
2.11 All non-standard flashing and trim details shall be designed and detailed by Architect or Engineer of Record.

3 Wall & Roof Finish
3.1 All exterior metal wall panels and visible roof panels shall have a two-Coat Fluoropolymer AAMA 621 finish containing not less than 70 percent PVDF resin by weight in color coat such as Kynar200 or Hylar5000 finish. A Galvalume finish shall be acceptable on low slope, non-visible roofs.
3.2 Insulation: In addition to the “hourglass” installation of roof and wall insulation, the Architect of Record shall provide details for additional insulation as required to meet building code. Methods including thermal blocks and proprietary systems (e.g. Simple Saver, Sky-Web Systems, etc.) shall be reviewed by Owner.
1 Structural Steel

1.1 Structural Steel shall comply with the following:

- AISC’s 303-05 “Code of Standard Practice for Steel Buildings and Bridges.”
- RCSC’s “Specification for Structural Joints Using ASTM A325 or A490 Bolts.”

1.2 Shop drawings will be required for all metal assemblies. Metal assemblies that have been installed prior to shop drawing submittal and A/E review are subject to rejection by the Owner, Architect, and/or Structural Engineer and replacement at the Contractor’s expense.

2 Welding

2.1 All welding shall be performed in accordance with the AWS “Structural Welding Code D1.1” by a welder certified in the types of welds indicated in the construction documents.

2.2 The Construction Documents shall indicate all welding requirements for connections to existing structural steel members.

2.3 No field welding to existing structural members shall be performed without the prior approval from the Structural Engineer of Record.

3 Field Modifications

3.1 No field modifications (e.g. to accomplish connection alignment, fit-up, mis-fabrication, opening locations, etc.) shall be made to structural components without the written approval of the Structural Engineer and Architect of Record.

4 Miscellaneous

4.1 Fire Resistive Protection:

- 4.1.1 The Construction Documents shall clearly indicate all members of the structural steel frame to receive fire resistive protection.

4.2 Concrete Topping:

- 4.2.1 The Construction Documents shall indicate the minimum concrete thickness and floor levelness requirements for concrete toppings over metal deck or precast concrete floor systems and provide recommendations for increasing the concrete thickness as required to compensate for deck and member deflections and residual camber.

4.3 Openings:

- 4.3.1 The Construction Documents shall indicate the framed opening requirements in the structural steel frame for connections of and passage for other work to be provided by the structural steel contractor. No openings shall be field cut in any structural members without the approval from the Structural Engineer of Record.
1 Framing Requirements

1.1 Construction Documents shall clearly indicate all wall types, heights and walls that extend to the underside of deck. All walls shall extend to the deck unless otherwise noted.

1.2 All non-structural interior walls framed to the underside of a floor or roof deck are to have deep leg deflection tracks at the top of the wall. Studs shall be mechanically fastened to deep leg tracks to allow for deflection in the floor system above.

1.3 Studs shall be tack welded or mechanically fastened to tracks and runners.

1.4 Provide 3/4" Channel bridging at 4’o.c. minimum or as recommended by the metal stud manufacturer.

1.5 Provide a minimum of two (2) studs per jamb on each side of all door openings and other wall openings greater than four feet in width.

2 Blocking

2.1 Horizontal and/or vertical fire retardant wood blocking or structural metal stud blocks are to be installed in metal stud walls where shelves, counter tops, monitors, screens, etc. are anticipated to be anchored to the wall.

3 Application Limitations

3.1 Light gauge steel framing may not be used to support the gravity load of masonry veneer unless specifically detailed in the Construction Documents.

4 Table of Framing Gauges

<table>
<thead>
<tr>
<th>Item</th>
<th>Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lintels, beams, column studs, bearing walls, etc.</td>
<td>As required by design</td>
</tr>
<tr>
<td>Interior non-bearing partitions</td>
<td>Minimum 20 gauge &quot;C&quot; sections or as required by design</td>
</tr>
</tbody>
</table>

Note: Gauge requirements may increase with wall height.

Note: Equivalency ratings of “dimpled” framing systems similar to Dietrich Ultra-Steel series are generally recognized.

5 Table of Miscellaneous Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound sealant</td>
<td>2 beads at full perimeter, both sides of partition</td>
</tr>
<tr>
<td>Sound sealant</td>
<td>At junctures with existing construction</td>
</tr>
<tr>
<td>Sound sealant</td>
<td>At electrical boxes (back butter holes)</td>
</tr>
</tbody>
</table>
1 Roof Insulation
1.1 Roof assemblies required to achieve a Class A fire rating:
   - polyisocyanurate insulation
   - installed in multiple layers with joints staggered in each direction
1.2 Roof assemblies not required to achieve a fire rating:
   - extruded polystyrene insulation should be considered
1.3 In new construction, consideration should be given to accomplishing roof slope with the structure so that tapered insulation is not required to achieve drainage, either at the time of construction or in the future.

2 Wall Insulation
2.1 Most wall systems should receive rigid insulation mounted on the exterior face of the wall.
   2.1.1 Such insulation should be installed in multiple layers with joints staggered both horizontally and vertically.
2.2 Type of insulation shall be determined on a case by case basis.
1 Shingles
1.1 Roofing shingles shall be fiberglass reinforced asphalt carrying a minimum of 30 year warranty.  
1.1.1 Shingles shall be algae resistant.  
1.2 Color, style, and other characteristics must be approved by Senior Architect.

2 Clay Tile
2.1 Color and style of clay tile roofing is a design consideration and will depend on the application and the location on campus and must be approved by the Senior Architect.

3 Slate
3.1 Use of slate on campus has been limited, with the Purdue Memorial Union being the most prominent example.  
3.2 Color, style, and other characteristics of slate roofing will be treated as a design decision and will be dependent on several factors.

4 Specialty Roofing
4.1 Roofing materials not listed above, including any “mimic” materials such as synthetic slate or metal tiles, will be considered in discussion with the project manager.
1 Metal Roofing

1.1 Except in special cases, metal roofing will be standing seam with concealed fasteners.
   1.1.1 Consideration should be given to the appropriateness of mechanically formed seams.

1.2 Finish shall carry a 30 year warranty.

1.3 All cut edges should be touched up with matching paint.

2 Metal Siding Panels

2.1 Exterior metal panel systems shall be dry-lock type and shall not be dependent on caulking or gaskets to be water tight.

2.2 Insulated panel systems are not recommended.

2.3 Non-insulated systems should be used in conjunction with appropriate insulation and vapor barrier elsewhere in the wall system.
1 General Considerations

1.1 Unless noted otherwise, roof membranes shall be built-up, cold applied, modified bitumen, with a granular surface.

1.2 Roofing systems must come with a minimum 20 year warranty that will not be voided as a result of maintenance and repair work being performed by our own roofing shop.

1.3 It must be assured that our maintenance personnel will be able to purchase appropriate materials from the manufacturer for regular maintenance operations.

1.4 Roofing system will allow for a refurbishment prior to the expiration of the warranty that will be accompanied by a full warranty extension.

1.5 Protective walking surfaces should be provided where foot traffic is anticipated for maintenance of equipment and other activity on the roof.

Note: There are approximately 180 buildings on campus, including residence halls. If the useful life of a roof is 20 years (typical for EPDM), then we will be replacing nine roofs on campus every year. The implications of moving to roofing systems that offer a longer useful life and extending each of those roofs even further via a refurbishment would reduce the number of roofing projects in any year by half. This can have tremendous implications. Beyond the reduced disruption of traffic flow, noise and vibrations within the building, damage to landscaping, consider the damage that is done to roof decks as old roofing is torn off and penetrations are made to secure new systems in place.

Numerous roofing materials promise longer useful life than EPDM. In general, this is a “you get what you pay for” scheme. However, modified bitumen systems provide an enhanced ability to accept a refurbishment project. They can, typically, be topped with more of the same material and, in most cases, the warranty can be extended.

The impact of a refurbishment project on the building and on campus is significantly less than a tear-off and replace project. Typically, flashings will be restored, isolated areas of wet insulation may be removed, if necessary, and a new coating will be applied over the existing roof. It is entirely possible for us to double the time period between complete tear-offs and thereby reduce by half the number of re-roof projects on campus during any roofing season.
1 Door Sizes
1.1 Only for special purposes can any door be less than 36” in nominal width.
1.2 In custom size openings, one leaf should always be 36”. Odd sized inactive leaves can be used in these situations.
1.3 Double doors are to be 36” leaves in pairs.

2 Doors in Classrooms:
2.1 Classroom doors are to have small vision lights with reflective glass.

Note: Vision lights allow individuals in the corridor to see into a classroom without having to open the door or otherwise being a distraction to those in the room.

3 Laboratory Doors
3.1 At least one door serving each laboratory should be in a larger opening, typically 4’-0”, with a 36” active leaf and a twelve inch inactive leaf to accommodate movement of equipment in and out of the lab.

4 Doors to Stairwells
4.1 Fire rated doors leading from corridors to stairwells should be steel with a painted finish.
4.2 Fire rated doors should be on an electromagnetic hold-open device tied into the building fire alarm system so they close automatically when the smoke detection system for door release service is activated. This will reduce wear and tear on the doors and provide an opportunity to improve air quality in the stairwells.

5 Doors in Animal Facilities
5.1 Specify stainless steel or fiberglass doors in animal facilities.

6 Surface Protection
6.1 Kickplates should be provided on the push side of all doors equipped with closers.
6.2 Oversized push plates should be considered on restroom doors and other high traffic doors without latching hardware.

7 Steel Frames
7.1 Door frames in masonry walls will be grouted full.
7.2 Door frames in the frame walls will be grouted only where necessary for acoustical control.

8 Exterior Doors
8.1 Metal frames shall be thermally broken.
8.2 Air leakage (maximum): 1.0 cfm/sf for swinging doors

9 Loading Dock Doors
9.1 Loading dock doors shall be equipped with weatherseals to restrict outside air infiltration while vehicles are parked in the doorway.
1 Function
1.1 Window function will be discussed in the program on a building to building basis. In general, fixed windows are preferred.
1.2 If there is a concern about the exterior appearance of combining operable and inoperable windows on the same building façade, it is acceptable to install operable windows and find a way to fix them in the closed position where appropriate.

2 Glass Type
2.1 Clear, low-E glass should be used in most cases, depending on the orientation.

3 Humidity
3.1 Window specifications must consider the heating season humidity levels within the building in order to avoid condensation on the glass or on the frames.

Note: Careful coordination with HVAC diffuser placement can also help control condensation.

4 Aluminum Windows
4.1 All aluminum windows must have thermally broken frames and insulated glazing.
4.2 Frame color will be determined during design.

Note: The goal of contextuality on the traditional campus requires consideration not only of the current condition of existing buildings, but how fenestration might have been handled historically.

5 Manifestation of Glazing*
5.1 Where large uninterrupted areas of transparent glazing separates two parts of the building or where it separates interior and exterior spaces on the same level, there is a risk of collision because it looks like people may walk from one area to the other.
5.2 To avoid this risk of collision one of two options should be implemented
   a. Use permanent manifestation to make glazing apparent (see paragraph 5.3).
   b. Use alternative indications of glazing, such as mullions, transoms, door framing or large pull or push handles.

5.3 Provide glass doors and glass walls (including glazed walls alongside a corridor) with all of the following:
   a. Manifestation at two levels – 36” and 60”.
   b. Manifestation that will contrast visually with the background seen through the glass from both directions and in all lighting conditions.
   c. Manifestation in the form of a logo or sign, a minimum of 6” high (repeated if on a glazed wall), or a decorative feature such as broken lines or continuous bands, a minimum of 2” high.
   d. Where glazed doors are beside or part of a glazed wall, they are clearly marked with a high-contrast strip at the top and on both sides.
   e. Where glass doors may be held open, they are protected with guarding to prevent people from colliding with the leading edge.

1 Keying
1.1 The Purdue Lockshop will procure cylinders, provide keying, and install cylinders on all academic building projects. Residence Halls staff will provide cylinders and keying for all residence hall projects.

2 As built schedules
2.1 Furnish ‘as-built’ or ‘as-installed’ schedule with closeout documents, including:
   • keying schedule
   • wiring/riser diagrams
   • manufacturers’ installation, adjustment and maintenance information
   • supplier’s final inspection report

3 Automatic door operators
3.1 Automatic door operators used for accessibility purposes shall be electro-mechanical.
   3.1.1 Besam Automatic Entrance Systems, Inc., model SW200i for high traffic and/or exterior doors
   3.1.2 LCN Closers, Inc., Benchmark
   3.1.3 Norton Door Controls, model 5900

4 Commissioning
4.1 Conduct commissioning tests three weeks prior to request for certificate of substantial completion.
4.2 Test door hardware operation with climate control system and stairwell pressurization system both at rest and while in full operation.
4.3 Test electrical, electronic and electro-pneumatic hardware systems for satisfactory operation.
4.4 Test hardware interfaced with fire/life-safety system for proper operation and release.

5 Warrantees
5.1 Provide manufacturers’ standard warranties for all hardware.

6 Mortise locksets and latchsets
6.1 Sargent 8200 Series, LW1B or LW1J.

6.2 Accepted substitutions: Schlage

7 Electromagnetic hold-open closers
7.1 Integrate with UL listed fire/life-safety alarm systems.
7.2 Multi-point units to have hold-open bypass at 80 deg or 140 deg. Closers to be swing-free/no-drift arms at pull-side mounted units.

8 Low operating force units
8.1 Doors with automatic door bottoms plus head and jamb seals cannot require more than two pounds operating force to open when closer is disconnected.

9 Wall & Floor-mounted Electromagnetic Door Holders
9.1 LCN’s to be SEM series or approved equivalent. Incorporate into U.L.-listed fire & life-safety system such that doors are to release to allow closure and latching when door’s zone is in alarm state.
9.2 Use the minimum projection required to allow door to open as widely as allowed by wall conditions and projection of door hardware.
1 General

1.1 Single door openers cannot be used on a door smaller than 36" wide.

1.2 Minimum width for passage shall be at least 32" clear.

1.3 Every exterior door with an automatic opener shall have an electric lock and a timer that first unlocks the door then signals the door to open. This sequence is to be activated by the push pad or RF receiver(s).

1.4 A key switch for Day/Night operation shall activate the electric lock (unlock the door) during open hours, unless the door is to a secure area. The time lock system can function as the Day/Night switch.

1.5 All doors shall have a dual channel RF receiver so that the interior pad can remain active when the exterior pad is shut off.

2 Vestibules

2.1 When a vestibule is less than 7' in depth (renovation only), the doors on each side of the vestibule should open at the same time.

2.2 One or more push plates shall be placed in a vestibule between doors. The push plate shall be within 4' of the door at 36" AFF. The foot of the icon on the push plate shall point toward the automatic door that it operates.

3 Handicapped door applications

3.1 Interior door at a firewall:

3.1.1 Door remains unlatched because of a device hooked to fire alarm system.

3.1.2 This device normally holds door unlatched until a fire alarm exists. Door is to operate as an inside door with an opener.

- Option 1: Hold fire door open with a hold-open device hooked to the fire alarm. With a fire alarm, the door is released and the closers close the door.
- Option 2: A pair of stand-alone smoke detectors with one on each side of the door shall either latch or close and latch the door.

3.2 Interior door with opener only:

3.2.1 Attach the opener to the wall above the door; use at least one RF receiver

3.2.2 Install palm switches within 4' of the door.

3.3 Exterior door with opener only:

3.3.1 Attach the opener to the wall above the door, use a dual RF receiver

3.3.2 Install palm switches within 4 feet of the door.

3.3.3 Install Day/Night Key switch to disable the outside palm switch by disabling the outside receiver. The inside palm switch shall always be active.

3.3.4 The handheld remote, on the same frequency or code as the outside push pad, will open the door only during unlocked times (Day).

3.3.4.1 An Employee may be issued a remote on the inside frequency (code) to act as a key for 24/7 use.

3.3.4.2 Door requirements include an electric lock and a time delay. The Palm switches and/or the remote will activate the time delay and the time delay will trigger the door opener.

3.3.4.3 Time delay (delayed one-shot) gives the door time to be electrically unlocked [bypass timer during unlocked times]

3.3.4.4 Students with remotes will have no remote control operation inside the building after hours. The push pad switch will always be active on the inside of the building.

3.4 Interior door with access control lock

3.4.1 Install Day/Night Key switch to disable the outside palm switch by disabling the outside receiver. The inside palm switch shall always be active.

3.5 Interior door with access control lock with "buzz-in"

3.5.1 Access control locks door, disables outside palm switch. "buzz-in" unlocks door.

3.5.2 Install Day/Night Key switch to disable the outside palm switch by disabling the outside receiver. The inside palm switch shall always be active.

3.6 Exterior door with access control lock

3.6.1 Access control locks door, disables outside palm switch

3.6.2 Install Day/Night Key switch to disable the outside palm switch by disabling the outside receiver. The inside palm switch shall always be active.

3.7 Interior with access control card access
3.7.1 The remote transmitter bypasses the access control and opens the door.

3.7.2 According to security, only 1 frequency setting for the push pad or remote may be required.

3.8 Exterior with access control card access

3.8.1 The remote transmitter bypasses the Harco system and opens the door. The code of the remote transmitter may be either on the code of the inside or outside push plate according to the privileges of the holder.

3.8.2 With the frequency or code of the hand held set for the outside push pad, the holder has 24/7 access.

3.8.3 With the frequency or code of the hand held set for the inside push pad, the holder has building open time access.

4 Approved equipment

4.1 Door openers

4.1.1 Besam Automatic Entrance Systems, Inc., model SW200i for high traffic and/or exterior doors

4.1.2 LCN Closers, Inc., Benchmark

4.1.3 Norton Door Controls, model 5900

4.2 Push pad, RF transmitters, RF receivers

4.2.1 Sedco

4.3 Door hardware (electrified panic hardware, electric strike)

4.3.1 VonDuprin

5 Approved additional components

5.1 Sedco

5.1.1 Heavy Duty “608 series” post with recess for push pad and plastic cap.

5.1.2 Rubber boot RB for switch of push pad (for outside use.)

5.1.3 Weatherproofing Box Gasket (Part #12001) for outdoor use.
1 Definitions

<table>
<thead>
<tr>
<th>Facility</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vending Facility</td>
<td>Facility consisting of beverage and/or snack machines to be controlled by a card slot mounted on each machine and is controlled by the central system CPU</td>
</tr>
<tr>
<td>Laundry Facility</td>
<td>Facility consisting of laundry machines (washers, driers) to be controlled by a card slot mounted on each machine and is controlled by the central system CPU</td>
</tr>
<tr>
<td>Copy Facility</td>
<td>Facility consisting of at least one (1) copy machine controlled by a card slot in same vicinity or on the machine itself and is controlled by the central system CPU</td>
</tr>
<tr>
<td>Office/Retail Outlet</td>
<td>Any singe gang RJ-45 type outlet for connection of point of sale device and controlled by central system CPU. (Not a standard PIC)</td>
</tr>
<tr>
<td>Door Switch</td>
<td>Flush mounted magnetic switch installed at the top of the door frame near the side opposite to the hinges for monitoring of door position</td>
</tr>
<tr>
<td>Controlled Door</td>
<td>Any door consisting of at least (1) door switch, but without a card slot near the controlled door and monitored by the central system CPU. (Referred to as a Point Door)</td>
</tr>
<tr>
<td>Card Reader Door</td>
<td>Any door consisting of at least (1) card slot, (1) door switch, (1) electrified piece of door hardware and that is monitored and controlled by the central system CPU</td>
</tr>
<tr>
<td>LX Switch</td>
<td>Switch located in panic bar mounted on door or inside a mortise type latch to monitor position of the latch</td>
</tr>
<tr>
<td>RX Switch</td>
<td>Switch located in magnetic lock panic bar mounted on door to monitor position of the panic bar (Request to Exit)</td>
</tr>
<tr>
<td>Power Transfer</td>
<td>Device connected to the door, on hinged side, and to the door frame for the purpose of transferring wires from the door frame to the door for monitoring and controlling the latches</td>
</tr>
<tr>
<td>Mortise Type Non-Electrified Device</td>
<td>Device located in or on door frame, opposite the hinged side of door</td>
</tr>
</tbody>
</table>

2 Scope

2.1 The work required under this section consists of providing labor and material to install necessary conduit and junction box rough-in’s for future access control of doors and for future point of sale control of vending facility, laundry facility, copy facility and office/retail point of sale device.

3 Controlled Door Installations

3.1 Controlled door consists of (1) Hoffman #A-12N124 box and (1) Hoffman #A-12N12P backplate installed near door. Location of box should not be in front of or above the door.

3.1.1 When the box elevation would be higher than ten feet above finished floor, consider installing the box below the floor or contact the Construction Manager who is responsible to obtain a location that shall be determined by a University representative.

3.2 If door is equipped with ADA Auto Door Opener install ½” EMT from the operator to the 12”x12”x4” Hoffman box.

3.3 New Construction Wooden or Aluminum Doors

3.3.1 From the 12”x12”x4” Hoffman box to each door, (1) ½” EMT shall be installed inside the door frame to a box located at the top of the door frame, opposite of the hinged side for the magnetic door switch.

3.3.2 With Electrified Panic Hardware or Mortise Type Electrified Lock.

3.3.2.1 From the 12”x12”x4” Hoffman box to each door, (1) ½” EMT shall be installed inside the door frame to a box located inside the door frame, on the hinged side of the door, approximately 6” above the middle hinge for the power transfer.

3.3.3 With Mortise Type Non-Electrified Device (Electric Strike).

3.3.3.1 From the 12”x12”x4” Hoffman box to each door, (1) ½” EMT shall be installed inside the door frame to a box located inside the door frame, opposite the hinged side of the door, directly across from the latch in the door for an electrified door strike.

3.4 Existing Construction Wooden or Aluminum Doors

3.4.1 From the 12”x12”x4” Hoffman box,
Wiremold type #700 shall be either

- Installed to the door frame where it is converted to a Wiremold #5785 combination connector that is flush to the top of door frame, opposite of the hinge side for magnetic door switch. Only to be used if the door frame is hollow.

- Installed to a Wiremold #V57242 utility box mounted flush to the top of the door frame opposite to the hinged side with a path into the door frame for magnetic door switch. Only to be used if door frame is hollow.

3.4.2 With Electrified Panic Hardware or Mortise Type Electrified Latch.

3.4.2.1 From the 12”x12”x4” Hoffman box to each door, Wiremold type 700 shall be installed near the door frame to a Wiremold #V57242 utility box located near the door frame, on the hinged side of the door, approximately 6” above the middle hinge for the power transfer.

3.4.3 With Mortise Type Non-Electrified Device (Electric Strike).

3.4.3.1 From the 12”x12”x4” Hoffman box to each door, Wiremold type 700 shall be installed near the door frame to a Wiremold #V57242 utility box located near the door frame, opposite the hinged side of the door, directly across from the latch in the door for an electrified door strike.

4 Card Reader Door Installations

4.1 Controlled door consists of (1) Hoffman #A-12N124 box and (1) Hoffman #A-12N12P backplate installed near door. Location of box should not be in front of or above the door.

4.1.1 When the box elevation would be higher than ten feet above finished floor, consider installing the box below the floor or contact the Construction Manager who is responsible to obtain a location that shall be determined by a University representative.

4.2 If door is equipped with ADA Auto Door Opener install ½” EMT from operator to the 12”x12”x4” Hoffman box.

4.3 New Construction Wooden or Aluminum Doors.

4.3.1 Card Reader door consists of flush mounted single gang junction box on latch side of door with (1) ¾” EMT in wall construction to new 12” x 12” x4” Hoffman junction box.

4.3.2 With Electrified Panic Hardware or Mortise Type Electrified Lock

4.3.2.1 From the 12”x12”x4” Hoffman box to each door, (1) ½” EMT shall be installed inside the door frame to a box located inside the door frame, on the hinged side of the door, approximately 6” above the middle hinge for the power transfer.

4.3.3 With Mortise Type Non-Electrified Device (Electric Strike).

4.3.3.1 From the 12”x12”x4” Hoffman box to each door, (1) ½” EMT shall be installed inside the door frame to a box located inside the door frame, opposite the hinged side of the door, directly across from the latch in the door for an electrified door strike.

4.4 Existing Construction Wooden or Aluminum Doors

4.4.1 Card Reader door consists of a Wiremold #V57242 utility box or Owner supplied card slot back box install on latch side of door. Install Wiremold #700 from box to 12” x 12” x4” Hoffman box.

4.4.2 From the 12”x12”x4” Hoffman box, Wiremold type #700 shall be either

- Installed to the door frame where it is converted to a Wiremold #5785 combination connector that is flush to the door frame. Only to be used if the door frame is hollow.

- Installed to a Wiremold #V57242 utility box mounted flush to the top of the door frame opposite to the hinged side with a path into the door frame. Only to be used if door frame is hollow.
4.4.4.2 From the 12”x12”x4” Hoffman box to each door, Wiremold type 700 shall be installed near the door frame to a Wiremold #V57242 utility box located near the door frame, on the hinged side of the door, approximately 6” above the middle hinge for the power transfer.

4.4.5 With Mortise Type Non-Electrified Device (Electric Strike).

4.4.5.1 From the 12”x12”x4” Hoffman box, Wiremold type #700 shall be either
- Installed to the door frame where it is converted to a Wiremold #5785 combination connector that is flush to the door frame. Only to be used if the door frame is hollow.
- Installed to a Wiremold #V57242 utility box mounted flush to the top of the door frame opposite to the hinged side with a path into the door frame. Only to be used if door frame is hollow.

4.4.5.2 From the 12”x12”x4” Hoffman box to each door, Wiremold type 700 shall be installed near the door frame to a Wiremold #V57242 utility box located near the door frame, opposite of the hinged side of the door, directly across from the latch in the door for the electrified door strike.

5 Laundry Facility

5.1 Install 12”x12”x6” Hoffman #A12N126 box, location shall be determined by a University Representative. Vending Vendor is responsible for equipment connection to vending machine.

5.2 Install 4”x4” box behind the laundry machines. This equipment requires (1) 4”x4” box for every 4 laundry machines. Install ¾” EMT from each 4” x 4” box to new 12”x12”x6” Hoffman box.

5.3 Each 4”x4” box shall have ¾” seal-tite flexible conduit installed to each of the four laundry machines.

6 Vending Facility

6.1 New Vending Machines may utilize wireless credit card technology, therefore eliminating the need for connection to BLACKBOARD. Verify the type of Vending Machines to be utilized.

6.2 Existing Vending Machines still utilizing Blackboard

6.2.1 Install (1) Hoffman # A-12N124 box mounted near the vending machines. Location of Hoffman box shall be determined by a university representative. Vending vendor is to be responsible for equipment connection to machine.

6.2.2 Existing Construction Blackboard Vending Facility

6.2.2.1 (1) Wiremold #5747 surface mount box for each machine with (1) Wiremold #700 type raceway to the Hoffman box.

6.2.3 New Construction Blackboard Vending Facility

6.2.4 (1) Single gang flush mount box for each machine with (1) ¾” EMT to the Hoffman box.

7 Copy Reader

7.1 (1) Wiremold #5747 surface mount box or Owner supplied card slot back box mounted on either the copy machine itself or on a box shown on Blackboard details.

7.2 (1) Wiremold #5747 surface mount boxes. First Wiremold #700 type raceway is to be installed from one of the 5747 boxes to discrete location where it can be converted to (1) ¾” EMT continuous from the box to within 18” to 24” from the hallway distribution system.

8 Office/Retail Outlet

8.1 New Construction outlet box shall be a 4 11/16” square flush mounted box. Boxes are to be 2 1/8” deep with single gang, square drawn extension or tile ring. Outlet box shall have (1) ¾” EMT continuous from the box to within 18” to 24” from the hallway distribution system.
TYPICAL CARD READER ROUGH-IN

NOTES:
1. LOCATE CARD READER CONTROL BOX AND JUNCTION BOXES ON WALL ADJACENT TO DOOR ON THE SECURE SIDE OF THE DOOR. BOXES ARE TO BE LOCATED ABOVE ACCESSIBLE CEILING WHEREEVER POSSIBLE AND NO LOWER THAN 10'-0" A.F.F. IN AREAS WITHOUT ACCESSIBLE CEILINGS.
2. COORDINATE ROUGH-IN WITH PURDUE ELECTRONICS SHOP PRIOR TO PERFORMING ANY WORK TO ROUGH IN DOOR FOR ACCESS CONTROL EQUIPMENT. VERIFY ALL LOCATIONS FOR ACCESS EQUIPMENT BOXES AND ENCLOSURES WITH PURDUE ELECTRONICS SHOP.
NOTES:
1. LOCATE CARD READER CONTROL BOX AND JUNCTION BOXES ON WALL ADJACENT TO DOOR ON THE SECURE SIDE OF THE DOOR. BOXES ARE TO BE LOCATED ABOVE ACCESSIBLE CEILING WHEREVER POSSIBLE AND NO LOWER THAN 10'-0" A.F.F. IN AREAS WITHOUT ACCESSIBLE CEILINGS.
2. COORDINATE ROUGH-IN WITH PURDUE ELECTRONICS SHOP PRIOR TO PERFORMING ANY WORK TO ROUGH-IN DOOR FOR ACCESS CONTROL EQUIPMENT. VERIFY ALL LOCATIONS FOR ACCESS EQUIPMENT BOXES AND ENCLOSURES WITH PURDUE ELECTRONICS SHOP.
1 General

1.1 Campus interior signage standard may be obtained from the Project Manager. (Purdue University Campus Signage Standards 8-9-2016.PDF)

1.2 Purdue exterior signage and wayfinding standards can be obtained from the Project Manager. (Exterior Wayfinding and Signage Project documents dated 1-30-2015).
1 General

1.1 The name of Post-frame Building Manufacturer is to be submitted with the bid.

1.2 Post-frame building shall be designed and installed in accordance with the latest edition of the Post-Frame Building Design Manual as published by the National Frame Builder’s Association, applicable local Building Code, ASTM References, and other applicable legal and EPA requirements and be certified by an Engineer registered in the State of Indiana.

1.3 Provide a complete building system of standard mutually dependent components and assemblies that form a Post-frame building capable of withstanding structural, environmental and other loads, and exposure to weather without failure or infiltration of water into building interior. Include primary and secondary framing, metal roof panels, metal wall panels, and accessories complying with requirements indicated.

1.4 Letter of Design Certification shall be submitted with the shop drawings. Letter of Design Certification shall include:

1.4.1 Signature of the Designer of Record who shall be a Registered Professional Engineer licensed in the State of Indiana

1.4.2 Building dimensions and elevations

1.4.3 Governing Building Code

1.4.4 Lateral Design procedure used

1.4.5 Design Criteria including dead, live, snow, seismic, collateral, wind, and concentrated loads; load combinations; methods of load application; and load path

2 Design Criteria

2.1 Post-Framed building shall be designed to support self-weight plus superimposed dead load, live load and environmental loads

2.2 A minimum collateral load of 5 PSF shall be applied to the entire structure to account for the weight of additional materials, systems, and/or equipment.

2.2.1 Additional 5 psf load shall be included for projects with a suspended or hard ceiling.

2.2.2 Collateral load shall not be included when considering load combination of (Dead + Wind Uplift)

2.2.3 Additional Collateral load shall be included in the roof design for mechanical rooms, laboratories, corridors, etc. or any other space that may experience hanging loads beyond the normal collateral dead load. Minimum 20 psf or as required by the design intent of the space.

2.3 Additional framing considerations shall be made for anticipated concentrated loads

2.4 The live load deflection of roof elements shall not exceed the following where L is the span of the element considered:

2.4.1 Exposed structure (no ceilings) shall not exceed L/180

2.4.2 Supporting plaster ceilings shall not exceed L/360

2.4.3 Supporting other ceilings shall not exceed L/240

2.5 Lateral deflections, or drift, at the roof level in relation to the slab-on-grade shall be calculated based on a 50-year mean recurrence interval and shall not exceed the following:

2.5.1 H/125 for buildings with exterior metal panel walls,

2.5.2 H/600 for masonry walls with steel stud backup walls

2.6 Maximum deflection for wall and roof panels under full dead and live and/or wind loads shall not exceed L/180.

2.7 Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for Class 60.

2.8 Columns: Column posts shall be attached above grade to

2.8.1 precast concrete pier; pier embedment depth per designer of record

2.8.2 cast-in-place concrete pier; pier embedment depth per designer of record

2.9 Wood Post embedded in soil, gravel or concrete shall not be permitted.

2.10 Frost Wall: If the building is to be thermally controlled, include a continuous perimeter reinforced concrete frost wall which is founded at or below the minimum frost depth prescribed by the building code.

2.11 Minimum slope for a mechanically seamed metal roof shall be 1:12.

2.12 Minimum slope for a manual snap-in
seamed roof shall be 3:12.

2.13 Aluminum roofing and siding shall not be acceptable unless approved by Owner.

2.14 All non-standard flashing and trim details shall be designed and detailed by Architect or Engineer of Record.

3 Wall & Roof Finish

3.1 All exterior metal wall panels and visible roof panels shall have a two-Coat Fluoropolymer AAMA 621 finish containing not less than 70 percent PVDF resin by weight in color coat such as Kynar200 or Hylar5000 finish. A Galvalume finish shall be acceptable on low slope, non-visible roofs.

3.2 Insulation: The Architect of Record shall provide details for additional insulation as required to meet building code. Methods including thermal blocks and proprietary systems shall be reviewed by Owner.
1 General
1.1 Elevator guiding members shall be planed steel “T” type.
1.2 Elevators shall have integrally mounted phones programmed for Owner’s “ring-down” phone system. No “remote monitoring” will be allowed to utilize this phone line.
1.3 For residence hall, athletic department and, overnight occupancy applications “vandal-proof” style fixtures with positive stop buttons are recommended.
1.4 Keys for fire service or fire panels shall be FEO-1K.
1.5 Door operators shall be closed loop in design with “full view” infrared protection. All horizontal door panels hall have two gibs per panel and removable/replaceable door hanger assemblies and up-thrusts. Vertical door assemblies will have “full view” infrared protection as well.
1.6 Any variance required for installations shall be processed and submitted by Purdue.
1.7 All traveling cables shall have 10% spare stranded conductors and a minimum of two spare shielded conductors.

2 Controllers
2.1 All controllers shall utilize selective/collective/automatic logic.
2.2 They shall be processor based, non-proprietary, and be provided with either on board diagnostic displays and keypads or, handheld tools, laptops, or PC’s that allow for total access to the logic system. No requirement for refresh or re-programming of diagnostic components is allowed.
2.3 Furnish three (3) sets of manuals including:
   2.3.1 Parts list/catalogue, sequence of operation/controller manual complete with instructions on installation, set-up, parameter adjustments and as-adjusted parameters list, drive set-up adjustments with as-adjusted parameters and schematics, set-up procedure of hatchway positioning, door operator(s) and a list of all as-adjusted parameters.
   2.3.2 Any templates or any additional instructional material utilized in installation and field adjustment of the equipment.
2.4 Include all controller settings and written instructions on how to perform all required tests. All traveler and controller wiring punch list (as landed). Include maintenance requirements and manuals for all equipment.
2.5 Include any/all diagnostic tools required for installation, set-up adjustment and maintenance of the equipment (non-job specific) which includes the following:
   - Board diagnostic with monitor
   - Hand held service tool and/or
   - Laptop with diagnostic software installed
2.6 Include all electrical ladder schematics related to the elevator equipment and its operation.
2.7 Provide comprehensive “maintenance control plan” that meet all code requirements and thoroughly details all testing procedure and protocol.

3 Hydraulic Elevators
3.1 “Holeless” hydraulic elevators shall be limited to 18’ of travel, be dual post applications, with pistons attached to top of car crosshead.
3.2 “Direct acting” hydraulic applications shall be limited to travels of 55’ or less, unless approved by owner in writing at the earliest stage of design that is practical.
3.3 The cylinders shall be installed in rigid PVC liners with a code compliant means to monitor for the presence of oil. Extended “dipsticks” are unacceptable.
3.4 Roped hydraulic applications must be approved by owner in writing at the earliest stage of design that is practical.
3.5 All hydraulic power units will be rated for 120 up starts per hour, have immersion type viscosity control, and battery lowering if not provided with generator back-up power. An SPDT (Single Pole Double Throw) auxiliary contact block will be provided in mainline disconnects where generator back-up is not provided.
3.6 All hydraulic applications shall have a machine room and pit ball shutoff valve shall have a factor of safety as calculated by rule 8.2.8.5 of ASME A17.1.
3.7 With the exception of designated hydraulic freight installations the minimum speed shall be 100 FPM.
3.8 All hydraulic applications shall have “soft-start’ solid state motor starters.
3.9 Utilization of MRL hydraulic elevators must be approved by Purdue for specific application due to noise and odor concerns.

4 Geared Traction Elevators
4.1 Geared traction elevators should be one to one overhead applied with 1/2” traction steel suspension means. For hoist-way adjacent or, basement designed applications dialogue should be had as early in the design phase as practical due to additional cost implications.
4.2 All geared traction applications shall utilize AC motors and VVVF drives with closed loop digital pulse feedback. Minimum speed shall be 200 FPM unless otherwise directed by the discipline specific representative.
4.3 All geared traction applications shall utilize brake lift monitoring circuitry.
4.4 All geared traction applications with “traction steel” suspension means shall have “quik-wedge” cable terminations on both ends.

5 Gearless Traction Elevators
5.1 Gearless traction applications shall be AC or AC synchronous permanent magnet design type motors with closed loop digital feedback. They shall be a minimum speed of 200 FPM unless otherwise directed.
5.2 Gearless applications shall be compounded no higher than 2/1.
1 General

1.1 Unless otherwise specified all wheelchair lifts will be a minimum capacity of 750 lb.

1.2 For rises less than 5', screw or roped hydraulic drive mechanisms are acceptable, for rises greater than 5' roped hydraulic is preferred.

1.3 Clear, enclosed runway applications exposed to direct sunlight shall have the appropriate code required cooling provided.

1.4 Exterior applications shall have provisions for maintaining the runway temperature between 50° and 79° Fahrenheit.

1.5 All lifts shall have powered doors and gates.

1.6 Lifts installed in obscure areas of the facility will require two way communication as applicable.
1 General

1.1 Unless otherwise specified docklifts shall be pit mounted, vertical travel, scissor type applications.

1.2 Hydraulic pumping units and controls shall not be located underneath the platforms.

1.3 If reservoirs are located in non-temperature controlled areas emersion type oil heaters shall be provided.

1.4 All lifts shall be provided with oil weep/recovery lines.

1.5 All lifts shall have up travel limits and velocity fuses.

1.6 All lifts will be provided with biodegradable oil.
   - Provide hinged bridge(s) with pull back chains on all installations.
   - Provide toe guard safety devices on installations where operators may not be Purdue staff.
   - Provide powder coat finishes.

1.7 All lifts shall be provided with side rails and safety chains.
1 Introduction

1.1 All new buildings to be designed using the CPTED (Crime Prevention through Environmental Design) guidelines.

Note: The field of design to reduce crime is an ever advancing one and many resources are available to assist the designer. One recognized resource is CPTED (Crime Prevention through Environmental Design). These guidelines include both general building layout theories as well as some specific recommendations.

1.2 At some point in the design review process, campus safety and security officers participate in a design review requiring specific locations where CPTED principles were applied.

1.3 Even when these principles are followed, there are specific requirements and limitations that need to be kept in mind when designing projects at Purdue University. Descriptions of these specific items can be found in the following sections.

1.3.1 Women’s Restroom Location: We will look carefully at the locations you have chosen for women’s restrooms.

Example: Restrooms should not be located at the end of blind hallways or too near areas (i.e. telephone stations) where stalkers can monitor the entrance with apparent innocence.

1.3.2 Parking lots must be placed so as to have unobstructed viewing of the area around parked cars. Similarly, the lots must be in site of public areas or windows.

2 Walking Surfaces

2.1 Provide slip resistant walking surfaces at building entrances. Walk-off mats may or may not satisfy this requirement.

2.2 Stair treads shall have slip resistant treatment.

3 Guard Rails

3.1 All pedestrian guardrails in areas of public access shall have a vertical baluster arrangement spaced at 4”o.c. Guardrails arranged with all horizontal members creating a “ladder effect” will not be acceptable.

4 Elevators

4.1 Elevators will be equipped with an Adams Switch for the fire service key.

5 Fire Hydrant Security Device

5.1 All new hydrants must have a locking security device to prevent unauthorized use. These will be purchased as a project line item and supplied by Purdue.
1 General

1.1 All pipe penetrations through interior walls will be sleeved and sealed to prevent air transfer.

Note: Large gaps around pipe and duct penetrations make HVAC balancing difficult.

1.2 Teflon Tape should be specified for threaded pipe on potable water systems, do not allow pipe dope.

Note: Pipe dope can put an oily film in the water and you either have to remove all the fittings until you find the one causing the problem or wait until the oily stuff leaches out. This happened when we built Hansen; it took weeks to figure out the source of the oily film and months before the oily film subsided.

2 Buried Piping

2.1 Supply piping should not be buried under floor slabs.

Note: Buried supply pipe will cause a big problem if it springs a leak, especially if it isn't discovered for a while. In Lilly we had buried RO water. There was a leak we didn't find for years (we knew there was a lot of water going somewhere but could not find a leak) until the floor caved in revealing a large cavity that had been washed away under the slab.

2.2 Do not bury any waste piping that is less than 3" pipe size.

Note: When there is a clog in the pipe then buried waste pipe less than 3" is hard to mechanically root out.

3 Above Grade Piping

3.1 Pitch piping to allow for complete drainage and install drain valves at low points.

3.2 Provide unions, flanges, isolating valves, and access space for service and removal of all equipment.

4 Above Grade Valves

4.1 Install a valve and a union within 12" downstream of the valve on all pressurized system branches or laterals.

4.2 All valves 2" and smaller must be removable.

4.3 Do not use sweat-fitting valves.

Note: Valves with sweat or soldered fittings are not removable for service; they have to be cut out.

4.4 Butterfly valves must be lug type with SS stem.

4.5 Ball valves should be “full port” (except for service stops and balancing valves).
1 Refer to HVAC Pipe Insulation
1 Installation

1.1 All cast iron piping will be installed according to the recommendations of the Cast Iron Soil Pipe Institute (CISPI).

1.2 For pipe that is 5" or larger the drawings must show space for rods and clamps.

Note: The Cast Iron Soil Pipe Institute recommend installing clamps and rods at every change of direction and take-off on pipe 5" and larger. These clamps and rods are difficult to insulate and take up a lot of space so we need to make sure they are clearly shown on the drawings.

1.3 The drawings must include a detail of the rods and clamps.

Note: Some contractors use all thread and friction clamps. This can put excessive stress on the coupling. Some contractors try to bend the rod to follow the path of the elbow, which will allow the rod to have too much spring and not provide the necessary support. The point is the designer must show how they want that clamping to be done.

1.4 The drawings must show the location and give a detail for horizontal bracing. This bracing should be placed by the designer but no less often than every 40 linear feet of pipe run.

Note: Cast Iron Soil Pipe Institute recommends sway bracing “as required”. Experience shows that bracing at 40’ intervals provides adequate support.

2 No-Hub Couplings:

2.1 When using no-hub piping require couplings that are manufactured or supplied directly by the pipe manufacturer/supplier.

Note: The manufacturers (e.g. Clamp-All, Husky, and Mission) make a case for using “heavy duty” couplings. Neither the pipe manufacturers nor CISPI recommend heavy duty couplings across the board. In addition, heavy duty couplings can cause problems where they overlap pipe ‘ears’ and support ‘wings’. Specifying that the couplings be supplied by the pipe manufacturer guarantees that we have an complete system that is installed per manufacturers recommendations.
PHYSICAL FACILITIES
2018 Consultant’s Handbook
Division 22 Plumbing
1100 PVC Drain Pipe

1 General

1.1 Special Consideration shall be given when specifying the use of combustible materials such as PVC in an air plenum.

Note: The piping system shall comply with ASTM E84 smoke/fire spread requirements and be a UL listed assembly for the purpose of protecting PVC piping within an air plenum.

1.2 Special Consideration shall be given when specifying the use of PVC in areas requiring heightened sound attenuation.

1.3 The use of cellular-core PVC pipe shall be prohibited.

2 Installation

2.1 Install above ground PVC piping according to ASTM D 2665. Install underground PVC piping according to ASTM D 2321. Join PVC piping according to ASTM D 2855 and ASTM D 2665 Appendixes.

2.1.1 Buried PVC shall be schedule 80 pipe with DWV fittings.

2.2 PVC piping exposed during construction to solar radiation shall be temporarily protected.

2.3 PVC piping (like vent stacks) exposed permanently to solar radiation shall be protected with minimum two coats of water-based latex paint.
1 General Requirements

1.1 When called for in the program, specify acid resistant materials from lab sinks and other drains to the riser or other point of significant dilution. In general this is a very limited run of acid resistant pipe.

Note: The procedure for campus is either to capture or, if unable to capture, to neutralize all liquid material prior to disposal. REM monitors this carefully; hence there should be no need for any APW. To be safe we run APW from the sink to the main where the waste stream is diluted.

1.2 All other waste pipe in the building can be of standard material.

2 Buried

2.1 When buried, acid waste and vent piping will be polypropylene drainage pipe with electrofusion joints.

2.2 When the reasonably anticipated waste water temperature is above the manufacturer’s listed temperature range for polypropylene pipe, buried, acid waste and vent piping will be stainless steel pipe and fittings with welded joints.

3 Above Grade

3.1 Provide mechanical joint polypropylene.

Note: The best pipe for APW was Duriron, but it is no longer available. Glass is an excellent material but also expensive and hard to work on, especially for future renovations. We have had poor performance on fusion weld plastic (heat welding where the pipe is melted together) the weld failure rate is too high and our shops do not have the equipment for repairs. The next option seems to be solvent weld CPVC but CPVC has significant problems. The manufacturers’ literature states that the chemical resistance data applies only to individual chemicals; CPVC has problems with mixed chemicals. Similarly, it has problems with surfactants, which are found in most soap. Thirdly, CPVC must be regularly flushed. Thus, the material of choice, the easiest to install, repair and renovate is mechanical joint polypropylene.
1 Transformer Vaults

1.1 Sump pumps in transformer vaults require an oil separator discharging to the sanitary waste system.

*Note:* There must be some method of draining transformer vaults but, if a transformer leaks, oil must not be pumped into the sanitary waste system.

2 Building Pumps

2.1 Building sump pumps will be submersible type – not tower type.

2.2 Provisions, such as a tripod, to assist a pump removal when lifted greater than 72” shall be provided as part of the sump pump package.

*Note:* Care should be given to the method of pulling the pumps for maintenance. Tower pumps are good equipment but when the sump has any depth they are a challenge to pull, requiring a crane with sufficient vertical free space. When a heavy sump pump is installed include a crane or some other means way to pull the pump

3 Mechanical and Electrical Equipment Vaults

3.1 Sump pumps in mechanical and electrical equipment vaults containing oil/petroleum/fuel storage containers or transformers with a capacity of 55-gallon or greater do an oil-sensing device in the water such that the pump shuts down when oil is present.

*Note:* An example of such a device can be found at http://www.stancorpumps.com/oil-minder2.htm

3.2 Sump pumps in these vaults must discharge into the sanitary waste system.
1 Installation

1.1 General guidelines:

<table>
<thead>
<tr>
<th>Use</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitories</td>
<td>Install a softener on hot water only</td>
</tr>
<tr>
<td>Food Preparation</td>
<td>Install a softener on hot water only</td>
</tr>
<tr>
<td>RO Water Make-Up</td>
<td>Install a softener</td>
</tr>
<tr>
<td>All other facilities</td>
<td>As directed in the Program</td>
</tr>
</tbody>
</table>

*Note:* Softeners are not installed as a matter of course. For most uses, the well water phosphate program keeps the hard water contaminants in suspension.

1.2 Brine tanks for water softeners should be constructed and located so salt bags will be lifted no more than 46 inches from the floor.

2 Control Heads

2.1 Fleck heads are preferred.

*Note:* Fleck heads have proven to be very reliable and having the same head at all locations provides for ease of training and parts storage.
1 General Issues
1.1 Plumbing fixtures and fittings in public spaces for new buildings and renovations must comply with the EPA Safe Drinking Water Act, and be WaterSense labeled.
1.2 Plumbing fixtures and fittings in public spaces for new buildings and renovations must comply with ASHRAE Standard 189.1 -2011 Section 6.3.2.1 “Building Water Use Reduction – Plumbing Fixtures and Fittings.
1.3 Visible parts of brass fixtures and accessories must be heavily chrome plated.
1.4 Provide loose key stops at all plumbing fixtures.
   1.4.1 Key Stops and Stop Cocks may not be compression fit design
   1.4.2 Key stops must be ‘heavy duty’ with ceramic cartridges.

2 Utility Room Fixtures
2.1 Precast service sinks should be floor mounted with hose, hose bracket, mop hanger, and pail hook double supply spout set at 36” above rim with SS wall protectors.
2.2 Faucets should have integral check valves and vacuum breaker.

3 Floor Drains and Clean-Outs
3.1 Floor drains in concrete slabs to have floor level trap clean-out large enough to allow the line to be "snaked".
3.2 Provide floor drains in all mechanical rooms, restrooms and in the vicinity of safety showers.
   Note: Floor drains near safety showers allow the shower to be tested and operated without the resultant water damage.
3.3 Clean-outs on buried drains shall extend through and be installed flush with the floor.
3.4 Clean-outs on overhead drains shall extend through and be installed flush with the floor above.
3.5 Concealed clean-outs shall be provided with an access panel or extend through the wall with a chrome plated cover installed flush with the wall.

4 Hose Bibs
4.1 Interior hose bibs shall have an integral vacuum breaker.
4.2 Exterior hose bibs shall be "freeze proof" with drain down to the exterior of the building and shall have an integral vacuum breaker.

5 Grease Traps
5.1 Grease traps should be located at point of use (under the sink).
   Note: Point of use traps are less expensive and easier to maintain than having a single large trap for the whole building.

6 Steam Water Heaters
6.1 Steam water heaters will be specifically designed for potable water heating. The heater shell should be capable of being disassembled and the heating section removed without disturbing the water or electric lines.
6.2 Water heater will be designed to sub-cool the condensate prior to discharge.
   Note: Shell and tube water heaters work well but when the tube bundle fails there is a significant delay in procuring and installing the replacement. In addition shell and tube heaters allow for hot condensate that, when close to the condensate pump results in cavitation.

7 Restroom Fixtures
7.1 Restroom should have a floor drain. The floor should not be sloped to the floor drain.
7.2 Flush valves are to be piston style mounted 12” above the fixture rim. Care should be taken to install appropriate water hammer arrestors as piston flush valves are more likely to hammer than diaphragm style.
   Note: Most designers are unaware of the advantages of piston valves; hence piston flush valves are not in their “standard” specifications. Piston valves are cheaper, handle larger fluctuations in water pressure, handle dirty water better, and last longer with less maintenance.
7.3 In general manual flush valves are to be used.
7.4 Water closets
- Siphon jet
- Elongated bowl
- Wall Hung
- Tested and verified able to pass at least 250 grams of solid waste material per flush

*Exception:* Floor mounted tank type may be used in the off campus farm and support buildings.

### 7.5 Urinals
- Blowout style
- Integral side panels.

### 7.6 Sinks
- White vitreous china for single sinks
- Corian® or equal material, neutral color with flecks for counter sinks
- Self-draining tops

### 7.7 Faucets
- 4” O.C.
- Lever handles
- Strainers
- Ceramic cartridge
- Use automatic faucets only with HW recirculating pump, so that warm water is immediately available at all times.
1 Intent
1.1 Buildings should have the strongest assurance that the potable water is free of contamination, including contaminants generated inside the building.

2 Buildings without Laboratories or Other Sources of Internal Contamination:
2.1 For an office, dormitory, or similar building, where the risk of internal contamination is low, then a single potable water system is run to all plumbing fixtures.
2.2 Such a system requires a duplex double check back flow preventer.

3 Laboratory Buildings
3.1 In laboratories, research facilities, or similar buildings with a high risk of internal contamination we have two separate water distribution systems: a potable domestic and an isolated laboratory distribution system.

Note: This method of separation was developed in the 1990’s in line with NIH standards.

3.2 The potable domestic water system will have a limited distribution within the building, used only in fixtures specifically use for human consumption or sanitation such as:
- Water fountains
- Coffee bars and snack areas
- Food preparation and kitchen areas
- Lavatories and restrooms

3.2.1 The potable domestic water system will include both hot and cold water.
3.2.2 The potable domestic water system requires a duplex double check back flow preventer premise protection.
3.2.3 Color and labeling code:

<table>
<thead>
<tr>
<th>Item</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe</td>
<td>Light blue</td>
</tr>
<tr>
<td>Label</td>
<td>Green background with white letters</td>
</tr>
<tr>
<td>Abbreviations</td>
<td>“Isolated Lab PCW” for cold, “Isolated Lab PHW” for hot</td>
</tr>
</tbody>
</table>

3.3 The isolated laboratory water system is for water that is delivered to general laboratory areas, fume hoods, cage washers, autoclaves, vivarium hose stations, and any other fixture not supplied by the “potable domestic water” system.

3.3.1 The isolated laboratory water system will include both hot and cold water in a distribution system independent of the “potable domestic water” system.

3.3.2 The isolated laboratory water system requires duplex reduced pressure backflow preventer premise protection and fixtures must still be protected with point of use vacuum breakers where appropriate.

3.3.3 Color and labeling code:

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</table>

4 Backflow Preventers
4.1 Since all backflow preventers must be periodically tested a design goal is for a building to have the minimum number of backflow stations.
4.2 Systems where service interruptions during testing are a problem require duplex preventers in a parallel arrangement.
4.3 Backflow preventers need a strainer located between the isolation valves.

Note: We have had good success with the following manufacturers:

Reduced Pressure Manufacturers:
- Febco Model 860
- Watts Series 909
- Wilkins 975 for sizes 2” and smaller
- Wilkins 300 Series for 2-1/2” and larger

Double Check Manufacturers:
- Febco Model 850
- Watts Series 709
- Wilkins 950 for sizes 2” and smaller
- Wilkins 300 Series for 2-1/2” and larger
1 Ventilation Rate Procedure
1.1 Ventilation design shall be documented using the ASHRAE 62.1 ventilation rate procedure and comply with Indiana Mechanical Code.
1.2 Ventilation rate procedure (VRP) shall be documented in electronic spreadsheet format with separate row for each building space and separate column for each VRP variable.

2 Steam-to-Heating Hot Water Generation
2.1 System shall be designed to operate within constraints below under variable steam conditions from 5 to 15 psig.
2.2 Heating hot water temperatures supplied at 180°F.
2.3 System shall be designed with a minimum of two independent heat exchangers with total combined capacity of 125% to 135% of system design load requirement.
2.4 System shall be designed to output steam condensate temperatures at 150°F.
2.5 Variances from above criteria shall be approved by Purdue Facility and Utility Engineering.

3 Perimeter Radiation
3.1 Classrooms, laboratories, hallways, etc. typically do not require perimeter radiation
3.2 Offices, meeting rooms, etc. typically do require perimeter radiation. This radiation should be on an independent piping circuit so the water temperature can be lower than the VAV reheat coil temperature.

Note: Office occupants frequently push their desks against the outside wall creating a ‘dead spot’ with little air movement. Anyone sitting at the desk will have cold feet. The simplest and best solution is external wall radiation in the offices.

4 Ceiling Plenums
4.1 In harmony with IAC 410 Article 33 all supply and returns are to be fully ducted and are to be solidly connected to the diffusion product.

Note: Technically, 410 IAC 33 (published by the Board of Health) applies to nursery and K-12 schools, but the principles are valid and should be followed for campus projects. Plenums cause numerous problems in balancing and air distribution. Almost without exception, every time we have acquiesced to the cry of “being fully ducted costs too much money” we have had problems with the HVAC system directly attributable to the plenums. Return plenums in interior spaces also cause balancing air distribution and moisture problems caused by the plenum being under a negative pressure pulling air from all the wall cavities, not just the rooms. This has the real potential of pulling in untreated air, which will condense and cause mold and mildew problems.

5 Stairway Dehumidification
5.1 Stairways must have temperature and humidity control.
5.2 An excellent way to achieve this is by using a dedicated AHU. The problem is that the AHU must be on the roof or in the fire rated enclosure; the ductwork cannot penetrate the walls.
5.3 Fan coil units may be used.
5.3.1 It is recommended that, if used, FCUs have the heating coil in the reheat position with a dehumidification control sequence.
5.3.2 FCUs cannot be used to bring in OA.
5.3.3 FCUs must be accessible.

Note: The Armstrong Hall stairway units are an example of units that are impossible to maintain.
5.4 Stairways should have air movement through them. Without definitive dehumidification and air movement there is an increased likelihood of a mildew and odor problem in a stairwell.
5.4.1 This may be able to be accomplished by allowing the relief air from the positively pressurized building to exit through the stairs.
5.4.2 It may also be possible to simply install magnetic hold-opens on the stair doors. In the event of a fire they would de-energize and the doors close. If this is done it may be possible to forego HVAC systems in the stairs, especially interior stairs.

6 Restroom Temperature Control
6.1 Minimum winter design indoor air temperature is 72°F.
6.2 If the restroom is not on a central AHU then heating can be accomplished using exterior wall radiation.
6.3 In general air conditioning is not required.
6.4 If air-conditioned the design temperature is to be 76°F.
7 Positive Building Pressure

7.1 All buildings should have a slight positive static pressure. Provide for sufficient OA intake and appropriate controls to maintain the building positively pressurized.

7.1.1 If controlling to pressure, maintain no more than 0.05" SP to ensure that building doors still close and open within the allowable force limits.
1 Standards

1.1 General-Duty Motor specifications shall be based on the following standards.

- Have a precision balanced rotor of 0.0003" peak to peak.
- Have cast iron frames with grounding lugs
- Be totally enclosed fan cooled
- Have shaft slingers on the drive end of the motor
- Use grease-able bearings with Mobil Polyrex or EM equivalent grease. Note: Each motor shall have a factory tag applied identifying what type of grease was installed at the factory.
- Have specified proper alignment
- An minimum insulation rating of Class F with a maximum Class B temperature rise at 1.15 Service Factor
- For all motors, motor frame, rotor, windings and bearings shall be warranted for three (3) years, on PWM power, against manufacturers defect.
- Belted Designs for motors 404T frame and up and will utilize Roller bearings.

1.2 Inverter-Duty Motor specifications shall meet all the requirements of General-Duty Motors above or as superseded by the additional following standards:

- Be wound with inverter spike resistant copper wire rated at a minimum of 2000 volt CIV (Corona Inception Voltage Capability).
- An minimum insulation rating of Class H with a maximum Class B temperature rise at 1.15 Service Factor
- For motors controlled by VFD’s, Be coordinated and rated for VFD use to prevent premature failure
- For motors controlled by VFD’s, either the motor rotors shall be grounded with a manufacturer’s supplied ground kit (e.g. AEGIS SGR Bearing protection kits) or motor shall be supplied with Inductive Absorbers (e.g. CoolBLUE Inductive Absorbers).
- Meet or exceed NEMA MG31 Part 1 for inverter duty motors.

2 Horsepower, Voltage and Phases

2.1 Motors ≤ 1/2 Hp can be single phase, 120 volt AC.

2.2 Motors > 1/2 Hp should be three phase AC.

2.3 The three phase voltage shall be selected dependent on building power availability.

2.4 Single phase 240VAC motors should only be used when replacing equipment already serviced with this voltage or when it is the only available service voltage in the building. 

Exception: Direct drive blower motors one half horsepower and less than can be single phase, 120 volt AC.

3 Efficiency

3.1 Design and specify motors that are labeled with a NEMA Premium label.

4 Preferred Speed, RPM

4.1 Standard motor speed is 1800 RPM.

Exception: Special speed motors can be used if reviewed and approved by the University engineers.

5 Motor Starter Controls and Variable Frequency Drives

5.1 Provide a motor starter control diagram for each motor.

Note: Control Function tables or columns in the Mechanical Equipment schedule sheets are not acceptable in lieu of the control diagrams.

5.2 Include all functions specified for the VFD control panel in the control diagram, including the manual start stop function.

6 Motor Nameplate Voltage Table

<table>
<thead>
<tr>
<th>Nominal System Voltage</th>
<th>Motor Nameplate Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>208</td>
<td>200</td>
</tr>
<tr>
<td>240</td>
<td>230*</td>
</tr>
<tr>
<td>480</td>
<td>460*</td>
</tr>
</tbody>
</table>

* Dual rated Motors – 230/460
1 Information applicable for all hangers

1.1 Prime coat all steel hangers and supports.

**Note:** When used with cold systems, such as chilled water, the hangers and supports will condense. If not prime coated the steel will prematurely corrode.

1.2 In addition to the intervals outlined in the Indiana Plumbing Code install hangers at every fitting and change of direction for all pipes and at every joint in cast iron pipe.

**Note:** Improperly supported pipe will experience excess stress and produce unexpected traps and air pockets affecting operation.

2 When hanging from concrete

2.1 When hanging from concrete care must be taken not to weaken the concrete by holes in the wrong location or hangers that can pull out.

2.2 In existing concrete construction new pipe hanger rod clips shall:

- be fastened to the sides of joists or beams
- use expansive, adhesive or screw in anchors installed in strict accordance with the manufacturer’s published documentation
- be at least four inches (4”) from the bottom of joists and six inches (6”) from the bottom of beams

2.3 Powder actuated and impact anchors shall not be allowed.

3 When hanging insulated pipe

3.1 When hanging insulated pipe care must be taken to prevent crushed and otherwise damaged insulation.

3.2 Provide rigid insulation inserts at all hangers and points of support for insulated piping 1½” and larger.

3.2.1 Inserts shall be fire retardant treated wood blocks, calcium silicate or other high density insulating material.

3.2.2 Insert shall be same thickness as adjoining pipe insulation and shall be provided with vapor barrier jacket.

3.3 A 180 degree galvanized sheet metal shield should be provided between the hangers or supports and the pipe insulation.

3.4 Pipe supports that are pre-insulated and have integral sheet metal shield are allowed.

**Note:** Such supports can save the insulator a lot of time. More importantly it allows the blocks to go in before the pipe is tested, otherwise the pipe must be installed laying on the hangers, tested, and then lifted so as to install the insulation between the hanger and the pipe.

4 Table of minimum insert and shield lengths

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Rigid Insert</th>
<th>Metal Shield</th>
<th>Shield Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1½” to 2½”</td>
<td>10”</td>
<td>6”</td>
<td>16</td>
</tr>
<tr>
<td>3” to 5”</td>
<td>12”</td>
<td>8”</td>
<td>16</td>
</tr>
<tr>
<td>6”</td>
<td>12”</td>
<td>8”</td>
<td>12</td>
</tr>
<tr>
<td>8” to 10”</td>
<td>16”</td>
<td>12”</td>
<td>12</td>
</tr>
<tr>
<td>12” and larger</td>
<td>22”</td>
<td>18”</td>
<td>12</td>
</tr>
</tbody>
</table>

5 Housekeeping pads

5.1 Housekeeping pads should be a minimum of 3½” inches thick with chamfered edges all around.

5.2 Housekeeping pads should extend a minimum of 4 inches beyond supported equipment.

5.3 Existing Construction: Elevated slabs shall be evaluated to determine if there is capacity in the structure for support of a new housekeeping slab.
1 Common Names & Software Names

1.1 University mechanical systems have a common name which is scheduled on the construction documents and consists of an alpha-numeral sequence assigned as outlined below. The name on the plans and specifications should match the name that will post-construction be used in the field and in our control sequence.

1.2 University mechanical systems also have a software DDC name which is found on control drawings and control system programming and consists of a different alpha-numeral sequence assigned by the controls developer.

1.3 The numeral portion both the common name and the software name of each scheduled mechanical unit is to be the same even though the alpha portion is different.

1.4 Typical examples of “common” vs “DDC” names:
   - ACP-1 may be the common name for first numbered AHU in the penthouse whereas the software name may be MI01.
   - CWPB-1A and CWPB-1B may be the common names for chilled water pumps whereas the software name may be MIP1.
   - HYPB-2A and HYPB-2B may be the common names for the hydronic heating water pumps whereas the software names may be MIP2.

2 Air Handling Units (e.g. ACP-#)

2.1 The first two digits indicate the type of unit:
   - AC Air Conditioning (with or without heating)
   - HV Heat & Vent
   - RA Return Air
   - OA 100% Dedicated OA
   - XX Other descriptor as needed

2.2 The third digit indicates location:
   - B Basement
   - G Ground
   - M Main
   - 1 First floor (2 = Second etc.)
   - A Attic
   - P Penthouse

2.3 The last digits are the number of the unit. Numbers are sequential, starting with 01, 02, etc. and continuing through all of the units.

3 SA, RA, and relief fans (e.g. RAM-#)

3.1 The first two digits indicate the use:
   - SA Supply Air
   - RA Return Air or Relief Air

3.2 The third digit indicates location as described for Air Handlers

3.3 The last digits are the number of the unit.

3.4 These share the same number as the AHU they serve, that is RAM-09 would serve ACM-09.

4 Computer Room A/C Units (e.g. CRAC-#)

4.1 CRAC units are numbered sequentially with AHUs

5 Exhaust fans (e.g. TE R- #)

5.1 The first two or three digits indicate the use:
   - TE Toilet Exhaust
   - GE General Exhaust
   - KE Kitchen Exhaust
   - HE Hood Exhaust
   - MHE Manifold Hood Exhaust
   - XX Other descriptors are assigned as needed

5.2 The third digit indicates location as described for Air Handlers

5.3 The last digits are the number of the fan.

5.3.1 Exhaust fans are numbered sequentially, such that each fan has a unique number.

5.3.2 If the exhaust fan is part of, and integral to, an AHU system, the fan will have the same number as the AHU.

**Exception:** Hood exhaust fans will be numbers according to room number where the hood is located, such that HE1-101-1, HE1-101-2, HE1-101-3, refer to fans serving hoods in room 101 and numbered sequentially.
6 Fan Coil Units (e.g. FCU-#)  
6.1 The letters FCU indicate type of equipment.  
6.2 The number is the room number served by the unit.

7 Pumping systems (e.g. HYPB-#)  
7.1 The first two digits indicate the use:  
   CW Chilled water  
   HY Hydronic heating water  
   XX Other descriptors are assigned as needed  
7.2 The third digit is always “P” indicating that it is a pumping system.  
7.3 The fourth digit indicates location as described for air handlers.  
7.4 The last digits are the number of the pumping systems.  
   7.4.1 Pumps are to be numbered sequentially, such that each pumping system has a unique number.  
   7.4.2 If the pumping system has more than one pump, then use a number plus a letter, such as CWBP-1A and CWBP-1B, for a chilled water pumping system with two pumps, located in the basement.

8 Misc. mechanical equipment (e.g. XX - #)  
8.1 The letters indicate type of equipment:  
   SP Sump pumps:  
   SEP Sewage ejector pumps:  
   CP Condensate pumps:  
   CVP Condensate vacuum pumps:  
   UH Unit Heaters:  
   CH Cabinet heaters:  
   XX Other descriptors are assigned as needed  
8.2 The last digits are the number of the pumping systems.  
8.3 Similar items are to be numbered sequentially, such that each item has a unique number.
1 **Labels on Exhaust Ducts**

1.1 Label will be an etched plastic sign permanently attached to the duct.

1.2 Labeling should occur at least in the following locations:
   - In the mechanical room.
   - At the exhaust fan.
   - On the roof.

2 **Labels on Pipes**

2.1 Piping shall be labeled at least in the following locations:
   - Valves
   - Changes in direction
   - Branches and take-offs
   - Behind access panels
   - Floor and ceiling penetrations
   - Room entry and exit

2.2 The pipe label shall include an arrow showing direction of flow. The arrow should be approximately six inches in length with the width to be determined by letter height.

2.3 The pipe label shall include an abbreviation of the service.

2.4 Table of letter sizes

<table>
<thead>
<tr>
<th>O.D.</th>
<th>Field Length (min)</th>
<th>Letter Size (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1¼&quot; and under</td>
<td>8&quot;</td>
<td>½&quot;</td>
</tr>
<tr>
<td>1½&quot; through 2&quot;</td>
<td>8&quot;</td>
<td>¾&quot;</td>
</tr>
<tr>
<td>2½&quot; through 6&quot;</td>
<td>12&quot;</td>
<td>1¼&quot;</td>
</tr>
<tr>
<td>8&quot; through 10&quot;</td>
<td>24&quot;</td>
<td>2½&quot;</td>
</tr>
<tr>
<td>10&quot; and over</td>
<td>32&quot;</td>
<td>3¼&quot;</td>
</tr>
</tbody>
</table>

2.5 Label colors shall comply with ANSI/ASME A13.1.

2.6 Piping systems shall be identified using the following labels:

**2.6.1 Domestic water abbreviations:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potable Cold Water</td>
<td>PCW</td>
</tr>
<tr>
<td>Potable Hot Water</td>
<td>PHW</td>
</tr>
</tbody>
</table>

**2.6.2 Process water abbreviations:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Lines, Sprinklers, etc.</td>
<td>FL</td>
</tr>
<tr>
<td>Condenser Water Supply</td>
<td>CWS</td>
</tr>
<tr>
<td>Condenser Water Return</td>
<td>CWR</td>
</tr>
<tr>
<td>Chilled Water Supply</td>
<td>CHWS</td>
</tr>
<tr>
<td>Chilled Water Return</td>
<td>CHWR</td>
</tr>
<tr>
<td>Hot Water Heating Supply</td>
<td>HWHS</td>
</tr>
<tr>
<td>Hot Water Heating Return</td>
<td>HWHR</td>
</tr>
<tr>
<td>Dual Temp. Water Supply</td>
<td>DTWS</td>
</tr>
<tr>
<td>Dual Temp. Water Return</td>
<td>DTWR</td>
</tr>
<tr>
<td>Heat Reclaim Piping</td>
<td>HR</td>
</tr>
</tbody>
</table>
### 2.6.3 Steam pipe abbreviations:

<table>
<thead>
<tr>
<th>Item</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Pressure Steam Supply</td>
<td>LPSS</td>
</tr>
<tr>
<td>Low Pressure Condensate</td>
<td>LPSR</td>
</tr>
<tr>
<td>High Pressure Steam Supply</td>
<td>HPSS</td>
</tr>
<tr>
<td>High Pressure Condensate</td>
<td>HPSR</td>
</tr>
</tbody>
</table>

### 2.6.4 Drain pipe abbreviations:

<table>
<thead>
<tr>
<th>Item</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanitary Waste</td>
<td>W</td>
</tr>
<tr>
<td>Sanitary Vent</td>
<td>V</td>
</tr>
<tr>
<td>Acid Proof Waste</td>
<td>APW</td>
</tr>
<tr>
<td>Acid Proof Vent</td>
<td>APV</td>
</tr>
<tr>
<td>Storm Sewer and Downspout</td>
<td>DS</td>
</tr>
<tr>
<td>Air Conditioner Drain</td>
<td>ACD</td>
</tr>
</tbody>
</table>

### 2.6.5 Misc., pipe abbreviations:

<table>
<thead>
<tr>
<th>Item</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Expansion</td>
<td>R-12, 22, etc.</td>
</tr>
<tr>
<td>Refrigerant Ammonia</td>
<td>REF - AMM</td>
</tr>
<tr>
<td>Refrigerant Brine</td>
<td>REF - BR</td>
</tr>
<tr>
<td>Water Softener Brine</td>
<td>WSB</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N2</td>
</tr>
<tr>
<td>Oil</td>
<td>OIL</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>CO₂</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>H₂S</td>
</tr>
<tr>
<td>Vacuum</td>
<td>VAC</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>GAS</td>
</tr>
<tr>
<td>LP Gas</td>
<td>LP GAS</td>
</tr>
<tr>
<td>Air</td>
<td>AIR</td>
</tr>
<tr>
<td>Oxygen - Medical</td>
<td>O₂</td>
</tr>
<tr>
<td>Oxygen - Welding</td>
<td>OXY</td>
</tr>
<tr>
<td>Acetylene</td>
<td>ACY</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>NOx</td>
</tr>
</tbody>
</table>
1 For remodeling projects
1.1 For remodeling projects when only a portion of an existing duct system is being replaced then the new duct insulation (internal or external) should match the existing.

2 External Insulation Locations
2.1 All large air ducts (in general all ductwork up to the VAV box or similar room control device) are considered permanent and would be hard to replace if the internal insulation began to degrade, thus the need for external insulation.
2.2 All inaccessible ductwork, where replacing the insulation or ductwork would be difficult, will have external insulation.
2.3 All VAV reheat coils, or all duct mounted coils will have external duct wrap that overlaps internally insulated duct by 2”.
2.4 OA ducts and plenums should have external insulation.
2.5 All ductwork exposed to humidity (e.g. close to humidifiers) should be externally insulated.

3 External Insulation Surface Finish
3.1 External insulation in locations where not seen by the public, the external insulation should be a fiberglass wrap with foil facing surface. These areas include mechanical rooms, unfinished areas, and areas above ceilings.
3.2 External insulation where it can be seen by the public should be rigid fiberglass with a paintable exterior surface that is painted to match the room.
3.3 External insulation exposed to the weather should be cloth-wrapped and have an external aluminum covering.

4 Internal Insulation Locations
4.1 Insulate small accessible ducts that can be easily replaced
4.2 Insulate SA and return ducts on small systems
4.3 Insulate SA ducts from the VAV box (or similar room control device) to the diffuser

Note: After the VAV box the ductwork is smaller and more easily replaced if the internal insulation liner breaks down and the insulation provides acoustical dampening.

4.4 If the system has no VAV box then insulate SA ducts after the room penetration to the diffuser
4.5 Insulate transfer ducts to reduce sound transmission and increase acoustical separation
4.6 Insulate RA ducts from the grille to the room penetration or continuing to the main trunk duct

5 Internal insulation pinning
5.1 Insulation on rectangular duct over 24” (both interior and exterior) should be pinned to the sheet metal at 12” on center.

Note: Though often done as a value engineering initiative, increasing the pinning distance more than 12” has been shown to cause premature failure with the insulation separating from the duct.

6 Round and oval ducts
6.1 Round and oval ducts in exposed areas must be double wall so the outer surface can be painted.
1 Fiberglass:

1.1 Fiberglass Insulation Table

<table>
<thead>
<tr>
<th>Item</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>650°F rating</td>
</tr>
<tr>
<td>Density</td>
<td>3½ lb./ft³</td>
</tr>
<tr>
<td>K Factor</td>
<td>0.25 at 100°F</td>
</tr>
<tr>
<td>Flame Spread</td>
<td>25 max composite rating</td>
</tr>
<tr>
<td>Smoke Developed</td>
<td>50 max composite rating</td>
</tr>
<tr>
<td>Fuel Contributed</td>
<td>50 max composite rating</td>
</tr>
</tbody>
</table>

2 PVC Covers

2.1 PVC insulated fitting covers should be sized to fit snugly and match pipe insulation thickness.

2.2 Visual inspection of PVC covers does not allow for verification of proper insulation under the cover. Specifications should allow for random testing of fittings to ensure proper insulation.

2.3 PVC jacket to be 0.030” for light traffic areas and 0.060” for high traffic areas.

3 Service Jacket

3.1 In general specify a high density white kraft paper, fiberglass reinforced service jacket bonded to aluminum foil.

Note: Be aware that perforating the cover with staples will allow moisture penetration.

4 Elastomeric insulation

4.1 Elastomeric insulation elbows coverings shall be in at least three pieces.

Note: For cold pipes elbow coverings with two pieces cut at 45 degrees allows for condensation to be trapped. On all pipes elbow coverings with two pieces cut at 45 degrees are more easily damaged.

4.2 Do not use elastomeric foam on pipe where the working temperature is greater than 130°F.

Note: Foam that is exposed to elevated temperatures becomes brittle.

5 Steam piping & fittings insulation

5.1 All steam piping and fittings should be insulated.

5.2 Insulate fittings with pre-formed fiberglass pieces or removable, re-installable insulated blankets.

6 Steam fittings blanket covers

6.1 Specify prefabricated, custom fit, removable and reusable insulation covers on all hot systems; including all valves, appurtenances, regulators, and bypasses 2” and larger. Installation will be after all testing of the steam lines.

6.2 The removable and reusable insulation cover will be installed as one unit, rather than two or more components requiring separate installations.

6.3 Tie-downs, anchor straps, & buckles can be used to secure the removable/reusable insulation covers in place. Do not allow lacing hooks and wire.

6.4 Insulation covers should overlap permanent insulation by at least 2”.

6.5 For operating temperatures between 100°F and 550°F, the insulation core material will be 1000°F rated ET-blanket.

6.6 Jacket material hot face can be either silicone impregnated fiberglass fabric (having a minimum density of 16 oz./cubic yard) or Teflon impregnated fiberglass fabric of similar density.

6.7 The cold face will be weatherproofed with the same fabric as the hot face.

6.8 All covers are to be sewn. Sewing thread should be Teflon coated fiberglass with 20# tensile strength and 1500 yards/lb. weight.

6.9 Insulation core thickness shall be 1” nominal thickness on temperatures up to 450°F. Over 450°F requires 2” nominal thickness.

7 Refrigeration Piping & Fittings:

7.1 When exterior to the building (exposed) then bundle the pipes together and cover the bundle with a weatherproof jacket.

7.2 At the wall penetration for refrigerant piping be careful to detail the sleeve, and insulation through the wall. This is particularly important for bundled pipes.
8 Minimum insulation thickness

<table>
<thead>
<tr>
<th>Duty</th>
<th>Pipe Size</th>
<th>Type</th>
<th>Minimum Thickness</th>
<th>recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP Steam</td>
<td>Up to 1¼&quot;</td>
<td>A</td>
<td>1½&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1½&quot; and larger</td>
<td>A</td>
<td>2&quot;</td>
</tr>
<tr>
<td>HP Steam</td>
<td>Up to 1¼&quot;</td>
<td>A</td>
<td>2½&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>½&quot; to 4&quot;</td>
<td>A</td>
<td>3&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4&quot; and larger</td>
<td>A</td>
<td>4&quot;</td>
</tr>
<tr>
<td>Steam Condensate</td>
<td>All</td>
<td>A</td>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td>Chilled Water</td>
<td>Up to 1½&quot;</td>
<td>A or B</td>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>½&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>½&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2&quot; and larger</td>
<td>A</td>
<td>1&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td>Condenser Water</td>
<td>Up to 2&quot;</td>
<td>A or B</td>
<td>½&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>½&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2½&quot; and larger</td>
<td>A</td>
<td>1&quot;</td>
</tr>
<tr>
<td>AHU Condensate</td>
<td>All</td>
<td>A or B</td>
<td>½&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>½&quot;</td>
<td></td>
</tr>
<tr>
<td>Roof Drains &amp; bodies</td>
<td>All</td>
<td>A</td>
<td>½&quot;</td>
<td></td>
</tr>
<tr>
<td>Hot Water Heating run-</td>
<td>Up to 2&quot;</td>
<td>A</td>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td>outs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Water Heating Mains</td>
<td>Up to 2&quot;</td>
<td>A</td>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2½&quot; and larger</td>
<td>A</td>
<td>1½&quot;</td>
</tr>
<tr>
<td>Heat Recovery Piping</td>
<td>All</td>
<td>A</td>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td>Refrigerant</td>
<td>All</td>
<td>B</td>
<td>Per manufacturer</td>
<td></td>
</tr>
</tbody>
</table>

"A" is fiberglass
"B" is elastomeric
"C" is Dow Corning - Trymer
1 University – Designer Information-Interaction:

1.1 Through the PM you should contact the Energy and Utilities (E&U) department at Purdue University during the schematic design phase to discuss general HVAC control systems. Early coordination of the mechanical design with the E&U department is essential.

1.2 The Designer is responsible for the operational sequences of the mechanical systems, but Purdue’s E&U department must approve before being issued. The Designer shall provide the E&U department with an electronic copy of the sequences of operation for our LAN-based mechanical controls library.

1.3 A pre-submittal meeting to review the BAS controls and architecture is to be scheduled. At a minimum the Mechanical Designer, Temperature Controls Vendor and a Representative of the Purdue E&U Department shall attend. Others may attend as necessary. This meeting is to be scheduled by the Mechanical Designer.

2 Systems Design Expectations

2.1 Emphasis should be placed on the latest indoor air quality and energy conservation principles during the design and sequence development process (i.e. LEED, ASHRAE 62.1 and 90.1 (as required by the state of Indiana)).

2.2 Individual room temperature control is expected on all projects.

2.3 Occupant adjustable thermostats should be in all private offices, secretarial areas, etc.

2.4 All systems shall have schematic drawings depicting all necessary components (sensors, valves, dampers, etc.) and their respective location in the system.

2.5 Notice the examples of the equipment numbering conventions (Section 0553 Equipment Identification). These are to be utilized to identify all equipment in project documentation.

2.6 All integrations between the BAS system and any 3rd party equipment that is deemed necessary shall be done utilizing BACnet over MSTP protocol.

3 Electrical Interaction

3.1 Coordinate all VFD, raceway, motor, and other electrical equipment specifications with the appropriate electrical sections of the Consultants Handbook.

3.2 The Mechanical Designer is responsible for coordinating with the University (E&U) the location of all necessary Purdue Information Connection (PIC) Access data Ports. Mechanical Designer will then work with the Electrical/Telecommunications Designer to include the pic locations on the appropriate drawings with any construction notes and references added to ensure the correct data pics are installed. A duplex set (2 ea. Individual of data pics) shall be installed where ever necessary. These PIC’s will be dedicated to the BAS system in the building for maintenance purposes. There is no permanent equipment that hooks up to these PIC’s.

3.3 Pics shall be located in all mechanical rooms that have HVAC air handling or pumping systems. The data pics shall either be installed in the BAS control cabinet if there is available space or in a Hoffman Nema 1 hinged door 6"x6"x4" with a Siemens lock installed in place of the thumb screw. Siemens lock part number is: 567-225, description CP567 LOCK & KEY ASSY-ALL CABINETS. All key from locks to be turned over to E&U department.

3.4 The Electrical contractor shall furnish and install all Purdue Information Connection (PIC) for the BAS system where indicated on construction documentation.

3.5 All modules, sensors, actuators, meters, and relays, transmitters, switches, wiring, tubing, conduit, and control components installed by the Electrical Contractor or the Temperature Control Contractor shall be compatible with the Purdue E&U DDC systems. No terminal strips shall be used. No equipment to be mounted on panel doors.

4 Mechanical Equipment Nomenclature

Purdue mechanical systems have two owner names, the common name, scheduled on the construction documents, and the software DDC name, found on control drawings and in control system programming. The assigned number for each scheduled mechanical unit is the same number as in the DDC software, but the assigned names are different. See E&U system and point nomenclature for a description of DDC names. Purdue’s standard naming for scheduled mechanical equipment follows.

1. Air handling systems: A C P- # (# = 1, 2, 3…):
   - First two letters indicate whether it has cooling (AC), return or relief air (RA), heating/ventilation only (HV), 100% dedicated OA (SA), or other descriptor.
   - Third letter indicates location: B = basement, 1 = first floor, 2 = 2nd floor, A = attic, P = penthouse, R = roof
   - Number air handling systems sequentially, such that each AHU system has a unique number. A supply and return/relief fan on the
same system share the same number. For new buildings start number equipment from the basement up through the building.

2. Computer Room A/C Units: CRAC - #: 
   - CRAC units are numbered sequentially with AHUs. See #1 above.

3. Exhaust fans: T E R- # (# = 1, 2, 3…): 
   - First two (or three) letters indicate whether it is toilet exhaust (TE), general exhaust (GE), kitchen exhaust (KE), hood exhaust (HE), manifold hood exhaust (MHE), or other descriptor.
   - The next letter indicates location: B = basement, 1 = first floor, 2 = 2nd floor, A = attic, P = penthouse, R = roof
   - Number all exhaust fans, regardless of type, sequentially, such that each fan has a unique number. (i.e. GEB-1, TE1-2, GER-3… etc.)
   - Number hood exhaust fans according to room number as in: HE1-101-1, HE1-101-2, HE1-101-3, serving room 101 and numbered sequentially.

4. Pumping systems: HY P B-# (# = 1, 2, 3…): 
   - First two letters indicate whether it is chilled water (CW), Hydronic heating water (HY), or other descriptor.
   - The third letter is always “P” indicating that it is a pumping system.
   - The fourth letter indicates location: B = basement, 1 = first floor, 2 = 2nd floor, A = attic, P = penthouse, R = roof
   - Number pumping systems sequentially, such that each pumping system has a unique number. If the pumping system has more than one pump, then use a number plus a letter, such as CWPB-1A and CWPB-1B, for a chilled water pumping system with two pumps, located in the basement.

5. Fan Coil Units: FCU - (room#) 
   - First few letters indicate type of equipment, followed by the room number that is served by the unit. Example: FCU-123

6. Misc. mechanical equipment: 
   - Sump pumps: SP-1, 2, 3…
   - Sewage ejector pumps: SEP-1, 2, 3…
   - Condensate vacuum pumps: CVP-1, 2, 3…
   - Unit Heaters, Cabinet heaters: UH-1, 2, 3…; CUH-1, 2, 3…

---

5 E&U System DDC Nomenclature

5.1 B B S S P P = Six-letter Point Name

<table>
<thead>
<tr>
<th>BB</th>
<th>SS</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-letter acronym for the Building (Example: FR = Freehafer)</td>
<td>Two-letter acronym for System (see below)</td>
<td>Two-letter acronym for DDC Point, Location / Function (Example: ST = space temp.)</td>
</tr>
</tbody>
</table>

5.2 S S System Description

| SYSTEM DESCRIPTION |
|--------------------|---|
| # # | Air Handling Unit (01, 02, 03…)
| P # | Pumping System (P1, P2…)
| B # | Boiler (B1, B2…)
| C # | Water Chiller Refrigeration (C1, C2…)
| D # | Direct Expansion Refrigeration (D1, D2…)
| E F | Electrical Feeder
| C N | Condensate System

5.3 PP - DDC Point – START/STOP

<table>
<thead>
<tr>
<th>START/STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>BO</td>
</tr>
<tr>
<td>CO</td>
</tr>
<tr>
<td>DO</td>
</tr>
<tr>
<td>EO</td>
</tr>
<tr>
<td>FO</td>
</tr>
<tr>
<td>GO</td>
</tr>
<tr>
<td>HO</td>
</tr>
<tr>
<td>JO</td>
</tr>
<tr>
<td>KO</td>
</tr>
<tr>
<td>OO</td>
</tr>
<tr>
<td>PO</td>
</tr>
<tr>
<td>QQ</td>
</tr>
<tr>
<td>RO</td>
</tr>
<tr>
<td>TO</td>
</tr>
<tr>
<td>VO</td>
</tr>
<tr>
<td>WO</td>
</tr>
</tbody>
</table>
### 5.4 DDC Point - STATUS

<table>
<thead>
<tr>
<th>STATUS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BI</td>
<td>Boiler</td>
</tr>
<tr>
<td>CI</td>
<td>Chiller Compressor</td>
</tr>
<tr>
<td>DI</td>
<td>DX Compressor or Dual Temp Pump</td>
</tr>
<tr>
<td>EI</td>
<td>Exhaust Fan</td>
</tr>
<tr>
<td>FI</td>
<td>Supply Fan</td>
</tr>
<tr>
<td>GI</td>
<td>General Exhaust Fan</td>
</tr>
<tr>
<td>HI</td>
<td>Hydronic Pump</td>
</tr>
<tr>
<td>PI</td>
<td>Pool Pump</td>
</tr>
<tr>
<td>QI</td>
<td>Heat Reclaim Pump</td>
</tr>
<tr>
<td>RI</td>
<td>Return or Relief Fan</td>
</tr>
<tr>
<td>TI</td>
<td>Toilet Exhaust Fan</td>
</tr>
<tr>
<td>VI</td>
<td>Vacuum Pump</td>
</tr>
<tr>
<td>WI</td>
<td>Chilled Water Pump</td>
</tr>
</tbody>
</table>

### 5.5 PP - DDC Point – HUMIDITY

<table>
<thead>
<tr>
<th>HUMIDITY</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH</td>
<td>Discharge Air Humidity</td>
</tr>
<tr>
<td>EH</td>
<td>Exhaust Air Humidity</td>
</tr>
<tr>
<td>OH</td>
<td>Outside Air Humidity</td>
</tr>
<tr>
<td>RH</td>
<td>Return Air Humidity</td>
</tr>
<tr>
<td>SH</td>
<td>Supply Air Humidity</td>
</tr>
</tbody>
</table>

### 5.6 PP - DDC Point – STATIC PRESSURE

<table>
<thead>
<tr>
<th>STATIC PRESSURE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>Cold Deck Static Pressure</td>
</tr>
<tr>
<td>DS</td>
<td>Discharge Air Static Pressure</td>
</tr>
<tr>
<td>ES</td>
<td>Exhaust Air Static Pressure</td>
</tr>
<tr>
<td>HS</td>
<td>Hot Deck Static Pressure</td>
</tr>
<tr>
<td>MS</td>
<td>Mixed Air Static Pressure</td>
</tr>
<tr>
<td>RS</td>
<td>Return Air Static Pressure</td>
</tr>
<tr>
<td>SS</td>
<td>Space Static Pressure</td>
</tr>
</tbody>
</table>

### 5.7 PP - DDC Point – TEMPERATURES

<table>
<thead>
<tr>
<th>TEMPERATURES</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>Cold Deck Temperature</td>
</tr>
<tr>
<td>DT</td>
<td>Discharge Air Temperature</td>
</tr>
<tr>
<td>FT</td>
<td>Glycol Return Temperature (at heat exchanger)</td>
</tr>
<tr>
<td>GT</td>
<td>Glycol Return Temperature (in coil) or Reheat Temperature</td>
</tr>
<tr>
<td>HT</td>
<td>Hot Deck Temperature</td>
</tr>
<tr>
<td>IT</td>
<td>Glycol Supply Temperature (at heat exchanger)</td>
</tr>
<tr>
<td>LT</td>
<td>Pre-cool Temperature</td>
</tr>
<tr>
<td>MT</td>
<td>Mixed Air Temperature</td>
</tr>
<tr>
<td>OT</td>
<td>Outside Air Temperature</td>
</tr>
<tr>
<td>PT</td>
<td>Preheat Air Temperature</td>
</tr>
<tr>
<td>RT</td>
<td>Return Air Temperature</td>
</tr>
<tr>
<td>ST</td>
<td>Space Temperature (occupied area)</td>
</tr>
<tr>
<td>TT</td>
<td>Heat Reclaim Air Temperature or Chiller Supply Water Temperature</td>
</tr>
<tr>
<td>UT</td>
<td>Hydronic System Return Temperature</td>
</tr>
<tr>
<td>WT</td>
<td>Chilled Water Temperature</td>
</tr>
<tr>
<td>YT</td>
<td>Hydronic System Supply Temperature</td>
</tr>
<tr>
<td>ZT</td>
<td>Zone Temperature</td>
</tr>
</tbody>
</table>

### 5.8 PP - DDC Point – DIFFERENTIAL PRESSURE

<table>
<thead>
<tr>
<th>DIFFERENTIAL PRESSURE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>Campus Chilled Water System Differential Pressure</td>
</tr>
<tr>
<td>WD</td>
<td>Building Chilled Water or Hydronic System Differential Pressure</td>
</tr>
<tr>
<td>VD</td>
<td>Vacuum Differential Pressure</td>
</tr>
</tbody>
</table>

### 5.9 PP - DDC Point – SPEED CONTROLS

<table>
<thead>
<tr>
<th>SPEED CONTROLS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FK</td>
<td>Supply Fan Speed Input</td>
</tr>
<tr>
<td>HK</td>
<td>Hydronic Pump Speed Input</td>
</tr>
<tr>
<td>RK</td>
<td>Return Fan Speed Input</td>
</tr>
<tr>
<td>WK</td>
<td>Chilled Water Pump Speed Input</td>
</tr>
</tbody>
</table>
### 5.10 PP - DDC Point – VALVES

<table>
<thead>
<tr>
<th>VALVES</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BV</td>
<td>Chilled Water Building Valve</td>
</tr>
<tr>
<td>DV</td>
<td>Discharge Valve</td>
</tr>
<tr>
<td>FV</td>
<td>Heat Reclaim Valve</td>
</tr>
<tr>
<td>GV</td>
<td>Reheat Valve</td>
</tr>
<tr>
<td>HV</td>
<td>Hot Deck / Heating Coil Valve</td>
</tr>
<tr>
<td>LV</td>
<td>Pre-cool Valve</td>
</tr>
<tr>
<td>MV</td>
<td>Mixing Valve</td>
</tr>
<tr>
<td>NV</td>
<td>Domestic Hot Water Valve</td>
</tr>
<tr>
<td>PV</td>
<td>Preheat Coil Valve</td>
</tr>
<tr>
<td>RV</td>
<td>Reheat or Radiation Valve</td>
</tr>
<tr>
<td>SV</td>
<td>Steam Valve in a Moderator System</td>
</tr>
<tr>
<td>VV</td>
<td>Humidity Valve</td>
</tr>
<tr>
<td>WV</td>
<td>Chilled Water Coil Valve</td>
</tr>
<tr>
<td>XV</td>
<td>Heat Exchanger Valve</td>
</tr>
<tr>
<td>ZV</td>
<td>Zone Valve</td>
</tr>
</tbody>
</table>

### 5.11 PP - DDC Point – DAMPERS

<table>
<thead>
<tr>
<th>DAMPERS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BD</td>
<td>Bypass Damper</td>
</tr>
<tr>
<td>CD</td>
<td>Cold Deck Damper</td>
</tr>
<tr>
<td>ED</td>
<td>Exhaust or Dilution Damper</td>
</tr>
<tr>
<td>FU</td>
<td>Supply Fan Vortex Damper</td>
</tr>
<tr>
<td>HD</td>
<td>Hot Deck Damper</td>
</tr>
<tr>
<td>MD</td>
<td>Mixed Air Damper</td>
</tr>
<tr>
<td>OD</td>
<td>Outside Air Damper</td>
</tr>
<tr>
<td>PD</td>
<td>Preheat Damper</td>
</tr>
<tr>
<td>RD</td>
<td>Return or Relief Damper</td>
</tr>
<tr>
<td>RU</td>
<td>Return Fan Vortex Damper</td>
</tr>
<tr>
<td>SD</td>
<td>Space Damper</td>
</tr>
<tr>
<td>ZD</td>
<td>Zone Damper</td>
</tr>
</tbody>
</table>

### 5.12 PP - DDC Point – FLOW

<table>
<thead>
<tr>
<th>FLOW</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF</td>
<td>Regional or Building Water Meter Flow Rate</td>
</tr>
<tr>
<td>AY</td>
<td>Regional or Building Water Meter, Flow Pulse or Pressure</td>
</tr>
<tr>
<td>WF</td>
<td>Local Water Meter, Flow Rate</td>
</tr>
<tr>
<td>DY</td>
<td>Discharge Air Flow</td>
</tr>
<tr>
<td>OY</td>
<td>Outside Air Flow</td>
</tr>
<tr>
<td>RV</td>
<td>Return Air Flow</td>
</tr>
<tr>
<td>RPSF</td>
<td>Regional Point - Steam Flow rate</td>
</tr>
<tr>
<td>RPSY</td>
<td>Regional Point - Steam Flow pulsed signal</td>
</tr>
<tr>
<td>CNCG</td>
<td>Condensate Flow meter</td>
</tr>
</tbody>
</table>

### 5.13 PP - DDC Point – MISCELLANEOUS

<table>
<thead>
<tr>
<th>MISCELLANEOUS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLDO</td>
<td>Boulevard Lights (Start/Stop)</td>
</tr>
<tr>
<td>DX</td>
<td>Liquid Line Solenoid Valve</td>
</tr>
<tr>
<td>D1, 2, 3...</td>
<td>Liquid Line Solenoid Valve</td>
</tr>
<tr>
<td>EA</td>
<td>Exhaust Damper Position</td>
</tr>
<tr>
<td>FL</td>
<td>Freeze Stat</td>
</tr>
<tr>
<td>OA</td>
<td>Outside Air Damper Position Switch</td>
</tr>
<tr>
<td>OC</td>
<td>Outside Air Damper Solenoid</td>
</tr>
<tr>
<td>QR</td>
<td>Occupant Override</td>
</tr>
<tr>
<td>RC</td>
<td>CO₂ Sensor</td>
</tr>
<tr>
<td>SL</td>
<td>Static Limit</td>
</tr>
<tr>
<td>V5</td>
<td>Virtual 45° Low Limit</td>
</tr>
<tr>
<td>ZC</td>
<td>Summer/Winter Solenoid</td>
</tr>
</tbody>
</table>

### 6 Additional Information

6.1 At closeout of the project the Temperature Controls Vendor will submit a digital copy of the project to the E&U department. The copy should contain but is not limited to the following:

1. All systems control drawings (In University provided .dwg format)
2. All control component (panels, modules, etc.) drawings (In University provided .dwg format)
3. All control code for the project
4. Systems graphics  
5. Project bible-plans  
6. Network layout  
7. Floor level device network

6.2 Temperature control standard details to be included in the bid documents will be provided by E&U department. These drawings identify standard installation details required by the E&U department.

6.3 The E&U department will provide the next sequential number for the following:
   1. Static IP addresses
   2. Langate numbers
   3. Panel numbers
   4. Module numbers
   5. System numbers.

6.4 Notify the Purdue E&U console (494-6285) prior to any work being done on live or existing units, panels or modules. Purdue reserves the right of first refusal on any salvaged materials.

6.5 Please contact the E&U department before proceeding if any directions in this guideline are unclear as well as with any questions not addressed in this guideline.
1 Sequences of Operation

1.1 A written sequence of operation for all Direct Digital Control equipment shall be submitted to the Energy and Utilities (E&U) department for review. A finalized version of the sequences of operations will be submitted to the E&U department in either word or .pdf format for reference and archiving purposes. The E&U department is available for consultation while developing these sequences of operation.

1.2 Identify the sequences by the individual mechanical system number and provide sequences for all air handling equipment, hydronic heating/cooling systems, individual room level control and any miscellaneous mechanical equipment monitored or controlled by E&U.

1.3 The sequence of operation for each piece of equipment should contain a description of the task of all input and output DDC points for monitoring or control, address the operation of the equipment as engineered, designed, and intended for DDC programming and contain, at the minimum, the following:

1. Run conditions
2. Occupied/Unoccupied cycle
3. 38°F Freeze protection alarm
4. Economizer cycle
5. Cooling control
6. Return Chilled Water control
7. Heating control
8. Humidification and Dehumidification control
9. Building Dedicated OAT
10. Delta P for Campus Chilled Water
11. Steam Pressure (Not Delta P)
12. Steam Temperature Sensor
13. Pressure control
14. Building static
15. AHU Systems
16. Hydronics water
17. Set points
18. Pressure
19. Temperatures
20. Humidity
21. Minimum Outdoor Air
22. Alarms
23. Set points for Alarming (When to alarm)

1.4 Contact the Controls Design Group to discuss programming in correlation with existing programming techniques utilized on campus.

1.5 Sequences of Operations should be written in outline format for ease of referencing and discussion. The following format should be adhered to:

I. Section
   A. Section parts
      1. Subsection parts
         i. Subset Category
            a. Subset

2 Sequence for a Safety on a Mixed Air System

2.1 When physical low limit sensor (set to 38°F) trips, hard wiring through the low limit sensor shall stop the fan.

2.2 The BAS shall close the outside air dampers, relief damper and open the return damper.

2.3 The return fan will be energized to 50% speed and an alarm shall be generated.

2.4 Chilled water control valve operation

The BAS system will monitor the entering air temperature, leaving air temperature and interior water temperature of the cooling coil. If any of the three temperatures starts to drop below 40°F (adj.) the output will increase in a direct linear fashion (NO LOOP CONTROL) to the chilled water control valve, opening the valve to allow circulation of water through the chilled water coil in order to avoid freezing. The chilled water control valve shall achieve full open position if any of the three temperatures reaches 35°F (adj.). All three temperatures (entering air temperature, leaving air temperature and interior water temperature) must be 40°F (adj.) or above before the chilled water cooling coil valve will be shut.

3 Sequence for a Safety on a Dedicated OA Unit

3.1 At a 45°F preheat temperature, a virtual low limit will be activated fully opening the preheat control valve.

3.2 When physical low limit sensor (set to 38°F) trips, hard wiring through the low limit sensor shall stop the supply fan.

3.3 Chilled water control valve operation

The BAS system will monitor the entering air temperature, leaving air temperature and interior water temperature of the cooling coil. If any of the three temperatures starts to drop below 40°F (adj.) the output will increase in a direct linear fashion (NO LOOP CONTROL) to the chilled water control valve, opening the valve to allow circulation of water through the chilled water coil in order to avoid freezing. The chilled water control valve shall achieve full open position if any of the three temperatures reaches 35°F (adj.). All three temperatures (entering air temperature, leaving air temperature and interior water temperature) must be
40°F (adj.) or above before the chilled water cooling coil valve will be shut.

4 Sequence for Enthalpy Economizer Control

4.1 Economizer cooling is enabled/disabled based on the return air and outside air enthalpy differential switchover set point with a 1.5 BTU/lb. dead band.

4.2 When the outside air enthalpy is no more than 1.0 BTU/lb. below the return air enthalpy, economizer cooling is disabled.

4.2.1 When economizer cooling is disabled the maximum outside air and relief dampers are fully closed, the return air damper is positioned for minimum outside air ventilation.

4.3 When the outside air enthalpy is below return air enthalpy by at least 2.5 BTU/lb., economizer cooling is enabled.

4.3.1 When economizer cooling is enabled maximum outdoor air, return air and relief air dampers modulate together to maintain a mixed air set point of 53°F. The dampers are allowed to modulate from full opened to full close.

5 Sequence for Cold Deck Chilled Water Control

5.1 Chilled water control valve shall modulate to meet the cold deck setpoint (typically 55°F).

5.2 A sensor installed in the last pass of the cooling coil shall monitor the return water temperature from the coil.

5.3 If the space humidity rises to 50% RH then discharge air temperature set point is reset downward utilizing the following reset:

<table>
<thead>
<tr>
<th>RH setpoint</th>
<th>Chilled water low limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-50%</td>
<td>55°F</td>
</tr>
<tr>
<td>60-100%</td>
<td>52°F</td>
</tr>
</tbody>
</table>

6 Sequence for Chilled Water Pumping Systems

6.1 Chilled water pumping systems shall be start/stoped by a campus chilled water differential sensor and shall be modulated by a differential pressure sensor installed across a cooling coil indicated on the blueprints.

7 Sequence for Static Pressure Reset

7.1 The static pressure will be reset based on the damper position in the control boxes served by the unit

7.2 One damper position will be maintained at 95% open (adj.) at all times

7.2.1 Polling of all associated control boxes will occur at five minute intervals (adj.) to determine which damper is the furthest open

7.2.2 If no damper position is at 95% open (adj.) then the output to the supply fan speed control will reduce until a box’s damper is driven to 95% open (adj.)

7.2.3 If more than one damper position is at 95% open (adj.) the supply fan speed control will ramp up until there is only one damper at 95% open (adj.)

7.3 If a damper position is at 100% open for more than 30 minutes (adj.) the damper position will be locked out of the polling, a default value of the damper position set point minus 3% issued for the box and an alarm will be generated. This lock out will remain until the control box is reviewed to determine the cause of the reading. If it is determined to be unrepairable the box in question will be permanently locked out the polling process. This will be termed a rogue zone box.

7.4 The static pressure reset will operate with a low limit of 0.5” wc (adj.) and a high limit of 2.0” wc (adj.) as determined by the Balancing Contractor.

7.5 High and low limit dead bands are utilized to maintain controlling damper between dead band limits.

8 Sequence for Discharge Temperature Reset

8.1 The discharge temperature set point will be reset based on the three factors

1. Fan speed
2. Outside air temperature
3. Cooling demand

8.2 If the supply fan speed reference signal is less than 40% (4 volts) then the discharge temperature reset mode shall be enabled

8.3 The base line discharge temperature set point will be established with the following reset table:

<table>
<thead>
<tr>
<th>Outside Air Temperature</th>
<th>Discharge Air Temperature Set point</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°F (adj)</td>
<td>65°F (adj)</td>
</tr>
<tr>
<td>70°F (adj)</td>
<td>55°F (adj)</td>
</tr>
</tbody>
</table>

8.4 Once the baseline temperature set point is established then polling of the spaces served for cooling requests will adjust the set point by adding a factor established from the following reset table:

<table>
<thead>
<tr>
<th>Cooling Request</th>
<th>Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>-5</td>
</tr>
</tbody>
</table>

8.5 Discharge temperature set point reset mode will be disabled if the return humidity exceeds 50% RH and
the cooling coil discharge temperature reset schedule activates to maintain the humidity levels in the space. When the return humidity reaches 40% RH then discharge temperature set point control may resume.
1 Pipe Penetrations
1.1 All pipe penetrations through interior walls will be sealed to prevent air transfer.

Note: Interior wall holes that are oversized can make pressure control difficult.

2 Pressure sensing locations
2.1 Each main line strainer and each heat exchanger needs a pressure sensing point with gage cock at the inlet and outlet.
2.2 To the extent possible all pressure sensing locations should be piped to a common pressure gauge.

Note: Using a single pressure gauge provides an accurate differential pressure measurement even when the gauge has lost calibration.

Exception: Small items (fan coil units VAV box reheat coils, etc.) may have PT plugs instead of gauges.

3 Thermometers
3.1 Each device using chilled or heating water should have thermometers at the inlet and outlet.

Note: Reading the heat exchanger differential pressure and temperature is critical for field verification of exchanger operation.

Exception: Small items (FCUs, VAV box reheat coils, etc.) may have PT plugs instead of a thermometer.

4 Balancing valves at the pump discharge
4.1 System designed to be constant volume should have a VFD controlling the speed to eliminate the need for balancing or triple duty valves.

Note: Using balancing valves to restrict flow uses more energy than using a VFD to reduce the pump speed.

5 Automatic flow controllers
5.1 Automatic flow controllers should be installed at the heat exchanger level.

Note: At the heat exchanger level, though Automatic Flow Controllers restrict the operating range of control valve by about 20% they are still the preferred approach for preventing pump overflow and limiting the time required by the balancing contractor.

6 Manual Balancing Valves
6.1 Systems designed to be variable flow should have few, if any, manual balancing valves.

Note: Unnecessary balancing valves add pressure to the system wasting energy.

6.2 When a control valve is present manual balancing valves are not to be used at the heat exchanger level.

6.3 When using manual valves to balance a circuit they must have be fully repeatable position (memory stop) globe valves as opposed to simple circuit balancing valves.

7 Isolation Valves
7.1 Install isolation valves at main piping distribution that isolating building sections, at all branch lines off main pipes, at all pieces of equipment, and at specialty items.

8 Piping
8.1 Pipes can be Type L copper or schedule 40 black steel.

Note: Be aware of electrolysis. Steel acts as an anode, giving up ions to the copper, the cathode. Thus, a system with a small amount of steel to a large quantity of copper will have premature failure of the steel pipe.

8.2 Water velocity shall not exceed 10 FPS.

Note: Velocities of 10 FPS will erode the pipe.

8.3 Pipe size should not be less than ¾”.

8.4 The first fitting inside a building must be a welded fitting.

Note: When the system is subjected to a pressure spike (as occasionally happens) this first fitting inside the basement takes the brunt of the pressure spike and has been known to catastrophically fail.

8.5 Other than the first fitting, grooved mechanical couplings may be used inside a building.

8.6 Mechanical compression couplings may be specified as a deduct alternate.

8.7 Comply with ASHRAE 90.1-2013 Table
6.5.4.6 Piping System Design Maximum Flow Rate in GPM when sizing hydronic piping systems as modified and listed in table below:

<table>
<thead>
<tr>
<th>Operating Hours/Year</th>
<th>≤ 4,400 Hours/Year</th>
<th>&gt; 4,400 Hours/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Pipe Size, in.</td>
<td>Other</td>
<td>Variable Flow/Variable Speed</td>
</tr>
<tr>
<td>2 1/2</td>
<td>85</td>
<td>130</td>
</tr>
<tr>
<td>3</td>
<td>140</td>
<td>210</td>
</tr>
<tr>
<td>4</td>
<td>260</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>610</td>
<td>470</td>
</tr>
<tr>
<td>6</td>
<td>570</td>
<td>860</td>
</tr>
<tr>
<td>8</td>
<td>900</td>
<td>1400</td>
</tr>
<tr>
<td>10</td>
<td>1300</td>
<td>2000</td>
</tr>
<tr>
<td>12</td>
<td>1900</td>
<td>2900</td>
</tr>
<tr>
<td>*14-24</td>
<td>6.5 ft./s</td>
<td>9.5 ft./s</td>
</tr>
</tbody>
</table>

*Maximum velocity for pipes over 14-24” NPS.

9 Utility meters

9.1 When new buildings are being designed multiple utilities supplied to the facility are to be individually metered including chilled water.

10 West Lafayette Chilled Water Design Data

10.1 Supply Temperature

10.1.1 Summer: 45°F is supplied to the building wall with good reliability (the system is above 48°F less than 2% of the time).

Note: The designer must take into account temperature rise inside the building.

10.1.2 Winter: 47°F is the winter basis of design

Note: The winter supply temperature is more likely to drift

10.2 The design return temperature is 63°F LWT from the coil

10.3 Differential Pressure

- 10 psig summer
- 15 psig winter

11 Chilled Water Pipe Coating

11.1 Corrosion resistant paint should be applied to all steel chilled water pipe prior to being covered with insulation.

12 Strainer screens size table

<table>
<thead>
<tr>
<th>Use</th>
<th>Pipe Size</th>
<th>Screen Size</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>2” and smaller</td>
<td>0.033 perforations (1/32” or 20 mesh)</td>
<td>250 PSI</td>
</tr>
<tr>
<td></td>
<td>2½” and larger</td>
<td>0.045 perforations (3/64” or 16 mesh)</td>
<td>125 PSI</td>
</tr>
<tr>
<td>Water</td>
<td>2” and smaller</td>
<td>0.062 perforations (1/16” or 10 mesh)</td>
<td>250 PSI</td>
</tr>
<tr>
<td></td>
<td>2½” to 4”</td>
<td>0.062 perforations (1/16” or 10 mesh)</td>
<td>125 PSI</td>
</tr>
<tr>
<td></td>
<td>5” and larger</td>
<td>0.125 perforations (1/8” or 7 mesh)</td>
<td>125 PSI</td>
</tr>
</tbody>
</table>

Note: Frequently contractors purchase one screen size for an entire project, or a strainer with a screen sized for steam is used for a hydronic system. When done the strainer clogs quickly. When followed this table avoids this problem.

13 Closed Loop Air and Sediment Control

13.1 Closed loop hydronic systems shall be installed with combination air eliminator/dirt separator with flanged, removable head for bundle removal for the purposes of cleaning and inspection; isolation valves; and integral drain valve for manual system flushing.
PHYSICAL FACILITIES
2018 Consultant’s Handbook
Division 23 HVAC
2113 Piping Methods and Materials

1 Pipe pressure testing table

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Pressure Requirement</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP steam and condensate</td>
<td>125 psig hydrostatic</td>
<td>6 Hours</td>
</tr>
<tr>
<td>HP steam and condensate</td>
<td>125 psig hydrostatic</td>
<td>6 Hours</td>
</tr>
<tr>
<td>Heating water</td>
<td>125 psig hydrostatic</td>
<td>6 Hours</td>
</tr>
<tr>
<td>Condenser water</td>
<td>125 psig hydrostatic</td>
<td>6 Hours</td>
</tr>
<tr>
<td>Chilled water</td>
<td>125 psig hydrostatic</td>
<td>6 Hours</td>
</tr>
<tr>
<td>Interior domestic water</td>
<td>125 psig hydrostatic</td>
<td>6 Hours</td>
</tr>
<tr>
<td>Drain, waste, and storm drain</td>
<td>standing water 10 feet of head</td>
<td>1 Hour</td>
</tr>
<tr>
<td>Sanitary and storm sewers</td>
<td>standing water, 10 feet of head</td>
<td>1 Hour</td>
</tr>
<tr>
<td>Fire lines</td>
<td>200 psig hydrostatic</td>
<td>6 Hours</td>
</tr>
<tr>
<td>Natural gas</td>
<td>90 psig air</td>
<td>2 Hours</td>
</tr>
<tr>
<td>Compressed air</td>
<td>150 psig air</td>
<td>2 Hours</td>
</tr>
<tr>
<td>Vacuum</td>
<td>24 in. Hg</td>
<td>2 Hours</td>
</tr>
<tr>
<td>Medical gas</td>
<td>150 psig hydrostatic</td>
<td>2 Hours</td>
</tr>
<tr>
<td>Deionized water</td>
<td>100 psig hydrostatic</td>
<td>6 Hours</td>
</tr>
<tr>
<td>Refrigerant - High side</td>
<td>275 psig dry nitrogen</td>
<td>24 Hours</td>
</tr>
<tr>
<td>Refrigerant - Low side</td>
<td>150 psig dry nitrogen</td>
<td>24 Hours</td>
</tr>
</tbody>
</table>

2 Testing Procedure

2.1 All tests are to be held for the minimum time with no loss of pressure.
2.2 All gravity tests are to be held long enough to visually inspect each joint with no visible loss of water for 15 minutes.
2.3 Any visible leakage or measured pressure drop is a cause for test failure. Additional tests will be required after corrective measures have been taken until satisfactory results are obtained.

3 Testing Records

3.1 Specify a signed and dated affidavit of testing to be provided to the owner’s representative within 72 hours of completion of testing.
3.2 Each affidavit should contain, as a minimum:
   - the date of the test
   - system or subsystem tested
   - test medium and pressure
   - duration of test
   - test results
   - name and signature of individual performing test
   - name and signature of witness to the test
   - whether the portion of pipe tested meets state and local regulations and Purdue requirements for leak testing
3.3 Copies of the affidavits are to be included in the Operation and Maintenance Manuals.

4 Cleaning of Steam Piping

4.1 Specify that for the first three (3) days of operation, condensate is to be discharged and not returned to the campus system.
   4.1.1 Exceptions should be at the discretion of the owner’s representative.

5 Cleaning of Chilled Water Piping

5.1 The entire system is to be hydraulically flushed with potable water through a backflow prevention device to remove construction debris.
5.2 All construction debris is to be disposed of in an appropriate manner as approved by the owner’s representative.
5.3 Scale and chemical contaminants is to be collected in a suitable container for disposal as instructed by the owner’s representative.
5.4 Remove, clean, and replace all strainers in the system.
5.5 Add de-greasing / de-scaling / de-rusting chemical specifically designed for compatibility with campus chilled water to the system, such as Grace Dearborn Ferrosol 345.
6  Welding and Soldering

6.1  Welders Testing and Certification

6.1.1  All pipe fitters, plumbers, or other craftsmen must pass an ASME or Pipe Welding Bureau welding test and present proof of current ASME certification before doing any welding on this job.

6.1.2  The owner’s representative shall approve all welders.

6.1.3  Welders should also be required to present a Continuity Record that shows continuity in each welding process from the time of the original test to the current date at a six-month interval.

6.2  All pipe fitters and plumbers must pass a soldering test before doing any soldering for this job.

6.3  Approval Period

6.3.1  Solderers shall be approved for a period not exceeding five years. After five years, or sooner, if soldering appears to be below standards, the welder/solderer will be required to retake the test.

6.3.2  If the ASME certification is used for approval, then a current certification must be presented for each job.

6.4  Identification Code

6.4.1  When a welder or solderer has been approved, he will be given an identification code number or letter.

6.4.2  For welds, this identification code must be stamped on all work welded by this welder.

6.4.3  1/4” stamp dies must be used at each weld.

6.4.4  The markings are to be clear and deep in the pipe so that the welder/solderer can always be identified.

6.4.5  For solder joints, the identification number shall be written on the pipe surface with permanent marker.

6.5  Improperly Identified Connections

6.5.1  Any weld not properly identified with a die stamped identification code number shall be removed and remade.

6.6  Testing and Replacing Connections

6.6.1  When directed by the owner’s representative the contractor will cut out sections of piping containing welds or solders for inspection and testing purposes. If a connection does not pass the Owner’s approved standards, the Contractor will be required to replace the test section of piping at no additional cost to the Owner.

6.6.2  When a connection is found to be acceptable and meets the owner’s approved standards, the owner will reimburse the Contractor for the replacement costs, and the Contractor will replace the test section of piping as directed by the owner’s representative. All time and material cost slips must be signed by the owner’s representative.
1 Steam Use

1.1 Wherever possible, steam from the central heating plant should be used as the primary heating medium.

*Note:* Electric heating, reheat or humidification should be avoided but there are times when electric heating is the reasonable choice.

1.2 Preheat and larger reheat coils typically use steam.

*Note:* Many designers prefer hot water preheat coils. The University has a long history with steam preheat coils which provides a confidence that using steam will produce a relatively trouble free system.

1.3 Smaller reheat coils typically use hot water from a steam to water heat exchanger.

2 Running HP steam

2.1 Running 125 psi steam through occupied spaces should be avoided.

*Note:* Safety is a primary concern. In the event of a catastrophic failure 125 psi steam can be very dangerous to the general public who would not know how to safely evacuate the area.

2.2 Running 125 psi steam through hidden spaces should be avoided.

*Note:* 125 psi steam piping must be located so as to be able to be inspected.

2.3 When there is a need building for a steam pressure greater than 15 psi (e.g. autoclaves, sterilizers, etc.) such steam can be provided by tapping into the middle of a two stage pressure reducing station.

2.3.1 To the extent possible the length of run should be limited and as direct as possible.

2.3.2 Avoid using such steam for uses that could be accomplished with LP steam.

3 Pressure relief valves

3.1 Pressure relief valves should be located so as to have a minimum of 24” clear above the valve.

*Note:* PRVs must be regularly tested by equipment that sits on the top of the PRV and that requires at least 24” for proper operation.

4 Building Level Desuperheaters

4.1 Operational experience indicates that there is no need for a desuperheater.

5 Trap sizing guidelines

5.1 For double trap systems (e.g. preheat coils), size each of the two double traps for full (100%) start-up flow.

*Note:* Traps sized for half flow are more likely to flood and have been shown to prematurely fail.

5.2 For single trap systems size each trap for full (100%) start-up flow with no safety factor.

6 Trap Location:

6.1 All traps, except those on radiation heating equipment, need to be located 12” below the devices they service.

*Note:* The 12” drip leg assures complete drainage of the heat exchanger under conditions of low load or full shut off.

*Exception:* Thermostatic traps on radiation equipment (radiators, fin tube, etc.) do not have to be located below the heat exchanger.

6.2 For double trap systems, the two traps should be at the different elevations. If that is impossible they must be piped in such a way that the condensate must flow past one trap before the other.

*Note:* Piping in this manner allows one trap to be used as the primary trap and the second as a true back-up.

6.3 Show the traps on the plans and elevation views.

*Note:* Designs that do not fully considered the trap placement cause problems in the field where there is not enough room for the traps or they are in front of a door, etc. Showing the traps in location and to scale on the drawing prevent this problem.

7 Hand Valves inside the Building:

7.1 Gate valves should be used for most live steam applications.

*Note:* Gate valves have a slower opening action that reduces the risk of one type of water hammer.

7.2 Full port ball valves can be used for low pressure trap isolation and condensate service.
Note: The seals in ball valves cannot take high temperatures so their use is limited to condensate or low pressure isolation where the superheat has been dissipated.

7.3 All hand valves must provide tight shut-off.
7.4 Install isolation valves at main piping distribution isolating building sections, at all branch lines off main pipes, at all pieces of equipment, and at specialty items.
7.5 Verify that the temperature rating of the valves matches the steam temperature at the site.

8 Hand valves outside the building
8.1 Hand valves outside the building should be gate valves.

9 Strainers in equipment rooms
9.1 Strainers in equipment rooms must have blowdown valves with a nipple and a cap on the blowdown side.
9.2 Round handled ball valves may be used as blowdown valves.

10 Dirt legs
10.1 All dirt legs are to have blowdown valves.

Note: Without a blowdown valve the dirt leg will, in short order, become full of crud and, thus, useless.

11 Steam pipe nomenclature

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPS</td>
<td>Steam ≤ 15 psig</td>
</tr>
<tr>
<td>HPS</td>
<td>Steam &gt; 15 psig</td>
</tr>
<tr>
<td>LPSR</td>
<td>LP condensate pipe after the steam trap but before the condensate pump</td>
</tr>
<tr>
<td>HPSR</td>
<td>HP condensate pipe after the steam trap but before any other equipment to which the condensate runs (flash tank, condensate receiver, etc.)</td>
</tr>
<tr>
<td>CP</td>
<td>Condensate after the condensate pump but before the condensate return in the tunnels.</td>
</tr>
<tr>
<td>CR</td>
<td>The condensate return system located in a utility tunnel, return condensate to the power plant. This is an atmospheric pressure, gravity flow system</td>
</tr>
</tbody>
</table>

12 Steam distribution conditions

<table>
<thead>
<tr>
<th>Steam Press</th>
<th>Saturation Temp</th>
<th>Typical Distribution Temp</th>
<th>Max Recorded Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 psig</td>
<td>353°F</td>
<td>550°F</td>
<td>650°F</td>
</tr>
<tr>
<td>15 psig</td>
<td>250°F</td>
<td>350°F</td>
<td>475°F</td>
</tr>
</tbody>
</table>

Note: At various locations in the tunnel distribution system the 125 psig steam is reduced to 15 psig and fed into the lower pressure line. Thus, the pressures and temperatures in the two systems can vary between superheated and saturated with respect to both location and season.
### 13 Design temperatures used for fitting selection

<table>
<thead>
<tr>
<th>Item</th>
<th>Temp for Material Selection</th>
<th>Temp for Equipment Sizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansion joints, anchors, etc.</td>
<td>650 °F - HP 475 °F - LP</td>
<td>650 °F - HP 475 °F - LP</td>
</tr>
<tr>
<td>Heat exchangers, control valves, coils, etc.</td>
<td>550 °F - HP 350 °F - LP</td>
<td>350 °F - HP 250 °F - LP</td>
</tr>
<tr>
<td>Control valves at steam radiators, fin tube, etc.</td>
<td>350 °F - HP 250 °F - LP</td>
<td>350 °F - HP 250 °F - LP</td>
</tr>
</tbody>
</table>

### 14 LP Steam piping materials

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>Seamless sch-40 carbon steel</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>100 psig design pressure</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>350 °F design temperature</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>150 psig hydrostatic test pressure</td>
</tr>
<tr>
<td>Fittings</td>
<td>≤ 2&quot;</td>
<td>125 lb cast iron - screwed</td>
</tr>
<tr>
<td>Fittings</td>
<td>≥ 2½&quot;</td>
<td>Standard weight steel – welded</td>
</tr>
<tr>
<td>Flanges</td>
<td>All sizes</td>
<td>150 lb. raised face</td>
</tr>
<tr>
<td>Bolting</td>
<td>All sizes</td>
<td>Alloy steel ASTM A193 grade B7 bolts and studs with A194 grade 2H nuts</td>
</tr>
<tr>
<td>Unions</td>
<td>≤ 2&quot;</td>
<td>300 lb., raised face, screwed, integral SS seat</td>
</tr>
<tr>
<td>Gaskets</td>
<td>All sizes</td>
<td>150 lb., 3/16&quot; thick, spiral wound with 1/8&quot; thick outer guide ring, 304 SS with Verdicarb Filler</td>
</tr>
<tr>
<td>Take-off</td>
<td>≤ 2&quot; main ≤ 2&quot; branch</td>
<td>Screwed or socket weld tees</td>
</tr>
<tr>
<td>Take-off</td>
<td>≥ 2½&quot; main ≤ 2&quot; branch</td>
<td>Reducing tee forged steel thread-o-let</td>
</tr>
<tr>
<td>Take-off</td>
<td>≥ 2½&quot; main ≥ 2½&quot; branch</td>
<td>Equal or reducing tee, nozzle weld with reinforcing as required, forged steel weld-o-lets</td>
</tr>
</tbody>
</table>
### 15 HP Steam piping materials (up to 70 PSIG)

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>Seamless sch-80 carbon steel</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>150 psig design pressure</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>550 °F design temperature</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>225 psig hydrostatic test pressure</td>
</tr>
<tr>
<td>Fittings</td>
<td>≤ 2&quot;</td>
<td>250 lbs. cast iron - screwed</td>
</tr>
<tr>
<td>Fittings</td>
<td>≥ 2½&quot;</td>
<td>Extra strong weight steel – welded</td>
</tr>
<tr>
<td>Flanges</td>
<td>All sizes</td>
<td>300 lb. raised face</td>
</tr>
<tr>
<td>Bolting</td>
<td>All sizes</td>
<td>Alloy steel ASTM A193 grade B7 bolts and studs with A194 grade 2H nuts</td>
</tr>
<tr>
<td>Unions</td>
<td>≤ 2&quot;</td>
<td>300 lb., raised face, SW, integral SS seat</td>
</tr>
<tr>
<td>Gaskets</td>
<td>All sizes</td>
<td>300 lb., 3/16&quot; thick, spiral wound with 1/8&quot; thick outer guide ring, 304 SS with Verdicarb Filler</td>
</tr>
<tr>
<td>Take-off</td>
<td>≤ 2&quot; main</td>
<td>Socket weld tees</td>
</tr>
<tr>
<td>Take-off</td>
<td>≤ 2&quot; branch</td>
<td></td>
</tr>
<tr>
<td>Take-off</td>
<td>≥ 2½&quot; main</td>
<td>Reducing tee forged steel sock-o-let</td>
</tr>
<tr>
<td>Take-off</td>
<td>≤ 2½&quot; branch</td>
<td></td>
</tr>
<tr>
<td>Take-off</td>
<td>≥ 2½&quot; main</td>
<td>Equal or reducing tee, nozzle weld with reinforcing as required, forged steel weld-o-lets</td>
</tr>
<tr>
<td></td>
<td>≥ 2½&quot; branch</td>
<td></td>
</tr>
</tbody>
</table>

### 16 Condensate piping materials

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>Seamless sch-80 carbon steel</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>100 psig design pressure</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>220 °F design temperature</td>
</tr>
<tr>
<td>Pipe</td>
<td>All sizes</td>
<td>150 psig hydrostatic test pressure</td>
</tr>
<tr>
<td>Fittings</td>
<td>≤ 2&quot;</td>
<td>250 lbs. cast iron – screwed</td>
</tr>
<tr>
<td>Fittings</td>
<td>≥ 2½&quot;</td>
<td>Extra strong weight steel – welded</td>
</tr>
<tr>
<td>Unions</td>
<td>≤ 2&quot;</td>
<td>300 lb., raised face, screwed, integral SS seat</td>
</tr>
<tr>
<td>Gaskets</td>
<td>All sizes</td>
<td></td>
</tr>
</tbody>
</table>

Page 4 of 4
Refer to Division 33 Utilities 6305 Condensate Pumps.
1 Safety Precautions
1.1 Safety relief valve discharge piping is to be run to the exterior of the building.
1.2 When the piping, the evaporator, or the condensing unit is located in an enclosed room consideration must be given to worker safety in the event of catastrophic piping failure.

Note: The designer must show calculations that indicate the percentage of breathable air in the enclosed room assuming full discharge of the refrigerant. Though rare this type of failure has occurred and must be considered.
1.3 If the calculations indicate a possible safety problem then consideration must be given to appropriate ventilation of the area such as cross ventilation, fan pulling off the floor, fan triggered by a refrigerant detector, etc.

2 All Refrigeration and Air Conditioning Lines
2.1 Use only refrigeration grade copper tube. Type “L” is preferred.
2.2 Tubing should be clean, dehydrated, and capped when received new.
2.3 Brace piping a minimum of every 6 feet with ‘cush-a-clamp’ and ‘super strut’ style supports.
2.4 Use only long radius sweat “Ls” elbows.
2.5 All refrigerant lines will be hard soldered using 15% silver-solder or better.
   2.5.1 Bleed dry nitrogen through the pipe as it is being soldered.
2.6 Size the line properly according to tonnage of unit and length of run using the manufactures’ recommendations.

3 Testing and Filling Procedure
3.1 The system will be pressurized with an appropriate tracer gas and tested using a proper detector, such as an electronic, to check for leaks.
3.2 After determining that there are no leaks the tracer gas is to be removed and a vacuum of 50 microns is pulled on the system.
   3.2.1 The vacuum pump will then be valved off and the system will be allowed to stand for 12 hours.
   3.2.2 If the level rises above 200 microns but does not reach ambient pressure you may assume there is still moisture in system and continue pulling a vacuum, repeating the test procedure.
3.2.3 If the level approaches ambient pressure you must assume there is still a leak in the system and repeat the procedure for leak testing.
3.3 When the vacuum level for the test period does not rise above 200 microns the system can be charged.
3.4 The “Super Heat” will be checked on the expansion valve.

4 Documentation
4.1 In line with EPA regulations the University has set up policies that must be followed by contracted refrigeration mechanics when working on, or installing, University owned equipment containing refrigerants. It is expected that all contractors will comply with relevant EPA, Federal, State and local rules and regulations.
4.2 Before proceeding with any repair or installation of refrigerant containing equipment, a copy of all Refrigeration Mechanic Certifications are to be submitted to the Construction Manager. These will be kept in a permanent record, allowing the University to demonstrate that all mechanics installing or repairing University owned equipment are properly certified.
4.3 Record the total charge and refrigerant type of each refrigerant circuit. This record will be posted at the unit and submitted to the University on the Refrigerant Usage Compliance Form.
4.4 A Refrigerant Usage Compliance Form must be completed and submitted to the Construction Manager.
4.5 Refrigeration Compliance Coordinator:
   Purdue Refrigerant Compliance Coordinator
   775 Ahlers Rd. PFSB Bldg.
   West Lafayette, Indiana 47907
   Ph.: 765-494-9566

5 General Design Requirements
5.1 Refrigeration piping systems conveying 10 tons of nominal cooling capacity or greater shall be designed by the Engineer-Of-Record in a manner that is in conformance with the listed manufacturers’ written installation, operation & maintenance manuals and refrigeration piping
5.1.1 If design is delegated (either in-part or in-whole) to the installing contractor, the Engineer-Of-Record shall review and ultimately approve project-specific, detailed design drawings produced and submitted by the installing contractor that shall include, but not be limited to the following: pipe sizing, floor-plan-specific pipe routing, suction riser details, trap details, velocity calculations, refrigerant specialties locations and specifications, and solenoid wiring diagram and control schematics.

5.1.2 In compliance with majority of refrigeration manufacturers’ guidelines: refrigeration piping shall not be routed underground.

6 Suction Lines
6.1 Install a ball valve at each evaporator that has remote condensing unit.
6.2 Slope ½” every 10’ back to the compressor.
6.3 Install “P” traps if evaporator is lower than the compressor.
6.4 When needed install vibration eliminators parallel with the compressor crank shaft. Eliminators are to be straight with no bends and to be braced on the end opposite the compressor.

7 Liquid Lines
7.1 Install a ball valve at the condenser on remote condensers. On multiple systems install ball valve on each system.
7.2 If the condensing unit does not have an internal dehydrator then install properly sized dehydrator.
7.3 If there is a solenoid valve then install a ball valve at the evaporator before the solenoid valve. If there is no solenoid valve then install a ball valve before the expansion valve.
7.4 Insulate with ½” thick insulation when the line is in extremely hot area, such as hot equipment rooms and roof tops.

8 Discharge Lines
8.1 Install a ball valve at the condenser on remote condensers.
  8.1.1 On multiple systems install ball valve on each system.

8.2 When needed install vibration eliminators parallel with the compressor crank shaft. Eliminators are to be straight with no bends and to be braced on the end opposite the compressor.

8.3 Install proper “P” traps and vertical raisers whenever needed to insure proper velocity for oil return to the compressor.

9 Evacuation of the Refrigeration System
9.1 Use proper methods to assure the system is free of air, moisture, and containments.
9.2 It is required that a good high vacuum pump and vacuum gauge be used to be assured a proper vacuum level before the unit is charged.

10 Air Cooled Condensing Units and Condensers
10.1 When the unit has been properly charged, it should have the “amount and type” of refrigerant in the system posted on the equipment or close by.
  10.1.1 On units with multiple systems, post the full charge of each system.
10.2 Locate the condenser such that:
  10.2.1 Air flow to the condenser will not be blocked (i.e. not close to a wall or another piece of equipment)
  10.2.2 Air flow to the condenser will not pick up hot air from another piece of equipment or condensing unit
  10.2.3 It can be readily serviced (it should not be blocked by ducts, water lines, conduit, etc.)
  10.2.4 The cover for the control panel or the cover for the compressor is fully accessible
10.3 Install a 115 volt, 20 amp receptacle close to the unit.
10.4 If the unit is to be used in the late fall, early spring, or all year round, make sure it is set up with components for cold weather application.
10.5 Posted on each condenser unit should be the location of the associated evaporator.
10.6 On systems with thermostatic expansion valves, the superheat should be set properly so the compressor receives the proper amount of suction cooling.

11 Water Cooled Condensing Units and
PHYSICAL FACILITIES
2018 Consultant’s Handbook
Division 23 HVAC
2300 Refrigeration Systems

Condensers
11.1 When the unit has been properly charged, it should have the “amount and type” of refrigerant in the system posted on the equipment or close by.
   11.1.1 On units with multiple systems, post the full charge of each system.
11.2 The unit should be set up with “Clean-out Valves” in the water supply and discharge lines of the condenser.
   11.2.1 A water shut off valve should be installed on the water supply line before the water regulating valve. Install a “clean out” valve, with a hose connection, between the shut off and water regulating valve.
   11.2.2 A water shut off valve should be installed on the water discharge line of the condenser. Install a “clean out” valve, with a hose connection, between the shut off and condenser.
11.3 A union should be installed in the water supply line before the water regulating valve so it can be removed for repair or replaced.
11.4 The unit should be located in a position so it can be serviced. It should not be blocked by ducts, water lines, conduit, etc.
11.5 Do not block the cover for the control panel or the cover for the compressor.
11.6 Install a 115 volt, 20 amp receptacle close to the unit.
11.7 The unit should have posted on it, or nearby, the location of the associated evaporator.
11.8 On systems with thermostatic expansion valves, the superheat should be set properly by the installing contractor so the compressor receives the proper amount of suction cooling.

12 DX Package Air Conditioners & DX Chillers
12.1 Locate the unit in a way that all removable covers can be removed for service.
12.2 On DX Package Air Conditioners and Chillers with remote condensers, post the type and amount of the full charge of refrigerant in the system.
12.3 On units with multiple systems, post the full charge of each system.

13 Walk-in, Reach-in & Roll-in Freezers
13.1 For freezers that normally run at 0°F or below, install, at a minimum, the following:
   13.1.1 A suction line accumulator to help prevent “slugging back” liquid refrigerant to the compressor
   13.1.2 An expansion valve remote bulb at 4 or 8 o’clock on suction line and insulate
   13.1.3 A solenoid valves, liquid and hot-gas, outside the freezer box and in a location that can be serviced
   13.1.4 A sight glass at the condensing unit, on systems with thermostatic expansion valves
   13.1.5 A heater and insulation on evaporator drain lines
13.2 Size the expansion and solenoid valves according to the BTU of the equipment or manufacture spec.
13.3 The lighting and alarm circuits should be all separate from the condensing unit and cooling coil.
13.4 Insulate suction line with ¾” wall insulation with cut corners.
13.5 Locate the evaporator in a location that it will blow towards the entrance door.

14 Walk-in, Reach-in & Roll-in Coolers
14.1 Install expansion valve remote bulb at 4 or 8 o’clock on suction line and insulate.
14.2 Size the expansion and solenoid valves according to the BTU of the equipment or manufacture spec.
14.3 Install solenoid valves in a location so they can be serviced.
14.4 Install sight glass at the condensing unit, on systems with thermostatic expansion valves.
14.5 The lighting and alarm circuits should be on a separate circuit from the condensing unit and cooling coil.
14.6 Insulate suction line with ½” wall insulation with cut corners.
14.7 Set the super heat on the thermostatic expansion valves.
14.8 Install the evaporator in a location that it will blow towards the entrance door.

15 DX Central Air Conditioners
15.1 Locate the unit in a way that all removable covers can be removed for service.

15.2 All removable covers should not be blocked by water lines, conduit, duct work, etc.

15.3 On DX Central Air Conditioners with remote condensing units, post the type and the full charge of refrigerant in the system. On units with multiple systems, post the full charge of each system.

15.4 10 ton or larger units, install replaceable core type suction and liquid dehydrators and filters.

15.5 Install ball valves on the inlet and outlet side of the dehydrators and filters so the cores can be changed.
Date:    ______ / ______ / ______
Building:   __________________________________________________________
Room No. or Unit Location __________________________________________________________
Company Name:  __________________________________________________________
Mechanic Name (Printed): __________________________________________________________
Mechanic Signature:  __________________________________________________________

**Equipment**

Type:  __________________________________________________________
Manufacturer:  __________________________________________________________
Model:  __________________________________________________________
Serial Number:  __________________________________________________________

**Refrigerant Information**

Type:  __________________________________________________________
System A System B System C
Equip Full Charge:  __________________________________________________________
System A System B System C
Amount Added:  __________________________________________________________
System A System B System C

**Leak Locations:**

System A ________________________________________________________ _______________
   Repair actions and results:  _______________________________________________________ System B _______________________________________________________________________
   Repair actions and results:  _______________________________________________________ System C _______________________________________________________________________
   Repair actions and results:  _______________________________________________________

**Recovery Unit:**

Name:  ________________________________________________________________
Model:  ________________________________________________________________
Serial:  ________________________________________________________________

**Notes:**
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
1 General HVAC Systems

1.1 All main HVAC ductwork should be galvanized steel.

1.2 When replacing ductwork in existing systems, the new duct should be designed to be similar to the original.

1.3 The last five (5) feet of supply ducting to an air diffusion product may be flexible duct pulled taut with no elbows or changes of direction. 

Note: Research indicates that flexible duct has a much greater pressure loss that steel, especially if the flex changes direction. Thus, keep flex duct usage to a minimum and only when pulled taut.

1.4 The last take-off(s) at the end of a run of ductwork must be drawn with an elbow or will leave two duct diameters of main duct after the take-off.

Note: If the take-off at the end of a straight run of duct simply comes off the side of the duct, close to the end, there will be significant turbulence causing a static pressure loss.

1.5 All sheet metal ductwork on the finished drawings should be drawn double line.

2 Dampers

2.1 All duct run-outs to diffusers need to have a manual volume damper at the branch take-off.

2.2 On air distribution ductwork systems or segments of systems in which volume airflow is pressure dependent, install multi-blade manual volume dampers at all main branches to assist in balancing.

2.3 If the blade length on a motorized damper is more than 36” the damper should be segmented.

Note: Dampers wider than 36” will twist on the shaft affect the damper operation.

2.4 To avoid a cold length of duct that could condense causing a water problem, OA and relief dampers should be placed as close to the louver plenum as possible.

3 Louvers

3.1 All louvers should be stationary blade type constructed of extruded aluminum and have integral exterior bird screen.

Note: Combination damper/louvers have proven to be unreliable.

Note: External bird screens, though a special order, prevent birds from building a nest in the louver blades.

3.2 All louvers should be designed with a resistance to airflow less than 0.10” w.g.

3.3 Intake louvers need to be “drainable” with a gutter at the lip of each blade to prevent water from running down the face of the louver.

3.4 If the bird-screen is on the outside face the intake louver gross velocities should be 157 FPM or free area velocity should be 350 FPM.

3.5 If the bird-screen is on the inside face the intake louver gross velocities should be 100 FPM or free area velocity should be 222 FPM.

Note: The velocities in 3.4 & 3.5 are to minimize snow entrainment.

3.6 Smooth transitions (30° angle with respect to longitudinal axis) shall be used to reduce duct from louver to general distribution duct size.

Note: “Plenum boxes” do not create uniform air velocity at louver face. The plenum-box-backed louver is susceptible to "plug-holing" even if selected at a 222 FPM free area velocity (this is an average velocity over the face area). The localized area of active intake will have a much greater velocity.

4 Snow Entrainment

4.1 The first defense against snow entrainment is shielding the louver face using a hood on the exterior of the louver.

4.1.1 The hood should be enclosed on the top and sides forcing air to enter vertically up.

4.1.2 Air velocity through the opening must be <400 FPM.

4.1.3 Air velocity behind the hood must be <200 FPM
4.2 The second defense against snow entrainment is an appropriately designed inlet plenum with a snow drop-out section that is sloped to drain, either out through the louver or a floor drain.

4.2.1 To calculate \( D \) (drop-out distance) use the snow free-fall velocity of 197 fpm. With \( VG \) as the louver gross area face velocity and the variable \( H \) as the louver height, then the drop out distance \( D \) is calculated by the equation:

\[
D \text{ (feet)} = H \times (\frac{VG}{197})
\]

4.3 Following the drop out section the plenum transitions to the duct size. Transition can be no more than a 30° angle.

4.4 The total distance from the louver to the duct can be no less than two duct diameters. If rectangular ductwork is used then the total distance from the louver to the duct can be no less than two hydraulic duct diameters.
### Low pressure duct sizing table

<table>
<thead>
<tr>
<th>Type</th>
<th>Use</th>
<th>Velocity (FPM)</th>
<th>SP Loss per 100'</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>After VAV box</td>
<td>≤ 1000</td>
<td>≤ 0.08&quot;</td>
</tr>
<tr>
<td></td>
<td>From riser to VAV box</td>
<td>≤ 1800</td>
<td>≤ 0.20&quot;</td>
</tr>
<tr>
<td></td>
<td>Vertical risers and main trunks</td>
<td>≤ 2000</td>
<td>≤ 0.20&quot;</td>
</tr>
<tr>
<td></td>
<td>Mechanical rooms</td>
<td>≤ 2000</td>
<td>≤ 0.20&quot;</td>
</tr>
<tr>
<td>RA</td>
<td>Plenum inlet</td>
<td>≤ 600</td>
<td>≤ 0.04&quot;</td>
</tr>
<tr>
<td></td>
<td>Grille connection</td>
<td>≤ 600</td>
<td>≤ 0.04&quot;</td>
</tr>
<tr>
<td></td>
<td>Above occupied rooms</td>
<td>≤ 1000</td>
<td>≤ 0.08&quot;</td>
</tr>
<tr>
<td></td>
<td>Vertical risers</td>
<td>≤ 1500</td>
<td>≤ 0.1&quot;</td>
</tr>
<tr>
<td></td>
<td>Mechanical rooms</td>
<td>≤ 1800</td>
<td>≤ 0.1&quot;</td>
</tr>
<tr>
<td>OA</td>
<td>Penthouse or mechanical room</td>
<td>≤ 1000</td>
<td>≤ 0.1&quot; overall</td>
</tr>
<tr>
<td>Relief</td>
<td>Penthouse or mechanical room</td>
<td>≤ 1000</td>
<td>≤ 0.1&quot; overall</td>
</tr>
<tr>
<td>Transfer</td>
<td></td>
<td>≤ 500</td>
<td>≤ 0.04&quot;</td>
</tr>
<tr>
<td>General exhaust</td>
<td></td>
<td>≤ 1500</td>
<td>≤ 0.08&quot;</td>
</tr>
<tr>
<td>Grease &amp; Kitchen hoods</td>
<td>Between 1500 &amp; 2000</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>Wet exhaust</td>
<td></td>
<td>≤ 1500</td>
<td>≤ 0.08&quot;</td>
</tr>
<tr>
<td>Fume hoods</td>
<td></td>
<td>Between 1500 &amp; 2000</td>
<td>DNA</td>
</tr>
</tbody>
</table>
1 **Discharge Stack:**

1.1 At any location with a risk of contaminating service workers, exhausts stacks are to discharge 10'-0" min. above the roof deck.

2 **Ducts**

2.1 No exhaust duct shall have internal lining.

3 **Fans**

3.1 Fan vibration need to be isolated from the ductwork with flexible connections.

3.2 Exhaust fans need to be located as close to the point of discharge as possible.

3.3 The duct at the fan discharge of each general exhaust system must be clearly labeled as to use and rooms served.

3.4 Special design consideration shall be given to fan inlet and outlet conditions to prevent excess energy consumption due to an unnecessarily high system effect factor as outlined in AMCA 201-02 (R2007).

4 **Filters**

4.1 If exhaust filtration is required the filter media must be in racks or frames and fully accessible.

5 **Restroom Exhaust**

5.1 Exhaust systems must be controlled by the campus BAS system.

5.2 Restrooms shall be exhausted from a source or sources opposite the air supplied into the space to avoid short-circuiting ventilation air from the breathable zone.

5.3 Follow the ASHRAE guidelines for air flow quantities.

6 **Shower Room Exhaust**

6.1 Install exhaust grilles above each shower stall, in shower rooms with multiple shower stalls that are divided from each other by at least one solid wall from floor to ceiling.

**Note:** local shower exhaust increases ventilation effectiveness and avoids moisture and condensation build up.
1 Filtration Media

1.1 The filter media should have a ‘tackifier’, dust holding agent, applied to the surface.

1.2 The final filter media should contain a fiber-bound anti-microbial agent, either a biocide or a biostatic.

2 Air Handling Unit Filters

2.1 Design filters to be either 24”x24” or 24x12” in face dimensions.

Note: The goal is to simplify filter replacement and avoid having boxes of odd sized filters lying around the mechanical rooms.

2.2 All filter racks must be designed to hold both a pre-filter and a final filter and be fully gasketed and sealed around the entire perimeter of each filter.

2.3 For units less than 60” tall, filter racks can have side access allowing the filters to be removed through the access door.

Note: The designer should verify that the ‘slide-in’ tray is sized to hold the specified filter.

2.4 For units more than 60” tall, filter racks should be ‘front loading’ with a securing system allowing the filters to be removed individually by a worker inside the unit.

2.5 All filter housings need a factory installed 0.0” to 2.0” magnehelic differential pressure gauge.

Note: This allows for quick visual confirmation of the pressure drop.

3 MERV Rating

3.1 MERV 6 pre-filter (when used)

3.2 MERV 13 main filter
1 Chilled Water Use

1.1 Where possible we use chilled water supply as the heat transfer media for water-cooled condensing units.

Note: Many refrigeration systems are designed with 55°F as the condensing media temperature and have operational problems at lower temperatures. The designer should verify that the refrigeration system can work properly using 45°F chilled water as the cooling media.

1.2 Install a solenoid isolation valve interlocked with the condenser/compressor energization to make sure flow is stopped when the unit is off.

2 Potable Water Back-Up

2.1 Potable water back-up is not typically provided.

2.2 When back-up is required use a plate and frame heat exchanger to separate the potable water from the equipment. This requires the equipment side of the exchanger to be pumped.

Note: The goal is to provide a definite separation between the potable and the chilled water to remove any possibility of cross contamination.

3 Potable Water Use

3.1 Where chilled water is not available potable water may be used to cool condensing units if specifically approved by Purdue Engineering. Such use is strongly discouraged.

3.2 When this is done try to run the water discharge to a storm drain and install a water meter so the flow can be deducted from the main sewer bill.
1 Design Coordination

1.1 Coordinate carefully between the mechanical and electrical designers so as to provide electrical service to this equipment.

Note: It is a common complaint that the mechanical and electrical work on a project is poorly coordinated. An example of this is VFDs: whether it is to be specified and supplied by the mechanical but installed by the electrical or specified by the mechanical but supplied and installed by the electrical.

1.2 Dimension the unit on the drawings in both the plan and elevation views showing the required clearances and access.

Note: The goal is to show that the AHU can fit in place and is no larger than designed. The windows must be placed at eye level while standing on the floor (e.g. Nano penthouse where one has to stand on a plastic 5 gallon bucket to look in the windows)

1.3 Dimension the location of cooling coil condensate discharge and trap. This detail must show that the coil supports and base rails are tall enough to allow for the condensate trap.

Note: When this detail is missed then we have had to core drill a hole in the floor to allow the trap to be installed (e.g. Morgan Burke basement).

1.4 Dimension the location of steam entrance and steam condensate discharge (when steam coils are used), including the traps and controls valves shown to scale with necessary maintenance access.

Note: When this detail is missed we have had to install traps in front of access doors (e.g. Windsor Dining penthouse).

2 Casing construction

2.1 Drain pans

2.1.1 Drain pan sheet metal should be “double broke” to ensure complete drainage.

2.1.2 The distance the drain pans extend past the face of the cooling coil should comply with the latest edition of ASHRAE 62.1. That distance should be at least 24”.

Note: Some manufacturers have this distance so little that water is regularly carried over past the drain pan.

2.1.3 Drain pans shall be fabricated of 16 gauge 304 stainless steel.

Note: This is to ensure that the drain pan is strong enough to be walked on.

2.1.4 Drain outlet should extend to the exterior of the casing.

Note: Some manufacturers do not extend the pipe to the exterior of the unit unless specifically specified.

2.1.5 If on the side of the drain pan the pipe invert is to be mounted below the bottom of the drain pan.

2.2 Unit penetrations:

2.2.1 Penetrations such as pipe, damper rods, etc. through cabinet should be made in the factory.

Exception: The hole for the steam condensate is frequently made in the field.

Note: The goal is to minimize the number of field drilled holes in the new air handlers. Some of those holes have been excessively large and poorly cut.

3 Fans

3.1 Mounting

3.1.1 Fans to be internally mounted with factory sized deflection springs isolated on structural steel base. Fan and motor assembly shall be internally isolated from unit casing with spring isolators furnished and installed by unit manufacturer.

3.1.2 Fan shall be attached to the unit casing through a flexible duct connection.

3.1.3 AHUs with single fans shall have the fan located and dimensioned, in both the horizontal and the vertical direction, so as not restrict air flow by the walls, ceiling, or floor.

3.1.4 AHUs with multiple fan units shall have a means of preventing backflow in the event of a fan failure.

3.1.4.1 In AHUs serving areas deemed ‘critical’ this must be done in a manner that does not add ‘system effect’ static pressure to the fans.

Note: Simply adding backdraft or automatic dampers will greatly reduce the efficiency of the fan.

3.1.4.2 In AHUs serving areas not deemed ‘critical’ this may be done in a manually applied method.

3.2 Fan Bearings

Note: The fan bearings should be designed for HVAC applications and that the lubrication schedule is considered. We have had some fans delivered with a ridiculously short recommended lubrication schedule. Do not allow poly lubrication lines.
3.2.1 Bearings to be pillow block ball bearings with a rating of 200,000 hour L-10.

3.2.2 Where lubrication lines are required lubrication lines should be metal (not poly tube) and the fitting is to be within sight of the greased bearing.

3.2.3 Bearings recommend lubrication interval schedule should be listed on the submittals and shall be no more frequent than every three months.

**Note:** Some manufacturers use bearings as a value engineering item and have provided bearings with a required service schedule as frequently as weekly.

3.3 Fan Motors

3.3.1 Fan motors are to have a grounded shaft designed for VFD operation.

3.3.2 Fan motor bearings for direct drive fans to be HVAC grade as described earlier in this guideline.

3.4 Fan Guard and Belt Guard

3.4.1 All systems shall provide maintenance staff protection by fan and belt guards.

3.4.2 Recommended belt guard construction is using 0.1046 inch (2.7 mm) thick, 0.75 inch (20 mm) diamond mesh wire screen welded to steel angle frame or equivalent; prime and finish coated, and shall conform to the shape of the assembly.

3.4.3 The belts must be able to be seen through the guard with the guard in place.

3.4.4 Belt guard will have tachometer opening.

3.4.5 Belt and fan guards shall be easily removable.

**Note:** Though this sounds like an obvious statement many factory manufactured belt guards have proven to be difficult to both see through and remove.

3.5 Return and Relief Fans

3.5.1 Design systems using return fans avoiding relief fans to the extent possible.

**Note:** Fans in the relief position are significantly harder to control than fans in the return position. To a large degree this is due to the range. In the return position the RA fan range is similar to that of the SA fan minus the building exhaust. When in the relief position the fan range must vary from the minimum OA to full flow during economizer (minus building exhaust). Such a range is difficult for both the fan and the motor.

3.5.2 Mount the return fan separately from the AHU, not in the same casing.

**Note:** The positive static pressure at the return fan discharge is one of the highest pressures in the entire system; similarly, the negative static pressure in the mixing chamber is about the lowest. When the two fans are mounted close together the control dampers between the return fan discharge and the mixing chamber must control accurately from 0% to 100% flow against a large and unstable differential pressure. Experience has shown that this is problematic. An example of this is occurred in Armstrong in August of 2011. Human error caused both the relief and return dampers to close while the fan was running. The result can be seen in the following photographs where the fan static pressure blew the damper out of the wall.

4 Motor Removal

4.1 For motors 15 Hp and larger provide a motor removal rail.
4.1.1 The removal rail shall be mounted in fan section, directly over motor, perpendicular to the side of the AHU.

4.1.2 The removal rail will be designed with roller so the motor can be fully removed from the air handler, to a distance the motor diameter plus a minimum of 6”, and lowered onto a dolly with the traversing arm able to freely move while carrying the motor weight.

4.2 Motor and largest component must be able to be removed through the access door or an easily removable panel. For roof-top units this may be done through the back wall of the unit.

5 Coil Sections

5.1 All pipe connections, including drains and vents, shall extend beyond the exterior of the unit.

5.2 Cooling coil piping shall be factory insulated through the AHU wall. Insulation shall be sealed so no condensation can leak into the wall of the AHU.

5.3 Cooling coil headers shall be located above the drain pan.

Note: Not having the header above the drain pan has, in the past, caused condensation damage.

5.4 Stacked coil racks and guides shall be designed for the individual removal of all coils. The full weight of each coil is to be carried by the coil rack during coil removal. Stacked coils must be able to be removed individually, such that the removal of the lower coils will not affect the upper coils.

5.5 All chilled water piping internal to the AHU shall be fully primed and painted.

Note: When these pipes are only primed and not painted premature corrosion has resulted.

6 Dampers and Controls

6.1 To facilitate damper motor installation damper shafts must extend 4” minimum beyond external casing wall.

6.2 Actuators are to be attached outside the unit not installed in the air stream.

Note: Unless specifically addressed actuators can be located in the air stream causing problems when those actuators require maintenance. This has occurred even in chemical exhaust systems so the staff must ‘suit up’ just to adjust the damper motor.

7 Access Doors

7.1 Access door performance shall be comparable to the wall panels.

7.2 Access doors shall be provided for all compartments.

7.3 Latch handles shall be operable from both inside and outside.

7.4 In general, doors shall open against the air pressure. If the door cannot open against the pressure then integral safety catches must be provided.

8 Electrical

8.1 Each accessible section shall be provided with interior light, 48” vapor proof where possible. If the unit is wider than 72” then install two 48” fixtures in fan section.

8.2 Lights shall have a common 60 minute wind-up / or solid state mechanical timer light switch or other means to prevent the lights being on unnecessarily.

8.3 Each unit to have at least one GFI receptacle on the outside AHU surface.

8.4 All lights and receptacles are to be wired to a single junction box. All wiring inside the air handler is to be run through “rain tight” EMT or “seal tight” flexible conduit.

8.5 All conduit connected to the AHU is to be isolated to prevent transmission of vibration.

9 UV Lights

9.1 UV lights will be installed as directed in the program.

9.2 When UV lights are not required in the program then provision will be shown in the design and submittals for future installation.

10 Rooftop Units

10.1 In addition to the foregoing rooftop units should meet the following requirements.

10.2 Unit will have a separate sloped roof designed for a snow load of 30 psf with a deflection of no more than L/240.

10.3 Units will have a minimum 8’-0” wide service vestibule.

10.3.1 Service vestibules need to have minimum 1½” drains. Plans and submittals to show that drains have freeze protection.
Note: It is inevitable that water will eventually leak in the vestibule and it must be drained.

10.3.2 Service vestibules may have a removable grated floor. If the unit does not have a grated floor, provide access for all traps.

Note: Vestibule steam traps are typically located under the vestibule floor. Many manufacturers have not adequately thought through access to those traps.

10.3.3 Manufacturer shall supply structural steel supports for piping and other hanging equipment located in the vestibule. This must be at least 2x2x1/4 square tube risers with “H” beams 6'-0” O.C.

Note: Many manufacturers supply a vestibule that is not robust enough to support the interior piping, causing significant problems during construction and resulting in a vestibule with reduced free access.
1 Hydronic Coils

1.1 Information applicable to all hydronic coils:
- Pipe connections are to be non-ferrous, e.g. red brass
- Tube wall thickness ≥ 0.025"
- Fin thickness ≥ 0.0095"
- Water Velocity ≥ 2.5 and ≤ 5 fps
- WPD ≤ 10''
- APD ≤ 1.00''
- ½" valved vent and ½" valved drain on the outside of the unit.

Notes: Some manufacturers use steel connections which can cause an electrolysis problem when connecting to a system with predominately copper pipe.

Some manufacturers use thinner walled tube. This causes a problem at the bends where the pipe is pulled (stretched) thinner on the outside. That is the point of the most erosion and causes premature failure.

Some manufacturers use thinner fins that are damaged easily.

Higher water velocities aggravate erosion.

Some manufacturers have vent and drain connections that are too small to be of any practical use.

1.2 Information specific to hydronic cooling coils
- Average face velocity ≤ 450 FPM
- ΔT ≥ 18°F (45°F to 63°F)
- Casing to be stainless steel ≥ 18 ga.

Note: Early research established 500 FPM as the velocity below which there is no moisture carryover. The problem is that designing for an average of 500 FPM means there will likely be areas of high velocity somewhere on the coil face causing moisture carry over. Simply lowering the average face velocity to 450 removes this possibility and provides a second benefit of significantly reducing pressure drop.

2 Steam Distributing Coils

2.1 Steam heat and reheat coils may be horizontal tube.

2.2 Steam preheat coils are vertical tube, steam distributing type, in the draw through configuration with top steam and bottom condensate header. Both steam and condensate headers are to be out of the air stream.

2.3 Information applicable to steam coils:
- Pipe connections are to be steel
- Casing to be galvanized steel ≥ 18 ga.
- Tube wall thickness ≥ 0.035"
- Inner tube diameter 5/8” OD
- Outer tube diameter 1” OD
- Fin thickness ≥ 0.0095"
- APD ≤ 0.50"

2.4 Stream preheat coils shall not be Internal Face and Bypass type.

Note: Though popular with designers IFB coils have a limited life span, with linkages prematurely binding. IFB coils also require extra length to ensure adequate mixing.

3 Cooling Coil Freeze Protection

3.1 The simplest and most reliable is to place the preheat coil and the chilled water coil on opposite sides of a plenum fan. In this way the fan is used for thorough mixing.

Note: Though plenum (aka plug) fans may be slightly less efficient than other fan types, being able to reduce the overall static pressure by a simpler pre-heat coil arrangement with no air mixers has proven to be advantageous.

3.2 A second method is to install a small circulating pump on the water coil. The pump is off and out of the water flow during the summer. In the winter the pump is turned on. The normal LWT sensor monitors the leaving water temperature. If the LWT falls below 35°F then the chilled water control valve opens.

3.3 The third method is to install two back to back, independently controlled preheat coils. The first one heats the air 20°F. Thus anytime the OA is below freezing this coil is wide open. The second coil heats the air 45°F.
1 In Classrooms
1.1 FCUs and unit ventilators are to be avoided in classrooms.  
Note: FCU & Unit Ventilators are not rugged and in a few years will 'shake rattle and roll' with an objectionable noise level.

1.1.1 When they must be used in classrooms, unit ventilators should be oversized so as to run on medium speed.

2 Fan Coil Unit Use
2.1 In general FCUs are to be avoided and used only where an FCU is the reasonable choice.  
Note: FCUs age quickly. In a few years they are a high maintenance item that looks worn.

2.2 FCUs must be designed as a four pipe unit with separate heating and cooling coils.

2.2.1 To aid in dehumidification consider placing the heating coil in the reheat position.

2.2.2 Exercise caution in the placement of FCUs to avoid excessive noise levels and ensure adequate accessibility for maintenance.  
Note: Maintenance staff must be able to get access the control valves, motor drive and filters. This is especially true for units overhead where the maintenance is performed on a ladder.

2.3 Do not bring un-tempered OA directly through an FCU or Unit Ventilator unless the mixing is performed in the RA ductwork far enough away and with at least two elbows to ensure proper mixing and avoid cold air stratification.

3 Chilled Water Coils
3.1 When dehumidification is not part of the operation then the chilled water coil should have a minimum of four rows.

3.2 When dehumidification is part of the operation then the chilled water coil should have a minimum six rows.

3.3 Size coils for Entering Water Temperature of 45°F

3.4 Size coils for Maximum Water Pressure Drop of 10 Ft. Head

3.5 Two-position (not be confused with two-way) chilled water control valves shall not be used unless specific application reviewed and approved by Purdue Engineering.  
Note: Two-position (on/off) valves cause unwarranted chilled water consumption through buildings accompanied with low chilled water return temperature.
1  Power busway testing procedure

1.1 Visually inspect each joint stack of the busway run for proper alignment.

1.2 Establish the busway method of grounding

1.2.1 New busways typically have a case ground but may have a ground bus in some cases

1.2.2 Existing systems that are being repaired or extended may have a ground bus bar or case ground

1.2.3 If the busway has a case ground perform the check listed below for the ground bus bar

1.3 Isolate each bus bar at both ends of the busway run including ground and neutral

1.3.1 Verify that there is complete separation of each phase, neutral and ground bus bar

1.4 Perform a continuity check for each phase, neutral and ground bus bar as follows:

1.4.1 Route an insulated wire from one end of the bus run to the other

1.4.2 Test each phase, neutral and ground bus bar one at a time and using the wire to complete the circuit

1.4.3 Check for continuity of each phase, neutral and ground bus bar

1.4.4 Verify no continuity to each of the following:

1.4.4.1 The remaining phase bus bars

1.4.4.2 The neutral bus bar

1.4.4.3 The ground bus bar

1.4.5 Example:

1.4.5.1 Secure the insulated test wire to Phase “A” at the end of the busway (opposite the test end)

1.4.5.2 Check for continuity on Phase “A” between the end of the same insulated wire and Phase “A” bus bar at the test end of the bus

1.4.5.3 Then verify no continuity between the end of the insulated wire and Phase “B”, Phase “C”, Neutral, and Ground bus bar

1.4.5.4 Note for busway with a ground bus bar:

1.5 After continuity has been verified for each phase, neutral and ground bus bar, terminate the ground bus at each end of the busway run. Make sure the ground bus bar is bonded to the equipment ground bus in the appropriate switchgear.

1.6 Verify continuity between the busway ground bus bar and the building system ground.

1.7 Verify continuity between the busway ground bus bar and the equipment ground bus in the appropriate switchgear.

1.8 Verify continuity between the busway ground bus bar if there is one and the busway case.

1.9 Perform a Megger test (insulation resistance test)

1.9.1 Between each phase and neutral bus bar to the ground bus terminal

1.9.2 Between each opposite phase

1.9.3 Perform Test at 1,000 VDC and record the readings

1.9.4 Example of Megger test:
- “A” Phase to – Ground
- “A” Phase to – Neutral
- “A” Phase to – Phase “B”
- “A” Phase to – Phase “C”
- Repeat for “B” and “C” phases

1.10 Reconnect each bus bar at both ends of the busway run including neutral.

1.11 Install all covers

2  Infrared Scan

2.1 At project substantial completion perform an infrared scan of the following equipment

2.1.1 Switchboards

2.1.2 Panelboards

2.1.3 Motor Control Centers

2.1.4 Transformers

2.2 Remove panels so joints and connections are accessible.

2.3 Prepare test and inspection report. Include notation of deficiencies and remedial actions taken.
1 Basic Electrical Requirements
1.1 All electrical systems shall be designed and specified as “fully-rated” systems. “Series-rated” systems are not acceptable.

2 Arc Flash, Short Circuit and Interrupting Rating Study Requirements
2.1 A complete Arc Flash, Short Circuit and Interrupting Rating Study for the electrical distribution system may or may not be required for the project. Refer to the A/E’s RFP for the project to verify the requirements for Project Studies.
2.2 Where an Arc Flash, Short Circuit and Interrupting Rating Study is not included in the A/E’s RFP as described above, the following shall be provided
   2.2.1 A system short circuit study, as required to determine the appropriate ratings to be included in the project specifications for new equipment
   2.2.2 An overcurrent protective device (OCPD) coordination study and interrupting rating study of the electrical system and recommended OCPD settings for the same.
   2.2.3 A preliminary calculation and report is required at the Design Development stage to review with specifications.
   2.2.4 A final report is due upon design completion which includes specified short circuit ratings for new equipment.
2.3 The information listed above shall be used to evaluate the short circuit and interrupting ratings of all switchboard and panelboard submittals to ensure all equipment is properly rated.

3 Data Gathering by Electrical Contractor
(Note: Also refer to Section 26-0573 Arc Flash Study Specification.
3.1 Include the following scope of work in the specifications to be performed by the E.C.
   3.1.1 E.C. shall provide documentation showing exact feeder lengths for all new feeders. Include conductor type and size as well as insulation type.
   3.1.2 E.C. shall provide and Install the Arc Flash labels

4 Organization of Drawings
4.1 Electrical has the discipline specific letter “E”
   4.1.1 Do not put electrical systems on T sheets
   4.1.2 Do not put Telecommunications systems on E sheets
   4.1.3 Number demolition drawings in series 000 -099
   4.1.4 Number Fire Alarm drawings in series 700 -799
   4.1.5 Number Card Access drawings in series 700 -799
   4.1.6 Number Security drawings in series 700 -799
   4.1.7 Number Audio Visual drawings in series 700 -799
   4.1.8 Number Other Special Electrical System drawings in series 700 -799

5 Demolition
5.1 Wire Removal
   5.1.1 When removing existing wiring devices the existing conductors are to be removed back to panel of origin or to the nearest junction box containing circuits and conductors that are to remain.
5.2 Through the Floor Conduit Removal
   5.2.1 When removing existing conduit cut off conduits below finished floor and patch opening.
5.3 J-Box Accessibility
   5.3.1 When an outlet or junction box becomes inaccessible for any reason (i.e. new lab benches or cabinets) the junction box must be relocated and all associated conduit and wiring modified and re-routed as required, to maintain accessibility.
5.4 Equipment Grounding
5.4.1 Specify all new equipment to be equipped with grounding provisions per current NEC requirements.

5.4.2 Many of the older existing branch circuit panels will not have an equipment ground bus for termination of equipment grounding conductors.

5.4.2.1 For each existing (and new) panel used to service or re-service any new or existing equipment respectively, provide and install an equipment ground bus in the branch circuit panel in question as required for termination of the equipment grounding conductors.

5.4.2.2 Provide a grounding bushing on the existing feeder conduit and route a new equipment grounding conductor from the grounding bushing to the new equipment ground bus.

5.5 Reuse of Existing Conduits:

5.5.1 Certain buildings do not have room for new surface mounted conduits or wire mold raceway. When directed to do so by the PM you can re-use existing conduit runs for installing new conductors within the following guidelines:

5.5.1.1 For home runs remove all the conductors in the existing conduits between a designated existing device and its panel of origin.

5.5.1.2 For conductors installed in conduits that branch off from the home run conduit the conductors need to be removed only to the first existing termination. (Termination is defined as a conductor splice or termination to existing device.)

5.5.1.3 Removed conductors must be replaced with all new conductors.

5.5.1.4 All new conductor runs must include a new equipment-grounding conductor. Pull the equipment-grounding conductor all the way to original receptacle outlet box. The new equipment-grounding conductor shall be used in conjunction with the original circuits and their replacement devices as well as any new circuits.

5.6 Supporting of Reused Conduit:

5.6.1 The contract documents need to clearly state that when existing conduits are reused, it is the responsibility of the E.C. to re-support that conduit as required per the NEC and project specifications. It should also caution the E.C. that any existing conduit or cabling relying on the present ceiling support system must be re-supported per the current NEC. This becomes especially important when suspended ceilings are removed during construction only to discover that the entire existing conduit was supported from the ceiling support iron (black iron) itself. The conduit in question must then be re-installed and re-supported as required even if it is not related to the ongoing project.

5.7 Replacement of Existing Devices:

5.7.1 When one device (receptacles, switches, etc.) is being replaced it may also be necessary to replace other devices on the same circuit. This first device is called the ‘device in question’ below. Replace other existing devices when either of the following conditions is met:

5.7.1.1 The device is located in the conduit run between the device in question and its panel of origin.

5.7.1.2 The device is located in a conduit run that branches off from the home run conduit between the panel and the device in question and is located in the same outlet box as the device described in paragraph 5.7.1.1.

5.7.2 Do not replace existing devices when either of the following conditions is met:

5.7.2.1 The device is served from the original home run circuit in question and located beyond the device in question.

5.7.2.2 The device is located in a conduit run that branches off from the home run conduit between the panel and the device in question and is located beyond the outlet box.

6 Service Continuity

6.1 Inconveniences to Occupants

6.1.1 Power interruptions must be properly coordinated to reduce inconvenience to the normal building activity to a minimum.

6.2 Interruption Arrangements

6.2.1 Arrangements for interruption of electrical service to University areas must be made in writing with the Project Manager at least one week before the proposed interruptions.

6.3 Interruption Hours

6.3.1 Interruptions of service in areas where University personnel are working will be made between the hours of 11:00 P.M. and 6:00
A.M. unless approved by Project Manager.

6.4 Continuity

6.4.1 Service continuity to existing equipment needs to be addressed with text similar to the following:

**Note:** Maintain service continuity to all existing loads that are to remain by modifying and/or extending conduit and wiring as required. Field verification of existing conduit runs and circuitry is to be done as required. This is applicable to receptacles, overhead power drops, disconnects, lighting, and wiring to fume hoods and mechanical equipment.

7 Panel Naming Convention for Switchboards and Panelboards

7.1 The panel designation can be up to five designators, the first three separated by a hyphen and the remaining designators separated by a decimal point.

7.2 Table for Position One

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Distribution Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICB</td>
<td>Isolation Circuit Breaker</td>
</tr>
<tr>
<td>MD</td>
<td>Main Distribution</td>
</tr>
<tr>
<td>SD</td>
<td>Sub Distribution</td>
</tr>
<tr>
<td>P</td>
<td>Branch Circuit</td>
</tr>
<tr>
<td>MCC</td>
<td>Motor Control Center</td>
</tr>
<tr>
<td>BD</td>
<td>Bus Duct</td>
</tr>
<tr>
<td>ATS</td>
<td>Automatic Transfer Switch</td>
</tr>
</tbody>
</table>

7.3 Table for Position Two

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Distribution Source or Transformer Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Power</td>
</tr>
<tr>
<td>L</td>
<td>Light</td>
</tr>
<tr>
<td>EQ</td>
<td>Equipment</td>
</tr>
<tr>
<td>P:P1</td>
<td>For Dry Type Transformer</td>
</tr>
<tr>
<td>P:L1</td>
<td>For Dry Type Transformer</td>
</tr>
<tr>
<td>G</td>
<td>Generator</td>
</tr>
<tr>
<td>EM</td>
<td>Emergency</td>
</tr>
<tr>
<td>LR</td>
<td>Legally required Standby</td>
</tr>
<tr>
<td>OP</td>
<td>Optional Standby</td>
</tr>
</tbody>
</table>

7.4 Table for Position Three

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Building Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>Sub-Basement</td>
</tr>
<tr>
<td>B</td>
<td>Basement</td>
</tr>
<tr>
<td>G</td>
<td>Ground</td>
</tr>
<tr>
<td>1</td>
<td>First</td>
</tr>
<tr>
<td>2</td>
<td>Second</td>
</tr>
</tbody>
</table>

7.5 Table for Position Four

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Sequential Panel Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>First Panel</td>
</tr>
<tr>
<td>2</td>
<td>Second Panel</td>
</tr>
<tr>
<td>3</td>
<td>Third Panel</td>
</tr>
<tr>
<td>4</td>
<td>Fourth Panel</td>
</tr>
</tbody>
</table>

7.6 Table for Position Five

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Sequential Sub-Panel Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>First Sub-Fed Panel (from another panel)</td>
</tr>
</tbody>
</table>

**Examples**

SD-L-B.2  Lighting Sub-Distribution Panel No. 2, located in Basement

MD-P-SB.1  Main Power Distribution Panel No. 1, located in Sub-Basement.
1 General
1.1 All conductors shall be of copper material continuous from outlet to outlet.
1.2 Conductors #8 AWG and larger shall be stranded.
1.3 Conductors smaller than #8 shall be either all solid or all stranded (not mixed.)
1.4 Do not allow use of salvaged conductors.
1.5 No material shall be installed that is corrosive, breeds or sustains mold growth, is moisture absorbing or whose properties exceed the following:
   - Flame spread - 25 Max
   - Smoked developed - 50 Max
   - Fuel contributed - 50 Max
1.6 Conductor Color Code
1.6.1 For existing construction color coding should be consistent with the system already installed
1.6.2 For new construction color coding shall be as shown in the table below:

<table>
<thead>
<tr>
<th>Item</th>
<th>120/208</th>
<th>277/480</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A</td>
<td>Black</td>
<td>Brown</td>
</tr>
<tr>
<td>Phase B</td>
<td>Red</td>
<td>Orange</td>
</tr>
<tr>
<td>Phase C</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>“A” phase neutral</td>
<td>White with a black tracer</td>
<td>Gray with brown tracer</td>
</tr>
<tr>
<td>“B” phase neutral</td>
<td>White with red tracer</td>
<td>Gray with orange tracer</td>
</tr>
<tr>
<td>“C” phase neutral</td>
<td>White with blue tracer</td>
<td>Gray with yellow tracer</td>
</tr>
<tr>
<td>Shared neutral</td>
<td>White with No tracer</td>
<td>Gray with No tracer</td>
</tr>
<tr>
<td>Switch leg return</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Three and four way “travelers”</td>
<td>Orange</td>
<td>Orange</td>
</tr>
<tr>
<td>Mechanical or equipment ground only</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>
1.7 Colors to be continuous through the insulation and from end to end. Field marking is not acceptable.

2 Conductors
2.1 None shall be smaller than #12, except #14 for motor control, #16 stranded for annunciator wiring and #18 TFFN solid for fixture wiring (ballast to socket).
2.2 Where required by enclosure size, terminal space, etc., provide stranded wiring for temperature control wiring, interlocks, etc.
2.3 Low voltage ballast control wiring may be #16 TFFN

3 Wire Types
3.1 #16 annunciator circuits only
3.1.1 Type TFF, TFFN, THHN, Stranded
3.2 #14 and larger for general use
3.2.1 Type THW, THHN/THWN, XHHW, THW-2, THWN-2, XHHW-2.
3.3 #14 for flexible connections and pendants to fixtures only
3.3.1 Stranded
3.3.2 For fluorescent fixtures or fixtures labeled not to exceed 90°C use type TFFN or equal.
3.3.3 For fixtures labeled not to exceed 105°C use a 105°C type THWN, THHN, MTW “trip-rated” wire or an approved equal.
3.3.4 For incandescent fixtures and/or high intensity discharge light fixtures not to exceed 150°C and other approved applications requiring high temperature insulation use a 150°C Type SFF-2 or equal.
3.4 #14 thru #3 AWG, 75°C wet locations
3.4.1 Type XHHW (or XHHW-2) or with neoprene jacket to be used below slabs, service entrances and exterior underground work, including campus site lighting (all installations in conduit).
3.5 #3 AWG or larger, where underground (in conduit).
3.5.1 Type XHHW or XHHW-2.
3.6 Direct bury cable installed underground (only when approved by Purdue Engineering) to be XHHW or XHHW-2.

4 Branch Circuit Conductors
4.1 Each 120V circuit of a 120/240V, 1PH, 3W system shall have its own 100% neutral.
4.2 Each 120V circuit of a 120/240V, 3PH, 4W system shall have its own 100% neutral.
4.3 Each 120V circuit of a 120/208V, 3PH, 4W system shall have its own 100% neutral.
4.4 Each 277V circuit of a 480/277V, 3PH, 4W system shall have its own 100% neutral.
4.5 When more than one neutral is in a common raceway, junction box, etc. each neutral shall be clearly identified with its associated phase conductor.
4.6 Each branch circuit conduit shall contain a separate green equipment grounding conductor sized per NEC.

5 Conductor Joints and Connections

5.1 In general #10 AWG and smaller conductor joints shall be made using “Scotchlock”, “Wire nut” or equal (copper sleeves are not acceptable).
5.2 Fluorescent Lights: Wiring connections within fluorescent fixture channel, #12AWG wire to #18AWG ballast wire, may be made using Kleinhuis “P-NUT” push-on butt connector, Cat. #2003/2.5/3 (stranded wire must be tinned prior to installation) or vinyl covered spring devices, “Scotchlock”, “Wire nut”, installed per manufacturer’s recommendations, or approved equal.
5.3 Motors (480V or less): For #10 AWG and smaller conductors - provide taped connector eye lug of motor lead to looped input conductors, using machine bolt/nut arrangement to facilitate rapid disconnecting.
5.4 All other connections in fixtures shall be made using vinyl covered spring device, “Scotchlock”, “Wire nut”, installed per manufacturer’s recommendations or an approved equal.
5.5 Connections under screw head terminals; solid conductors shall have formed eyes, stranded conductors shall have an approved nylon compression terminal as T & B “Sta-Kon” or approved equal.
5.6 Connection on receptacles can be back wired if receptacle is provided with a screw and clamp feature.

6 Tape for 600 Volt Insulated Conductors

6.1 Normal temperature installations use Scotch #33, 88.
6.2 For wet locations use self-vulcanizing rubber insulating tape equal to Scotch #2210 with vinyl tape outer coat.
1 General
1.1 All grounding conductors shall be insulated and enclosed in a raceway.
1.2 All ground conductors shall be “GREEN”.
1.3 The use of bare conductors is not permissible except where located in building footings, or specified in Job Scope.

2 Feeder Conduits
2.1 Provide a separate, insulated, “GREEN”, grounding conductor in each feeder conduit. Bond conductor to each end of enclosing metal raceway.

3 Branch Circuit Conduits
3.1 Provide a separate, insulated “GREEN”, grounding conductor in each branch circuit conduit.

4 Bus Duct
4.1 All bus duct flange ends (when cable connected) shall have a properly sized ground bar with lug (as required) for bonding to the equipment ground bus in switchboards as well as to “XO” in the power transformer throat.

5 Panelboards
5.1 All panel boards and switchboards shall have an equipment grounding bus.

6 Separately Derived Systems
6.1 Separately derived systems shall be grounded per NEC
6.2 Where a neutral conductor is derived a grounding electrode conductor shall be routed to one of the following:
   6.2.1 The building grounding electrode system bus bar
   6.2.2 A common electrode grounding conductor designed as described in 2008 NEC 250.30(A)(4) for such applications shall be provided in each electrical room containing sub-distribution level equipment. Review proposed locations with Purdue Engineering.
   6.2.3 The nearest available effectively grounded structural member
6.2.4 Metal water pipe grounding electrode as specified in 2008 NEC 250.30(A)(1).
Note: This grounding method must be approved by Purdue on a case by case basis.

7 Grounding Electrode System
7.1 Within the building main electrical room, install a copper bus bar, 1/4 by 4 inches of sufficient length (two feet minimum) to act as the grounding electrode system termination point for all grounding electrodes as described in NEC 250.52 A. The bus bar shall be capable of accepting NEMA 2-hole pattern lugs. This bus bar shall be called the building grounding electrode system bus bar. Each conductor terminated thereon shall have a label affixed to it identifying the conductor’s opposite end (i.e. Ufer ground).
7.2 All terminations shall be by exothermic welding “Cadweld”.
7.3 Ground rods shall be ten feet in length by ¾” diameter.

8 Transformers serving buildings on main campus
8.1 Transformers serving the buildings of the main campus are considered to be separately derived systems. The bonding of the neutral will take place at the transformer only.
8.2 An equipment (supply side) bonding jumper will be routed from the XO of the building transformer to the ground bar of the first building disconnecting means. This conductor will be continuous and one piece of wire with no intermediary splices.
8.3 Size to be based on NEC or 12.5 percent of the largest phase conductor, whichever is larger.

9 Building grounding
9.1 At the A/E’s discretion, buildings shall be encircled with an appropriately sized (per NEC) bare, stranded copper conductor.
9.1.1 Conductor shall be buried outside the building foundation and below possible frost line.
9.1.2 A (10’) ten-foot copper-weld ground rod shall be installed at each corner and at 100 to 150 foot intervals along building walls.
9.1.3 The ground loop shall be connected to the main building-grounding electrode.

9.2 All grounds shall be bonded to the ground loop. The ground loop shall be connected to the main building-grounding electrode.

9.3 All exposed building columns shall be bonded to this ground loop.

9.4 Concealed building columns shall be grounded at 50 to 75 foot intervals around building.

9.5 All connections of grounding conductors to columns, ground rods, etc., shall be by exothermic welding “Cadweld” or approved for the purpose mechanical crimp splices.

10 Ufer Grounding

10.1 Ufer grounding systems shall be per NEC Article 250 Section III. The foundation rebar shall be connected to the building column and the ground loop. The ground loop shall be connected to the main building-grounding electrode. All connections of grounding conductors to columns, foundation rebar, other ground conductors etc., shall be by exothermic welding “Cadweld”.

10.2 An external electrode shall always be present to prevent foundation damage that can result from high fault currents.

11 Triad and other ground rod arrangements

11.1 Where two or more ground rods are installed, spacing shall be a minimum of twice the rod length between any two adjacent ground rods.
1 Conduit Supports & Hangers

1.1 Support maximum separation is 8’ for conduits ¾” and smaller.
1.2 Supports for suspended conduits shall be from galvanized all-thread steel rods, ¼” minimum size.

2 Requirements for Inserts and Anchors

2.1 When hanging from concrete care must be taken not to weaken the concrete by holes in the wrong location or hangers that can pull out.
2.2 Hanger rod clips or devices shall:
    - be fastened to the sides of joists or beams
    - use expansion, adhesive or screw in anchors installed in strict accordance with the manufacturer’s published documentation
    - be at least four inches (4”) from the bottom of joists and six inches (6”) from the bottom of beams

2.3 Powder actuated, impact or drop-in anchors shall not be allowed.

3 Housekeeping Pads

3.1 All floor mounted electrical equipment installed in mechanical rooms, electrical rooms, boiler rooms, penthouses, below grade spaces, areas that are or may become wet and areas exterior to the building shall be furnished with a housekeeping pad.
3.2 Interior pads should be a minimum of 3½” inches thick with chamfered edges all around.
    3.2.1 Housekeeping pads should extend a minimum of 4” inches beyond supported equipment.
    3.2.2 Existing Construction: Elevated slabs shall be evaluated to determine if there is capacity in the structure for support of a new housekeeping slab.
3.3 Exterior pads shall be air-entrained, reinforced concrete, and shall extend 4” beyond all accessible sides of the equipment footprint, shall be 6” minimum high and shall have chamfered edges.
    3.3.1 Edges of exterior slabs shall turn down a minimum of 12” into the ground unless otherwise required to be deeper to prevent slab heaving.
1 Conduits

1.1 All conductors for each and every electrical system shall be installed in a raceway.

1.2 Minimum size of conduits shall be per NEC, and increased as necessary for installation conditions such as bends, insulation, etc. In general use 3/4” minimum, except as follows:

1.2.1 ½” for runs in 4” masonry walls
1.2.2 ½” for motor control circuits
1.2.3 ½” for motor power circuits
1.2.4 ½” for switch legs to single switches
1.2.5 ½” for end of run (dead end) devices (one conduit only)

1.3 Separate conduit systems shall be provided for:

1.3.1 Each lighting system
1.3.2 Each lighting control system
1.3.3 Convenience outlets
1.3.4 Each power system by voltage level
1.3.5 Each different system as further defined:

- Telephone (see Division 27 Communications)
- Fire Alarm
- Emergency lighting and EXIT signage
- Battery lighting
- Emergency power
- Audio Visual
- Control systems
- Building Automation Control Systems

1.3.6 Except by special permission, separate conduits are required for each feeder, each equipment branch circuit, and for all special systems

1.4 Common conduits will be acceptable for:

1.4.1 Branch circuits originating from the same panel for lighting and outlets
1.4.2 Motor branch circuits, or for a motor circuit and its associated control wiring.
1.4.3 Lighting power and lighting control wiring can be in the same conduit provided the insulation to the control wiring is greater than the highest voltage in the conduit and the manufacturers have stated that it is acceptable to do so.

1.5 All conduits shall be concealed except as follows:

1.5.1 Electrical and mechanical equipment spaces

1.6 All conduits shall bear the Underwriter's Label.

1.7 All conduits shall be of U.S. manufacture.

1.8 Where GRC or IMC enters a box or other fitting through a knockout, an approved double locknut and bushing shall be provided.

1.9 Conduit bushings shall be threaded type, having insulated inserts equal to O.Z., steel, type "B". Bushings for feeder conduits shall be grounding type, having lay-in type lug. Threadless bushings may be used in special instances only.

1.10 Six 1” spare conduits up and two 1” spare conduits down shall be installed from each flush mounted light and power panelboard, telephone cabinet, control cabinet and electronic systems cabinets of all descriptions and terminated in space above or at respective ceilings in 4” square boxes with blank covers, two conduits per box. None are required out bottom of panels of slab on grade.

2 Electrical Metallic Tubing (EMT or Thinwall)

2.1 In general 2” is the maximum allowable trade size allowed, unless otherwise noted. This does not apply for audio/visual, telecommunications and special systems

2.2 Feeder conduits 2” and under may be EMT

2.3 EMT will be installed with steel set screw, insulated throat, concrete tight type couplings and connectors as manufactured by Appleton, OZ/Gedney, UL/CSA listed, and meeting Federal Spec #WF408D). Other type fittings will not be acceptable.

3 Rigid Heavy Wall Conduit (Rigid or Intermediate Metal Conduit (IMC))

3.1 Rigid heavy wall conduit shall be installed in the following locations:

3.1.1 Concrete slabs and all poured walls (1” minimum concrete cover, or as required by ACI)

3.1.2 Under slab or underground and encased in 3” minimum concrete, except where located four or more inches below bottom of lowest slab in granular fill
3.1.3 Exposed exterior locations (rigid only)
3.1.4 All exterior masonry constructions
3.1.5 Where exposed to mechanical injury
3.1.6 All explosion proof work (rigid only)
3.1.7 "Vaportight" and "watertight" work
3.1.8 In or above prefabricated concrete decking.

3.2 Rigid heavy wall conduit shall be installed in the following manner:

3.2.1 Square cut and reamed after cutting threads.
3.2.2 Installed in accordance with Underwriter's Laboratories Standard UL6 for Rigid and UL/242 for IMC.
3.2.3 Installed with double locknuts and bushings except for threaded hubs.
3.2.4 Used for sleeves except where sheet metal is approved elsewhere.
3.2.5 Installed with all threaded fittings (the use of set screw or compression type not acceptable)
3.2.6 Where exiting or entering a concrete slab, extend Rigid or IMC at least 36" before adapting to EMT.
3.2.7 Where Rigid or IMC enters a junction box or any enclosure within 60" of exiting or entering a concrete slab, the Rigid or IMC shall be continuous into the enclosure.

4 Rigid Non-Metallic Conduit (PVC)

4.1 Conduit shall be heavy wall, rigid, schedule 40, PVC, Carlon "Plus 40" or equal.
4.2 In general for underground site lighting branch circuits only, no concrete encasement is required. Other types of installations may require concrete encasement as indicated on the drawings, other sections of these specifications, as directed by the Owner or by NEC.
4.3 Entire installation shall be watertight.
4.4 Where exiting or entering a concrete slab, PVC shall be adapted to Rigid or IMC at least 12" prior to exiting or entering the slab.
4.5 Utility transformer secondary building entrance; Concrete encased schedule 40 PVC. All underground 90 deg. bends shall be long radius elbows, 24" minimum, at stub-up locations utilize long radius Galvanized Rigid 90 deg. elbows, 24" minimum radius. Galvanized rigid conduit shall be installed from elbow up through slab and groundings bushing installed. Minimum radius of elbows and conduit size shall be increased as necessary depending on length of run and number and configuration of bends/elbows (i.e. distances between bends and/or elbow) to reduce drag and pulling tensions.

5 Skeletal Conduit Systems

5.1 Conduits shall be 10 feet lengths of 4" EMT separated 18" to 24" at 10-foot intervals as necessary to clear walls, obstructions, etc.
5.2 Connectors are not required. Bushings however, are required. Use insulated push-on bushings (by Arlington) installed on each end of each conduit section. Ream and smooth cut ends to prevent cable damage.
5.3 Provide two supports for conduit sections on 4 foot spacing.
5.4 Provide sleeves through walls where shown, full size or sized as shown. Patch walls around sleeves per NEC section 300-21. Seal each sleeve with appropriate fire stop.

6 Flexible Metallic Conduits

6.1 "Greenfield" (hot dipped galvanized) is to be used in dry locations only.
6.2 Used for final connections to all recessed fixtures, installed in adequate lengths (6' maximum) for fixture servicing and convenient removal.
6.3 Flex connectors shall be UL listed for grounding, squeeze type, malleable iron with insulated throat, one or two screw type as O-
Z/Gedney, T & B, Raco or approved equal (set screw type, die-cast or screw-in type are not acceptable).

**6.4** Flexible conduit fittings with external ground connection may be required under special circumstances as shown on Drawings, listed in Job Scope or as directed by the Owner’s Representative.

### 7 Flexible Liquid-Tight Metallic Conduit

**7.1** To be used in damp or wet locations, including exterior, water softener, brine handling and equipment located within air chamber of air handling equipment, with NEC grounding.

**7.2** To be used for final connections to all motors, 3 ft. maximum length, unless otherwise approved.

**7.3** Liquid tight fittings shall be UL listed for grounding, ferrule and sleeve type with insulated throat as O-Z/Gedney “4Q” series, T & B, Appleton “ST” or Carlon “Carflex fitting for Carflex or approved equal.

**7.4** Minimum allowable size is ½” unless otherwise noted, 3/8” permissible for fixture whips.

**7.5** Supported within 3 ft. of motor terminals and 6 ft. of lighting fixtures.

### 8 Fittings

**8.1** Conduit Bodies:

- **8.1.1** “LBD” and Mogul size for 1” and larger conduits.

- **8.1.2** Cast ferrous material for exterior, watertight and vapor tight locations with gaskets at covers.

- **8.1.3** As manufactured by Appleton, Pyle National or Crouse Hinds or Killark.

**8.2** Expansion Fittings

- **8.2.1** Installed in each run of conduit that crosses a building expansion joint, outside or within structural slabs.

- **8.2.2** Provided with bonding straps.

- **8.2.3** As manufactured by O.Z. or approved equal.

- **8.3** Conduit Seals (Vapor and Water)

- **8.3.1** Installed in each run of conduit between different temperature zones likely to cause condensation and circulation of moisture.

- **8.3.2** Installed in each run of conduit between a hazardous location and a non-hazardous (per NEC) location likely to cause the spread of vapors, dust, etc.

- **8.3.3** Filled with proper sealing compound in accessible locations.

- **8.3.4** Installed in walls where conduits enter/leave below grade. OZ/Gedney Type “FSK”, Link Seal “LS” series or equal.

### 8.4 Conduit Hubs

- **8.4.1** Conduit hubs shall be installed for all GRC or IMC terminations to sheet metal type enclosures for installations requiring a watertight or dust tight seal.

- **8.4.2** Hubs shall have insulated throat and recessed O-Ring seal.

- **8.4.3** Hubs shall be as O-Z/Gedney, T & B, Myers or approved equal.

### 9 Conduits Penetrating Roof:

**9.1** One conduit per sleeve

**9.2** Minimum height of sleeve not less than 12” above roof membrane

**9.3** Provided rain shield on conduit overlapping sleeve a minimum of 2 inches

**9.4** Secure rain shield to conduit with stainless steel pressure clamps

**9.5** Provide flashing as required

### 10 Outlet Boxes

**10.1** General

- **10.1.1** Every switch, light, wall receptacle, signal device, telephone outlet, etc., shall be provided with an outlet box.

- **10.1.2** “Through wall” and “Handy boxes” are not acceptable

- **10.1.3** Boxes installed “Back to Back” or within 12” center to center, penetrating opposite sides of wall construction, and installed in a fire resistive and/or fire rated wall shall not be permitted.

**10.2** Sizing

- **10.2.1** All boxes shall be sized in
accordance with NEC.

10.2.2 Four inch square x 2 1/8" deep for 2 or more conduits or devices

10.2.3 Four inch octagon or square boxes are to be used for fixture outlets.

10.2.4 Three inch x two inch (3"x2") conduit switch box 2½” deep for single conduit (dead-end), Raco #503 in drywall and Raco #690 in masonry or approved equal.

10.3 Approved Manufacturers

10.3.1 Appleton
10.3.2 Steel City
10.3.3 Raco

11 Surface Raceways

11.1 Metal Raceways

11.1.1 All surface metal raceways and fittings shall be as manufactured by the Wiremold Co., West Hartford, CT, and Hubbell or approved equal. Factory finished color shall be ivory,

11.1.2 One Piece Surface Metal Raceways:

11.1.2.1 Wiremold #500 or #700 Series and fittings or Hubbell equal

11.1.3 Two Piece Surface Metal Raceways:

11.1.3.1 Wiremold #2100 Series or Hubbell equal

11.1.3.2 Wiremold #3000, #4000, #6000 Series or Hubbell equal

- #3000 = 2-3/4" W x 1-7/32" D
- #4000 = 4-3/4" W x 1-3/4" D
- #6000 = 4-3/4" W x 3-9/16" D

11.1.4 Where two-piece raceway covers pass through walls, floors, and/or ceilings, the cover shall be cut on both sides of the wall, floor or ceiling (maximum of 6” from edge of penetration) to permit removal of the cover on each side of the obstruction.

11.2 Non-Metal Raceways

11.2.1 All surface non-metallic raceways and fittings shall be as manufactured by the Panduit Co. or Hubbell.

11.2.2 One Piece Non-Metallic Surface Raceway:

11.2.3 Panduit Type L

11.2.4 Two Piece Surface Non-Metallic Raceways

Raceways

11.2.4.1 Panduit Type "T" Series
11.2.4.2 Hubbell “Basetrak”, series

11.2.5 Where two-piece raceway covers pass through walls, floors, and/or ceilings, the cover shall be cut on both sides of the wall, floor or ceiling (maximum of 6” from edge of penetration) to permit removal of the cover on each side of the obstruction.

11.3 Troughs

11.3.1 All troughs and fittings shall be as manufactured by Square D, Hoffman or approved equal.
### 12 Table of Mounting Heights

<table>
<thead>
<tr>
<th>Device</th>
<th>Reference</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switches</td>
<td>floor - top</td>
<td>+ 4' - 0&quot;</td>
</tr>
<tr>
<td>Outlets</td>
<td>floor – bottom</td>
<td>+ 1' - 6&quot;</td>
</tr>
<tr>
<td>Plugstrip</td>
<td>floor – top</td>
<td>+ 4' - 0&quot;</td>
</tr>
<tr>
<td>Dimmer</td>
<td>floor – top</td>
<td>+ 4' - 0&quot;</td>
</tr>
<tr>
<td>Wall Speaker</td>
<td>ceiling - top</td>
<td>+/- 1' - 0&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(verify)</td>
</tr>
<tr>
<td>Telephone Outlet</td>
<td>floor – bottom</td>
<td>+ 1' - 6&quot;</td>
</tr>
<tr>
<td>Wall Phone</td>
<td>floor - bottom</td>
<td>+ 4' - 0&quot;</td>
</tr>
<tr>
<td>Wall Phones - Handicapped</td>
<td>floor - center</td>
<td>+ 3' - 4&quot;</td>
</tr>
<tr>
<td>Fire Alarm Station</td>
<td>floor - top</td>
<td>+ 4' - 0&quot;</td>
</tr>
<tr>
<td>Safety Switch</td>
<td>floor - top</td>
<td>+ 6' - 0&quot;</td>
</tr>
<tr>
<td>Motor Starter</td>
<td>floor - top</td>
<td>+ 6' - 0&quot;</td>
</tr>
<tr>
<td>Relay Panel</td>
<td>floor - top</td>
<td>+ 6' - 0&quot;</td>
</tr>
<tr>
<td>Branch Circuit Panel</td>
<td>floor - top</td>
<td>+ 6' - 0&quot;</td>
</tr>
<tr>
<td>Push Button</td>
<td>floor - bottom</td>
<td>+ 4' - 0&quot;</td>
</tr>
<tr>
<td>Control Station</td>
<td>floor - bottom</td>
<td>+ 4' - 0&quot;</td>
</tr>
<tr>
<td>Microphone Outlet</td>
<td>floor - bottom</td>
<td>+ 1' - 6&quot;</td>
</tr>
<tr>
<td>Clock</td>
<td>ceiling - top</td>
<td>+/- 1' - 0&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(verify)</td>
</tr>
<tr>
<td>Bells</td>
<td>ceiling - top</td>
<td>+/- 1' - 0&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(verify)</td>
</tr>
<tr>
<td>Control Station for Electric</td>
<td>floor - center</td>
<td>+ 3' - 0&quot;</td>
</tr>
<tr>
<td>Operated Doors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** All references are from finished floor or ceiling to the device box.
1 Materials & Construction
1.1 Cable tray and all associated fittings shall have rounded edges and smooth surfaces.
1.2 Cable tray, fittings and accessories shall be Aluminum, unless design considerations dictate a different material.
1.3 Cable tray radius shall be 12” minimum.
1.4 Rung spacing shall be 6” O.C. minimum.
1.5 Tray depth shall be 4” minimum.

2 Support
2.1 Cable trays shall be supported from building structure using hangers manufactured by tray manufacturer and sized for the tray being installed and per manufacturers’ written recommendations.

3 Approved Manufactures
3.1 B-Line Systems
3.2 Mono Systems
3.3 Square D
1 General
1.1 This Guideline is applicable to all new construction, building renovations, replacement programs or repair.
1.2 For all other than new construction, remove the existing labeling and replace with new labeling applicable to the changes as prescribed in this guideline.

2 Switchboards, Motor Control Centers, Power Panels
2.1 Provide an engraved plastic label with 3/4” high letters, securely attached, identifying the unit, voltage, phase, wire.
   Example: MDP-1, 208Y/120V, 3Ø, 4W
2.2 Label branch switches, starters, etc., with an engraved plastic label with 3/16” high letters securely attached to exterior of device.
2.3 Label to include the name of the load it is feeding and with the source of the power.
   Example: ACP-20 fed from MCC 20, Cubicle 5A located in room #B64
2.4 For switchboards with ground studs, provide an engraved plastic label with 3/4” high letters, securely attached, identifying the compartment of the gear that contains the studs as such.
   Example: Ground Studs
2.5 For switchboards with metering, provide an engraved plastic label, securely attached, identifying the nominal CT ratio and PT ratio.

3 Automatic Transfer Switches
3.1 Label "Normal" and “Emergency” poles with engraved plastic tag.
3.2 Label transfer switches with source designations as "Normal Switchboard M-L-1" or "Emergency - Diesel Generator".

4 Plug-In Bus Ducts
4.1 Label all plug-in bus ducts in each room, with stenciling, indicating voltage, phase, and panel designation.
4.2 Label all bus plugs per NEC #110-22.

5 Panelboards
5.1 Provide a frame, approximately 5" x 8", inside the door with plastic protected typewritten directory card identifying all circuits with Owner's final room number.
   Example: Room 204 - outlets - North wall
5.2 Provide an engraved plastic label with 1/4” high letters on interior of panel cover (or outside of panel without doors) identifying panel, voltage, phase, wire, and source of feed.
   Example: L-B-1, 208Y/120V, 3Ø, 4W - MDP-1, Circuit 4

6 Pull & Junction Boxes, Feeder Bus Taps
6.1 Identify by stenciling on the boxes, system use, etc., as directed.
6.2 Covers for pull and junction boxes shall be marked with felt tip pen, crayon or other approved permanent marking means, indicating system type i.e. lighting, power, emergency, etc., panel and circuit number, if applicable destination, etc.
   Example: EM RM. #213, Panel E-1, Cir. #1, 3, 5

7 Starters, Disconnect Switches
7.1 Label each with engraved plastic label with 3/16” high letters securely attached to the exterior of device as follows: Equipment served, Source of feed and circuit number.
   Example: ACP-20 fed from MCC 20, cubicle 5A located in room #B64

8 Devices
8.1 Outlet covers should be marked with a clear label with black lettering indicating panel and circuit.
   Example: Panel PR2-B4, Cir. #3
8.2 Switch plates should be marked with a clear label with black lettering indicating panel and circuit.
   Example: Panel PL3-A2, Cir. #13

9 Conductors (All Voltages)
9.1 Feeder wires shall be identified with voltage, phase and destination at each access
9.2 For branch circuit conductors, wiring shall be identified with wrap-on wire markers.

9.3 Wire markers shall be T & B #WBC or approved equal, vinyl cloth with factory painted letters and numbers.

9.3.1 Number shall indicate associated terminal in starter, panel board, etc.

9.4 All transformers, secondary switchgear, feeders, bus ducts, power sub-feeds to motors, etc., shall be completely phased out as to sequence and rotation and so labeled.

9.5 Phase sequence shall be N-A-B-C, proceeding in direction of left to right, front to back, top to bottom. All phases and neutral shall be identified with 1" Brady wrap-on wire markers.

9.6 Identify conductors of different systems at each junction box; pull box, and termination with tags as approved by Owner's Representative.

9.7 Where two or more neutrals are included in same conduit, at each panel, junction box, etc. the proper neutral wire shall be permanently and effectively identified with its branch circuit conductor(s) taped together and labeled with circuit number(s)]. The neutrals shall have a colored strip that corresponds to the phase color of the non-grounded conductor.

9.8 Each feeder and branch phase conductor shall have colored insulation that runs its full length and corresponds to the phase the wire will connect to (i.e. black red and blue)

10 Isolation Circuit Breaker Remote Pushbutton Enclosure

10.1 Provide an engraved plastic label with 3/4" high letters, securely attached to the door of the enclosure, identifying the Isolation Circuit Breaker it controls.

Example: ICB-P-B-1
1 Summary

1.1 Provide a complete Arc Flash Hazard Analysis for the project indicated in the accompanying RFP. The Analysis may be performed:
- independent of the construction project
- in concert with the A/E of record during the design and construction phases of the project

1.2 When performed independent of a construction project.
   1.2.1 The AFC (Arc Flash Consultant) is expected to survey the building, collect appropriate data and prepare reports as described in the RFP.
   1.2.2 Recommendations to reduce incident energy levels shall be included in the draft report for review by Purdue. Recommendations that are immediately implemented shall be reflected in the final report; outstanding recommendations will be addressed in future capital projects and the study updated at that time.

1.3 When performed in concert with the A/E of record during the design and construction phases of the project.
   1.3.1 The AFC is expected to coordinate and correspond regularly with the A/E as required to review the electrical design as it progresses and provide input to the design to provide the lowest incident energy levels practical.
   1.3.2 This collaborative process is expected to occur throughout the entire design and construction phase of the project.

2 Quality Assurance

2.1 Studies shall be prepared using Power Tools software by SKM Systems Analysis, Inc. updated to the most recent version.

2.2 Studies shall be signed and sealed by a Professional Engineer registered in the State of Indiana.

2.3 Studies shall be prepared per current applicable codes and standards.

2.4 Studies shall be based on systems designed and specified as “fully-rated” systems. “Series-rated” systems are not acceptable.

3 Safety and Security

3.1 The AFC shall comply with all applicable OSHA regulations as well as the most current edition of NFPA-70E when doing on-site field investigation and data gathering. Determination of appropriate PPE during data gathering shall be the responsibility of the AFC.

3.2 All access to the project work site shall be coordinated through Purdue.

3.3 There are not planned power outages for the purpose of conducting the Arc Flash Hazard Assessment. The AFC must submit a written request to Purdue University’s Arc Flash Coordinator assigned to the project if an outage is needed.
## 4 On-Site Data Gathering and Reporting

### 4.1 The following data shall be gathered and summarized:

<table>
<thead>
<tr>
<th>Item</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locations</td>
<td>Room number of all equipment that will require Arc Flash Hazard labels</td>
</tr>
<tr>
<td>Fuses</td>
<td>Manufacturer, type, Amp rating, Short circuit rating, etc.</td>
</tr>
<tr>
<td>Circuit Breakers</td>
<td>Manufacturer, type, voltage rating, Amp rating, Short circuit rating, settings, etc.</td>
</tr>
<tr>
<td>Panels and Switchboards</td>
<td>Manufacturer, type, Voltage rating, Amp rating, Short Circuit Rating, Ratings of circuit breakers / fuses, etc.</td>
</tr>
<tr>
<td>Primary Transformers</td>
<td>Manufacturer, rating, impedance, fusing, short circuit available, etc.</td>
</tr>
<tr>
<td>Secondary Transformers</td>
<td>Manufacturer, type, Voltage rating, Amp rating, impedance, fusing, etc.</td>
</tr>
<tr>
<td>Wire &amp; Cable</td>
<td>Size, insulation type, conductor type, length, etc.</td>
</tr>
<tr>
<td>SCR and/or Isolation Transformers</td>
<td>Size, impedance, fusing, voltage rating, current rating etc.</td>
</tr>
<tr>
<td>Disconnects, Combination Motor Starters</td>
<td>Manufacturer, type, Voltage rating, Amp rating, Short Circuit Rating, OCPD Rating, etc.</td>
</tr>
<tr>
<td>Bus Duct</td>
<td>Manufacturer, Voltage rating, Amp rating, conductor type, short circuit rating, impedance value (based upon model number), etc.</td>
</tr>
<tr>
<td>Buckets &amp; Disconnects on the duct</td>
<td>Amp rating, OCPD Rating, length, etc.)</td>
</tr>
<tr>
<td>Equipment Panels</td>
<td>All end use equipment that is permanently connected to the building electrical system. Document all short circuit ratings, fusing / circuit breakers, etc.</td>
</tr>
<tr>
<td>Motors and other equipment that will contribute to the available short circuit current</td>
<td>Collect motor data for all motors 50 hp and above</td>
</tr>
<tr>
<td>VFD</td>
<td>Manufacturer, Voltage rating, Amp rating, bypass, OCPD Rating, etc.</td>
</tr>
<tr>
<td>Engine-Generator</td>
<td>Manufacturer, type, Voltage rating, Amp rating, KVA rating, KW rating, impedance, etc.</td>
</tr>
<tr>
<td>Automatic Transfer Switch</td>
<td>Manufacturer, Voltage rating, Amp rating</td>
</tr>
</tbody>
</table>
5 Infrared Scan Requirements:
5.1 As required by the RFP, at the time data is being gathered from existing equipment for the Arc Flash Hazard Analysis the AFC shall also utilize an Infrared Camera to scan the equipment being surveyed.

6 System Short Circuit Analysis
6.1 Calculate the maximum available short circuit current in amperes rms symmetrical at each point of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit.
6.2 Study electrical distribution system scenarios that result in maximum and minimum fault current. These scenarios shall include at a minimum the following:
   - Normal configuration.
   - Emergency power system operation.
   - Tie breaker closed and respective main open where these configurations exist.
6.3 Scenarios evaluated shall also make use where available of the maximum and minimum fault current values available from Purdue Utilities. Request these values from Purdue University.

7 Equipment Evaluation Analysis
7.1 Confirm that interrupting ratings are equal to or higher than calculated ½ cycle symmetrical fault current for 600 Volt over current protective devices.
7.2 Interrupting Rating Analysis
   7.2.1 Calculate momentary and interrupting duties on the basis of maximum available fault current.

8 Shock Hazard Analysis
8.1 Perform a Shock Hazard Analysis in accordance with NFPA 70E.
8.2 The completed study shall determine:
   - Voltage exposure at each location.
   - Shock Protection Boundaries
     o Limited Approach
     o Restricted Approach
   - Required PPE for shock hazard protection.

9 9 Overcurrent Protective Device Coordination Analysis
9.1 Protective Device Coordination Study for all system devices (adjustable and fixed).
9.2 Provide TCC curves for each type of breaker down to and including the 20A and 30A breakers in branch circuit panelboards.
9.3 The coordination study shall include TCC curves for all devices on the emergency system and verify proper coordination thereof per NEC.
9.4 Tabular Format of Settings Selected for Overcurrent Protective Devices:
   - Device Tag
   - Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   - Circuit-breaker sensor rating; and long-time, short-time, instantaneous settings and ground fault where applicable
   - Fuse-current rating and type.
   - Ground-fault relay-pickup and time-delay settings.
9.5 Coordination Curves:
   9.5.1 Provide settings of overcurrent protective devices to achieve selective coordination.
   9.5.2 Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company’s upstream devices.
   9.5.3 Prepare separate set of curves for the switching schemes and for emergency periods where the power source is local generation.
   9.5.4 Overcurrent Protection Devices and Fuse Recommendations: (Construction Related Projects)
   9.5.5 The AFC shall make recommendations during the design phase of the project to the A/E in regard to the specification of overcurrent protective devices and fuse ratings that provide for the lowest incident energy levels and greatest degree of coordination. The A/E shall include this information as “basis of design” on the contract documents. The AFC shall strive to avoid selection of proprietary equipment and devices and shall advise Purdue when such devices are necessary or warranted to achieve
incident energy goals.

9.5.6 The AFC shall review and make recommendations during the construction phase of the project to the A/E in regard to the submitted overcurrent protective devices and fuse ratings to ensure the submitted equipment complies with the incident energy levels established during the design phase.

10 Arc Flash Hazard Analysis

10.1 Arc Flash Study Limits

10.1.1 These study requirements exceed the requirements of the NFPA-70E standards and shall include all electrical equipment on the buildings power distribution system as described below:

10.1.1.1 Buildings served by Purdue Utilities shall be studied from the primary side of the service entrance transformer at the first system connection in the first existing manhole.

Note: The system available fault currents and X/R ratio values at the first existing manhole referenced will be furnished by Purdue.

10.1.1.2 Buildings served by a public utility shall be studied from the primary side of the service entrance transformer using fault current and X/R ratio values that the AFC obtains from the public utility.

10.1.1.3 All electrical panel boards and load centers.

10.1.1.4 All three phase electrical equipment disconnect switches.

10.1.1.5 All bus ducts.

10.1.1.6 All open transformers.

10.1.1.7 All Variable Frequency Drives (VFD)

10.1.1.8 DC systems where applicable.

10.1.1.9 UPS Systems where applicable.

10.1.1.10 All disconnect switches that are integral to equipment that is hardwired to the building electrical system (HVAC equipment, Kitchen equipment, etc.)

10.1.2 The intent is that all electrical equipment subject to access while energized or that is a point of a Lock out / Tag out operation is labeled. Notable exclusions from the study include 20 Amp lighting branch circuits, receptacle branch circuits and enclosed transformers.

10.1.3 The study requirements shall include all electrical distribution system components that are served by power source rated 50 Volts or greater.

10.2 Arc Flash Hazard Analysis:

10.2.1 Analysis methods shall conform to NFPA 70E and IEEE 1584.

10.2.2 Analysis shall calculate and assign Arc Flash values based upon worst case operational configuration. Summaries shall indicate both conditions. Applied labels shall reflect the highest IE value. Examples include:

- UPS’s shall be assumed to be in bypass mode.
- VFD’s shall be assumed to be in bypass mode.
- ATS’s & MTS’s shall be assumed to be on standby power.

10.2.3 Calculate the Arc Flash Incident Energy (IE) for each point in the system(s). This includes values for the line side of each main overcurrent device in panel boards, switchboards, MCCs.

10.2.4 Calculate the Arc Flash Boundary distances for each point in the system(s). This includes values for the line side of each main overcurrent device in panel boards, switchboards, MCCs.

10.2.5 Prepare recommendations based upon modeling OCPD device settings and ratings to lower IE level no higher than 8 cal cm2.

Note: Temporary maintenance settings via. a maintenance switch can be used to accomplish this if necessary, with Purdue’s approval.

10.2.6 Report shall contain the Arc Flash Evaluation showing the bus name, protective device name, bus (kV), bus bolted fault (kA), protective device arcing fault (kA), trip / delay time (sec.), arc type, arc flash boundary (in.), and working distance (in.), incident energy (cal/cm2).

10.2.7 The completed study shall include:

- Device Tag for each point assessed
- Voltage exposure at each location
- Available bolted fault current
- Arc-Flash Protection Boundary
- Working Distance
- Incident Energy (in cal/cm2)
11 Deliverables

11.1 Email Reports

11.1.1 “As-Drawn” Study: These are a series of partial reports as described in the RFP submitted electronically. This report is completed by the Final Review Construction Documents Submittal phase.

11.1.2 “Construction” Study: This report is a partial report as described in the RFP submitted electronically. This is a report conducted after submittal phase of the project to ensure equipment and devices being supplied are acceptable to the AFC and result in the lowest incident energy.

11.2 Draft Reports

11.2.1 Construction and Non-Construction Related Projects have the following draft report as detailed in the RFP:

11.2.2 Final Report Draft: Draft version of final report to convey the pertinent information for review and discussion and document any preliminary recommendations.

11.3 Infrared Scan Report – When required by the RFP.

11.3.1 Report shall be submitted in hardcopy and softcopy format.

11.3.2 Report shall be separately bound from all other study reports.

11.3.3 Report shall contain the following sections:

- Cover sheet that identifies the building name, building abbreviation, date of review, AFC Company contact information.

11.4 Final Report - Softcopy

11.4.1 Compact Disk #1

- PDF files only
- Label shall read “Report Copy”

11.4.2 Compact Disk #2

- PDF, Excel, DWF, SKM Backup Files with Libraries.
- Label shall read “Archive Copy”

11.5 Final Report Format - Hardcopy

11.5.1 Report Binders shall be vinyl covered cardboard nominally 11.75” Tall by 10.5” Wide with clear plastic sleeves on the outside front, back and spine for insertion of printed coversheets. The integral binder shall be three (3) ring, D shape with minimum size of 1” and maximum size of 4”. The size of binder used shall be consistent with report being bound.

11.5.2 Report covers shall be consistent with the sample reports and shall include the following information:

11.5.2.1 Back Cover: AFC Company contact information centered at bottom of cover.

11.5.2.2 Spine: Information with bottom of text toward back of binder from left to right:

- Left end: Purdue University Logo, “West Lafayette Campus” below logo
- Centered: Building Name with Building Abbreviation (All Caps, large type, bold font) below
- Right end: “Arc Flash Study”, Report Date below in format “09/30/2010”

11.5.2.3 Front Cover: Purdue University Logo, Building Name, Building Abbreviation, “Arc Flash Study”, Date, AFC Company Logo.

11.5.3 Tabbed Dividers: Report shall be tabbed with labeled dividers for each section.

11.5.4 Pages: Pages shall be printed double sided and numbered by section, when
appropriate, in the lower right hand corner. (Make note of the requirement for overcurrent protective device tabular information to be located on left side with associated Time Current curve on the facing page located on the right side printed in color.)

11.5.5 Drawing sleeves shall be clear plastic, three hole punched sized for 8.5” x 11” paper. A separate sleeve shall be provided for each drawing. Drawings shall be folded and inserted into the sleeve so that the title block is visible.

11.5.6 Compact Disk Sleeves shall be clear plastic three hole punched and sized to hold two compact disks.

11.5.7 Compact Disks shall have label with Purdue Logo, “West Lafayette Campus”, Building Name, Building Abbreviation (all caps, large type, bold), Arc Flash Study, Report Date (style 09/30/2010) and “Report Copy” or “Archive Copy” as appropriate.

11.5.8 Drawings shall be produced per CADD standards and shall be D-Size or E-Size drawings with a Purdue University standard border that contains the applicable information about the project. Drawing text shall be 13 point and Bus names shall be 12 point bold.

11.6 Final Report Contents – Construction Related projects

11.6.1 Table of Contents with numerical chapters and page numbers indicated.

11.6.2 Introduction
- Brief summary of the study, including the project name, building name and contact information for the AFC.
- Description of the format of the report and what is contained within each chapter.

11.6.3 Findings and Recommendations
11.6.3.1 This section of the report shall be separated into three areas:
- A line by line analysis of all locations with a greater than Category 2 hazard level, include recommendations to lower the incident energy to achieve a PPE Category of 2 or lower
- A line by line analysis of any Overcurrent Protective Device coordination issues, including recommendations to improve coordination

11.6.4 Table of Calculated Arc Flash Data (As Found)
- Narrative summary
- Table Arc Flash Evaluation IEEE 1584 Bus + Line Side Report (Table shall be based on running multiple scenarios to report the worst case condition)

11.6.5 Table of Calculated Arc Flash Data for Recommendations as if they were implemented, where applicable.
- Narrative summary
- Table Arc Flash Evaluation IEEE 1584 Bus + Line Side Report (Table shall be based on running multiple scenarios to report the worst case condition)

11.6.6 Single Line Diagrams
- Narrative description and schedule of drawings included.
- An accurate detailed One-Line electrical diagram of the system shall be created as part of this project. Information on the One-Line Diagram shall include, but not be limited to:
  - Electrical Structure
  - Voltage at each point (e.g. 480/277, 120/240, 120/208, etc.)
  - Bolted short circuit current available at each point in the system.
  - Horsepower of major motors connected to the system from 50 Hp and above.
  - Plant standard names of all panels and equipment.
  - Room numbers for location of all panels and equipment.
  - Arc Flash Incident Energy Levels at each point in Cal / cm2
  - Transformer sizes
  - Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

11.6.7 Feeder and Transformer Data
- Table of SKM input data for cables, transformers, utilities, etc.
- Single Line diagram with data blocks indicating the following values:
11.6.8 Summary of Calculated Fault Currents
- Narrative summary of findings and brief description of analysis.
- “Dapper Unbalanced Fault Report” separate Fault Reports shall be included for each utility and standby power scenario.

11.6.9 Coordination Curves, Device Settings (As Found) – Construction Related projects when project has existing structures when applicable.
- Narrative summary.
- Device information and settings and associated Time vs Current curves on facing pages.

11.6.10 Coordination Curves Device Settings (As Found and per Recommendations as if they were implemented, where applicable)
- Narrative summary.
- Device information and settings and associated Time vs Current curves on facing pages.

11.7 Computer Files and Libraries
11.7.1 Narrative / Reports: A complete soft copy of report shall be submitted in PDF format.
11.7.2 Spreadsheets: All tables located in and referenced within the report shall also be submitted in Microsoft Excel format.
11.7.3 SKM System Analysis Files: A complete set of project data files, libraries and output files in their native format.
11.7.4 Drawing Files: Single line diagrams shall be submitted in AutoCAD DWF format.

11.8 Labels
11.8.1 Labels shall be standardized and comply with the requirements of the Arc Flash Label Standard that are attached as an exhibit to this document.
11.8.2 Labels shall be printed for Line Side Incident Energy Levels only.

11.8.3 Labels shall be supplied, printed and installed by the AFC.

11.8.4 Labels shall be placed on the exterior surface of equipment and panel boards. Surface shall be properly prepared to receive the label. (Exception: Panel boards located in public corridors shall be labeled on the inside of the panel board door that is accessible without exposing energized parts.)

Breaker settings confirmation.

The AFC shall verify that the breaker settings specified in the arc flash study have been programmed into the installed breakers.

12 General Label Requirements
Purdue shall witness label application
12.1 Label shall be self-adhesive
12.2 The Brady part numbers are:
   - (See Purdue Physical Facilities Engineering for the latest information on Brady part numbers).

12.3 General Information Requirements (All location specific data shall be right justified on the label.)
12.3.1 Room
   - <Data field with Room #>
   - Format example: “3102”

12.3.2 Date:
   - <Data field with Month (3 Letter Format) / Year (4 Digit Format)>  
   - Format example: “Apr / 2011”

12.3.3 Device Name:
   - <Data field with Device Name>
   - Format example: “ELP3L-B-1 (MCB Lineside)”

12.3.4 Fed From:
   - <Data field with upstream Device Name>
   - Format example: “ESDPPH-1 EDS-3 Disc”

12.3.5 Arc Flash Hazard Boundary:
   - <Data field with distance in inches>
   - Format example: “4 inches”
12.3.6 Incident Energy at:
- <Data field with distance in inches>
- <Data field with incident energy in #.# cal/cm^2>
- Format example: "18 inches 6.00 cal/cm^2" (Note that incident energy shall be indicated to two decimal places.)

12.3.7 Shock Hazard Exposure:
- <Data field with voltage in volts>
- Format example: "208 Volts"

12.3.8 Limited Approach Boundary:
- <Data field with distance in inches>
- Format example: "42 Inches"

12.3.9 Restricted Approach Boundary:
- <Data field with distance in inches>
- Format example: "Avoid Contact"

12.3.10 Calculations per IEEE 1584 (Preprinted on label)

12.3.11 Purdue University Logo (Preprinted on label)"
1 Overview

1.1 It is the intent of the University to limit our employee’s exposure hazard to an incident energy level of 8 Cal./Cm$^2$ or less when working on or around energized electrical equipment.

1.2 Mitigation in this context implies the relocation of an Arc Flash incident energy level ≥ 25 Cal./Cm.$^2$ to an area (separate lockable space) not requiring periodic entry of qualified personnel. It is recognized that the piece of equipment with this rating is only included to reduce the Arc Flash Category of downstream equipment requiring periodic service. The equipment is only intended to open under a fault unless provided with a remotely operated power actuated device. If the device is not power actuated, the transformer primary power will be removed before the device could be manually reset.

2 Summary

2.1 For new construction or major renovations involving new electrical services make the following considerations during the Schematic Design Phase

2.1.1 Work with the Arc Flash Consultant if one has been assigned to the project

2.1.2 Establish the transformer secondary Arc Flash Category

2.1.3 Assume Arc Flash Category Dangerous if unable to actually establish a rating

2.1.4 Determine a method to relocate the Dangerous level to an area other than the main electrical room or vault

3 Considerations for Transformer Secondary or Switch Gear Main Line side Rating - Arc Flash Category Dangerous

3.1 An interrupting device needs to be placed between the secondary of the transformer and the main Switchboard capable of reducing the incident energy at the line side of the Main Circuit Breaker (the Switchboard category rating) to an acceptable incident level of no more than 8 Cal./Cm.$^2$. In some instances this may require a device that has a “Normal” mode and a “Maintenance” mode Arc Flash level reduction feature. When this feature is used, a remote selector switch and pilot light are required. The switch and pilot light may be in the same enclosure as the remote “Open” and “Close” pushbutton operators and pilot lights.

3.2 The device should be in a separate room or area from the electrical room or vault

3.3 The transformer secondary side breaker will be in its own separate enclosure

3.4 The device should be capable of remote operation (motorized)

3.5 A remote operator’s panel will be provided, preferably in the electrical room. This panel will be located outside the Arc Flash Hazard Boundary, as calculated by the SKM model. Refer to guideline 26 2413 – Switchboards for remote operator details.

3.6 The remote operators shall be installed in an enclosure with a clear cover. The enclosure shall be equipped with a hasp capable of accepting a padlock.

3.7 The installation shall take into consideration weather and provisions for routine maintenance (in the case where the breaker is located in an outdoor environment).

3.8 The Main Service Switchboards (MDPs) will have provisions for easy connection of grounding cables to be used during maintenance or alterations

4 Alternate Considerations for Transformer secondary or Switch Gear Main Line side Rating - Arc Flash Category Dangerous

4.1 Architect / Engineer may propose alternate designs if they provide the same level of protection (incident energy of 8 Cal./Cm.$^2$ or lower) for the electrical personnel operating the equipment

5 Items to include in the Schematic Design

5.1 Simplified one line diagram from source through first Switchboard

5.2 Building footprint showing location of Arc flash Category Dangerous equipment

5.3 Brief explanation of the electrical system, its Arc Flash levels, means of mitigation and operation of Equipment
1 Electrical Switchboard Schedule

1.1 The Electrical Switchboard Schedule shall be shown on the project electrical drawings. It shall include the following:

1.1.1 Switchboard Name
1.1.2 Room Number of Switchboard Location
1.1.3 Identification of Main Breaker size. Main Lug Only is to be avoided except for side by side switchboards and switchboards in the same room as their source of origin (feed).

1.1.4 Circuit Description
1.1.4.1 Identify spares and spaces
1.1.5 Circuit breaker size
1.1.5.1 Amperage
1.1.5.2 Number of poles
1.1.6 A,B,C phase load chart
1.1.7 Panel design values
1.1.7.1 Continuous Ampere Rating
1.1.7.2 Bus Short Circuit Rating
1.1.7.3 Voltage, number of Phases, and number of Wires
1.1.8 Connected, Demand and Design load values

1.2 Panelboard Door and Directory

1.2.1 Refer to Identification for Electrical Systems for instructions on Switchboard Labeling and Branch Circuit Labeling

2 Electrical Panelboard Schedule

2.1 The Panelboard Schedule shall be shown on the project electrical drawings. It shall include the following:

2.1.1 Panel Name
2.1.2 Panel Mounting (Surface or Recessed)
2.1.3 Room Number of Panel Location
2.1.4 Identification of Main Breaker size. Main Lug Only is to be avoided except for side by side panels and panels in the same room as their source of origin (feed).

2.1.5 Circuit Description
2.1.5.1 Identify spares and spaces
2.1.6 Circuit breaker size

2.1.6.1 Amperage
2.1.6.2 Number of poles
2.1.7 A,B,C phase load chart
2.1.8 Panel design values
2.1.8.1 Continuous Ampere Rating
2.1.8.2 Bus Short Circuit Rating
2.1.8.3 Voltage, number of Phases, and number of Wires
2.1.9 Connected, Demand and Design load values

2.2 Panelboard Door and Directory

2.2.1 Refer to Identification for Electrical Systems for instructions on Door Labeling and Directory
1 Lighting Panelboard Schedule
1.1 The Lighting Panelboard Schedule shall be shown on the project electrical drawings. It shall include the following:

1.1.1 Panel Name
1.1.2 Panel Mounting (Surface or Recessed)
1.1.3 Room Number of Panel Location
1.1.4 Identification of Main Breaker size. Main Lug Only is to be avoided except for side by side panels
1.1.5 Circuit Load Description
   1.1.5.1 Identify spares and spaces
1.1.6 A, B, C phase load chart
1.1.7 Circuit breaker size
1.1.8 Panel design values
   1.1.8.1 Continuous Ampere Rating
   1.1.8.2 Bus Short Circuit Rating
   1.1.8.3 Calculated fault Current
   1.1.8.4 Voltage, number of Phases and number of Wires
1.1.9 Connected, Demand and Design load values
1.2 Panelboard Door and Directory
   1.2.1 Refer to Identification for Electrical Systems for instructions on Door Labeling and Directory

2 Lighting Fixture Schedule
2.1 The Lighting Fixture Schedule shall include the following.

2.1.1 Primary fixture specification (voltage, lamp type, number of lamps per fixture, color temperature, mounting method, etc.)

2.1.2 Two (2) additional fixture models by other manufacturers deemed by the lighting designer to be “equal” to the primary fixture model and manufacturer.

2.1.3 Manufacturer’s catalog number for all fixtures listed.

2.1.4 When it is determined that there are less than two fixtures “equal” to the primary fixture listed there shall be an “allowance price” provided (on the schedule).

2.1.5 The Fixture Schedule shall be included with the drawing schedules (not in the specifications only).

2.1.6 Every effort shall be made to insure that the fixtures listed are represented by multiple lighting vendors.
1 General
1.1 Power Monitoring Device shall be U.L. listed and labeled.
1.2 Reference Section 33 0900 Utility Meters
   1.2.1 Additional information on termination of electrical meters to the Data Concentrator Control Panel (DCCP).
1.3 Approved Manufacturers:
   • Schweitzer Engineering Labs (SEL) model 735
   • SEL model 735-1

2 Electrical Circuit Monitors:
2.1 All meters shall be equipped with Ethernet communication capabilities
2.2 All meters shall be equipped with harmonic monitoring capabilities to at least the 15th harmonic.

3 Installation of Power Monitoring Devices:
3.1 The Power Monitoring Device shall be installed in a compartment which is isolated from energized bus.
   3.1.1 The compartment shall also contain a disconnecting means for the Power Monitoring Device as well as a C.T. shorting block.
   3.1.2 All components shall have guarding in place to be considered “finger-safe” inside the compartment with respect to voltage above 50 volts.
   3.1.3 Wire Current Transformers to a 6-pole shorting block with a dedicated X1 and X2 wire for each CT.
3.2 A 1” flexible non-metallic conduit shall be routed from the metering compartment to the exterior of the switchgear.
3.3 The raceway will be extended in the field by the E.C. from the switchgear to the DCCP.

4 Connecting and Networking of Power Monitoring Devices:
4.1 All data stored in the Power Monitoring Device shall be accessible to external devices by way of Ethernet communication.

5 Additional Network Media Options:
5.1 Network connections shall be established using industry standard Ethernet protocols such TCP/IP. All components shall work with existing Ethernet Gateway, Router, and Hub technology.

6 Current Transformer (CT)
6.1 The CT shall be sized based on calculated demand load of the switchboard
   6.1.1 The nameplate shall be as close as possible without going below the calculated demand load.
6.2 The CT shall have an ANSI accuracy rating of 0.3 at a Burden of B0.5. The accuracy class is expressed as 0.3B0.5.
6.3 The CT shall have a rating factor (RF) of at least 3.0 @ 30°C but is preferred to be 4.0 @ 30°C and 3.0@55°C

7 Test Switch
7.1 Each meter shall be installed and wired with a test switch. The test switch shall be a ten pole ABB FT-1 (SEL part number 240-1010). The test switch shall be mounted directly below the meter.

8 Documentation
8.1 A folder shall be supplied with the switchboard located in the isolated meter compartment with the following contents
   A. Meter
      • SEL factory calibration report
      • SEL settings files (Digital Copy from SEL Quickset export)
   B. CT Specifications
      • Accuracy
      • Burden
      • Rating Factor
      • Dimensions
      • Model Number
      • CT Ratio
   C. PT Specifications
      • Accuracy
      • Burden
      • Rating Factor
      • Dimensions
      • Model Number
D. Power Monitoring Circuit Diagram

9 Commissioning

9.1 Meter operation will be confirmed when the commissioning for the DCCP is conducted.
1 General Controls

1.1 Unless noted below, all lighting is to be controlled via “dual technology” vacancy sensors.

1.1.1 The intent is that a room occupant will be required to turn the lights on manually when entering a room and have the ability to turn the lights off while in the room or upon leaving the room.

1.1.2 Lights will time off if the occupant leaves the room without manually turning the lights off. “Time-Delay-Off” feature shall be set for less than 15 minutes.

1.2 Corridors

1.2.1 Occupancy sensors only, no manual controls.

1.3 Mechanical, Electrical, and Communications Equipment Rooms

1.3.1 No automatic controls, wall mounted manual switches at all entries.

1.4 Laboratories

1.4.1 All under-counter lighting is to be tied to a local occupancy sensor as well as the master lighting control switch(es) located by the door(s).

1.4.2 Ambient lighting is to be controlled from ceiling or wall mounted sensors as well as the master lighting control switch(es) to manually turn the lights on and off.

1.5 Offices

1.5.1 Smaller offices, where cubicle partitions are not used, wall mounted vacancy sensors are to be utilized. In larger (multi occupant) offices, a combination of ceiling and wall mounted sensors may be used.

1.5.2 A means to manually turn off the lights will be provided.

1.6 Interior stairwells

1.6.1 Light fixtures are to remain illuminated at all times. In an effort to conserve energy each fixture will be fitted with an integral occupancy sensor in order to provide dual lighting levels (10-15 fc when the space is occupied and 1-5 fc when unoccupied).

1.7 Exterior controls

1.7.1 In general, exterior fixtures will be controlled via a photocell and timeclock with a manual override switch.

2 Daylight Harvesting

2.1 In all spaces (other than labs) where it is determined that a significant amount of sunlight may be present during the day photo-sensors are to be utilized in an effort to take advantage of daylight harvesting opportunities.

3 Sequence of Operations

3.1 The engineer shall provide a written sequence of operations on the electrical drawings.

4 Wiring Diagrams

4.1 The engineer shall provide wiring diagrams of the lighting controls on the electrical drawings.
1 Power and Lighting Wiring

1.1 Wiring for 208Y/120V, 3PH, 4W and 480Y/277V, 3PH, 4W branch circuits shall be installed in conduit.

1.2 Wiring for 208Y/120V, 3PH, 4W and 480Y/277V, 3PH, 4W feeders and services:
   1.2.1 Shall be installed in Rigid or IMC conduits.
   1.2.2 Conduit two inch or smaller it may be EMT.

1.3 Wiring for site lighting shall be installed in schedule 40 PVC conduits, without concrete encasement.

1.4 Wiring for Engine-Generator Control and Power Wiring shall be installed in:
   1.4.1 Outdoors
     - Rigid
     - IMC
     - Concrete encased or covered PVC conduit.
   1.4.2 Indoors
     - EMT conduit.

2 Power Limited Circuits

2.1 Wiring for Nurse Call, Door Alarm, Fire Alarm, Telephone, Cable TV, Building Automation Control Systems, and other related Power Limited Circuits and Systems should be installed in conduits, but at the Owner’s option, may be installed without conduits.

2.2 Cat 5 wiring for lighting control systems may be installed in skeletal conduit.

2.3 Wiring without conduits
   2.3.1 Utilize multi-conductor cables (for each respective system) of size, insulation, etc., suitable for the particular application.
   2.3.2 All cables, insulation, etc., shall be in full conformance with The National Electrical Code and U.L. requirements.
   2.3.3 Must have a dedicated, independent support system
     - Bridal rings
     - Skeletal systems.
   2.3.4 Shall be run parallel to building grids.
   2.3.5 Shall be supported at each device drop off.

2.3.6 Shall be supported at least every five feet.

3 Fire Alarm Devices

3.1 At the Owner’s option wiring for Fire Alarm Devices only may be installed using the appropriate “Riser” or “Plenum” rated cables as per NEC and in accordance with University Safety and Security Department requirements.
1 Specifications

1.1 Standards

1.1.1 NEMA TP-1
1.1.2 NEMA Premium
1.1.3 DOE CSL-3 efficiency
1.1.4 Transformers should be rated for no more than a 115°C temperature rise
1.1.5 Transformer sound level shall be guaranteed not to exceed NEMA standards

1.2 Transformer shall have primary voltage taps.

1.2.1 Provide a minimum of 4 at 2-1/2% steps
1.2.2 2-FCAN and 2-FCBN

1.3 Termination compartments.

1.3.1 Indoor type shall be Extra large
1.3.2 Exterior type shall be equipped with “Drip-proof” weather shield.

1.4 Transformers shall have electrostatic shielding when specified.

1.5 Insulation System

1.5.1 220°C
1.5.2 VPI (Vacuum Pressure Impregnated)

1.6 Cores

1.6.1 Steel laminated cores

1.7 Windings

1.7.1 Primary and Secondary windings shall be either copper or aluminum based on the recommendation of the A/E and AFC (Arc Flash Consultant).

2 Installation

2.1 Transformer core to be visibly grounded to frame.

2.2 Do not install below mechanical systems that could leak unless a “Drip-proof” weather shield is specified

2.3 Do not stack transformers one above the other

2.4 Transformers shall be supplied with a heavy duty safety switch, appropriately sized for the primary side. The disconnect switch shall be installed within sight of the transformer.

3 Approved Manufacturers

3.1 ABB
3.2 ACME
3.3 GE
3.4 Siemens
3.5 SOLA HEVI-DUTY
3.6 Square D (Sorgel)
3.7 Jefferson Electric
1 General
1.1 Switchboards shall be U.L. listed and labeled.
1.2 Each switchboard shall have its own main disconnecting means unless it is located in the same room as its source of origin. In most cases this will be a main breaker, molded case switch or fusible switch.
1.3 In general, switchboards shall be located in electrical equipment rooms or other equipment rooms designed for such.
1.4 These rooms shall be accessible by qualified personnel only and have corresponding signage stating such.
1.5 Switchboards shall not be located in corridors or other areas of public access.

2 Approved Manufacturers
2.1 Siemens
2.2 Square D
2.3 G.E.

3 Enclosure
3.1 Dead front and totally enclosed construction, front access.
3.2 Constructed of #12 gauge minimum steel, reinforced with channels and angles as necessary.
3.3 Provided with space as shown for future branches, bussed and equipped for the addition of breakers or fusible switch units.
3.4 Provided with Kirk type interlock arrangements if needed.
3.5 Removable, hinged door arrangement and adequate means of access to equipment for inspection and servicing without removal from switchgear assembly.
3.6 Wiring troughs shall have removable, hinged access doors.

4 Branch Switches
4.1 "QMB" type branches - quick make/quick break spring-loaded type, actuated by lockable handle.
4.2 Side hinged fuse access panels only.

5 Circuit Breakers
5.1 All breakers (Main and Distribution) shall be fully rated.
5.2 Series connected rated systems are not acceptable.
5.3 Breakers shall have provisions for Lock-Out / Tag-Out, capable of accepting padlocks.
5.4 Breakers over 225 Amps shall have adjustable electronic trip units unless the AFC (Arc Flash Consultant) recommends otherwise.
   5.4.1 Selectable settings required for arc fault mitigation are to be coordinated with the Arc Flash Hazard Analysis prior to project bid.

6 Construction
6.1 All bus bars to be plated copper of 98 percent conductivity.
6.2 All bus bars shall be braced for maximum short circuit protection.
6.3 All bus bar contacts and joints shall be plated.
6.4 Provide supported bus extension to bus duct connections, whether incoming service or outgoing feeders. Cable connections to bus duct from switches are not desired.
6.5 All distribution devices shall be group mounted.
6.6 Main bus location shall be as required to clear conduit access space in board, as well as aisle space on walkthrough boards.
6.7 The main section shall contain barriers, isolating it from the other sections of the switchboard.
6.8 Provide fiberglass Unistrut or equal cable supports in boards.
6.9 Provide copper bus bar pieces on switch load side for rear cable connection to lug, 600A size and above where applicable (main service switchboards only).
6.10 Horizontal (thru) bus shall be fully sized, extended and pre-drilled to accommodate future switchboard sections with standard splice plates.
6.11 Blank compartments shall be bussed and equipped to accept future breakers.
6.12 Switchboards shall be equipped with rodent barriers.
6.13 Switchboards shall be equipped with
barriers separating the wiring gutters from the bus bars. Removable barriers are preferred over taped bus.

6.14 Exterior Switchboards
6.14.1 In general shall be in NEMA 3R gasketed enclosure
6.14.2 Where switchboard is located in a corrosive environment, enclosure shall be type NEMA 4X
6.14.3 Shall be equipped with bottom closure plate
6.14.4 Shall be equipped with rodent barriers
6.14.5 Shall be equipped with strip heaters with wiring labeled and extended out to terminal blocks
6.14.5.1 The strip heaters shall have a dedicated power supply
6.14.6 Doors shall be hinged and pad-lockable

7 Miscellaneous

7.1 Provide engraved plastic one-line diagram on each board.
7.2 Provide an engraved plastic label on the front of the switchboard indicating the nominal CT ratio and PT ratio.
7.3 Provide a minimum 1/4" x 2" size cross sectional area copper equipment grounding bus in each switchboard and connect grounding bushings of feeder conduits.
7.4 Allow 3'-0" minimum clearance in rear of rear access boards.
7.5 Allow 4'-0" minimum clearance in front of all boards.

8 Isolation Circuit Breaker (ICB)

8.1 Located between the utility transformer secondary and the Main Service Switchboard.
8.2 Adheres to all Main Service Switchboard guidelines.
8.3 To have maintenance mode only where indicated by the Arc Flash study.
8.3.1 Maintenance mode will be indicated by a blue LED on the Isolation Circuit Breaker switchboard

8.3.2 Maintenance mode will be selected by a keyed switch on the Isolation Circuit Breaker switchboard. The keyed switch positions are to be clearly labeled “Maintenance Mode” and “Normal” respectively.

8.4 To be remote operation (see Typical Remote Pushbutton Enclosure Detail on page 6)
8.4.1 Operation unit to be installed in lockable enclosure capable of accepting a padlock with a 3/8” dia. hasp (for lock-out tag-out purposes).
8.4.2 Lockable enclosure to have breaker status indicator lights
• Indicator lights to indicate closed and open status and be labeled accordingly.
• Indicator lights to be red and green respectively
• Indicator for Maintenance Mode (when used) to be blue

8.4.3 Lockable enclosure to contain pushbuttons for remote circuit breaker operation
• Green pushbutton operation to cause the circuit breaker to open and be labeled accordingly.
• Red pushbutton operation to cause the circuit breaker to close and be labeled accordingly.

8.4.4 Lockable enclosure to contain keyed selector switch for Maintenance Mode operation. The keyed switch positions are to be clearly labeled “Maintenance Mode” and “Normal” respectively

9 Main Service Switchboards (MDP)
9.1 Freestanding NEMA Class I – to and including 2000A.
• 20” maximum depth
9.2 Freestanding NEMA Class II or Class III over 2000A.
• 32” minimum depth for front access
• 48” minimum depth for side or rear access
9.3 Provide special provisions for bus duct connections where the bus duct enters the switchgear
9.4 50,000A minimum "withstand" bracing and components.
9.5 Provide surge protection device (SPD).
  9.5.1 Remotely mounted on top of the MDP flush with the front of the switchgear in order to minimize lead lengths
  9.5.2 Feed from a dedicated branch circuit breaker located as close as possible to the SPD
9.6 Provide provision for grounding each phase bus bar to the ground bus. This shall be accomplished via a ball stud and socket clamp grounding system.
  9.6.1 Provide with one set of grounding cables with four socket clamps
  9.6.2 Provide cabinet or means for storing the grounding cables in the same room as the switchboard equipped with the ground studs.

10 Sub distribution Switchboards (SDP)
10.1 Freestanding NEMA Class I – to and including 2000A.
  • 20” maximum depth
10.2 50,000A minimum "withstand" bracing and components.

11 Provide Electronic Power Monitoring and Control
11.1 Refer to Division 26 Section 0913 of these guidelines.

12 Other Instrumentation, Control Power and Power Supplies
12.1 Any control power and power supplies shall be in a compartment isolated from any energized bus.
12.2 The compartment shall also contain a disconnect switch to disconnect power to the applicable components.
12.3 All components in the compartment shall have guarding in place to be considered "finger-safe" with respect to voltage above 50 volts.
12.4 All control wiring for switchboard and circuit breakers shall be wired to an accessible terminal strip in an isolated compartment within the switchgear. Both ends of the wiring shall be properly labeled.

13 Warranty
13.1 Warranty shall be the standard factory warranty from the date of purchase or from installation and shall include all parts, labor, travel and other expenses.
13.2 The Engineer of Record shall investigate pricing for an extended warranty and make recommendations to the owner.

14 Documentation
14.1 In addition to the standard Owner's Manual requirements, the project specifications shall require that a separate electronic copy (in PDF format), of the certified factory drawings shall be sent to the University Senior Electrical Engineer and to the Arc Flash Consultant.

15 Submittals
15.1 Coordination Meeting: The Electrical Contractor and Manufacturer's Representative shall schedule a review meeting with the Owner, Engineer of Record, and Arc Flash Consultant prior to officially submitting product data and shop drawings via the submittal process. The intent of the meeting will be to discuss and review products and shop drawings to demonstrate compliance with the project requirements and Purdue standards.
15.2 Product Data: For each type of switchboard, overcurrent protective device, metering device, accessory, and component indicated include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings (including C.T. and P.T. ratios), accessories, and finishes.
15.3 Also include the product data requested in the Switchboard Application Data Sheets, Branch Circuit Breaker Application Data Sheets, and Branch Fusible Switch Application Data Sheets.
  15.3.1 Uncompleted Application Data Sheet forms may be requested from the University Senior Electrical Engineer to be returned to the same.

16 Shop Drawings
16.1 Review Meeting: The Electrical Contractor and Manufacturer’s Representative shall
schedule a review meeting with the Owner and Engineer of Record prior to releasing the shop drawings for manufacture.

16.1.1 The intent of the meeting will be to review the shop drawings for compliance with the project requirements and Purdue standards.

16.1.2 The shop drawings shall be completely detailed and include an itemized Bill of Material.

16.1.3 The following parties shall be invited:
  - Contractor
  - Equipment Manufacturer’s Representative
  - Purdue Project Manager
  - Purdue Project Engineer
  - Purdue Senior Electrical Engineer
  - Purdue Electrical Observer (if applicable)
  - Arc Flash Consultant
  - A/E Engineer of Record

16.2 Deliverables for each switchboard and related equipment shall include:
  - Dimensioned plans
  - Elevations
  - Sections
  - Details, including required clearances and service space around equipment.
  - Tabulations of installed devices equipment features, and ratings (including C.T. and P.T. ratios).

16.3 Detail incoming busway into the switchboard.

16.3.1 Note type of feeder and show feeder entrance into switchboard (top or bottom fed, switchboard section number, cable or bus).

16.4 Detail bus configuration, current, and voltage ratings.

16.5 Detail short-circuit current rating of switchboard and overcurrent protective devices.

16.6 Detail illustrating additional gutter space requirements for distribution sections.

16.7 Detail metering equipment, accessories, connections and wiring diagrams.

16.8 Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

16.8.1 List adjustable circuit breaker setting types.

16.9 Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submittal shall also include a list of each overcurrent device provided indicating all upstream and downstream devices that will coordinate with the provided devices.

16.10 Include schematic and wiring diagrams for all power, signal, and control wiring within the switchboard enclosure.

16.11 Detail grounding balls and associated bus when grounding balls are specified.

16.12 Detail the wiring diagram for the motorized remote operated circuit breaker when the motorized remote operated circuit breaker is specified.
**17 Typical Remote PB Enclosure**

**TYPICAL REMOTE PB ENCLOSURE**

<table>
<thead>
<tr>
<th>TAG</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>16&quot;H X 16&quot;W X 6&quot;D NEMA 12 BOX SIMILAR TO HOFFMAN CSD16166 WITH CWHPTO HANDLE</td>
</tr>
<tr>
<td>b</td>
<td>13&quot; X 13&quot; PANEL</td>
</tr>
<tr>
<td>c</td>
<td>11&quot; X 7&quot; WINDOW KIT</td>
</tr>
<tr>
<td>d</td>
<td>4 BUTTON ENCLOSURE</td>
</tr>
<tr>
<td>e</td>
<td>LED PILOT LIGHT, 30mm</td>
</tr>
<tr>
<td>f</td>
<td>PUSHBUTTON, 30mm</td>
</tr>
<tr>
<td>g</td>
<td>ENGRAVED LAMINATED PLASTIC NAMEPLATE</td>
</tr>
<tr>
<td>h</td>
<td>LEGEND PLATE</td>
</tr>
</tbody>
</table>

**SCHEDULE NOTES:**
THE INTENT OF THIS SCHEDULE IS TO CALL OUT THE MAJOR PIECES OF THE SYSTEM. IT IS NOT INTENDED TO CALL OUT EVERY PIECE OF MATERIAL NEEDED. CONTRACTOR SHALL INCLUDE ALL NECESSARY PARTS AND PIECES FOR A COMPLETE AND SAFE OPERATING SYSTEM. COLORS: OPEN = GREEN, CLOSE = RED VOLTAGE PER BREAKER MFR RECOMMENDATIONS. VERIFY ALL WIRING REQUIREMENTS AND CONNECTIONS WITH CIRCUIT BREAKER MANUFACTURER. ALL INTERNAL WIRING TO BE IN CONDUIT OR WIREWAY.
### Application Data Sheet for Switchboards

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Vendor Name</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Name &amp; Location of Manufacturing Plant</td>
<td></td>
</tr>
<tr>
<td>Incoming Service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Incoming Service Voltage</td>
<td></td>
</tr>
<tr>
<td>3a</td>
<td>Phase</td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>Wire</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mains (MLO or MCB)</td>
<td></td>
</tr>
<tr>
<td>4a</td>
<td>Mains Rating (Amperage)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Neutral (Full or Half)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Service Entrance Equipment Rated (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>6a</td>
<td>If 6 No, is the equipment protected by class L fuses ahead of this equipment or is it protected by circuit breaker ahead of this equipment</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Short Circuit Withstand Rating (Bus Bracing)</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>Lowest AIC of Installed Device</td>
<td></td>
</tr>
<tr>
<td>7b</td>
<td>Fully Rated (Yes or No)</td>
<td>Series Rated Not Acceptable</td>
</tr>
<tr>
<td>8</td>
<td>Incoming Feed (Top, Bottom, Left, or Right)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Underground Pull Section (None required, Non-bussed, or Bussed)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Incoming (Cables or Busway)</td>
<td></td>
</tr>
<tr>
<td>10a</td>
<td>If 10 is Cables, Type of Lugs (Standard Mechanical, Compression, or Limiter)</td>
<td></td>
</tr>
<tr>
<td>10a.i</td>
<td>If 10a is Limiter Lugs, Phase Quantity &amp; Size</td>
<td></td>
</tr>
<tr>
<td>10a.ii</td>
<td>If 10a is Limiter Lugs Neutral Quantity &amp; Size</td>
<td></td>
</tr>
<tr>
<td>10a.iii</td>
<td>If 10a is Limiter Lugs or Compression Lugs by Others, List Manufacturer &amp; Catalog No.</td>
<td></td>
</tr>
</tbody>
</table>
### Switchboard Construction

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10b</td>
<td>If 10 is Busway, List Manufacturer and Catalog No.</td>
</tr>
<tr>
<td>10bi</td>
<td>If 10 is Busway, List Current Rating</td>
</tr>
<tr>
<td>10b.ii</td>
<td>If 10 is Busway, List Short Circuit Rating</td>
</tr>
</tbody>
</table>

### Switchboard Construction

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Enclosure Type (Indoor, Outdoor, NEMA/IEC Rating)</td>
</tr>
<tr>
<td>12</td>
<td>Construction (Rear Connected, Front Connected)</td>
</tr>
<tr>
<td>13</td>
<td>Construction Notes (Customer has Access to: Front Only, Front &amp; Rear, Rear Only, Side, Left, or Right)</td>
</tr>
<tr>
<td>14</td>
<td>Paint (ANSI 61 Light Grey Standard, Indoor, Outdoor, or Other)</td>
</tr>
<tr>
<td>15</td>
<td>Type of Bus (Tin Plate Copper, Silver Plated Copper)</td>
</tr>
<tr>
<td>16</td>
<td>Ampere Rating of Through Bus</td>
</tr>
<tr>
<td>16a</td>
<td>Type of Bus (Non-Tapered, Fully Bussed)</td>
</tr>
<tr>
<td>16b</td>
<td>Bus Cross Section Based On: (65 C Rise Over 40 Ambient, or 50 C Rise Over 40 Ambient)</td>
</tr>
<tr>
<td>17</td>
<td>Lifting Eyes (Yes or No)</td>
</tr>
<tr>
<td>18</td>
<td>Shipping Splits (Factory Choice or Single Sections)</td>
</tr>
</tbody>
</table>

### Metering

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Meter Provided (Yes or No)</td>
</tr>
<tr>
<td>19a</td>
<td>If 21 Yes, List Meter Manufacturer</td>
</tr>
<tr>
<td>19b</td>
<td>If 21 Yes, List Meter Model No.</td>
</tr>
<tr>
<td>19c</td>
<td>Installation Configuration (Hot or Cold Sequence)</td>
</tr>
<tr>
<td>20</td>
<td>Metering Compartment Provided (Yes or No)</td>
</tr>
<tr>
<td>21</td>
<td>CTs Provided (Yes or No)</td>
</tr>
<tr>
<td>21a</td>
<td>CT Manufacturer</td>
</tr>
<tr>
<td>21b</td>
<td>CT Model Number</td>
</tr>
<tr>
<td>21c</td>
<td>CT Ratio</td>
</tr>
<tr>
<td>21d</td>
<td>CT ANSI Accuracy and Burden Class</td>
</tr>
<tr>
<td>21e</td>
<td>CT RF at 30 C</td>
</tr>
<tr>
<td>21f</td>
<td>CT RF at 55 C</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Main Disconnects</strong></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Main Circuit Breaker (Yes or No)</td>
</tr>
<tr>
<td>22a</td>
<td>If 22 Yes, Type (Molded Case - Thermal Magnetic Trip, Molded Case - Solid State Trip, Insulated Case - Solid State Trip, Low Voltage Power Breaker - Solid State Trip, Adjustable Trip)</td>
</tr>
<tr>
<td>22a.i</td>
<td>If 22a Low Voltage Power Breaker - Solid State Trip, List Frame Catalog No., Ampere Rating, and Trip Rating</td>
</tr>
<tr>
<td>22a.ii</td>
<td>If 22a Adjustable Trip Settings, List Trip Unit Catalog No.</td>
</tr>
<tr>
<td>22b</td>
<td>If 22 Yes, Manually or Electrically Operated</td>
</tr>
<tr>
<td>22b.i</td>
<td>If 22b Electrically Operated, is the control wiring run to an accessible terminal strip in an isolated compartment (Yes or No)</td>
</tr>
<tr>
<td>22c</td>
<td>If 22 Yes, Stationary, Drawout, or Plug-In</td>
</tr>
<tr>
<td>22d</td>
<td>If 22 Yes, Solid-State Catalog No.</td>
</tr>
<tr>
<td>22e</td>
<td>Breaker Auxiliary Contacts (52a)</td>
</tr>
<tr>
<td>22f</td>
<td>Maintenance Mode (Yes or No)</td>
</tr>
<tr>
<td>22f.i</td>
<td>If 22f Yes, is there a blue LED indicator light on the gear (Yes or No)</td>
</tr>
<tr>
<td>22.f.i</td>
<td>If 22f Yes, is there a keyed selector switch on the gear (Yes or No)</td>
</tr>
<tr>
<td>23</td>
<td>GFI Protection for Main Disconnect (Yes or No)</td>
</tr>
<tr>
<td>23a</td>
<td>If 23 Yes, Type (Internal or External)</td>
</tr>
<tr>
<td>23a.i</td>
<td>If 23a is External, is there a Stationary Relay &amp; Monitor Panel with Test Function (Yes or No)</td>
</tr>
<tr>
<td>23a.ii</td>
<td>If 23a Is External, is there a Zone Selective Interlock (Yes or No)</td>
</tr>
<tr>
<td>23a.iii</td>
<td>If 23a.ii is Yes, what is it Interlocked With</td>
</tr>
<tr>
<td>23b</td>
<td>If 23 Yes, is Ground Fault Protection Ahead of this Equipment (Yes or No)</td>
</tr>
<tr>
<td>23c</td>
<td>If 23 Yes, is Feeder Ground Fault Protection Required (Yes or No)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>23c.i</td>
<td>If 26c Yes, How Many Feeder Circuits</td>
</tr>
<tr>
<td>24</td>
<td>Shunt Trip for Remote Tripping (Yes or No)</td>
</tr>
<tr>
<td>24a</td>
<td>If 24 Yes, Power Provided by Manufacturer or Other</td>
</tr>
<tr>
<td>24b</td>
<td>If 24 Yes, List Voltage Required</td>
</tr>
<tr>
<td>25</td>
<td>Kirk Key Interlock (Yes or No)</td>
</tr>
<tr>
<td>25a</td>
<td>If 25 Yes, Coordination Required with Other Locks (Yes or No)</td>
</tr>
<tr>
<td>26</td>
<td>Tie Circuit Breaker (Yes or No)</td>
</tr>
<tr>
<td>26a</td>
<td>If 26 Yes, Same Manufacturer and Model Number as Main Circuit Breaker (Yes or No)</td>
</tr>
<tr>
<td>27</td>
<td>Main Fusible Switch (Yes or No)</td>
</tr>
<tr>
<td>27a</td>
<td>If 27 Yes, Switch Type (BP Switch, VB Switch, Other)</td>
</tr>
<tr>
<td>27b</td>
<td>If 27 Yes, Switch Amperage Rating</td>
</tr>
<tr>
<td>27c</td>
<td>If 27 Yes, Fuse Type (Class L, Class J, Class RKI, Class RK5, Class T)</td>
</tr>
<tr>
<td>27d</td>
<td>If 27 Yes, Fuses to be Furnished by (Manufacturer or Others)</td>
</tr>
<tr>
<td>27e</td>
<td>If 27 Yes, Fuse Amperage Rating</td>
</tr>
<tr>
<td>28</td>
<td>Service Surge Protection Device Type</td>
</tr>
<tr>
<td>28a</td>
<td>Mounting (Internal or External)</td>
</tr>
<tr>
<td><strong>Branch Circuits</strong></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Have you completed and submitted the Branch Circuit Breaker and Branch Fusible Switch Application Data Sheets?</td>
</tr>
<tr>
<td><strong>Other Options and Modifications</strong></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Mimic Bus Color (Black or Specify Other)</td>
</tr>
<tr>
<td>31</td>
<td>Tape Wrapped Bus, Excluding Joints (Yes or No)</td>
</tr>
<tr>
<td>32</td>
<td>Compartmentalization (Yes or No)</td>
</tr>
<tr>
<td>32a</td>
<td>If 32 Yes, Main Only or Main and Branches</td>
</tr>
<tr>
<td>33</td>
<td>Heaters (Yes or No)</td>
</tr>
<tr>
<td>33a</td>
<td>If 33 Yes, Control Power by Manufacturer or Others</td>
</tr>
<tr>
<td>33b</td>
<td>If 33 Yes, Controls (Humidistat or Thermostat)</td>
</tr>
</tbody>
</table>
Show Location of Labeling on Shop Drawings. The following Special Labeling is Required:
- CT Ratio
- CT ANSI Accuracy and Burden Class
- CT RF at 30 C or 55 C

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Ground Bus Size</td>
</tr>
<tr>
<td>36</td>
<td>Ground Bus Location</td>
</tr>
<tr>
<td>37</td>
<td>Ground Bus Material</td>
</tr>
<tr>
<td>38</td>
<td>Barriers Between Sections (Yes or No)</td>
</tr>
<tr>
<td>39</td>
<td>Barriers in Wiring Gutters (Yes or No)</td>
</tr>
<tr>
<td>40</td>
<td>All breakers equipped with a lockout device to accept a padlock for LOTO (Yes or No)</td>
</tr>
</tbody>
</table>

In general, items and descriptions apply to all 3 phases unless otherwise noted.
## Application Data Sheet for Branch Circuit Breakers

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Circuit Breaker Designation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type (Molded Case - Thermal Magnetic Trip, Molded Case - Solid State Trip, Insulated Case - Solid State Trip, Low Voltage Power Breaker - Solid State Trip, Adjustable Trip)</td>
<td></td>
</tr>
<tr>
<td>1a</td>
<td>If 1 Low Voltage Power Breaker - Solid State Trip, List Frame Catalog No., Ampere Rating, and Trip Rating</td>
<td></td>
</tr>
<tr>
<td>1b</td>
<td>If 1 Adjustable Trip Settings, List Trip Unit Catalog No.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Manually or Electrically Operated</td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>If 2 Electrically Operated, is the control wiring run to an accessible terminal strip in an isolated compartment (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Stationary, Drawout, or Plug-In</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Solid-State Catalog No.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>GFI Protection for Main Disconnect (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>5a</td>
<td>If 5 Yes, Type (Internal or External)</td>
<td></td>
</tr>
<tr>
<td>5a.i</td>
<td>If 5a is External, is there a Stationary Relay &amp; Monitor Panel with Test Function (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>5a.ii</td>
<td>If 5a Is External, is there a Zone Selective Interlock (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>5a.iii</td>
<td>If 5a.ii is Yes, what is it Interlocked With</td>
<td></td>
</tr>
<tr>
<td>5b</td>
<td>If 5 Yes, is Ground Fault Protection Ahead of this Equipment (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Shunt Trip for Remote Tripping (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>6a</td>
<td>If 6 Yes, Power Provided by Manufacturer or Other</td>
<td></td>
</tr>
<tr>
<td>6b</td>
<td>If 6 Yes, List Voltage Required</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Kirk Key Interlock (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>If 7 Yes, Coordination Required with Other Locks (Yes or No)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Breaker Auxiliary Contacts (52a)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>All breakers equipped with a lockout device to accept a padlock for LOTO (Yes or No)</td>
<td></td>
</tr>
</tbody>
</table>
# Application Data Sheet for Branch Fusible Switches

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Switch Type (BP Switch, VB Switch, Other)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Switch Amperage Rating</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Fuse Type (Class L, Class J, Class RKI, Class RK5, Class T)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Fuses to be Furnished by (Manufacturer or Others)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Fuse Amperage Rating</td>
<td></td>
</tr>
</tbody>
</table>
1 General
1.1 Panelboards shall be U.L. listed and labeled.
1.2 Each panelboard shall have its own main disconnecting means. In most cases this will be a main breaker or molded case switch.
1.3 In general, panelboards shall be located in electrical equipment rooms or other equipment rooms designed for such.
   1.3.1 These rooms shall be accessible by qualified personnel only and have corresponding signage stating such.
1.4 Panelboards shall not be located in corridors or other areas of public access.
1.5 Panelboards shall not be used as the Main Distribution Panel.
1.6 Integrated panelboard assemblies are not acceptable for projects at Purdue University.
1.7 The engineer of record should verify the available fault current at each panel to ensure that the interrupting rating of the breakers (as specified) is adequate.

2 Approved Manufacturers
2.1 Siemens
2.2 Square D
2.3 G.E.

3 Branch Circuit Panelboards - Lighting or Power 225 amps and less
3.1 208Y/120 volt and 120/240 volt panelboards:
   • Be not less than 20" wide
   • Circuit breakers to be bolt on type
   • All breakers (Main and Distribution) shall be fully rated. Series connected rated systems are not acceptable
   • Buss bars to be silver or tin plated copper
   • 15 and 20 amp trip curves should be as recommended by the AFC (Arc Flash Consultant)
   • Breakers need to indicate tripped condition by a means other than the off position
   • Have a hinged-to-box (tub) front door construction. Panelboards shall require the use of two things to access energized parts; a key to open the panel door that exposes the breakers as well as the screws securing the panelboard front and a hand held tool (screwdriver) to open the cover that exposes energized parts
   • Panelboards with 30 or more branch circuits shall have a minimum of two self-latching locks for each door
   • Panelboards shall be equipped with 20% spare breakers of each size. A/E shall note that it is not the intention of this guideline to provide an extra panelboard just to meet the requirement for 20% spare breakers

3.2 480Y/277 volt panelboards:
   • Be not less than 20" wide
   • Circuit breakers to be bolt on type
   • All breakers (Main and Distribution) shall be fully rated. Series connected rated systems are not acceptable
   • Buss bars to be silver or tin plated copper
   • 15 and 20 amp trip curves should be as recommended by the AFC (Arc Flash Consultant).
   • Breakers need to indicate tripped condition by a means other than the off position.
   • Have a hinged-to-box (tub) front door construction. Panelboards shall require the use of two things to access energized parts; a key to open the panel door that exposes the breakers as well as the screws securing the panelboard front and a hand held tool (screwdriver) to open the cover that exposes energized parts
   • Panelboards with 30 or more branch circuits shall have a minimum of two self-latching locks for each door.
   • Panelboards shall be equipped with 20% spare breakers or each size. A/E shall note that it is not the intention of this guideline to provide an extra panelboard just to meet the requirement for 20% spare breakers

4 Power Panelboards (PP) - Power greater than 225 amps
4.1 Circuit breaker panelboards to be equal in construction to Square D I-line style or Siemens P4 and P5 series.
4.2 Fusible panelboards to be equal to Sq. D. QMB or Siemens, VB6 series.
4.3 Shall have copper bus with silver or tin plating for phase, neutral and ground conductors.
4.4 Conform to industry standard temperature rise ratings as tested by an independent laboratory.
4.5 All breakers (Main and Distribution) shall be fully rated. Series connected rated systems are not acceptable.

4.6 Under 1200 amp panels to have a hinged-to-box (tub) front door construction.

4.7 Each panelboard’s wiring gutter shall be a minimum of the manufacturer’s standard gutter width plus the following:
   - 225 A. and below – Standard gutter width
   - Greater than 225 A. through and including 400 A., Standard gutter width plus an additional 4” on each side
   - Greater than 400 A. through and including 800 A, Standard gutter width plus an additional 6” on each side
   - Greater than 800 A. through and including 1000 A., Standard gutter width plus an additional 6” on each side up to a maximum panelboard width of 46” (for a single section tub)

4.8 Alternative methods
   4.8.1 Increasing the wiring gutter cross sectional area by adding depth to the tub.
   4.8.2 Increasing the overall wiring gutter cross section area by adding a factory manufactured wiring gutter extension of the same height and depth as the panelboard tub.

5 Warranty

5.1 Warranty shall be the standard factory warranty from the date of purchase or from installation and shall include all parts, labor, travel and other expenses.

5.2 The Engineer of Record shall investigate pricing for an extended warranty and make recommendations to the owner.

6 Documentation

6.1 In addition to the standard Owner’s Manual requirements, the project specifications shall require that a separate electronic copy (in PDF format), of the certified factory drawings shall be sent to the University Senior Electrical Engineer and the project Arc Flash Consultant.
1 Motor Control Equipment

1.1 All controllers shall be equipped with solid-state type overload elements, equipped with single phase protection. The overload relay must be of the manual reset type, auto-reset features are not acceptable.

1.2 Overload elements shall be sized for actual motor amperes, but shall not exceed motor nameplate rating.

1.3 Motor controllers Reference standard is Square D, Allen Bradley, Siemens, G.E. or equal.

1.4 Minimum size controller shall be size 0.

2 General Description

2.1 Controllers shall:

2.1.1 Be complete with 120 volt fused control transformer, (dual fusing in primary, single fusing in secondary and grounded secondary) where the system voltages are 208V, 240V, 480V.

Exception: Controllers installed on 208V systems need not be furnished with a control transformer when a neutral conductor is provided.

Note: A separate fuse holder and fuse must still be provided for the control circuit and sized to protect the devices in the control circuit.

2.1.2 Have cover-mounted push-to-test pilot light.

2.1.3 Have NEMA rating of size required, NEMA size 0 minimum.

2.1.4 Be complete with solid-state type overload elements per speed or step, sized for actual motor amps, but not to exceed nameplate rating.

2.2 All terminations shall be mechanical screw type suitable for 75°C copper wire.

3 Single Phase Controllers

3.1 Manual Controller/non-interlocked/without thermal protection:

- HP (horsepower) rated.
- 1 HP maximum at 120 volts.
- Toggle type.
- Enclosure as required for location.
- Flush or surface mounted as required for location.

- With separate neon "on" pilot where required.
- One or two pole as required.
- Reference standard Bryant #30002, 30102.

3.2 Manual Controller/non-interlocked/with thermal protection:

- HP (horsepower) rated.
- 1 HP maximum at 120 volts.
- Toggle type.
- Reference standard is Square D, Allen Bradley, Siemens, G.E. or equal.

3.3 Automatic/Interlocked:

- Designed for switching motor loads.
- 1 HP maximum at 120 volts.
- Reference standard is Square D or equal.

4 Three Phase Controllers

4.1 Manual Controller/non-interlocked/with thermal protection:

- Designed for starting motor loads.
- 7-1/2 HP maximum at 230 volts (size 0 minimum).
- Toggle type STOP-START and "ON" pilot in cover.
- 3 pole - 120 volt coil voltage.
- Reference standard is Square D, Allen Bradley, Siemens, G.E. or equal.
5 Control Stations

5.1 Provide heavy duty or "Hand-Off-Auto" selector switches equal to Allen Bradley Bulletin 800H on controllers for equipment.

5.2 The equipment includes, but shall not be limited to the following:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Hand-Off-Auto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Heating Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Heat Recovery System Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Hydronic Pumps</td>
<td>X</td>
</tr>
<tr>
<td>A.C. Units</td>
<td>X</td>
</tr>
<tr>
<td>Return Air Fans</td>
<td>X</td>
</tr>
<tr>
<td>Exhaust Fans</td>
<td>X</td>
</tr>
<tr>
<td>Steam Condensate Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Steam Vacuum Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Air Compressors</td>
<td>X</td>
</tr>
<tr>
<td>Vacuum Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Sump Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Sewage Pumps</td>
<td>X</td>
</tr>
<tr>
<td>Dionizer Pumps</td>
<td>X</td>
</tr>
</tbody>
</table>

*Note:* If equipment has been determined, by the Owner/User to be automatically controlled only, do not connect the "Hand" side.

6 Control Center Reference Standard

6.1 Square D - Class 8998 - Model 6 or Equal equipment by Siemens
1 Ratings
1.1 Three Phase 208Y/120 volt lighting systems with neutral.
  1.1.1 Rated 600 volt, 3 phase, 4 wire with full size neutral
1.2 Three Phase 240 volt power systems
  1.2.1 Consult Senior Electrical Engineer for these systems
1.3 Three Phase 480Y/277 volt power systems with neutral
  1.3.1 Rated 600 volt, 3 phase, 4 wire with full size neutral

2 Sound Levels
2.1 Inaudible when located in service shafts and loaded to rated capacity.

3 Protection
3.1 General purpose “Indoor Type” shall be used for Plug-in bus duct.
   3.1.1 Enclosure Class shall meet one of the following standards
        • NEMA 12
        • IEC IP40
   3.1.2 Provide closure plates at each suspended slab as a seal, with fire rated material packed around the busway and between the plates.
3.2 Vaults, unconditioned spaces, and exterior installations (including tunnels) “Outdoor Type” shall be used for all Feeder Bus Duct.
   3.2.1 Enclosure Class shall meet one of the following standards
        • NEMA 3
        • IEC IP54
   3.2.2 Use where located in unheated spaces such as vaults
   3.2.3 Use where located below gratings or outside buildings
   3.2.4 Use for all feeder bus duct inside buildings.
   3.2.5 Arrange installation to drain condensation.
   3.2.6 Provide closure plates at each wall penetration as a seal, with fire rated material packed around the busway and between the plates.

4 Material
4.1 Copper bus bars
4.2 Painted steel case

5 Plug-In Style Busway
5.1 Sizes
   • 100A
   • 225A
   • 400A
5.2 Configuration
   • 3 phase, 4 wire
   • Neutral and phase conductors of equal size
   • The busway shall have a copper ground system consisting of one of the following:
     • A separate 50% rated copper internal ground bus.
     • A 50% rated ground bus consisting of two pieces of copper completely enclosing the phase bus bars.
     • The sheet metal case enclosing the busway shall act as the ground only when approved to do so on a case by case basis by Purdue Engineering. In this case both flanged ends shall terminate with a ground bar affixed to the case and equipped with a lug.
5.3 Plug positions
   • Provide on both sides of Busway
   • Provide hinged covers for all plug openings
   • Plug positions two feet on centers
5.4 Plug-in units
   • Circuit breaker type
   • Common trip for all poles
   • Copper bus bars
   • Operator handle for opening or closing from a floor position

6 Joints
6.1 Sandwich style joint stack
6.2 Snap head torque joint bolt for initial
installation

7 Installation

7.1 Install bidirectional sway restraints at each end and at manufacturers recommend intervals on rod suspended systems.

7.2 Design and install with NEC front clearance requirements for plug in units, on both sides of the busway.

7.3 Specify pre-energizing testing procedures.

7.4 Include re-torque requirements and procedures after one year of energized operation.

8 Approved Manufacturers

8.1 GE
8.2 Square D
8.3 Siemens
2018 Consultant’s Handbook
Division 26 Electrical
2726 Wiring Devices

1 Switches and Receptacles
1.1 General
1.1.1 "Interchangeable" type devices are not acceptable.
1.1.2 All devices shall be Ivory in color, except for special purposes
   - Orange for isolated ground
   - Blue for surge devices
   - Red for emergency power.
1.1.3 Install all receptacles with the “U” ground down.
1.1.4 All wiring devices (receptacles, switches, etc.) shall be specification grade, “extra heavy duty industrial” type or the heavy duty commercial type when industrial type is not offered.
1.1.5 All wiring devices terminations must be “tailed-out” and “side wired”.
1.1.6 All receptacles to have one piece brass mounting strap.
1.1.7 USB type receptacles are not permitted.
1.2 Approved Manufacturers:
   - Hubbell
   - Leviton
   - P&S.

2 Outlet Boxes
2.1 General
2.1.1 Every switch, light, wall receptacle, telephone outlet, data plug, etc. shall be provided with an outlet box
2.1.2 “Through” and “Handy boxes” are not acceptable
2.1.3 Boxes installed “Back to Back” or within 12 inch center to center, penetrating opposite sides of wall construction and installed in a fire resistive and /or fire rated wall shall not be permitted
2.2 Sizing
2.2.1 All boxes shall be sized in accordance with NEC rules
2.2.2 Four inch square by 2 ¼” deep for two or more conduits or devices
2.2.3 Four inch octagon or square boxes for fixture outlets

2.2.4 Three by two inch conduit switch box 2½”deep for single conduit (dead end)
2.2.5 Raco #503 or approved equal in drywall
2.2.6 Raco #690 or approved equal in masonry

2.3 Approved Manufacturers
   - Appleton
   - Raco
   - Steel City.

3 Poke-thru Devices
3.1 General
3.1.1 Fire rated poke-thru devices for power, data, and A/V to vary on size depending on utilities needed
   - 4” poke-thru for power only
   - 6” poke-thru for power only or power and data
   - 8” poke-thru for power and data or power, data, and A/V
3.1.2 Coordinate design requirements with ITaP and Purdue A/V
3.2 Approved Manufacturers
   - Wiremold/Legrand “Evolution” series
   - Hubbell “SystemOne”series

4 Floor boxes
4.1 General
4.1.1 Coordinate design requirements with ITaP and Purdue A/V
4.2 Approved Manufacturers
   - Wiremold/Legrand “Evolution” series
   - Hubbell “SystemOne”series
1 Low Voltage Fuse Manufacturers

1.1 Buss “Fusetron” - FRN-R/FRS-R.
1.2 Buss “Low Peak” - LPN-RK/LPS-RK.
1.3 Buss “Low Peak” - KRPC.

2 Motor Protection

2.1 Fuses for motor protection shall be sized not to exceed 125% of the motor nameplate data current, except fuses protecting motors with variable frequency drives that shall be sized per drive manufacturer's recommendations.

3 Amp Rating

3.1 Fuses rated at 600 amperes or less shall be UL Class “R” rejection type or Class "J" type. In most cases Low peak fuses should be used.
3.2 Fuses rated 601 amperes and larger shall be UL Class “L” current limiting bolt-in rejection type with at least a 45 second time delay at 200%.

4 Additional Description

4.1 "Fusetron" types shall have 200,000 A.I.C. RMS Symmetrical per UL Standards with minimum opening time of 10 seconds at 500% rating and UL Class RK-5.
4.2 “Low Peak” type shall have 200,000 A.I.C. RMS symmetrical with minimum opening time of 10 seconds at 500% rating. The short circuit element shall be silver sand UL Class RK-1. Provide stick-on labels on enclosure cover indicating size and type for this fuse type.
4.3 "Hi-Cap" type shall have 200,000 A.I.C. RMS symmetrical with minimum opening time of 4 seconds at 500% rating and current limitation per UL Standards. Silver linked.
1 Manual Motor Starting / Disconnect Switches

1.1 Fractional HP (1/3 HP maximum) 120V switches with overload protection shall be Buss "SSY" fused switch unit or equal. Switches with overload protection shall be Square D, Class 2510 or equal.

1.2 Switches without overload protection shall be Square D, Class 2510 or equal manual motor switch.

2 Disconnect Type

2.1 Fusible or non-fusible equal to Square D “H series”, Siemens “VB-2” with visible jaw.

2.2 With solid neutral where required.

2.3 As manufactured by Square D or Siemens.

2.4 "Heavy duty" type for all fusible and non-fusible uses
1 Integral Disconnects
1.1 In general, we use an integral disconnect switch. The disconnect type shall be a molded case breaker. Provide an integral service bypass on each VFD only when called out to do so.

2 Ratings
2.1 The VFD shall be sized at 100% of the motor current based on the motor horsepower as described in the NEC 430.250.
2.2 The VFD shall be rated (and name plated) for a 50°C ambient temperature.

3 Line Reactor
3.1 The VFDs shall be equipped with a 3% – 5% line reactor or equivalent.

4 Isolation By-Pass
4.1 The VFD by-pass shall be isolated with barriers from components in the VFD “normal” operation mode.

5 Power Wiring
5.1 All power wiring shall be routed by itself in metallic conduit.

6 Control Wiring
6.1 All control wiring shall be routed in a separate metallic conduit apart from the power wiring. This includes wiring to Electrical Interlock contacts referenced below.

7 Electrical Interlocks
7.1 All safety disconnects located on the load side of the VFD will be equipped with a set of normally open electrical interlock contacts connected in series with the VFD control circuit.
7.2 Specify the electrical interlock contacts to break before and make after the primary contacts of the associated disconnect.
7.3 The wiring to the electrical interlock will be in metallic conduit and routed separately from the power conductors.

8 Isolation Transformers
8.1 Use isolation transformers for voltage matching only, or when the VFD manufacturer specifically recommends that they be used for their drive.
8.2 When input power transformers are required, it should be stipulated that they not be located directly below the VFD in order to avoid raising the ambient temperature around the drive.
8.3 The contract drawings should clearly illustrate the location of the drive isolation transformer away from the VFD.

9 VFD Installation
9.1 The VFD specification should indicate that the wiring methods and installation of the drive be per the manufacturers’ recommendations.
Note: Coordinate VFD and motor to prevent premature bearing failure.
9.2 The VFD and Motor combination should be recommended by both the VFD and Motor manufacturers as an acceptable matched set.

10 Diagrams
10.1 The drawings need sufficient wiring diagrams, illustrations, and notes for the EC to terminate all wiring for the VFD and its associated systems, i.e. fire alarm etc.
10.2 The VFD specification should indicate that the wiring methods and installation of the drive be per the manufacturers’ recommendations. This would include items such as the routing of all conductors in metallic conduit as well as the routing of control conductors in separate metallic conduits from the power conductors.

11 VFD Location
11.1 The designing A & E firm shall locate the VFD where the ambient temperature is within the limits designated by the VFD manufacturers.

12 Acceptable Manufacturers
12.1 ABB
12.2 Allen Bradley (Power Flex)
12.3 Square. D
1 General
1.1 All Packaged Generator Assemblies shall conform to UL 2200 and be appropriately tagged.
1.2 All Packaged Generator Assemblies shall meet the requirements for Emergency Systems, NEC Section 700
1.3 All Packaged Generator Assemblies shall have a Seismic Restraint & Vibration Isolation Submittal
1.4 Provide a concrete pad that extends at least 4 feet from the generator base on all sides.
1.5 This equipment (including the engine generator, generator controls, access platform and automatic transfer switch(es)) should be supplied by a single Supplier who has been regularly engaged in the sales and service of engine-generators, generators, engine auxiliaries, transfer switches, and controls for a minimum of five years.
1.6 The Supplier must have a local representative who can provide factory-trained servicemen, required stock of replacement parts, and technical assistance.

2 Fuel and Fuel Tank
2.1 The fuel shall be diesel with a 24-hour tank unless specified otherwise. Fuel tank shall meet all EPA requirements. Obtain Purdue approval if sizing tank other than 24-hour.
2.2 Fuel fill shall be inside the enclosure
2.3 Fuel overflow shall be inside the enclosure
2.4 Fuel level gage shall be inside the enclosure

3 Life Safety Transfer Switch
3.1 Life safety loads are to be on their own transfer switch.
3.2 The life safety transfer switch shall be fed as per the applicable NEC section 700
3.3 The transfer switch for life safety can be of the open transition style

4 Standby and optional Standby Transfer Switch
4.1 Legally required standby and optional standby loads each are to be on a separate transfer switch.

4.2 The standby and optional standby transfer switch shall be fed as per the applicable NEC sections 701 and 702
4.3 These transfer switches shall be of the closed transition style
4.4 Note: Refer to Section 26-3600 Automatic Transfer Switches

5 Emergency shutdown
5.1 Do not specify a remote Emergency stop button for remote installation inside the building.
5.2 Do not specify a remote Emergency stop button for installation on the outside of the housing enclosure.

6 Generator access
6.1 Provide a service platform when the top of access doors are more than 72 inches above grade. Set the platform elevation such that the top of the access doors are no more than 72 inches above the platform. Provide a commercially available platform assembly.
6.2 All service points are to be accessible without the use of a ladder. Stairs should be used to access the platform.
6.3 The walkway (stairs and platform) shall meet standards of OSHA 3124 - Stairways and Ladders and NEC minimum working space requirements.
6.4 Platform and stairs are to be removable for major servicing, and only connected to the generator by bolts or properly supported from the concrete pad surrounding the generator base with required isolation.
6.5 Maintain bonding integrity within the generator assembly and any service platforms connected to the frame assembly.
6.6 All Panel Doors must be lockable.
6.7 Generator doors are to be hinged and mounted with removable hardware. Lift-off panels are not acceptable unless they are hinged.
6.8 If fluid fill or other inspection points are on the top exterior of the unit, provide a means of access. This should be removable with a storage space within the enclosure.

7 Sound Considerations
7.1 All panels to be fitted with sound absorbing media
7.2 Provide sound attenuation so that the noise level at 7 meters is less than 80 dB.

8 Lights
8.1 Include switched service lights inside the enclosure
8.2 Provide lights inside the generator service yard. Lights to be on battery back-up.

9 110 VAC Power
9.1 Include a 110 VAC service duplex receptacle inside the enclosure
9.2 Provide the battery charger with a cord and plug. Do not hard wire the charger for ease of removal to perform maintenance.

10 Air Intakes
10.1 Shall be provided with motorized dampers to prevent snow infiltration.
10.2 Shall be screened to keep birds out.

11 Approved Manufacturers
11.1 Caterpillar
11.2 Cummins Power Generation
11.3 Kohler
11.4 MTU Onsite Energy
1 Description of System

1.1 Diesel engine driven electric generating unit is to be factory assembled, tested and certified to operate at the stated nameplate values

1.2 480Y/277 output voltage, 3PH, 4W, 60Hz, grounded neutral or as specified on the drawings

1.3 Fully rated for continuous operation at elevations up to 1000 feet above sea level and ambient temperatures of 95°F

1.4 System Components

- Diesel engine
- Direct connected generator
- Exciter
- Exhaust system with noise abatement
- Automatic starting equipment
- Control and instrument panels and devices
- Common steel base
- Batteries and charging system
- Power disconnect switch(is) and automatic transfer switch(is)
- Vibration pads (steel spring isolators for inside installations)
- EPA Emissions compliant for Emergency Stationary Internal Combustion Engines
- EPA spill containment compliant 24 hour fuel tank

2 Quality Assurance

2.1 Equipment shall meet all applicable requirements of SAE, IEEE, NEMA, NEC and ANSI/NFPA 110 Standards

2.2 The engine, generator and all major items shall be by U.S. manufacturers

2.3 The manufacturer shall assemble and factory test the unit

2.4 Normal factory tests shall include maximum and continuous net brake horsepower over the operating speed range of the engine

2.5 The authorized dealer with a service and parts facility within 60 miles of the project site shall take delivery from the factory and complete assembly of all dealer supplied options

3 Submittals

- Drawings and operating characteristics of proposed engine generator set

4 Warranty

4.1 Standard two year parts and service for all components

4.2 Extended five year parts and service on engine and accessories, generator, exciter and system controls

5 Engineering Field Service

5.1 Provide service technical support to the installing contractor during installation

5.2 Check out all equipment installation, wiring, field connections using a certified field service technician

5.3 Set up and test all controls, verify operation and adjustment of mechanical systems

5.4 Provide a four step running load test with a resistive load bank

5.5 Each step should be at least one hour in duration, with the final step at 100 percent load

5.6 Written inspection startup report

5.7 The generator shall be turned over to the owner with a full fuel tank after all testing has been completed

6 Diesel Generator

6.1 Engine Requirements

6.1.1 Industrial, multi-cylinder, four stroke, 1800 RPM for operation on No. 2 domestic fuel

6.1.2 Fuel system complete with fuel filter and priming pump

6.1.3 Lubrication full pressure engine
driven positive displacement sump pump, full flow filter

6.1.4 Cooling system pressure type with radiator, pusher type fan, coolant shutoff valves and drain on oil cooler to facilitate service. Provide coolant to minus 35°F

6.1.5 Air intake with dry type filter

6.1.6 Immersion heater system to maintain engine coolant and lube oil temperature in readiness for fast starting. Pipe remotely with shutoff service and drain valves.

6.1.7 Engine Block heaters shall have coolant shut-off valves on both sides

6.1.8 Engine Block heaters shall be cord and plug connected

Note: Items 6.1.7 & 6.1.8 are designed to facilitate maintenance

6.2 Electrical Starting System

6.2.1 Not less than 24 VDC

6.2.2 Heavy duty cranking motor with drive mechanism

6.2.3 Heavy duty storage batteries with metal frame or box

6.2.4 Master disconnect switch with lock out lever kit, suitable for multiple padlocks or lockout hasp

6.2.5 Cranking motor capable of cranking engine five times in rapid succession without overheating and sufficient speed for minus 20 degF starting

6.2.6 Storage batteries with capacity to start the engine generator five times consecutively as specified

6.3 Governor

6.3.1 Electronic, adjustable isochronous suitable for providing accurate speed control and droop stabilization

6.3.2 Maximum observed speed band, plus minus 0.25% deviation from rated at constant load

6.3.3 Speed droop adjustable from 0% to 7% for load application from no load to full load

6.4 Safety Devices

6.4.1 Safety controls which will shut down the engine and open the generator main circuit breaker

6.4.1.1 Over-speed stop between 115% and 125% of rated speed

6.4.1.2 High coolant temperature cutout

6.4.1.3 Low oil pressure cutout with adjustment set to operate when oil pressure drops below manufacturer’s recommendation

6.4.1.4 Engine over-crank cutout adjustable from 15 to 60 seconds

6.4.2 Safety controls should be programmed to record and store alarms as well as safety actuation. Alarms should be adjustable by the Owner. Cutouts should only be adjustable by manufacturer’s field service technician.

6.5 Generator

6.5.1 Alternating current, single bearing, direct connected, separately excited, externally regulated, synchronous type, Class F insulated with an amortisseur winding, drip proof self-ventilated enclosure

6.5.2 Continuous rating as specified on the nameplate, conforming to referenced standards including wave form, telephone influence factors

6.5.3 Total harmonic distortion less than 5% with control conforming to IEEE 519

6.5.4 Extend all leads to a main termination terminal box, adequate in size to make all terminations including neutral and ground

6.5.5 Neutral shall be isolated from ground and shall maintain lugs for connection from normal and engine generator source and load wires. The neutral shall have easily accessible provisions for readily accepting a system bonding jumper to ground in the case of a separately derived system.

6.5.6 Provide a suitable generator field discharge resistor automatically connected and disconnected as required for proper operation

6.6 Output Circuit Breaker(s)

6.6.1 The output circuit breaker with shunt trip shall be mounted on the unit frame assembly.

6.6.2 Circuit breaker shall be 100% rated and equipped with auxiliary contacts to monitor position

6.6.3 Circuit breaker shall be insulated case, heavy duty with RMS digital sensing trip unit
6.6.4 A ground fault sensing system shall be provided to sound/indicate an alarm locally

6.6.5 Ground fault detection shall not trip the circuit breaker

6.7 Exciter

6.7.1 Built in alternator type mounted on generator shaft, directly connected to the generator field windings without intervening brushes, slip rings or commutators

6.7.2 Not less than 6 solid state rectifiers and surge protectors

6.8 Voltage Regulation

6.8.1 Static type, 3 phase voltage regulator

6.8.2 Adjustment of rated voltage over a range of plus minus 10 %

6.9 Manual and Automatic Start Operation

6.9.1 Generator to be able to complete an automatic engine starting and load transfer after sensing a predetermined, adjustable single or multiple phase voltage sag

6.9.2 Upon restoration of normal power, generator is to be able to sequence phase rotation and automatically transfer load back to normal source and shut the engine generator down

6.9.3 Manual-Off-Automatic selector located on generator control panel

6.9.3.1 Resetting of the automatic engine control after a failure by moving the selector switch from “Auto” to “Off” and then back to “Auto”

6.9.3.2 Manual starting and stopping of the engine without transferring the load when placing the selector switch in the “Manual” position

6.9.3.3 Prevent any operation of the engine generator in any mode when placing the selector switch in the “Off” position.

6.10 Starting Control Guidelines

6.10.1 The controller shall start the engine generator set when the normal supply voltage in any phase drops below a predetermined value, programmable from 100% to 85%

6.10.2 The engine generator will operate until normal voltage is restored to a predetermined value, programmable from 85% to 100%

6.10.3 The engine generator will monitor the normal voltage for an adjustable time period, programmable from 0 to 30 minutes and if no interruption is experienced the unit will synchronize phasing and transfer the load back to normal source

6.10.4 The engine generator will continue to run for a predetermined value, programmable from 0 to 5 minutes for a no load cool down and then shut down

6.10.5 Delay time in initiation of the engine starting control is to be adjustable from 0 to 2 minutes

6.10.6 Provide indicating light that the load is on engine generator source

6.10.7 Transfer of load to the engine generator source after 90 % of rated voltage and frequency values have been achieved

6.10.8 Permit simulation of normal power failure without load transfer by a maintained contact switch

6.10.9 Permit manual retransfer of the load to normal service, during the adjustable 5 to 30 minute delayed return transfer period, by a momentary contact switch

6.10.10 Permit load to be continuously supplied by the engine generator set, regardless of normal power condition, through use of a maintained contact switch

6.11 Instrument /Control Panels

6.11.1 Provide one or more panels mounted on a common supporting system that is part of the steel base for the engine generator assembly.

6.11.2 Provide fully identifying name plates permanently attached to the panels or structure.

6.11.3 Provide a vibration isolation system to prevent premature failure of electronic components

6.11.4 Provide Modbus communication between RTU’s and Generator Control Panel

6.11.5 Control functions

• Manual-Off-Auto selector switch
• Engine Start push button
• Engine Stop push button
• Main Circuit Breaker
  o Shunt Trip
  o Over current rip
6.11.6 Programmed Display Alarms

- Low Oil Pressure Pre Alarm
- Low Oil Pressure Alarm
- High Coolant Temperature Pre Alarm
- High Coolant Temperature Alarm
- Low coolant level
- Failure to Crank
- Failure to generate
- Overspeed Stop
- Overcrank

6.11.7 Programmed Display Measured Values

- Fuel pressure
- Battery Voltage
- Battery charging current
- Output voltage
- Output frequency
- Output current
- Run time hour clock, accumulated
- Kilowatt Hour
1 Emergency Power Types

1.1 Battery Racks

1.1.1 It is rare that we use this type of alternate power source.

1.1.2 If the designer believes a rack of emergency batteries is the appropriate power source contact the PM to get written approval before proceeding.

1.2 Individual Battery Packs

1.2.1 In buildings that are not served by an emergency generator or central EMAC unit, emergency power for lighting may be provided via an individual battery pack (similar to the Bodine B50 ST for fluorescent fixtures or the Bodine BSL17C-C2ST for LED fixtures). In the case of LED fixtures, the emergency LED driver shall be factory installed and matched to the LED load as per the manufacturer's instructions. For fixtures using the TLED lamps, verify that the emergency driver is compatible for the specific application and include the supporting documentation in the submittals.

1.2.2 The battery pack is to be integral to the fixture, and self-testing (monthly and yearly), with visual status indicator lamp, test switch, and audible alarm.

1.3 Remote Inverter

1.3.1 LED fixtures that are external to the building or are not able to employ individual battery packs may be powered from a remote inverter that has been approved by the fixture manufacturer as being compatible with the fixture.

1.3.2 A centralized system should be utilized and located in the main electrical room.

1.4 Generators

1.4.1 For most larger and all research buildings this is our first choice.

1.4.2 Generators are to be diesel powered with the skid mounted fuel tank under the generator. The tank should hold enough fuel for 24 hours of operation.

1.4.3 Each distinct emergency power system load (defined below) should have a separate automatic transfer switch.

2 System Classifications

2.1 Emergency Power Loads are defined as having power available within 10 seconds of the failure of the normal supply.

2.2 Standby Power Loads are defined as having power available within 60 seconds of the failure of the normal supply.

Note: Classifications are to be as outlined in the 2006 IBC and the Indiana Building Code

3 Items Considered Emergency Power Loads

3.1 The generator should be sized to carry at least the following items (emergency power loads):

- Emergency exit lighting (including exit signs and means of egress illumination)
- Emergency Voice/Alarm Communication Systems
- Fire Alarm and Automatic Fire Detection Systems
- Elevator car lighting in underground or high rise buildings
- Occupancies with highly toxic and toxic materials and those containing pyrophoric materials such as silane gas

3.2 Items Considered Standby Power Loads

- Smoke control systems
- Elevators (including accessible means of egress elevators)
- Fume hood exhausts and air handling units

Note: The goal is to operate these systems as necessary to prevent negative pressure situations or the accumulation of toxic fumes in buildings.

4 Additional Power System Information

4.1 In buildings equipped with a fire pump, the pump is to be connected to the building transformer prior to the main building disconnect through a separate transfer switch.

4.2 Any additional loads connected to the alternate power source should have a transfer switch separate from those listed above.

4.3 Supplementary information regarding emergency and standby loads is located in Chapter 27 of the International Building Code.

Note: A table summarizing that information is found at the end of this section.
5 Battery Pack Requirements

5.1 Units to be self-testing.

5.1.1 This includes every 30 days and once a year the unit is to do a complete test including a manufacture approved discharge test that test the full functionality of the unit and its capacity to meet the 90 minute lighting capacity.

5.1.2 All testing is to be completely automatic including the annual test. Report of a test failure is to be both audible and visual.

5.2 Units are to maintain exit lighting for 90 minutes
### 6 Table of Emergency and Standby Loads

<table>
<thead>
<tr>
<th>Category</th>
<th>Power Systems</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Occupancies</td>
<td>Emergency</td>
<td>Voice Communication Systems in Group A Occupancies</td>
</tr>
<tr>
<td>Exit Signs</td>
<td>Emergency</td>
<td></td>
</tr>
<tr>
<td>Means of Egress Illumination</td>
<td>Emergency</td>
<td></td>
</tr>
<tr>
<td>Semiconductor Fabrication</td>
<td>Emergency</td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I-3 Occupancies</td>
<td>Emergency</td>
<td>Power for doors in Group I-3 Occupancies</td>
</tr>
<tr>
<td>High Rise Buildings</td>
<td>Emergency</td>
<td>Emergency voice/alarm communication systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emergency Elevator car lighting</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Fire Command Center</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Fire pumps</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Lighting for mechanical equip. rooms</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Elevators</td>
</tr>
<tr>
<td>Underground Buildings</td>
<td>Emergency</td>
<td>Emergency voice/alarm communications system.</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>Fire alarm systems</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>Automatic fire detection systems</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>Elevator car lighting</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>Egress lighting and exit sign illumination</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Smoke management system</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Smoke-proof enclosure</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Fire pumps</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>One elevator to serve all floors with the capability of transferring power to any elevator</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Emergency power loads.</td>
</tr>
<tr>
<td>Hazardous Materials</td>
<td>Emergency</td>
<td>Highly Toxic or Toxic Materials</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>Occupancies with Pyrophoric Materials and Silane Gas</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Organic Peroxides</td>
</tr>
<tr>
<td>Membrane Structures</td>
<td>Emergency</td>
<td>Exit Signs in Temporary Tents (IFC Code)</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Auxiliary Inflation Systems (Section 3102.8.2)</td>
</tr>
<tr>
<td>Covered mall buildings (&gt; 50,000 ft²)</td>
<td>Standby</td>
<td>Systems Capable of Operating Emergency Voice/Alarm Communication</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Standby</td>
<td>Smoke Control System</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Accessible Means of Egress Elevators</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Horizontal sliding doors</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Airport Traffic Control Towers</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Elevators</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>Smoke Proof Enclosures</td>
</tr>
</tbody>
</table>
1 **Modes of Operation**

1.1 The UPS (Static Uninterruptible Power Supply) shall be designed to operate as an on-line reverse transfer system in the following modes:

1.1.1 Normal: The UPS inverter continuously supplies the critical AC load. The rectifier/charger derives power from the normal AC source and supplied DC power to the inverter while simultaneously float-charging a power reserve battery.

1.1.2 Emergency: Upon failure of the normal AC power, the critical AC load is supplied by the inverter, which, without any switching, obtains power from the battery. There shall be no interruption in power to the critical load upon failure or restoration of the normal AC source.

1.1.3 Recharge: Upon restoration of normal AC power (after a normal AC power outage) the rectifier/charger shall automatically restart, walk-in, and gradually assume the inverter and battery recharge loads.

1.1.4 Bypass: If the UPS must be taken out of service for maintenance or repair, or should the inverter overload capacity be exceeded, the static transfer switch shall perform a reverse transfer of the load from the inverter to the bypass source with no interruption in power to the critical AC load.

2 **Applications**

2.1 Emergency Egress Lighting UL 924 Listed as Auxiliary Lighting and Power Equipment.

2.2 Minimum 90 minutes run time on stand-by (batteries) at rated output kVA.

2.3 Front access.

3 **Approved Manufacturers (Emergency Lighting Inverters)**

3.1 Controlled Power Company Model ELU.

3.2 STACO Energy Lighting Inverter

4 **Factory Warranty**

4.1 2 years following shipment from factory.

4.2 Batteries, 15 year prorated with full replacement in the first year.
1 General
1.1 This Section includes transfer switches rated 600 V and less, including the following:
1.2 Automatic transfer switches

2 Products
2.1 Manufacturers
2.1.1 Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   • ASCO Power Technologies
   • Russelectric

3 General Transfer-Switch Product Requirements
3.1 Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
3.2 Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
   3.2.1 Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
   3.2.2 Switch Action: Double throw; mechanically held in both directions.
   3.2.3 Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
   3.2.4 Enclosures: General-purpose NEMA Type 1 enclosure, unless otherwise indicated on plans.

4 Automatic Transfer Switches
4.1 Comply with Level 1 equipment according to NFPA 110.
4.2 Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
4.3 Retain paragraph below if digital communication system is used for remote annunciation or for remote annunciation and control, or if building management system is present at facility and uses protocol such as Modbus to poll data from devices, or uses SCADA systems.
4.5 For optional standby and standby applications Include the following functions and characteristics for automatic closed transition transfer switches:
   4.5.1 Fully automatic make before break
   4.5.2 Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100ms.
     • Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
     • Initiation occurs without active control of generator.
     • Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
   4.5.3 Failure of power source serving load initiates automatic break-before-make transfer.
   4.5.4 The transfer switch controls shall also be provided shall also be provided with a “Failure Recovery” circuit, designed to prevent the Normal and Emergency contacts from remaining closed at the same time for more than 100 milliseconds during closed transition mode. During the process of transferring between sources, if one of the two single-solenoid operators fails to open its main contact, the ATS control panel will recognize the condition and send a signal to re-open the last operator that successfully closed. Following the Failure Recovery operation, the “Extended Parallel” light will be illuminated and the ATS controls will be locked out. The Failure Recovery Circuit will be operational whether the controls are transferring in both directions. As a second level of protection, the ATS controls are provided with (2) sets of Form-C contacts that can be used to shunt trip one of the two source breakers to actively separate the utility and generator sources, in the event that “Failure Recovery” was not successful.
   4.6 In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase System LCD controller/display. Shall include the following features:
   4.6.1 Self Diagnostics: The controller shall contain a diagnostic screen for the purpose of detecting system errors.
4.6.2 Data Logging: The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in non-volatile memory:

- Current system status.
- Event Logging:
  - Data and time and reason for transfer normal to emergency
  - Data and time and reason for transfer emergency to normal
  - Data and time and reason for engine start.
  - Data and time engine stopped.
  - Data and time emergency source available.
  - Data and time emergency source not available.

4.6.3 Statistical Data:

- Total number of transfers.
- Total number of transfers due to source failure.
- Total number of days controller is energized.
- Total number of hours both normal and emergency sources are available.

4.7 For applications requiring metering include the following power quality meter: SEL 735 Power Quality Meter connected to transfer switch load terminals:

4.7.1 The power monitor shall be flush mounted to the transfer switch enclosure.

4.8 Automatic Transfer-Switch Features:

4.8.1 Test Switch: Simulate normal-source failure.

4.8.2 Switch-Position Pilot Lights: Indicate source to which load is connected.


- Normal Power Supervision: Green light with nameplate engraved “Normal Source Available.”

5 Additional Features

5.1.1 Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.

5.1.2 Push-button programming control with digital display of settings.

5.1.3 Integral battery operation of time switch when normal control power is not available.

5.2 For critical applications include the following functions and characteristics for bypass/isolation switches:

- Bypass to the load-carrying source shall be accomplished with no interruption of power to the load (make before break contacts). Designs which disconnect the load when bypassing are not acceptable. The bypass handle shall have three operating modes: “Bypass to Normal,” “Automatic,” and “Bypass to Emergency.”

6 Source Quality Control

6.1 Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

6.2 If transfer switch remote test/monitor is required then include: transfer switch remote annunciator system

6.3 Functional Description: Remote annunciator panels shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:

- Sources available, as defined by actual pickup and dropout settings of transfer switch controls.
- Switch position.
- Switch in test mode.
- Failure of communication link

6.4 Annunciator Panel

6.4.1 LED-lamp type with audible signal and silencing switch

6.4.2 Indicating Lights: Grouped for each transfer switch monitored.

6.4.3 Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.

6.4.4 Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.

6.4.5 Mounting: flush.

6.4.6 Lamp Test: Push to test or lamp test switch on front panel.

6.4.7 Key operator with lockout function.
6.4.8 Ethernet Communications with web interface.

7 Warranty

7.1 Special Warranty: Manufacturers standard form in which manufacturer agrees to repair or replace components of transfer switch and associated auxiliary components that fail in materials or workmanship within specified warranty period. Warranty is comprehensive and shall include all parts & labor for specified period.

7.2 Warranty period: 100% parts & labor for (2) Years from shipment, then 100% parts only for (5) Years from shipment.
1 Certifications, Ratings, Submittals

1.1 SPD shall meet UL 1449 -4th edition.
1.2 SPD shall bear the UL Mark and shall be listed to most recent editions of UL 1449. “Manufactured in accordance with” is not equivalent to UL listing and is not acceptable.
1.3 SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR). Fuse ratings shall not be considered in lieu of demonstrated withstand testing of SPD, per NEC 285.6
1.4 The SPD’s ratings for a given manufacturer must be listed by specific mode on the UL “Online Certifications Directory” website. The website link is: http://database.ul.com/cgi-bin/XYV/cgifind.new/LISEXT/1FRAME/index.html
1.5 The UL Category is VZCA. Include this information in the submittals. The SPD information on the UL website takes precedence over the manufacturers' own literature.
1.6 Submittals shall include UL 1449 Listing documentation verifying:
   - Short Circuit Current Rating (SCCR)
   - Voltage Protection Ratings (VPRs) for all modes
   - Maximum Continuous Operating Voltage rating (MCOV)
   - I-nominal rating (I-n)
   - Type 1 Device listing as required depending on the location of the device.
1.7 Submittals shall include:
   - Shop drawings with manufacturer installation instruction manual
   - Line drawings detailing dimensions and weight of enclosure
   - Internal wiring diagram illustrating all modes of protection in each type of SPD required
   - Wiring diagram showing all field connections and manufacturer’s recommended wire and breaker sizes

2 General

2.1 SPD to be Type 1 and be located on the load side of the main distribution switchboard main overcurrent device or line side of the main distribution switchboard main disconnecting means when an isolation breaker is present.
2.2 SPD to be mounted externally from the switchboard in its own enclosure (as recommended by IEEE). Lead lengths should be kept to a maximum of 36”. Use low impedance cable where required similar to ASCO AccuGuide Cable.
2.3 Each SPD to be equipped with its own disconnecting means when located on the line side of the main overcurrent protection.
2.4 Each SPD shall include a surge counter.
2.5 Each SPD shall be fed from its own disconnecting means. In most cases this will be a main breaker, branch breaker or fusible switch
2.6 In general, SPDs shall be located in electrical equipment rooms or other equipment rooms designed for such
   2.6.1 These rooms shall be accessible by qualified personnel only and have corresponding signage stating such
2.7 SPDs shall not be located in corridors or other areas of public access
2.8 SPDs are to be remote mounted as close as possible to the Main Distribution Panel
2.9 SPDs are to be on the line side of the main overcurrent protective device
2.10 MOV’s shall have either overcurrent or over temperature protection or both.
2.11 Inominal should be 20 kA per a UL test.
2.12 Minimum surge current capability 100kA / mode.
2.13 SCCR 200 kA
2.14 Each SPD to have a minimum ten (10) year warranty

3 Approved Manufacturers

- Advanced Protection Technologies (ASCO Power Technologies)
- Surge Suppression Inc. (SSI).
- Current Technologies
- Or equal
## 4 VPR (Voltage Let Thru)

<table>
<thead>
<tr>
<th>System Voltage</th>
<th>L-N</th>
<th>L-G</th>
<th>L-L</th>
<th>N-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>208Y/120V</td>
<td>700V</td>
<td>700V</td>
<td>1200V</td>
<td>700V</td>
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<td>480/277V</td>
<td>1200V</td>
<td>1200V</td>
<td>1800V</td>
<td>1200V</td>
</tr>
</tbody>
</table>
1 Photometrics & Lighting Power Densities

1.1 In general, all interior lighting designs should provide as much of a volumetric solution as possible, minimizing the min-to-max ratio in all spaces.

1.2 At a minimum, the lighting designs are to meet the LPD levels outlined by the Indiana Energy Code. Where possible, LPD’s are to be less than those prescribed by the Energy Code.

1.3 With the exception of areas where regulatory rules apply, the following illumination levels are to be used when designing lighting systems. Primarily, the general reference used to determine lighting levels will be the “recommended levels” found in the “IESNA Lighting Handbook”. Where practical, task lighting will be utilized to meet the suggested lighting levels.

1.4 Provide point by point photometrics for the lighting design in each space (including corridors, and stairwells). Include the light loss factor used, maximum levels, minimum levels, average levels and max. to min. ratios. Also provide point by point photometrics as described above for egress lighting. The photometrics should be provided at the DD drawing review level as well as the FRCD review level.

2 Fixture types

2.1 LED is the preferred fixture type

2.2 Non LED fixtures are allowable if LED fixtures do not meet special requirements and after consultation with the University Senior Electrical Engineer

3 Lamps

3.1 Fluorescent Lamps

3.1.1 Shall be 3500K, T8 lamps

3.1.2 The use of T5 lamps are to be limited to architectural fixtures that are not available in T8. All proposed uses of T5 lamps are to be approved by Purdue’s Senior Electrical Engineer.

3.1.3 The use of U-tubes and biax lamps is not acceptable.

3.2 LED Fixtures

3.2.1 The use of LED fixtures is acceptable but must be approved by Purdue’s Senior Electrical Engineer.

3.2.2 LEDs must have a 5 year warranty on the entire fixture.

3.2.3 The manufacturer needs to provide a certified photometric report (per IESNA LM-79) from an approved DOE lab.

3.2.4 The manufacturer must be able to provide a Lumen Depreciation Report to support the LED chip manufacturer’s IESNA LM-80 test data.

3.2.5 LEDs must meet DOE “Energy Star” requirements for LED lighting.

3.2.6 The entire assembly shall be UL listed.

4 Ballasts

4.1 All fluorescent lighting installations shall be designed and specified with electronic ballasts.

4.2 Both 120V and 277V ballasts may be used (depending on application) as both voltages are used on campus.

Note: Be mindful of which applies to your project.

4.3 For new building projects lighting will generally be 120V. The use of 277V lighting systems is to be approved by Purdue’s Senior Electrical Engineer.

4.4 In computer labs dimming is to be used. Dimming increments are to be either 50/100% or 30/60/100%.

4.5 In classrooms where dimming is required, full range 5% dimming ballasts are to be used.

4.6 All ballasts shall be “programmed start” and have lamp striation reduction feature.
### 5 Fixture Styles

<table>
<thead>
<tr>
<th>Area</th>
<th>Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classrooms</td>
<td>Refer to “Design Guidelines for Instructional Spaces” section of this document</td>
</tr>
<tr>
<td>Restrooms</td>
<td>Overhead fixtures to be 1’x4’ recessed single lamp fixtures with acrylic lens</td>
</tr>
<tr>
<td>Corridors</td>
<td>Fixtures are to be 1’x4’ recessed single lamp fixtures set perpendicular to corridor. Fixture type used will depend on corridor size, and surface reflectance</td>
</tr>
<tr>
<td>Mechanical, Electrical, and Communications rooms</td>
<td>Plastic “weatherproof” gasketed 4’-2T fluorescent fixture</td>
</tr>
<tr>
<td>Interior stairwells</td>
<td>Fixtures are to be located above landings only where they are accessible from an 8’ ladder (Do not locate fixtures above stair treads). Fixtures shall be “dual level switching” via an integral occupancy sensor. Low level to maintain light levels in the stairwell above minimum required.</td>
</tr>
<tr>
<td>Open stairwells</td>
<td>Fixtures are to be located above a flat surface where they can be accessed, for maintenance, via a ladder, scaffolding, or a man-lift (owned by Purdue). Access to the fixtures shall not require an “engineered solution”</td>
</tr>
<tr>
<td>Glass enclosed stairwells</td>
<td>Where daylight illuminates the stairwell throughout the day, fixtures are to be switched via a photo-sensor. Fixtures can be off, but need to be capable of energizing during a power outage via battery pack or generator.</td>
</tr>
</tbody>
</table>

### 6 Space Illumination Levels

<table>
<thead>
<tr>
<th>Area</th>
<th>Lighting Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Labs</td>
<td>20-30fc</td>
</tr>
<tr>
<td>Classrooms</td>
<td>50fc at each desktop, with full range dimming. Fixtures are to be placed to limit or minimize shadowing effect on walls. Refer to the “Design Guidelines for Instructional Spaces” section of this document</td>
</tr>
<tr>
<td>Laboratories</td>
<td>30-40fc general lighting with 80-100fc on work surfaces. Care should be taken to minimize shadowing on work surfaces. Do not place a fixture in front of a fume hood that is equipped with a light source. When task lighting is not used, care should be taken to minimize shadowing of the work surface (i.e. do not rely on fixtures mounted down the center of the aisle between work benches).</td>
</tr>
<tr>
<td>Office Areas</td>
<td>25-30fc general lighting, supplemented with task lighting</td>
</tr>
<tr>
<td>Restrooms</td>
<td>20-30fc general lighting, 45fc in front of mirrors</td>
</tr>
<tr>
<td>Corridors</td>
<td>10-15fc, utilizing single tube fixtures mounted perpendicular to the corridor axis</td>
</tr>
<tr>
<td>Mechanical and Electrical rooms</td>
<td>15-25fc at floor level</td>
</tr>
<tr>
<td>Stairwells</td>
<td>10-15fc occupied, 1-5fc unoccupied</td>
</tr>
</tbody>
</table>
1 General
1.1 In general the emergency lighting at Purdue falls into four categories: generator operated, self-contained battery operated, central EMAC unit controlled, or central inverter system (for LED fixtures).

1.2 On all new projects emergency lighting shall be either via emergency generator or a self-contained battery pack, similar to the Bodine B50ST for fluorescent fixtures or the Bodine BSL17C-C2ST for LED fixtures. For LED fixtures the emergency LED driver shall be factory installed and matched to the LED load as per the manufacturer’s instructions.

1.3 The use of wall mounted battery packs is not acceptable.

1.4 Not all emergency fixtures are “night-lights” (i.e. in lecture halls, labs, large office areas, etc.). In these instances the emergency lighting shall be controlled via a “generator transfer device”, similar to Bodine #GTD20A.

1.5 When an emergency ballast or driver is installed in a fixture, the test switch and indicator lamp shall be mounted in a location that is readily visible and accessible from an 8’ ladder, without having to disassemble the fixture in any way.

1.5.1 Flush mounted fixture – a flush mounted box located adjacent to the fixture is to be used.

1.5.2 Surface or Pendant mounted fixture – mounted on fixture housing or in surface mounted box.

2 Exterior fixtures above doors, lighting the means of egress

2.1 LED fixtures are preferred, similar to RAB WPLED20/PC

2.2 Means of emergency power when the building does not have a generator

<table>
<thead>
<tr>
<th>Preferred</th>
<th>Self-contained battery pack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptable</td>
<td>Battery pack remotely mounted inside the building</td>
</tr>
<tr>
<td>By Approval</td>
<td>Central inverter system to serve only the exterior emergency fixtures or inaccessible interior fixtures</td>
</tr>
</tbody>
</table>
1 General

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>Sturdy construction (commercial grade) requiring only simple hand tools to open the housing for maintenance</td>
</tr>
<tr>
<td>Finishes</td>
<td>Brushed aluminum, white or black with matching end and ceiling mounts</td>
</tr>
<tr>
<td>Lamps</td>
<td>LED*</td>
</tr>
<tr>
<td>Lettering color</td>
<td>Green unless existing signs in building are another color. Then, match to existing color in building</td>
</tr>
<tr>
<td>Self-Diagnostic</td>
<td>Exit sign shall be available as single or double faced unit with universal “snap-out” directional arrows</td>
</tr>
<tr>
<td>Standard</td>
<td>Shall be “Dual-Lite”</td>
</tr>
</tbody>
</table>

*Self-luminous exit signs are prohibited from use on Purdue projects unless specifically approved for use by REM’s Radiological Management Section.

2 Required Testing

2.1 Battery operated exit signs shall be equipped with a self-diagnostic feature that includes a 30-day test and annual 90-minute discharge test or testing as directed by the manufacturer.

2.2 Both tests are to be fully automatic.
1 Exterior Lighting

1.1 Exterior lighting fixtures on Purdue’s campus are primarily limited to the historic “gothic” style at campus pedestrian areas, and “shoebox” fixtures at parking lots, along roadways, and at the contemporary areas of campus.

Note: In an effort to provide a more sustainable and energy efficient campus, we have decided to move from the traditional HPS light source, found throughout campus, to LED.

1.2 Color temperature is not to exceed 5100°K.
1.3 All fixture choices (style and source types) are to be approved by the Director of Campus Master Planning and Sustainability.

2 Photometrics

2.1 Provide point by point photometrics for the exterior lighting design. Include the light loss factor used, maximum levels, minimum levels, average levels and average uniformity ratio as described below. The photometrics should be provided at the DD drawing review level as well as the FRCD review level.

3 Requirements for concrete pole bases

3.1 Ground rods are not required in pole bases.
3.2 Concrete pole bases in parking areas are to be set on concrete bases 3'-0” above finished grade.
3.3 Concrete pole bases in green spaces are to be 2” above finished grade.
3.4 Conduits in concrete bases to be either RGS or fiberglass.
3.5 Buried conduit to be PVC.
3.6 Each base is to have a spare conduit (1” min.) stubbed into adjacent green space

4 Parking, Roadway, and Area Lighting

4.1 Parking, roadway, and area lighting fixtures should conform to the criteria listed in the table, below.
4.2 New installations typically utilize LED light sources.
4.3 Area lighting refers to building site, walkway, and open space lighting.
4.4 Bollards are discouraged because they do not illuminate the facial features of oncoming pedestrians. They can be used in some special circumstances, but each case must be approved individually by the Director of Campus Master Planning and Sustainability.

5 Landscape Lighting

5.1 In general, decorative landscape lighting is to be avoided.
5.2 Approval must come from the Director of Campus Master Planning and Sustainability.
## Table of Lighting Requirements

<table>
<thead>
<tr>
<th>Traditional Campus</th>
<th>Pole</th>
<th>Light</th>
<th>Light Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Area Lighting</td>
<td>Sternberg Catalog #9312-TO, color gloss black</td>
<td>Sternberg 1335 LED Revere, Catalog #1335/PT/4A1R45T3/C TA/TEK-BK, color gloss black</td>
<td>Average lighting level is to be 1 fc with an average uniformity ratio of 4.0 ($E_{avg}/E_{min}$) measured at the pavement</td>
</tr>
<tr>
<td>Parking Lots</td>
<td>Square pole, 30’ tall, color dark bronze</td>
<td>Lithonia CSX1-LED, color dark bronze</td>
<td>Average lighting level is to be 1 fc with an average uniformity ratio of 4.0 ($E_{avg}/E_{min}$) measured at the pavement</td>
</tr>
<tr>
<td>Roadway</td>
<td>Square pole, 30’ tall, color dark bronze</td>
<td>Lithonia CSX1-LED, color dark bronze</td>
<td>Average lighting level is to be 1 fc with an average uniformity ratio of 4.0 ($E_{avg}/E_{min}$) measured at the pavement</td>
</tr>
<tr>
<td>Crosswalk</td>
<td>Square pole, 30’ tall, color dark bronze</td>
<td>Lithonia CSX1-LED, color dark bronze</td>
<td>Average lighting level is to be 2 fc with an average uniformity ratio of 4.0 ($E_{avg}/E_{min}$) measured at the pavement</td>
</tr>
<tr>
<td>Contemporary Campus</td>
<td>Pedestrian Area Lighting</td>
<td>Square pole, 14’ tall, color platinum silver</td>
<td>KIM Entablature Standard LED, color platinum silver</td>
</tr>
<tr>
<td>Parking Lots</td>
<td>Square pole, 30’ tall, color platinum silver</td>
<td>KIM Entablature Standard LED, color platinum silver</td>
<td>Average lighting level is to be 1 fc with an average uniformity ratio of 4.0 ($E_{avg}/E_{min}$) measured at the pavement</td>
</tr>
<tr>
<td>Roadway</td>
<td>Square pole, 30’ tall, color dark bronze</td>
<td>Lithonia CSX1-LED, color dark bronze</td>
<td>Average lighting level is to be 1 fc with an average uniformity ratio of 4.0 ($E_{avg}/E_{min}$) measured at the pavement</td>
</tr>
<tr>
<td>Crosswalk</td>
<td>Square pole, 30’ tall, color dark bronze</td>
<td>Lithonia CSX1-LED, color dark bronze</td>
<td>Average lighting level is to be 2 fc with an average uniformity ratio of 4.0 ($E_{avg}/E_{min}$) measured at the pavement</td>
</tr>
</tbody>
</table>
### 2018 Consultant’s Handbook

**Division 26 Electrical**

**5600 Exterior Lighting**

<table>
<thead>
<tr>
<th>Perimeter Parkway</th>
<th>Roadway</th>
<th>Valmont 26'-6&quot; Aluminum Pole w/ 5'-0&quot; and 3'-0&quot; Mast Arms, color dark bronze</th>
<th>GE Evolve LED Series ERMC, color dark bronze</th>
<th>Average lighting level is to be 1 fc with an average uniformity ratio of 4.0 ($E_{avg}/E_{min}$) measured at the pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garages</td>
<td></td>
<td>LED with a combination of bi-level (occupancy sensor) and photocell controls.</td>
<td>Average lighting level is to be 5 fc when occupied and not less than 1 fc average when unoccupied.</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

*Deviations from the above table are to be approved by the Director of Campus Master Planning and Sustainability.*

*“Traditional Campus” includes most of the West Lafayette campus*

*“Contemporary Campus” includes Discovery Park and a pedestrian mall between Jischke Drive and the Agricultural and Biological Engineering Building*

$E_{avg}$ – *minimum maintained average horizontal illuminance at pavement*

$E_{min}$ – *minimum horizontal illuminance at pavement*
1 Introduction

1.1 In the design of Telecommunications systems in Purdue facilities, the overall consideration should be to understand and treat telecom as a utility. It should be assumed that all new offices will be equipped with telephone circuits and one or more computer workstations. These are currently connected via separate intra-building networks but will eventually migrate to one converged network incorporating both voice and data services. Currently, all dedicated 2-wire and 4-wire, security, fire, etc. operate on a copper backbone. The data network operates on copper from the workstation to the telecommunication room and then is connected via fiber optic cable to the Purdue fiber optic backbone. Purdue’s CATV system (BTV or Boiler Television) operates over a mixture of coaxial cable and fiber optic cables.

2 Design

2.1 The design team for renovations and new building construction shall include a BICSI certified RCDD (Registered Communications Distribution Designer) with 5 years of experience.

3 PIC Quantity and Location

3.1 The program will supersede this table, if it calls for more than what is listed.

<table>
<thead>
<tr>
<th>Room</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices</td>
<td>for one staff member typically 120 –180 asf</td>
<td>1 data PIC location (with 2 ports)</td>
</tr>
<tr>
<td></td>
<td>for multiple staff members typically 120 asf per person</td>
<td>1 data PIC location (with 2 ports) for every person</td>
</tr>
<tr>
<td>Computer labs</td>
<td>Adequate number and type of PICs to accommodate equipment</td>
<td>2 video + 2 data per seat</td>
</tr>
<tr>
<td>Conference rooms</td>
<td>1 video, 2 data, minimum</td>
<td></td>
</tr>
<tr>
<td>Classrooms</td>
<td>1 video, 2 data, minimum</td>
<td></td>
</tr>
<tr>
<td>Special areas</td>
<td>See Building Program</td>
<td></td>
</tr>
</tbody>
</table>

Note: PICs shall not be installed in modular furniture. PICS shall be installed in walls where furniture is in close proximity to the wall. Floor boxes and poke-thrus may be installed next to furniture that is not in close proximity to a wall to service the required locations. Owner furnished jumpers can be installed from the floor boxes or poke-thrus through the furniture to provide connectivity to customer equipment. Exceptions will be considered during the design phase on a case by case basis and shall be reviewed by Purdue’s Information Technology Infrastructure Services department.

PIC Location in Typical Office

![PIC Location in Typical Office](image)
4 Special Circuit Requirements:

4.1 Every FACP (Fire Alarm Control Panel) requires two voice cables, terminated per telecom specifications, to be installed from the nearest telecommunications room.

4.2 Every environmental control cabinet requires two data cables, terminated per telecom specifications, to be installed from the nearest telecommunications room.

4.3 Every building electrical switch gear meter requires two data cables, terminated in an enclosure outside of the metering cabinet per telecom specifications, and to be installed from the nearest telecommunications room.

4.4 Every elevator requires one voice cable, terminated per telecom specifications, to be installed from the nearest telecommunications room.

5. Wireless Network Systems for Data

5.1 Wireless network systems shall be engineered by Purdue’s Information Technology Infrastructure Services (ITIS) department during the design phase of the project. ITIS will provide the A&E with wireless access point locations based on a computer generated site survey for new and existing buildings so they may be incorporated into the construction documents. The contractor will be responsible for installing a turn-key wireless system as part of the project. The wireless system shall be included in the building project budget.

5.2 Existing wireless access points affected by construction shall be removed by Purdue prior to the beginning of construction and reinstalled once construction is complete.

6. Location and Configuration of Telecommunication Rooms (TR):

6.1 Every building shall be served by at least one telecommunications room. Multi-story buildings shall have a minimum of one telecommunications room per floor. These telecommunications rooms shall be located so that every new or future PIC is by wire length within 90 meters of its distribution point in the telecommunications room. This includes areas where PICs are not currently designed to be installed but may be installed in the future (i.e. Far ends of the building, attic spaces, mechanical rooms, etc.).

6.2 The BDF room must be located within the building at or near the point where the facilities enter the building. Locate telecommunication room to be accessible directly from a hallway; access through a mechanical room or other space is not permitted.

6.3 The location of the BDF telecommunications room shall be within 50ft of the point where electrical facilities enter the building.

6.4 The BDF and IDF telecommunication rooms shall be sized by ports served and rectangular in shape with no structural obstructions.

| BDF and IDF Telecommunication Room Sizes Based on ANSI/TIA/EIA-569-B Standards |
|-----------------------------------------------|-----------------------------------------------|
| Serving Area by Telecommunications Data Port Counts | Minimum Telecommunication Room Size (ft.) |
| Less than 288 ports on one frame and no future expansion allowed | 5’ x 8’ (must have double out-swing doors) |
| Less than 864 ports | 10’ x 15’ |
| More than 864 ports | 10’ x 15’ + 3’ per each additional 288 ports |

Multiple telecommunications rooms per floor required if wire length to any new or future PIC will exceed 90 m

7 Construction of the Telecommunication Room Service Entrance:

7.1 Typical service entrance for Telecommunications shall be a minimum of two 4” rigid conduits from nearest utility tunnel location or maintenance hole (manhole) into a BDF room. Additional entrance conduits may be required based upon area (ASF) of building and number of Telecommunications circuits required. Preferred method is to install conduits below grade between the tunnel and the BDF room.

7.2 No more than 180° of total bends are allowed between pulling points when installing underground entrances. All bends must be long, sweeping bends with a radius of no less than ten times the internal diameter (ID) of the conduits.

7.3 Where maintenance holes (manholes) are required, a separate maintenance hole and maintenance hole entry must be provided for Telecommunications facilities. Maintenance hole covers must be marked "COMMUNICATIONS". All hardware in maintenance holes must be galvanized. Maintenance holes must be equipped with bonding
inserts and struts for racking, pulling eyes, and ladders. Maintenance holes must be equipped with a sump hole and grounded per Purdue University specifications. Conduit runs between maintenance holes (manholes) shall not exceed 500 ft.

8 Construction of Communication Pathways

8.1 To keep average horizontal cable runs to 50 meters, with a maximum of 90 meters, locate each telecommunication room close to the center of the area it serves and vertically aligned up through the building as practicable.

8.2 Communications pathways shall be easily accessible and designed for flexibility and relative ease of modification.

8.3 Pathways shall be designed for voice, data, video, and Owner-approved low voltage cabling. Systems, such as fire alarm, security, building automation, etc., shall have a separate pathway for wire management. This may be a separate tier on the corridor cable basket/tray.

8.4 Provide cable basket/tray system, properly designed to handle required cable loading for building plus 50% expansion for future applications, above the ceilings in the corridors and elsewhere as required.

8.5 Design a distribution cable basket/tray system within the corridors that allows 3" of clearance between the basket/tray and the ceiling, 6" of clearance in front of the basket/tray, and 12" of clearance above the basket/tray. No systems shall pass through the cable tray. Basket type cable tray is recommended and may be center hung or wall hung on each side of the corridor. Basket tray shall be easily accessible.

9 General Construction of the Telecommunication Rooms:

9.1 All telecommunication room walls shall have an added layer of 3/4" plywood, B-B ext. grade 5. Plywood must be fire-retardant and unpainted. Install the plywood vertically on walls from 6" to 8'-6" AFF from corner to corner. All walls shall be painted with a light-colored paint.

9.2 All walls shall extend from floor to underside of upper deck to create an environmentally-controlled enclosed space free of dirt and debris.

9.3 All BDF and IDF telecommunication rooms shall have ladder type cable tray installed around the perimeter of the room. (Typical elevation is 7"-2" AFF or per direction from Purdue ITIS department.)

9.4 Suspended ceilings are not permitted in telecommunications rooms.

9.5 Minimum ceiling height shall be 8'-6".

9.6 Doors shall be lockable, opening 90° or greater and 36" wide x 80" min height.

9.7 Hinge doors to open outward unless corridor width will not accommodate out-swing without reducing egress. If door must swing in, then assure that BDF room size is increased to accommodate in-swinging door.

9.8 Fire rating of doors and sprinkling of room shall be as required by code.

9.9 Hardware: hinges, lockset, stop, kick plate and closer by Purdue Standards. Prep doors for card access.

9.10 Locking: Cylinder shall be Purdue standard for BDF rooms. Use storage room functionality locks. Deliver cylinder to Owner for keying and installation by the General Contractor.

9.11 It is not permissible to route any mechanical, electrical, or special application systems through the telecommunication room, including HVAC ducts, plumbing, gas lines, air lines, clean outs, door access controls, etc. that do not directly serve the telecommunications room.

10 Structural Requirements of Telecommunications Rooms:

10.1 The floor rating under distributed loading shall be greater than 100lb/ft².

10.2 Walls may be of concrete block or stud wall construction. In stud wall construction, studs should be 20 GA galvanized channel type with 5/8" Type X gypsum board. Walls shall be finished to underside of deck and deck painted.

11 Mechanical Construction Requirements of Telecommunication Rooms:

11.1 Provide heating, ventilation and air conditioning that will maintain a temperature range of 60° - 80° Fahrenheit. Dedicated fan coil units (FCU) are preferred since the telecommunications rooms operate 24/7. FCU shall be installed just outside of the telecommunications rooms and ducted to the room. FCUs should be equipped with economizers where possible.

11.2 No mechanical equipment shall be installed on or in front of the plywood or impair the routing of telecommunication cables.

11.3 Mechanical designers shall work with
telecommunications designers to ensure that space is available for access to cable tray in corridors. No utilities other than telecommunications shall be installed within 6” of either side of the tray or 12” above the tray. Cable tray shall be installed a minimum of 3” above ceiling grid.

12 Electrical Construction Requirements of Telecommunication Rooms:

12.1 Provide a minimum lighting level of 50 foot-candles measured 1 meter above the finished floor level.

12.2 Provide a minimum of one dedicated, 110V, 20A double-duplex electrical outlets which are on separate circuits on each wall. One of these outlets shall be installed on the wall nearest the equipment frame racks.

12.3 Provide a minimum of two dedicated, 208V, 30A, twist lock (NEMA L6-30R), single phase electrical outlets, and located 25” behind the front rail of the equipment frame on the wall in each telecommunications room BDF and IDF for a UPS. These outlets are to be installed in a 24” section of 6000 Wiremold surface mount raceway along with the 20A outlets. These outlets shall be backed up by the building generator. Each to be phased as follows: 1st outlet on A-B, 2nd on B-C, and third on C-A.

12.4 Provide a minimum of two dedicated, 208V, 20A, twist lock (NEMA L6-20R), single phase electrical outlets, and located 25” behind the front rail of the equipment frame on the wall in each telecommunications room BDF and IDF for a UPS. These outlets are to be installed in a 24” section of 6000 Wiremold surface mount raceway along with the 30A outlets. These outlets shall be backed up by the building generator. Each to be phased as follows: 1st outlet on A-B and 2nd on B-C.

12.5 Provide a minimum of two 110V, 20A, single-duplex outlets on two different circuits within the same section of 6000 Wiremold surface mount raceway as the 208V outlets.

12.6 A separate duplex 110V, 20A outlet to be labeled as “service” shall be provided within the telecommunication room for tools, test sets, etc.

12.7 No electrical panel boards are permitted within the telecommunication room.

13 Removal and/or Relocation of Telecommunications:

13.1 Existing PIC cabling may be reused if the cable is long enough to reach the new location and passes the most recent category test for the particular cable. Where existing cables will not reach, new cables shall be installed to the TR. We require all relocated cables to be tested prior to moving to ensure the cable will meet the category performance level set at the time it was manufactured.

13.2 Per the NEC (National Electrical Code), legacy voice and data systems not used within renovated areas shall be removed as part of the project. The A&E firm shall identify legacy systems within the proposed renovated areas and contact ITIS for usage verification.

Note: Some legacy cabling still contains active circuits which must be verified and relocated in such a manner as to minimize customer disruption.

14 Bid package specifications and drawings:

14.1 The design team shall utilize the latest Purdue University Master Specifications for Telecommunications on all projects. These are available from the following site (all one link):

http://www.itap.purdue.edu/telecommunications/infrastructure/div27_specifications.html

14.2 Items that do not apply may be edited out of the Master Specifications for a specific project. New items may not be added or changed without the consent of the Purdue Information Technology Department.

14.3 Telecom drawings should have their own “T” series, numbered as outlined in Chapter 2 “General Requirements & Communication” as shown below. Drawings are to include no less than the following:
Table 3

<table>
<thead>
<tr>
<th>Sheet</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-0xx</td>
<td>Site Plans</td>
<td>Exterior pathways and inter-building backbones</td>
</tr>
<tr>
<td>T-1xx</td>
<td>Floor Plans</td>
<td>TR distribution zones and backbone riser system complete for each floor. Include symbols legend.</td>
</tr>
<tr>
<td>T-2xx</td>
<td>BDF and IDF Distribution Zones</td>
<td>All telecommunications drop locations and cable IDs</td>
</tr>
<tr>
<td>T-3xx</td>
<td>Equipment Rooms</td>
<td>Plan views, TR details, wall elevations, equipment frame layouts, and etc. for all communication rooms</td>
</tr>
<tr>
<td>T-4xx</td>
<td>Typical Drawings</td>
<td>Faceplate configurations, labeling, grounding, risers, fire stopping, ADA, and etc.</td>
</tr>
<tr>
<td>T-5xx</td>
<td>Schedules</td>
<td>Cable wiring schedule</td>
</tr>
</tbody>
</table>

14.3 The design team shall use the following Purdue standard telecommunication symbols on the floor plans:

- Special Circuit PIC
- Data only PIC
- TV only PIC
- Wireless Access Point PIC
- Above Ceiling PIC
- Data only PIC; Floor Fed
1 Geotechnical Engineer

1.1 The Geotechnical Engineer is required to be experienced with soil conditions in the region where the project site is located.

1.2 The geotechnical engineer shall evaluate the existing project data, obtain and evaluate all additional data as required to support the design and construction, and prepare a Geotechnical Report.

2 Subsurface Soils Information

2.1 Subsurface soil information, if provided, is included for the Geotechnical Engineer and the consultant’s information only, and is not guaranteed to fully represent all subsurface conditions. The data included in the RFP are intended for proposal preparation and preliminary design only.

2.1.1 If no subsurface soil information is available, the Consultant shall perform, at his expense, such subsurface exploration, investigation, testing, and analysis as his Designer of Record deems necessary for the design and construction of the foundation system.

2.2 All work by the Geotechnical Engineer at the project location, if required, shall be coordinated with the Project Manager and shall not interfere with normal university operations. Prior to the Foundation Work Design submittal, provide a Geotechnical Report (an editable Adobe Acrobat PDF version on CD and two printed copies) for review and record keeping purposes. The report shall become the property of the University.

2.3 Geotechnical reports generated during construction shall be provided to the project manager in a timely manner so as to not affect the project schedule. In addition, provide an editable Adobe Acrobat PDF version and two printed copies for record keeping purposes.

3 Geotechnical Report

3.1 Submit a written Geotechnical report based upon subsurface investigation data and all additional field and laboratory testing accomplished at the discretion of the Geotechnical Engineer. The Geotechnical Report shall include the following:

3.1.1 The project site description, vicinity map and site map with soil boring locations.

3.1.2 Results of all the soil borings, field and laboratory testing.

3.1.3 Engineering analysis, discussion and recommendations addressing:

3.1.4 Settlement

3.1.5 Bearing Capacity

3.1.6 Determination of the seismic site class, with discussion on whether shear wave testing is/was appropriate for the site

3.1.7 Indiana Building Code will apply on university projects

3.1.8 Foundation selection and construction considerations (shallow, deep, special); dimensions, and installation procedures.

3.1.9 Site preparation (earthwork procedures and equipment), compaction requirements, building slab preparation (as applicable), soil sensitivity to weather and equipment, and groundwater influence on construction

3.1.10 Sheeting and shoring considerations, as applicable

3.1.11 Pavement design parameters; include recommended design thicknesses and materials, include pavement design calculations

3.1.12 Calculations to support conclusions and recommendations

3.1.13 Recommendations shall be presented on a structure-by-structure basis

3.2 The Geotechnical Report shall be signed by a registered Geotechnical Engineer.

3.3 The submitted report shall be accomplished by a cover letter identifying any recommendations of the report proposed that are to be adopted into the design which are interpreted by Consultant Engineers as either conflicting with or modifying the Geotechnical or Pavement-related requirements of the RFP.

4 Geotechnical Site Data required in Design Drawings and Specifications

4.1 The Consultant’s final Specifications and design drawings shall include the subsurface data presented in the Geotechnical Report including:

4.1.1 Logs of Borings and related summary of laboratory test results and groundwater observations.

4.1.2 The locations of all borings shall be indicated on a site drawing.

4.1.3 The applicable design drawings shall include reference to the Geotechnical Report including the Company Name, report number, date, allowable soil bearing pressure, and site classification
1 Types
1.1 When developing site plans for new development on the University campus, three parking lot types are considered appropriate: short term parking, long-term parking and visitor parking.

2 Space Size
2.1 The standard parking space size is 9 feet by 18 feet. Handicapped parking spaces are 8 feet by 19 feet with a 5-foot access aisle; van accessible handicapped parking spaces require an 8-foot access aisle.
2.2 Perimeter parking is encouraged to utilize a two-foot overhang to reduce the amount of paved area. Overhang area may not reduce the minimum sidewalk width or parking lot setback if required by community zoning requirements.

Note: Common parking bay widths for 90 degree parking is 60’; 18’+24’+18’

3 Construction Methods
3.1 Most campus parking lots have been constructed of asphalt concrete. Storm water considerations shall be accounted for in design. Design shall comply with TCPWQ/ WLaf /PU storm water ordinance and technical standards.
3.2 Parking lot construction shall provide positive surface drainage. Parking lots shall not be utilized as storm water detention areas.
3.3 Compacted granular fill is required for parking lot sub-base.
3.4 Pavement thickness and granular sub-base thickness shall be determined by a soils engineering report and shall consider the type of traffic; e.g., automobile or truck.

4 Driveway Width
4.1 Driveway curb cuts should be a minimum of 24 feet wide with 10 foot radii curb returns. If turn lanes are required additional width shall be required, up to a maximum of 36 feet.
4.2 Internal driveway widths of less than 24 feet are permitted (e.g. turn-around, passenger drop-offs, etc.); however, they must be posted "No Parking Fire Lane".

5 Parking Angle
5.1 The preferred parking angle is 90 degrees. Angled parking (60 degrees and 45 degrees) is permitted when one-way circulation is required or on narrow lots that will not accommodate 90 degree parking.

6 Pedestrian Routes
6.1 Provision for pedestrian routes in parking areas shall be identified. Evaluations of origin and destination routes are required for parking lots.
6.2 Pedestrian routes in conflict with vehicle aisles, circulation routes and parking stalls must be minimized.
6.3 Pedestrian routes should include walkways perpendicular as well as parallel to parking rows.

7 Street Access
7.1 Access from a parking lot to the street system should provide a safe transition for vehicles and pedestrians. Stopping and turning movements for vehicles shall consider pedestrian circulation patterns with conflicts identified and minimized as design decisions are incorporate.
1 General
1.1 Asphalt pavements on the main campus are to be surfaced with hot-mix asphalt concrete.

2 Reference
2.1 The principle reference for materials and methods is the "Indiana Department of Transportation Standard Specifications," latest edition (INDOT).

3 Installation Methods
3.1 All installation and sub-grade preparation methods shall conform to the appropriate section of the INDOT Spec.
3.2 Unsuitable sub-grade material shall be removed and replaced with compacted suitable material or covered with appropriate construction grade fabric prior to subbase installation.
3.3 Tack coat will be used only when overlayment of existing asphalt concrete must be postponed longer than five months.

4 Light Duty Pavement
4.1 Description:
   4.1.1 One and a quarter inch (1.25") of compacted top on top of two inches (2") of compacted binder on top of four inches (4") of compacted type #53 granular sub-base
4.2 Uses:
   • Pedestrian walks with minimal vehicular traffic expected and no emergency vehicles planned.

5 Medium Duty Pavement
5.1 Description:
   5.1.1 One and half inches (1.5") of compacted top surface on top of three inches (3") of compacted binder on top of eight inch (8") of compacted Type #53 limestone sub-base
5.2 Uses:
   • Pedestrian walks with moderate vehicular use expected or for use as planned emergency access.
   • Parking areas with no mass transit vehicles using driving lanes.
   • Service drives, e.g. roads without

6 Heavy Duty Pavement
6.1 Description:
   6.1.1 One inch and one-half inches (1 1/2") of compacted top surface on top of 4.5 inches (4.5") of compacted binder on top of twelve inches (12") of compacted type #53 limestone sub-base
6.2 Uses:
   • Parking and drive lanes with trucks & mass transit (bus) use.
   • Main and central campus roads.

7 Pavement Sections
7.1 Use pavement sections per City of West Lafayette, Indiana Typical Construction Guidelines and Details, most recent addition.

Note: Justify chosen pavement sections within soils report. Heavy Bus traffic continues to be an issue for pavements.
1 Curb Access Ramps

1.1 Follow Purdue typical standard detail for Curb access ramps. Cast iron inserts preferred for detectable and visual warning. Meet all ADA requirements.

2 Curbs and Gutters

2.1 On campus we use an integral curb and gutter section.

2.2 Straight INDOT type curb sections shall be used adjacent to arterial West Lafayette streets on campus.

2.3 The Purdue rolled curb section shall be used on internal campus roadways.

2.4 Dowell new curb and gutter to adjacent existing curbs to prevent settlement. 2 #4 rebar for reinforcing
1 Location

1.1 Purdue requires thermoplastic pavement markings for crosswalks and stop bars.

**Note:** Use INDOT approved pavement marking material for crosswalks and stop bars. Durability and retro-reflectivity shall meet MUTCD latest recommendations.

1.2 Lane and parking stall markings shall be INDOT approved paint with glass beads.
PHYSICAL FACILITIES
2018 Consultant’s Handbook
Division 32 Exterior
3000 Site Improvements

1 General
1.1 The Director of Campus Master Planning and Sustainability shall be responsible for approval of the final landscape and site design for all building projects during the design process.
1.2 Deviations from the approved design during construction shall be agreed to in writing by the Director of Campus Master Planning and Sustainability and the Project Manager.
1.3 More information on Purdue’s landscape and grounds can be found at: http://www.purdue.edu/physicalfacilities/

2 Campus Design Contexts
2.1 The present West Lafayette campus landscape developed from a 1924 Beaux Arts plan between Ross-Ade Stadium at the north and the College of Veterinary Medicine at the south. It includes a dense collection of predominantly early twentieth century brick buildings facing linear green spaces punctuated by large open space malls. Post WWII expansion led to the development of several modern student residence halls and recreation areas to the west. The tree canopy across campus is generally organized in a park-like, naturalistic arrangement except in formally organized malls and plazas where plants are arranged more architecturally. A more contemporary landscape in the southwest quadrant of campus includes Discovery Park and the Life and Health Sciences Mall. These areas include distinctly contemporary buildings, unique site patterning, and a unique vocabulary of site fixtures and furnishings to distinguish them from the rest of campus. State and Third streets are planned for a more urban, mixed-use character than the rest of campus. The landscape design for a project on campus should express a relationship to the campus context in which it occurs.

3 Site Design
3.1 In general, green space should be maximized and excessive pavement should be avoided. Large, necessary paved areas should be shaded, broken up, or screened with plantings and green space. Exposed utility equipment and service dock areas should be architecturally screened from view.

3.2 Plazas and Building Entrances
3.2.1 Paving at main building entrances and plazas should have a higher level of finish than plain concrete. Stone, clay brick unit pavers, decorative or colored concrete is preferred.

3.3 Pedestrian Routes
3.3.1 Campus pedestrians tend to move in straight lines between origins and destinations. These routes should be controlled via walls and fencing when they are not in the best interest of the project landscape. Plants will not control pedestrian movement.
3.3.2 Pedestrian street crossings should be designed to occur at intersections, not at mid-block.

3.4 Sidewalks
3.4.1 Sidewalk widths must consider the volume of pedestrian traffic anticipated but should be at least eight-feet wide to accommodate snow removal equipment.
3.4.2 Concrete walks shall be six-inches thick with welded wire fabric because they are often used by service and emergency vehicles. (Note this is a Purdue req’t over and above WLaf standard walk)
3.4.3 Campus sidewalks typically include a medium broom finish perpendicular to the direction of travel, bordered by a smooth-troweled “picture frame” at all joints and edges. The troweled picture frame should be two-inches wide or, the finish may match that of adjoining concrete.

3.5 Pavers
3.5.1 While a variety of pavers can be found in various locations across campus, the most common type is precast concrete in the Uni-Décor pattern. The most common color is a blend of red, charcoal, and tan similar to Reading Rock OC II.
3.5.2 Unit pavers should be designed to support vehicular loads.
3.5.3 In general the concrete unit pavers deteriorate and fail under are harsh winters and the snow removal means. It is campus responsibility to the students to provide a clear and safe route to and from classes. Clay brick unit pavers are preferred as they are more resilient to the Midwest weather and the campus snow clearing methods.

3.6 Waterproofing
3.6.1 Waterproofing materials used to coat tunnel tops and other structures exposed at grade must be of a color to complement the surrounding landscape features as approved by the Director of Campus Master Planning and Sustainability.

3.7 Fencing
3.7.1 The historic “smoking fence” with decorative cast posts and pipe rails generally surrounds the campus perimeter. This fence is painted gloss black.
3.7.2 Post and chain fence is used elsewhere on campus, primarily as a pedestrian control device and frequently in combination with low evergreen hedges. This fence is painted gloss black, except at the Life and Health Sciences Mall where post and chain fence is
3.7.3 Stainless steel post and cable fence is used in Discovery Park.  
Note: Details for each fence style are available from Purdue.

3.7.4 Chain Link Fence

3.7.4.1 Permanent chain link fencing of any type is, generally, not acceptable on campus. (accept in service areas, ie power plant, shops, etc)

3.7.4.2 Temporary construction and tree protection fencing must be six-foot high chain link.  
Note: See Section 32-3113 of this Guideline.

3.7.5 The use of plastic fencing is prohibited on campus.

3.8 Walls and Structures

3.8.1 Free standing, retaining, and other site walls and structures should not be constructed of plain concrete or interlocking concrete systems. Materials should complement the associated building’s materials and features.

3.8.2 All elevated (2'-4' tall) masonry site amenities shall have ‘Skate Cuts’ (4" wide and 1" deep) installed at a minimum 4’ apart and placed to work with the joint layout of the amenity.

3.9 Bus Shelters

3.9.1 Campus bus stop locations are coordinated with the Greater Lafayette Public Transportation System's (GLPTC) City Bus program.

3.9.2 Bus stops are located to facilitate access and minimize route schedule disruption. GLPTC provides shelters at high demand boarding locations.

3.9.3 Purdue typically provides a concrete slab foundation and 120V electrical power for each shelter.

3.9.4 The standard shelter is Daytech Limited ADF05x10N and has a black powder-coat color.

4 Signage and Wayfinding

4.1 All exterior signage on the West Lafayette campus is coordinated with the Purdue University Exterior Wayfinding and Signage Project Design Intent Drawings of January 30, 2015. This information and additional guidance is available from the Director of Campus Master Planning and Sustainability.
1 References

1.1 Industrial grade. INDOT Standard Specifications, Section 603, 910.18.
1 Site Furnishings and Fixtures

1.1 The coordination of site furnishings and fixtures on the West Lafayette campus creates a consistently recognizable campus landscape aesthetic. To that end, all site furnishings on Purdue’s campus should match the standards noted below except as approved by the Director of Campus Master Planning and Sustainability.

1.1.1 While building and structure fixtures and furnishings may differ, they should not extend beyond the building and its associated landings, terraces, stairs, etc.

2 Emergency Telephones

2.1 Emergency telephones are gloss black Talk-a-Phone tower model ETP-MT-72 with white “Emergency” text.

2.2 The tower must be mounted flush with surrounding pavement in order to be ADA compliant.

2.3 Locations must be coordinated with the Purdue Police Department.

3 Seating

3.1 In general, seating areas should be developed at building entrances and in locations with significant pedestrian activity.

3.1.1 Remote or isolated seating is generally not desirable.

3.2 Academic Campus

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Landscape Forms, Inc. “Plexus”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Black Powdercoat</td>
</tr>
<tr>
<td>Color at Life and Health Sciences Park Mall</td>
<td>Silver Powdercoat</td>
</tr>
<tr>
<td>Mount</td>
<td>Embedded Posts</td>
</tr>
</tbody>
</table>

3.3 Discovery Park

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Landscape Forms, Inc. “Stay”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Silver Powdercoat</td>
</tr>
<tr>
<td>Mount</td>
<td>Surface Mount</td>
</tr>
</tbody>
</table>

3.4 Historic Residence Halls

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Landscape Forms “Scarborough” w/Strap Seat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Black Powdercoat</td>
</tr>
<tr>
<td>Mount</td>
<td>Surface Mounted Modern</td>
</tr>
</tbody>
</table>

3.5 Residence Halls

<table>
<thead>
<tr>
<th>Backed</th>
<th>Dumor “Bench 11” 11-60 or 11-80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backless</td>
<td>Dumor “Bench 105” 105-60PL or 105-80PL</td>
</tr>
<tr>
<td>Plastic/Metal Color</td>
<td>Redwood/Bronze or Gray/Black</td>
</tr>
<tr>
<td>Mount</td>
<td>S-1 Embedment</td>
</tr>
</tbody>
</table>

4 Tables

4.1 Include at least one accessible table in all installations.

4.2 Academic Campus

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Landscape Forms, Inc. “Carousel”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Black Powdercoat</td>
</tr>
<tr>
<td>Color at Life and Health Sciences Park Mall</td>
<td>Silver Powdercoat</td>
</tr>
<tr>
<td>Top</td>
<td>Catena w/Umbrella Hole</td>
</tr>
<tr>
<td>Seats</td>
<td>Metal Grid</td>
</tr>
<tr>
<td>Mount</td>
<td>Surface Mount</td>
</tr>
</tbody>
</table>

4.3 Discovery Park

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Landscape Forms, Inc. “Mingle”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Silver Powdercoat</td>
</tr>
<tr>
<td>Top</td>
<td>Catena w/Umbrella Hole</td>
</tr>
<tr>
<td>Seats</td>
<td>Perforated Aluminum</td>
</tr>
<tr>
<td>Mount</td>
<td>Surface Mount</td>
</tr>
<tr>
<td>Umbrella</td>
<td>Shade, Perforated Aluminum</td>
</tr>
</tbody>
</table>
4.4 Historic Residence Halls

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Landscape Forms, Inc. “Carousel”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Black Powdercoat</td>
</tr>
<tr>
<td>Top</td>
<td>Catena w/Umbrella Hole</td>
</tr>
<tr>
<td>Seats</td>
<td>Strap</td>
</tr>
<tr>
<td>Mount</td>
<td>Surface Mount</td>
</tr>
</tbody>
</table>

4.5 Modern Residence Halls

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Dumor 76-42PL or 76-44PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic/Metal Color</td>
<td>Redwood/Bronze or Gray/Black</td>
</tr>
<tr>
<td>Mount</td>
<td>S-1 Embedment</td>
</tr>
</tbody>
</table>

5 Trash and Recycling Receptacles

5.1 One (1) Trash and one (1) recycling receptacles should be located at all major building entrances. A recycling receptacle signage plate will be provided by Purdue.

5.2 Academic Campus and Residence Halls

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Landscape Forms, Inc. “Petosky”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Trash: Black Powdercoat w/ Black Powdercoat Lid</td>
</tr>
<tr>
<td></td>
<td>Recycle: Black Powdercoat w/ Ivy Powdercoat Recycling Lid</td>
</tr>
<tr>
<td>Color at Life and Health Sciences Mall</td>
<td>Trash: Silver Powdercoat w/ Silver Powdercoat Lid</td>
</tr>
<tr>
<td></td>
<td>Recycle: Silver Powdercoat w/ Ivy Powdercoat Recycling Lid</td>
</tr>
<tr>
<td>Mount</td>
<td>Embedded Posts</td>
</tr>
</tbody>
</table>

5.3 Discovery Park

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Landscape Forms, Inc. “Pitch” – side opening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Trash: Silver Powdercoat w/ Silver Powdercoat Lid</td>
</tr>
<tr>
<td></td>
<td>Recycle: Silver Powdercoat w/ Ivy Powdercoat Recycling Lid</td>
</tr>
</tbody>
</table>

6 Bicycle racks

6.1 Bicycle racks are spaced 2'-8” apart on minimum 6'-8” deep concrete pads. A typical layout can be provided.

6.2 Rows of bicycle racks in large parking areas should be spaced 10'-0” apart.

6.3 Bicycle parking areas should be located adjacent to legal riding routes (streets or bicycle paths).

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Madrax U238-SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color at Discovery Park and Life and Health Sciences Mall</td>
<td>“Old” Silver Powdercoat 38/91020</td>
</tr>
<tr>
<td>Color at All Other Locations</td>
<td>Gloss Black Powdercoat</td>
</tr>
</tbody>
</table>

7 Planters

7.1 Dura Art Stone “Radius” Style D, Light Sand Blast Finish

8 Ash Urns

8.1 Gloss black, embedded post Forms+Surfaces “Ash Buttler” UBUTMD or UBUTLG receptacles are only installed at designated smoking areas across campus.
1 General

1.1 Landscape irrigation must be included in all landscape projects. Drip irrigation should not be utilized because it regularly becomes exposed in mulch beds and causes extra maintenance work. It is important to place plants with different water needs on separate zones.

1.2 Equipment

1.2.1 Irrigation controllers should be Rain Bird ESPLXMEF with IQ Network Communication cartridge GPRS cell cards and Rain Bird flow sensors (size depending on the flow of each zone). Irrigation controllers should be placed near building corners to maximize visibility for programming.

1.2.2 The master valve should be a Rain Bird PEB sized the same as the main line.

1.2.3 The distance between the master valve and the flow sensor shall be 10x the size of the pipe in inches.

1.2.4 The distance between the first turn and the flow sensor shall be 5x the size of the pipe in inches.

1.2.5 All valves should be Rain Bird PEB series.

2 Piping

2.1 All pipes, including laterals, should be Schedule 40.

2.2 Avoid pipe sizes of 2½” and 1¼”.

2.3 Pipe sizes of 2”, 1½” and 1” should be used.

3 Wiring

3.1 Multi strand wire shall be used, not single strand.

3.2 3M DBY’s should be used for all wire splices, and a valve box should be used if a wire junction splice is needed.

4 Spray Nozzles

4.1 Avoid spray nozzles and use the more water efficient MPRs.

4.2 All turf spray heads, if used, should be Rain Bird 4”-6” pops with PRS 45’s for MPRs and PRS.

4.3 All rotors should be Rain Bird PRS Plus.
1 General

1.1 Minimal or easy maintenance is desirable for all plantings.

1.2 Plantings should be simple in design, complement building elevations, and reinforce the scale and context of the site.

1.3 Residential courtyards and outdoor use areas can be designed with a greater variety of materials.

1.4 Increasing plant variety and interest is desired near building entrances.

1.5 Native plants and ecological plantings are encouraged but must be carefully designed since their aesthetic is very different from the traditional manicured campus landscape.

1.6 Plant Seasonal Interest

1.6.1 Plant selection should consider that most of the community is on campus between mid-August and mid-May.

1.6.2 Campus plantings must be carefully designed to remain attractive during winter months when deciduous plants are leafless. For this reason, it is important to include evergreens and plants with winter interest.

1.7 The Purdue Arboretum

1.7.1 The West Lafayette campus is designated as The Purdue Arboretum. Horticulture and Landscape Architecture Department faculty and students maintain a database of campus plants, plant tours, and other information which is available on the arboretum website:

http://www.arboretum.purdue.edu/

1.7.2 Plants specified for use on campus projects should consider the arboretum’s list of desired plants, available upon request.

1.8 Plantings and Energy Conservation

1.8.1 Plants should be selected and located to maximize the energy efficiency of campus buildings.

1.8.2 East and west building faces should be shaded from summer sun.

1.8.3 Evergreens placed north and west of buildings, particularly when entrances occur on those sides, can temper the chilling effects of winter winds.

1.8.4 Paved surfaces should be shaded and, green roofs should be considered, to help counteract the overall “heat island” effect of the urban campus environment.

1.8.5 Plantings should be arranged to facilitate cooling summer breezes which predominate from the west and southwest.

2 Plantings and Security

2.1 Plantings should be designed to maintain visibility so pedestrians can always be fully aware of others in their surroundings, and so law enforcement can have clear views as they patrol campus.

2.2 Building foundation plantings should not create hidden areas adjacent to ground level windows.

2.3 Lighting should be coordinated with outdoor plantings so they do not diminish nighttime illumination.

3 Streets and Street Trees

3.1 Street trees should be planted within a minimum six-foot wide parkway between curbs and pedestrian sidewalks.

3.2 Care should be taken to identify and anticipate those areas where high volumes of pedestrian traffic are likely to cross parkways and compact soils. In those areas, pedestrian control fencing may be necessary.

4 Undesirable Plants

4.1 A number of plants have characteristics or susceptibilities which make them unsuitable for use on campus. They should not be specified for use without special exception.

4.2 In the following table, invasive plants marked with an asterisk (*) are specified in standard erosion control specifications and should be removed from those specifications before inclusion in construction documents for campus projects.
<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer platanoides</td>
<td>Norway Maple</td>
<td>Invasive</td>
</tr>
<tr>
<td>Acer saccharinum</td>
<td>Silver Maple</td>
<td>Weak Wood</td>
</tr>
<tr>
<td>Ailanthus altissima</td>
<td>Tree of Heaven</td>
<td>Invasive</td>
</tr>
<tr>
<td>Alliaria petiolata</td>
<td>Garlic Mustard</td>
<td>Invasive</td>
</tr>
<tr>
<td>Alnus glutinosa</td>
<td>Black Alder</td>
<td>Invasive</td>
</tr>
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<td>Bromus inermis</td>
<td>Smooth Brome</td>
<td>Invasive</td>
</tr>
<tr>
<td>Celastrus orbiculatus</td>
<td>Oriental Bittersweet</td>
<td>Invasive</td>
</tr>
<tr>
<td>Cirsiun arvense</td>
<td>Canada Thistle</td>
<td>Invasive</td>
</tr>
<tr>
<td>*Coronilla varia</td>
<td>Crown Vetch</td>
<td>Invasive</td>
</tr>
<tr>
<td>Eleagnus umbellate</td>
<td>Autumn Olive</td>
<td>Invasive</td>
</tr>
<tr>
<td>Euonymous alatus</td>
<td>Winged Spindle Tree</td>
<td>Invasive</td>
</tr>
<tr>
<td>Euonymous fortune</td>
<td>Purple Winter Creeper</td>
<td>Invasive</td>
</tr>
<tr>
<td>*Festuca elatior</td>
<td>Tall Fescue</td>
<td>Invasive</td>
</tr>
<tr>
<td>Fraxinus spp.</td>
<td>Ash</td>
<td>Malodorous Fruit</td>
</tr>
<tr>
<td>Ginkgo biloba (female)</td>
<td>Female Ginkgo</td>
<td>Insects, Diseases</td>
</tr>
<tr>
<td>Glechoma hederacea</td>
<td>Creeping Charlie</td>
<td>Invasive</td>
</tr>
<tr>
<td>Gleditsia triacanthos</td>
<td>Honeylocust</td>
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</tr>
<tr>
<td>Hemerocalis 'Stella d’Oro’</td>
<td>Stella d'Oro Daylily</td>
<td>Overplanted</td>
</tr>
<tr>
<td>Hemerocalis 'Happy Returns'</td>
<td>Happy Returns Daylilly</td>
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</tr>
<tr>
<td>Hesperis matronalis</td>
<td>Dame’s Rocket</td>
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</tr>
<tr>
<td>Humulus japonicas</td>
<td>Japanese Hops</td>
<td>Invasive</td>
</tr>
<tr>
<td>*Ilex spp.</td>
<td>Holly</td>
<td>Soil pH Too High</td>
</tr>
<tr>
<td>Imperata cylindrical (from tissue culture)</td>
<td>Japanese Bloodgrass (from tissue culture)</td>
<td>Invasive</td>
</tr>
<tr>
<td>Lespedeza bicolor</td>
<td>Bicolor lespedeza</td>
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</tr>
<tr>
<td>Lespedeza cuneata</td>
<td>Sericea lespedeza</td>
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</tr>
<tr>
<td>Ligustrum vulgare</td>
<td>Common Privet</td>
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</tr>
<tr>
<td>Lonicera Japonica</td>
<td>Japanese Honeysuckle</td>
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</tr>
<tr>
<td>Lonicera maackii</td>
<td>Amur Honeysuckle</td>
<td>Invasive</td>
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<tr>
<td>Lonicera morrowii</td>
<td>Morrow Honeysuckle</td>
<td>Invasive</td>
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<tr>
<td>Lonicera tatarica</td>
<td>Tartarian Honeysuckle</td>
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<tr>
<td>Lysimachia nummularia</td>
<td>Creeping Jenny</td>
<td>Invasive</td>
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<tr>
<td>Lythrum salicaria</td>
<td>Purple Loosestrife</td>
<td>Invasive</td>
</tr>
<tr>
<td>Malus spp. (disease susceptible)</td>
<td>Crabapples (disease susceptible)</td>
<td>Apple Scab, Fire Blight, Powdery Mildew</td>
</tr>
<tr>
<td>Scientific Name</td>
<td>Common Name</td>
<td>Reason</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------</td>
<td>--------------------------------</td>
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<tr>
<td>Melilotus alba</td>
<td>Sweet Clover</td>
<td>Invasive</td>
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<td>Microstegeum vimineum</td>
<td>Japanese stilt grass</td>
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<tr>
<td>Miscanthus sinensis</td>
<td>Maiden grass</td>
<td>Invasive</td>
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<tr>
<td>Morus alba</td>
<td>White Mulberry</td>
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<tr>
<td>Ornitogalum umbellatum</td>
<td>Star of Bethlehem</td>
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<tr>
<td>Phalaris arundinacea</td>
<td>Reed Canary Grass</td>
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<td>Phragmites australis</td>
<td>Common Reed or Phragmites</td>
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<td>Pinus nigra</td>
<td>Austrian Pine</td>
<td>Diplodia Tip Blight</td>
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<td>Pinus sylvestris</td>
<td>Scotch Pine</td>
<td>Diplodia Tip Blight, Pine Wood Nematode</td>
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<td>Platanus occidentalis</td>
<td>Sycamore</td>
<td>Litter</td>
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<td>Pueraria lobata</td>
<td>Kudzu</td>
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<tr>
<td>Pyrus calleryana ‘Bradford’</td>
<td>Bradford Pear</td>
<td>Weak Wood</td>
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<tr>
<td>Quercus palustris</td>
<td>Pin Oak Iron</td>
<td>Chlorosis</td>
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<td>Rhamnus cathartica</td>
<td>Common Buckthorn</td>
<td>Invasive</td>
</tr>
<tr>
<td>Rhamnus frangula</td>
<td>Glossy Buckthorn</td>
<td>Invasive</td>
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<tr>
<td>Rhododendron spp.</td>
<td>Rhododendron, Azalea</td>
<td>Soil pH Too High</td>
</tr>
<tr>
<td>Rhus aromatic ‘Gro-Low’</td>
<td>Fragrant Sumac</td>
<td>Maintenance Issues</td>
</tr>
<tr>
<td>Robinia pseudoacacia</td>
<td>Black Locust</td>
<td>Invasive</td>
</tr>
<tr>
<td>Rosa multiflora</td>
<td>Multiflora Rose</td>
<td>Invasive</td>
</tr>
<tr>
<td>Salix x blanda</td>
<td>Wisconsin Weeping Willow</td>
<td>Weak Wood, Cankers</td>
</tr>
<tr>
<td>Sorbus spp</td>
<td>Mountain Ash</td>
<td>Borers, Cankers</td>
</tr>
<tr>
<td>Tilia spp</td>
<td>Linden</td>
<td>Japanese Beetle</td>
</tr>
<tr>
<td>Ulmus carpinifolia ‘Accolade’</td>
<td>Accolade Elm</td>
<td>Japanese Beetle</td>
</tr>
<tr>
<td>Ulmus pumila</td>
<td>Siberian Elm</td>
<td>Invasive</td>
</tr>
<tr>
<td>Viburnum opulus v. opulus</td>
<td>Highbush Cranberry</td>
<td>Invasive</td>
</tr>
<tr>
<td>Vinca minor</td>
<td>Periwinkle</td>
<td>Invasive</td>
</tr>
</tbody>
</table>
5 Storm Water Management
5.1 Site design should encourage storm water surface infiltration wherever possible.
5.2 Rain gardens and other infiltration plantings must be at least 10 feet from building foundations, exterior walls, utility tunnels/vaults, etc.
5.3 Paved surfaces should be graded to maintain sheet flow of storm water for the longest possible distance.
5.4 Shade tree canopies should be arranged to maximize coverage over paved surfaces in order to intercept rainfall and slow storm water runoff.

6 Parking Lots
6.1 Campus parking lots should be screened with low, evergreen shrubs and planted with shade trees to maintain the park-like appearance of campus, to limit summer heat gain from paved surfaces, and to slow storm-water runoff from paved areas. The selections and locations of perimeter screen plantings should anticipate snow removal storage.
6.2 Parking lots should be graded to maximize sheet flow of storm water and utilize planting areas as infiltration sites whenever possible.
6.3 Internal planting islands should be organized to facilitate the efficient removal of snow during winter months.

7 Landscape Protection
7.1 Landscape Protection Plans
7.1.1 Prior to the start of design work, the consultant will develop a Landscape Protection Plan.
7.1.1.1 The plan will identify the location, tree number, canopy size, and root zone area, of each existing tree.
7.1.1.2 The plan will include an appraisal table noting the value of each tree and whether it is to be protected, relocated, and/or removed as part of the project.
7.1.1.3 The Campus Arborist will provide data for the appraisal table. Our standard notes will also be included on the plan. A sample plan can be provided.
7.1.2 Tree types, locations, sizes, and root zone areas may be provided as part of the project survey. Should the survey be incomplete at the start of design, Physical Facilities can provide base information from which the plan can be developed.
7.1.3 The consultant will work with the Project Manager, Grounds Landscape Architect, and Campus Arborist to understand landscape protection goals impacting the project and to establish protective fence and mulch locations as the project design develops.

Note: Ideally, the Landscape Protection Plan will be located after the survey and before the demolition plan in the construction documents.

7.2 Landscape Protection Specifications
7.2.1 Contract document specifications will include the section titled “Tree Protection and Trimming” which can be provided by the PM. It should be included verbatim except Part 1.2.b. which the consultant will modify to coordinate with other, related sections in the project specifications booklet.
7.2.2 The required content of the Landscape Protection Plan has been carefully coordinated with verbiage in the tree protection specification section. Neither should be modified without prior approval of the Director of Campus Master Planning and Sustainability.

8 Soil
8.1 Soil Compaction
8.1.1 Most of campus occurs on the Wabash River terrace and is underlain with well-drained sands and gravels. However, upper soil layers on campus project sites are typically over-compacted during construction and must be ripped or loosened to restore permeability.
8.1.2 It is important to require the general contractor to verify that subsoil bulk density is between 1.0 and 1.4 grams per cubic centimeter (g/cc) prior to placing topsoil on site. While not preferable, if acceptable subsoil bulk density cannot be achieved, subsurface drainage will be required.
8.1.3 Placed topsoil must also have a bulk density between 1.0 and 1.4 g/cc before planting can begin. Acceptable test methods include AASHTO T 19M/T 19-00 (2004) or ASTM C 29/C 29M-97 (2003).

8.2 Soil pH
8.2.1 Soils in this area tend to have high pH levels causing ericaceous and acid loving plants to fail.
8.2.2 Specifications should not allow contractors to lower soil pH with amendments such as sulfur in order to meet spec because amended soils will revert to higher pH levels over time.
8.3 Bio-soil

8.3.1 Purdue has developed a topsoil mix for bio-swales and rain gardens on campus. This bio-soil mix has more silt and clay content than typically specified because high quantities of local sands raise pH to unacceptable levels.
1 General
1.1 This guideline provides the design criteria, minimum quality and materials for the excavation and backfilling of utility piping trenches.
1.2 Materials and installations shall be in accordance with the following industry and association standards.
   • INDOT Standard Specifications – Latest Edition
   • AASHTO Standards
   • ASTM – Material & Testing Specifications
   • AWWA – Water Works
   • OSHA Regulations (Standards – 29CFR) Part 1926 Subpart P – Excavations, in addition to other related OSHA Standards
   • City of West Lafayette Standards, Specifications & Details – Latest Edition
1.3 Design Conditions: The Engineer shall determine the appropriate trench depths, widths and sidewall slopes and clearly indicate them on the Drawings.

2 Description of Materials
2.1 Fill and Backfill:
2.1.1 Suitable earth removed from the excavation, free of rocks, boulders, stones, bricks, batts, plaster, mortar or other debris.
2.1.2 All backfill shall be free from cinders, ashes, refuse and organic material.
2.1.3 Backfill should consist of natural materials such as loam, clay, sand, gravel or other similar materials where appropriate. Frozen soil may not be used for backfill.
2.2 Lightly Consolidated Backfill:
2.2.1 The use of ordinary backfill, as defined above, placed with 85% degree of compaction to support the trench conditions and protect the pipe. This condition is achieved by placing the backfill material in 12 inch layers and lightly compacting after each layer.
2.3 Sand for backfill will contain less than 10% by weight of loam and clay passing a ¾” sieve with no more than 5% by weight remaining on a US No. 4 sieve. Sand is graded from fine to course.
2.3.1 Well graded sand is the preferred material, and shall be used unless otherwise stated or approved by the Owner’s Representative.
2.4 Gravel for backfill will contain only minimal amounts of loam and clay, consisting of a generally uniform particle size not exceeding 2 inches, #53 aggregate.
2.5 Crushed stone for backfill will contain limestone or ledge-rock material which all passes a ½ inch sieve, but 25% or less passing a US No. 100 sieve.
2.6 Compacted Sand or Granular Material describes the use of sand, gravel or crushed stone, placed in layers and compacted after each layer to achieve a consistent compaction rate measuring approximately 95% or greater for the Standard Proctor Test, AASHTO T-99 or ASTM D698, Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures using 5.5 LB Rammer and 12 inch Drop.
2.6.1 If required AASHTO T-180 or ASTM D1557 can also be used if considered appropriate to the backfill material.
2.6.2 Sand is the preferred material, and shall be used unless otherwise stated or approved by the Owner’s Representative.
2.7 Backfill under roads & sidewalks
2.7.1 All backfill under new or existing roadways, sidewalks etc. that are eighteen inches (18”) above the pipe shall be approved #53 aggregate or flowable fill.
2.8 Backfill under precast trenches & tunnels
2.8.1 All backfill under precast trenches, duct banks, half-tile and/or concrete utility tunnels shall be flowable fill.
2.8.2 All backfill adjacent to precast trenches, concrete utility tunnels and other underground concrete structures subject to vehicular loading shall be flowable fill.
2.9 Backfill under existing utilities
2.9.1 Where existing utilities are undermined and compaction underneath cannot be verified, backfill with flowable fill.
2.10 Backfill for pipe leak repairs
2.10.1 All backfill for leak repair excavations shall be clean sand.
2.10.2 If involving a paved area, the fill shall meet requirements above.
2.10.3 If involving a grassy or landscaped area, fill with sand up to 12” below surface, and Purdue Grounds will install finish landscaping.
2.11 Pipe Bedding
2.11.1 Use coarse sand 30% passing a No. 50 sieve and 3% or less passing a No. 100 Sieve.
2.11.2 After excavating the trench and prior to laying the pipe, a 6 inch minimum layer of sand shall
be placed and compacted evenly along the base of the trench.

2.11.3 The pipe shall be surrounded by sand, and covered by a 12 inch minimum layer of sand compacted evenly along the pipe.

2.12 Pipe installed under new or existing tunnels shall be encased in flowable fill.

2.13 Topsoil shall comply with Purdue University soil guidelines.

2.14 All concrete patches shall be to Purdue Class 4A LS Specifications, copies of which are on file and all other applicable sections of these specifications.

2.15 Sidewalks, curbs, gutters, and floor slabs shall be replaced to match existing.

3 Installation Guidelines

3.1 Existing Conditions

3.1.1 Contractor shall be deemed to have inspected the site and satisfied himself as to actual grades and levels and the true conditions under which the work is to be performed.

3.2 Protection

3.2.1 Furnish, place and maintain all supports, shoring and sheet piling which may be required for the sides of the excavation or for protection of adjacent existing improvements. The adequacy of such systems shall be the complete responsibility of the Contractor.

3.2.2 Furnish and install all shoring and bracing as required to insure the existing structures such as piping and valve pits remain fully supported by undisturbed soil at all times. It shall be the sole responsibility of the Contractor to design, install and remove excavation shoring in such a manner as to insure that the existing structures are not damaged.

3.3 Excavation

3.3.1 The work site shall be prepared in advance of the work to be done. Where the excavation is in a high public access area (including roads) advanced notice should be given to the owners of the adjacent property and other affected parties. In such cases the length of open trench and excavation shall be minimized by staging the works to minimize disruption to the public where possible.

3.3.2 Adequate barricades and warning signs shall be posted around the site at all times, alerting the public to the hazardous conditions and restricting site access to authorized works personnel only.

3.3.3 All trenches shall be excavated in accordance with AWWA C600 and OSHA 1926 Subpart P. Make excavations to dimensions, elevations and sidewall slopes as indicated on Drawings.

3.3.3.1 Owner will not pay for excavations carried below indicated grades without Owner's/Engineer's written authorization.

3.3.3.2 Where unauthorized excavations are made below indicated elevations under slabs restore to proper elevations as specified for compacted backfill; and if under footings, restore with compacted engineered fill.

3.3.3.3 Excavation for formed concrete shall be sufficient width to allow for convenient construction and removal of forms.

3.3.4 Excavation for below grade walls shall be sufficient to allow for application of waterproofing and drainage materials indicated.

3.3.5 Excess soil from the excavation must be placed away from the trench to ensure no runoff from the soil will be directed into the excavation. Alternatively the soil may be stockpiled as specified by the Owner’s Representative.

3.3.6 Excess excavated material and material determined unsuitable for use as fills or topsoil shall be disposed of off the site.

3.3.7 Where unmarked utility lines or other underground obstructions or piping may be uncovered within the work area, notify the Owner/Engineer or the agencies or service utility companies having jurisdiction thereof, and take necessary measures to prevent interruptions of service if live.

3.3.7.1 Should such lines or services be damaged, broken or interrupted through the Contractor’s own negligence, those services shall be repaired immediately and restored by him at his own expense.

3.3.7.2 Abandoned lines, meters and boxes, obstructions or piping, shall be removed, plugged or capped in accordance with the requirements and approval of the agencies affected, or as directed by the Owner/Engineer.

3.4 Backfilling

3.4.1 The placement of fills shall be done under the supervision of the Soils Engineer.

3.4.2 Bedding and backfill for pipe shall
consist of a six (6") inch layer of sand placed and compacted in the trench to provide uniform bedding for the conduit.

3.4.2.1 The entire trench around the pipe shall be evenly backfilled with sand as the bedding in six (6") inch layers and compacted into place to a minimum height of twelve (12") inches above the top of pipe.

3.4.2.2 This layer of material shall be to 95% or greater Standard Proctor, AASHTO T-99 (AASHTO T-180) or ASTM D698 (ASTM D1557) or equivalent acceptable test and test results shall be provided for the Owner’s Representative as evidence of compliance.

3.4.3 Above the layer of compacted sand, Backfill shall be placed in maximum twelve (12") inch lifts and compacted in placed, up to the level indicated on the Drawings.

3.4.4 Prior to commencing compaction, soils shall be brought to optimum moisture content. Thoroughly mix each lift before compaction to assure uniform distribution of water content. Owner’s Representative shall approve the moisture content, and method of adjusting the moisture content.

3.4.5 Backfill under new or existing roadways, sidewalks etc. to specified depth shall be approved #53 aggregate placed in eight (8") inch lifts and compacted to a 95% density. Flowable fill is acceptable.

3.4.6 Compaction

3.4.7 All fills shall be compacted using equipment capable of compacting each lift its full depth. Moisture during compaction operations shall be maintained at optimum content.

3.4.8 Hydraulic compaction of backfill is not permitted without approval from the Owner’s Representative. Even with approval, at no time shall water be added to any backfill placed in a trench in freezing or potentially freezing conditions or at any time where the trench base and sides form an impenetrable clay boundary which would prohibit the infiltration of water into the surrounding soil.

3.4.9 The compacting equipment shall be approved equipment of such design, weight and quantity to obtain the required density in accordance with soil compacting specifications. Water distributors equipped with a suitable sprinkling device shall be used to add moisture to the soil if required.

3.4.10 Compaction operations shall be continued until the fills are compacted to not less than 95% of the maximum density as determined in accordance with AASHTO T-99 (AASHTO T-180) or ASTM D698 (ASTM D1557).

3.4.10.1 Any areas inaccessible to a roller shall be consolidated and compacted by mechanical tampers.

3.4.10.2 The equipment shall be operated in such a manner that hardpan, cemented gravel, clay or other chunky soil material will be broken up into small particles and become incorporated with the material in the layer.

3.4.11 Excavation shall be sized so that compaction equipment has sufficient operating clearance to achieve specified compaction throughout all areas of fill.

3.5 Grading

3.5.1 All areas covered by the Project, including excavated and filled areas and adjacent transition areas, shall be uniformly graded so that finished surfaces are at the elevation noted. Areas to receive future topsoil shall be graded to allow for such material.

3.5.2 Finished surfaces and surfaces to receive paving and aggregate base shall be reasonably smooth, compacted, and free from irregular surface drainage and shall not vary more than 0.10 foot from the established grade.

3.5.3 Ditches, gutters and swales shall be finished to permit proper surface draining.

4 Testing Guidelines

4.1 Quality Control

4.1.1 The Owner/Engineer will engage and pay for the services of a recognized Testing Laboratory specializing in Soil Mechanics for the making of tests of material to determine their suitability for fills, maximum density and optimum water content, the preparation of the materials for fills, the continuous inspection and supervision of the excavating, the placing of the fills, and the making of in-place density test for each compacted layer of fills.

4.1.2 The testing firm shall have a bona fide representative present to observe and test the entire engineered fills operation.

4.1.3 The backfill material shall be tested at regular intervals, in all critical places and around all fittings and valves.

4.1.4 A report should be produced and submitted to the Owner’s Representative which contains information on the compaction achieved at each fitting and valve and for every 300 feet approximately at each layer and on both sides of the pipe.
4.1.4.1 Where the length of the new pipeline is less than 300 feet, a compaction test shall be performed in at least two locations and reported.

4.1.4.2 The As-Built drawings shall also contain the locations of the compaction tests. Submit testing plan for approval.

4.1.5 An average of two (2) tests per lift of each area is required. However, the exact number of tests will depend on the weather and at the discretion of the Soils Engineer. Testing firm shall test and approve all materials used in engineered fills operation.

4.1.6 Should tests indicate that the required density was not attained, the Contractor shall remove fills to depths required and as determined by the test. Repeat tests and operations until required density is attained.

4.1.7 The Owner/Engineer, upon the recommendation of the Testing Laboratory, will have the power of rejection of materials, equipment or operating procedures which are not suitable to produce the results specified.

4.1.8 The Contractor shall cooperate with the Testing Laboratory and shall allow the Soil Engineer ample time to conduct tests. Operation of equipment shall be discontinued when the operation interferes with testing.

4.2 Guarantee

4.2.1 The Contractor shall be responsible for one year from the date of acceptance of the project by the Owner for the grade, backfill and compaction on the works completed under these Specifications.

4.2.2 Acceptance of the work and payment for the same shall not release the Contractor from any responsibility.
1 Applicability
1.1 All piping, fittings, equipment, etc. from the exterior utility mains to the building valve located after the meter or, in the case of domestic water, the backflow preventer, is considered utility piping.
1.2 All piping after the valve described in paragraph 1.1 is considered interior piping.
1.3 All utilities serving a new building, existing building with new service, or remodeled building will be metered as determined by Purdue Utilities.

2 General Equipment Placement
2.1 “Equipment” defined as all utility meters and Data Concentrator Control Panel (DCCP).
2.2 All newly installed equipment must be serviceable while standing on the floor with the centerline no higher than 48" above floor. Where that is not possible discuss options with the University project engineer.
2.3 All equipment shall be installed with a definitive means of service and removal to exterior of building.
2.4 All equipment shall require at least 18” service clearance above, below and on one side.
2.5 All mechanical meters shall be supported as required by the manufacturer.
2.6 Meters shall be installed with the manufacturers recommended straight run of pipe, both upstream and downstream, based on the size of meter to be installed.

3 Chilled Water Meter
3.1 Chilled water meters shall be in-line electromagnetic, owner furnished, and contractor installed.
3.2 Meters are to be installed in the return piping with a bypass for critical installations. If the meter must be installed in the supply piping consult Purdue University for approval prior to installation.
3.3 Meters should be installed in horizontal piping. If a vertical riser is the only location available for installation, the flow direction must be up.
3.4 All meters shall be sized for the load of the building and not necessarily matching service line size.
3.5 Manufacturers straight run requirements, accuracy requirements, and orientation must be met.
3.6 Connections to the piping shall be minimum ANSI class 150 flanges
3.7 For installations in non-metallic pipe, external grounding rings will be required to be installed, bonded, and tied to an appropriate building grounding system.

3.8 Approved Manufacturers
- Endress + Hauser (coordinate the size and model number with Purdue University Energy and Utilities Engineering)

4 Domestic Water Meter Installations
4.1 Use metallic pipe from the building wall penetration to the backflow preventer. Pipe can be:
- Ductile iron pipe with flanged fittings
- Schedule 40 Galvanized Pipe with galvanized rolled fittings and couplings
- Type L Copper Tube with rolled or sweat fittings
4.2 All domestic water meters shall include a bypass with a lockable valve. 4.3 Service valves 2” or larger shall be:
- AWWA C-708 or approved equal
- Non-rising stem gate valve
- Epoxy coated
- Resilient seated

4.4 Domestic Water Meter
5.1 Domestic water meters shall be owner furnished contractor installed, and shall be in-line electromagnetic installed in the building supply piping with a bypass.
5.2 Manufacturers straight run requirements, accuracy requirements, and orientation must be met.
5.3 All domestic water meters shall be piped independent, and shall not be deductive to the main meter. Irrigation and other services that will enter the storm drains shall have a separate, non-deductive meter.
5.4 All meters shall be sized for the load of the building and not necessarily matching service line size.
5.5 Connections to the piping shall be minimum ANSI class 150 flanges
5.6 For installations in non-metallic pipe, external grounding rings will be required.
5.7 Consult the Purdue University Energy and Utilities Mechanical Project engineering group if there is a concern with this meter technology and placement for the application.
5.8 Approved Manufacturers
- Endress + Hauser (coordinate the size and model number with Purdue University Energy and Utilities Engineering)
6 Steam Metering

6.1 All new buildings, existing buildings with new steam services and all remodeled buildings shall have both the steam supply and the condensate return metered.

*Note: This is to capture any steam used for humidification, sterilization etc. or find issues when condensate is being sent to drains.*

6.2 Steam Condensate Meters

6.2.1 Condensate meters shall be owner furnished contractor installed, and shall be in-line vortex shedding.

6.2.2 Connections to the piping shall be minimum ANSI class 125 flanges.

6.2.3 Manufacturers straight run requirements, accuracy requirements, and orientation must be met.

6.2.4 All meters shall be sized for the load of the building and not necessarily matching service line size.

6.2.5 Approved Manufacturers

- Endress + Hauser (coordinate the size and model number with Purdue University)

6.3 Steam Supply Meters

6.3.1 Steam meters shall be owner furnished contractor installed, and shall be vortex shedding or conditioning orifice plate.

6.3.2 Connections to the piping shall be flanged. Flange classes to be determined by service.

6.3.3 Manufacturers straight run requirements, accuracy requirements, and orientation must be met.

6.3.4 All meters shall be sized for the load of the building and not necessarily matching service line size.

6.3.5 The meter shall be capable of withstanding superheated steam temperature and pressure

6.3.6 The meter shall be capable of pressure and temperature compensation measuring with an integral temperature sensor and a remote mounted pressure sensor wired to the meter transmitter.

6.3.7 The meter shall be factory calibrated.

6.3.8 Approved Manufacturers

- Endress + Hauser (coordinate the size and model number with Purdue University Energy and Utilities Engineering)

7 Steam Meters in Distribution Mains

7.1 A self-averaging pilot tube is the preferred steam meter when measuring steam in distribution mains.

7.1.1 The meter should have the ability to be used in bi-directional flow without changing the sensor's position or valves.

7.1.2 The transmitter should have a turndown range to 100:1

7.1.3 The transmitter shall be NIST certified, shall have Modbus protocol communication or as approved by Purdue Utilities.

7.1.4 Transmitters shall be ±0.1% accurate or better and drift less than ±0.1% of URL over 8,000 hrs.

7.2 Approved Manufacturers

- Systems for Industry
- Cameron Measurement Systems

7.3 Coordinate the size and model with Purdue University Energy and Utilities Engineering

8 Chilled Water Temperature Sensors

8.1 Chilled water temperature sensors and thermowells shall be owner furnished contractor installed.

8.2 Two sensors shall be installed, one in the supply line and one in the return line. They shall be installed outside the manufacturers straight run requirements of the meter.

8.3 Where chilled water service is 4" in diameter and smaller, a 2.5" thermowell shall be used.

8.4 Where chilled water service is 5" in diameter or larger, a 4" thermowell shall be used.

8.5 Approved Manufacturers

- Pyromation (coordinate the size and model number with Purdue University Energy and Utilities Engineering)

9 Steam Condensate Temperature Sensors

9.1 Steam condensate temperature sensors and thermowells shall be owner furnished contractor installed.

9.2 One sensor shall be installed, and shall be located outside the manufacturers straight run requirements of the meter.
9.3 When a steam condensate line is 4" in diameter and smaller, a 2.5" thermowell shall be used.
9.4 When a steam condensate line is 5" in diameter or larger, a 4" thermowell shall be used.
9.5 Basis of Design
- Pyromation (coordinate the size and model number with Purdue University Energy and Utilities Engineering)

10 Electrical Meters
10.1 Reference Division 26 Section 0913 of these guidelines.

11 DCCP
11.1 DCCP shall be owner furnished and contractor installed. A location must be identified on the design drawings for the panel in a location normally accessible to maintenance personnel (e.g. mechanical rooms).
11.2 Each DCCP will be provided with a wiring schematic. All metering equipment will be wired according to this document by the contractor.
11.3 Each Wire to and from the DCCP shall be colored according to what is called out on the DCCP wiring schematic.
11.4 The equipment connected to the DCCP shall be properly tagged on both ends of the wire. Each multi-conductor signal cable shall have a tag on both the outer sheath as well as each individual conductor within the cable.
11.4.1 Each 24V power conductor shall be tagged according to the DCCP schematic.
11.4.2 The tag on the outer sheath shall be the 14 character equipment identifier which can be found on the DCCP schematic.
   Example: 1088SC02ME0150
11.4.3 The tag on each individual signal wire shall include the information as shown on the schematic which indicates where the conductor originates from the DCCP.
   Example: I:2.2+
11.4.4 Each communication cable for the electrical meters shall be tagged with the correct meter number.
11.5 All utility meters (i.e. chilled water, domestic water, steam or steam condensate, and electric) and temperature sensor communications shall be routed in conduit to the identified DCCP location.
11.6 Each electromagnetic flow meter (i.e. chilled water, and domestic water) as well as each Electrical meter shall receive its own 24V power supplied by the DCCP according to the wiring schematic located in the DCCP.
11.7 Each electromagnetic flow meter will receive a 2-wire communication cable from the DCCP to each location.
11.8 Each Vortex Shedding meter will receive power and communication from a single 3-wire cable from the DCCP to each Location.
11.9 Each Temperature sensor will receive a single 3-wire cable from the DCCP to each location
11.10 Each electrical meter will receive an Ethernet cable from the DCCP to each location.
11.11 There shall be dedicated conduit for mechanical meters, electrical meters, power to the panel, and communication to the BDF room respectively. All conduits shall be a minimum of 1 inch in diameter. Conduit shall not be overfilled to allow easy pull of wire for future replacement.
11.12 Ethernet communication shall be routed in conduit from the PIC within the DCCP to the BDF room.
11.13 A dedicated 110V circuit shall be routed and terminated at the DCCP by the contractor according to the schematic provided with the DCCP.
11.14 All field devices are to be terminated by the contractor. The contractor is to leave a six foot coil of all power and communication wire for the commissioning agent to perform final terminations within the DCCP.
11.15 DCCP shall not be energized by the contractor. The DCCP consultant is responsible for the final check of wire terminations, energizing the DCCP, and commissioning of the DCCP.
1 General

1.1 The potable water distribution system is supplied by a 1.5 million gallon water tower and 9 on site wells with a pumping capacity of approximately 7,000 GPM. Operating pressures range from 20 to 100 psi with the norm being approximately 75 psi.

1.2 Potable water lines are direct buried in clean sand with the preferred piping material being cement-lined ductile iron or high density polyethylene (HDPE).

1.3 System valves are resilient seat gate valves.

1.4 All pipe joints are to be mechanically restrained and in certain circumstances double restrained. Thrust blocks are not permitted.

1.5 Materials and installations shall be in accordance with the following industry and association standards. In the event new editions supersede any of the herein mentioned Standards, the latest edition shall apply.

- ANSI / AWWA C104 Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water
- ANSI / AWWA C110 Ductile Iron and Gray Iron Pipe Fittings
- ANSI / AWWA C111 Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings
- ANSI / AWWA C115 Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges
- ANSI / AWWA C150 Thickness Design of Ductile Iron Pipe
- ANSI / AWWA C151 Ductile Iron Pipe, Centrifugally Cast
- ANSI / AWWA C153 Ductile Iron Compact Fittings 3 in. thru 24 in. for Water Service
- ANSI / AWWA C600 Installation of Ductile Iron Mains and Their Appurtenances
- ANSI / AWWA C605 Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings
- ANSI / AWWA C651 Disinfecting Water Mains
- Indiana Department of Environmental Management (IDEM) Regulations in Indiana Administrative Code, Title 327 – Water Pollution Control Division
- Indiana Plumbing Code
- Indiana Fire Code
- National Sanitation Foundation Standards 60 and 61.
- All IDEM, AWWA, and 10 State standards

2 Design Parameters

2.1 150 PSIG design pressure

2.2 100°F design temperature

2.3 150 PSIG hydrostatic test pressure for a 2 hour duration. Plus or minus 5 PSIG differential.

2.4 Maximum 6 feet per second (fps) water velocities

2.5 All pipe, fittings, and pipe joining materials used for potable water systems shall be lead, copper, arsenic, zinc, synthetic organic compound, and volatile organic compound free.

2.6 New distribution main line materials shall be determined with Utilities Engineering for each project.

2.7 Straight piping runs shall consist of push joints with gripper gaskets.

2.8 Thrust and momentum control devices shall consist of a double restraint as follows:

- 2.8.1 Mechanical Joints with Lug Style Restraining Glands and additional clamps with rods
- 2.8.2 Mechanical Joints with Dual Lug Style Restraining Glands

2.9 Dual thrust and momentum control devices are required for all 11.5° or greater changes of direction, tees, fittings, changes of diameter, valves, hydrants and dead ends

2.10 Thrust blocks are not allowed

2.11 The Owners representative shall approve all restraining and anchoring methods.

2.12 Separation of water mains and sewers shall meet the requirements of IAC 327.

2.13 Consult Utilities Engineering if an application is believed to be outside of these conditions.

3 Ductile Iron Pipe Materials & Equipment

3.1 Piping

- 3.1.1 Ductile Iron shall be made in accordance with AWWA C150 and C151. Control of the chemical constituents shall insure that the pipe produced is suitable for satisfactory drilling and cutting in the field.

- 3.1.2 The pipe shall be AWWA pressure class 350 and shall have a thin bituminous coated cement lining, complying with AWWA C104.
3.2 Fittings

3.2.1 All fittings for use with ductile iron pipe shall be AWWA pressure class 350 with mechanical joints, and shall meet the requirements of AWWA C110 and/or C153.

3.3 Mechanical Joints

3.3.1 Mechanical joints on pipe and fittings shall comply with AWWA C110 and C115.

3.4 Gaskets

3.4.1 Gripper Gaskets: Push joint gaskets shall be EPDM rubber with stainless steel grip inserts complying with AWWA C111

3.4.2 Mechanical Joint gaskets shall be EPDM rubber complying with AWWA C111.

3.5 Connecting Hardware

3.5.1 All connecting hardware material shall consist of 304 grade stainless steel machine bolts and nuts complying with ASTM A108.

3.5.2 All bolts shall be furnished with full sized, semi-finished, hexagon stainless steel nuts. Stainless T-bolts are permitted for use on mechanical joints.

4 High Density Polyethylene Pipe (HDPE) Materials & Equipment

4.1 HDPE pipe shall meet the requirements of ASTM D3035, D3350 and/or F714, and AWWA C901 and/or C906.

4.2 HDPE pipe shall be DR-11 or DR-13.5 with a working pressure rating of 160 psig at a water temperature of 73°F.

4.3 HDPE pipe size shall be determined for each specific application. HDPE pipe has significantly smaller inside diameter than ductile iron pipe, therefore it is sometimes oversized to achieve the desired inside diameter. However consideration must be given to connecting the larger HDPE pipe to flanges and fittings of ductile iron pipe.

4.4 HDPE fittings shall be selected to provide a working pressure rating of 160 psig. This may require fittings of the next numerically lower size with a thicker wall. Consider the effect of the reduction in inside diameter on fluid velocity and pressure loss if multiple fittings will be required for an installation.

4.5 HDPE pipe shall be limited to nominal 12” diameter without approval from Utilities Engineering.

4.6 HDPE pipe shall be joined by thermal butt-fusion in accordance with the manufacturer’s recommendations.

4.7 Transitions from ductile iron to HDPE pipe shall be done with a valve. Follow the manufacturer’s recommendations for connecting HDPE to mechanical joint valves. Where lug style fittings are used, a stainless steel sleeve shall be provided.

4.8 HDPE pipe shall be DIPS sizes and have three BLUE horizontal color stripes equally spaced around pipe.

4.9 HDPE pipe shall be laid with a trace wire to facilitate future locating.

4.9.1 Trace wire shall be #12 THHN solid copper.

4.9.2 Trace wire shall be affixed to outside of pipe to resist backfill.

4.9.3 Trace wire color code shall follow piping color code.

4.9.4 Trace wire shall be brought into a building junction box and labeled.

4.9.5 An additional valve box shall be installed at the origin of the HDPE piping run to house trace wires. No wire terminations shall be in the valve box, simply coil the trace wire in the box.

5 Installation Guidelines

5.1 Pipe Restraints

5.1.1 Repair couplings and dresser couplings used for connecting to sections of existing piping shall be protected with thrust and momentum control devices.

5.1.2 Thrust and momentum control devices shall be installed so as to allow the use of trench boxes and other similar confined space entry safety devices.

5.1.3 Thrust and momentum control devices shall be installed to allow for maintenance of strainers, water meters, backflow prevention devices, instrumentation and other ancillary devices. In this case maintenance includes disassembly and removal of devices.

5.1.4 Terminate the pipe entering the building with an ANSI Class 125 bolt flange and a resilient seat gate valve. The piping shall be restrained by means of retaining rods tied back...
into the concrete wall.

5.1.5 Restraining rods and fastener threads shall be fully brush coated with an approved anti-seizing compound just prior to use. Unused threads shall remain coated with anti-seizing compound when construction is complete.

5.1.6 Washers and nuts shall be used on both sides of all connections. Bolt and rod threads shall extend 1” beyond nuts.

5.2 Piping

5.2.1 At all times and in all places, a minimum depth of 5 feet cover over the top of the pipe must be maintained, per Indiana Administrative Code 327 IAC 8-3.2-17, to prevent thermal influences and protect the pipe from light surface loads. As Built drawings of the pipe system must be produced by the Contractor showing the elevation of the pipe and the depth to surface and shall be submitted to the Owner’s Representative at the completion of the works.

5.2.2 Foreign material shall not be allowed to enter the pipes, fittings or other items while they are stored, lowered into the trench and connected to the system. The pipes and fittings shall be lowered in such a manner as to prevent damage to the materials and protective coatings and linings. After each segment of pipe is lowered into the trench, it shall be immediately assembled and connected into the pipeline network at the correct line and grade. Any open ends of pipe shall be closed by a watertight plug or by an alternative but equally secure method at the end of each working day.

5.2.3 All buried lines shall be spaced 30” apart with clear side spacing to facilitate future repairs or expansion.

5.2.4 Cathodic protection shall be discussed with Energy and Utilities Engineering for each project.

5.2.5 Branch lines shall take-off at horizontal centerline of main or above.

5.3 Flanges

5.3.1 When flanges are used to connect HDPE pipe to ductile iron pipe or valves, verify bolt pattern and dimensions, and verify that all components will provide a minimum of 160 psig design pressure for the joint.

6 Irrigation Connections

6.1 Irrigation taps to water mains shall be made with a mechanical joint tee or a ductile iron mechanical joint tapping sleeve. Band clamps are not acceptable. The irrigation branch shall include a minimum 4” resilient seat gate valve connected to the tee with a Foster adapter. The valve shall be operable from the finished grade through a 5¼” valve box set with a Valve Box Adapter II.

7 Hydrostatic Testing New Sections of Exterior Pipe

7.1 Visual Test

7.1.1 After completion of the sterilization and testing process, new piping may be filled with potable water. As new or repaired sections are filled with potable water all joints, fittings and attached equipment shall be visibly inspected for leaks. All visible leaks are to be repaired regardless of the amount of leakage.

7.2 Pressure Test

7.2.1 The new and repaired main and fittings shall be pressure tested at 150 PSIG for a 2 hour duration. Plus or minus 5 PSIG differential.

7.2.2 Test Restrictions:

7.2.2.1 Valves shall not be operated in either direction at a differential pressure exceeding the rated working pressure.

7.2.2.2 The test pressure shall not exceed the rated pressure of the valves.

7.2.3 Pressurization:

7.2.3.1 After the pipe has been laid, all newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure as stated in 7.2.1. Each valved section of pipe shall be slowly filled with water, and the specified test pressure (based on the elevation of the lowest point of the line or section under test and corrected to the elevation of test gauge) shall be applied by means of a pump connected to the pipe.

7.2.3.2 It is good practice to allow the system to stabilize at the test pressure before conducting the leakage test.

7.2.4 Air Removal

7.2.4.1 Before applying the specified test pressure, air shall be expelled completely from the section of piping under test. If permanent air vents are not located at all high points, corporation stops shall be installed at such points so that the air can be expelled as the line
is filled with water. After all the air has been expelled, corporation stops shall be closed and the test pressure applied. At the conclusion of the pressure test, the corporation stops shall be plugged.

7.2.5 Examination

7.2.5.1 All exposed pipe, fittings, valves, hydrants and joints shall be examined carefully during the test. Any damage or defective pipe, fittings, valves, hydrants or joints that are discovered following the pressure test shall be repaired or replaced with sound material, and the test shall be repeated until satisfactory results are obtained.

7.3 Return the Repaired Main and Fittings to Service

7.3.1 Operation of the potable water distribution system shall by an Authorized University Water Works Employee.
1 General

1.1 This guideline provides the design criteria, minimum quality and materials for the selection, fabrication and installation of potable water valves.

1.2 Materials and installations shall be in accordance with the following industry and association standards.

- ASME B16.1 Gray Iron Pipe Flanges and Flanged Fittings
- ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
- ASME B31.1 Power Piping Code
- ASTM Materials
- AWWA C509 Resilient Seated Gate Valves for Water Supply Service
- AWWA C515 Reduced Wall, Resilient Seated Gate Valves for Water Supply Service
- AWWA C550 Protective Interior Coatings for Valves and Hydrants
- AWWA C800 Underground Service Line Valves and Fittings
- AWS Welding

1.3 All valves shall open counter clockwise.

1.4 All pipe, fittings, and pipe joining materials used for potable water systems shall be lead, copper, arsenic, zinc, synthetic organic compound, and volatile organic compound free. All pipe, fittings, and pipe joining materials for potable water systems shall comply with the EPA requirements enacted into law on January 4th, 2011 in the Reduction of Lead in Drinking Water Act, which established an effective date of January 4th, 2014. This Act amends the Safe Drinking Water Act (SDWA).

1.5 Bleach ports shall only be installed when directed by Utilities Engineering. Typically temporary blind flange bleach ports are preferred.

1.6 Consult Utilities Engineering if an application is believed to be outside of these conditions.

2 Materials & Equipment

2.1 Valve Boxes

2.1.1 Furnish and install adjustable 5-1/4” valve boxes on all new valves buried in the ground.

2.1.2 The boxes shall be cast iron of proper length and with a base suitable for valve size.

2.1.3 The boxes shall have covers marked “Water”.

2.1.4 The boxes shall have a 12” concrete ring or square poured around the valve box at grade. The concrete shall be a minimum of 6” thick.

2.1.5 The boxes shall be sealed at the valve bonnet using a resilient valve box adapter. The adapter shall prevent settling and shifting, center the operating nut and protect the epoxy coating of the valve.

2.2 Valves on Pipe 2” and Less:

2.2.1 This section only applies to corporate stops.

2.2.2 Valves shall be the same size as the pipe.

2.2.3 Valves shall be threaded brass, quarter turn ball valves, or ball-type corporate stops.

2.2.4 Valves shall have male iron pipe thread on both ends and tee head for slotted key operation.

2.2.5 Valves shall have a minimum of 12” of schedule 80 brass pipe or ductile iron pipe on either side of valve through the valve box.

2.3 Bleach Ports

2.3.1 Bleach ports shall consist of 6” brass nipple and 2” brass ball valve with brass plug. All items shall have threaded fittings.

2.4 Valves on Pipe Greater than 2”:

2.4.1 Valves greater than 2” shall be resilient wedge type with non-rising stem to meet or exceed the requirements of the AWWA C509 and C515 Standards.

2.4.2 The valve body, bonnet and wedge shall be constructed of ASTM A536 Ductile Iron.

2.4.3 The exterior of the ductile iron wedge shall be encapsulated with EPDM rubber.

2.4.4 All internal and external ferrous surfaces of the valve body and bonnet shall have a fusion bonded epoxy coating free of visible holidays, complying with the AWWA C550 Standard. This coating shall be applied electrostatically prior to assembly and cover bolt holes and flange to body surfaces.

2.4.5 The wedge shall be symmetrical and seal with flow in either direction. There shall be no exposed metal seams, edges or fasteners within the water way. The gate when fully open
shall result in the full diameter of the water way to be unobstructed and equal to the nominal size of valve. There shall be no recesses to trap debris or obstruct flow when fully open. The valve shall not be used for flow rate control.

2.4.6 The stem and its nut shall be high strength ASTM B763 Manganese Bronze in compliance with the AWWA C509 and C515 Standards.

2.4.7 The operating nut shall be constructed of ductile iron. The nut shall have four flats at the stem connection and shall evenly distribute input operating torque to the valve stem. The nut shall be 2” square AWWA size nut.

2.4.8 Valves must have thrust washers located above and below the thrust collar.

2.4.9 All body – to – bonnet and bonnet – to – cover seals shall be pressure energized O-rings. Flat gaskets shall not be allowed. The valve shall have triple O-ring stem seals. Two O-rings shall be located above and one O-ring located below the thrust collar. The lower two O-rings shall provide a permanently sealed lubrication chamber.

2.4.10 Fasteners shall be hexagonal shaped Type 304 stainless steel bolts and nuts. End connections shall be mechanical joints.

3 Installation Guidelines

3.1 All valve operators shall be no more than 5 feet below grade.

3.2 All valves shall be fully closed and fully opened twice by hand before installation. Any valve that is not operable by hand shall not be accepted and not installed.

3.3 After installation all valves shall be left in the open position unless otherwise instructed by Utilities Engineering.

3.4 Operation of the potable water distribution system shall be by an Authorized Purdue University Water Works Employee.
1 General
1.1 This section describes the procedure to ensure the delivery of potable water as approved by Indiana Department of Environmental Management.
1.2 All repaired or newly constructed potable water lines must be properly disinfected by one of the methods described below and be approved by the owner’s representative before resuming service. The appropriate method shall be applied to all pipe on either side of any new piping or fittings and continuing to the nearest mechanical valves that can stop water flow so as to isolate the piping.
1.3 For the purpose of the procedure outlined below, “Authorized University Employees” are a Water Works Operator appropriately trained and employed by Purdue University.
1.4 For this section of the guidelines underground pipe includes all piping prior to, that is on the system side of, the building backflow prevention system or, if no backflow prevention equipment exists, the main shut-off valve on the interior of the building.
1.5 Each disinfection process will be recorded on a Potable Water Line Disinfection Monitoring form. Copies of this form will be forwarded to the Utilities Department and the original will be filed in the Water Works Office.
1.6 Operation of the potable water distribution system (the opening and closing of valves) shall be by a University Water Works Employee.

2 Air Testing
2.1 Under no conditions will air pressure be allowed as a testing medium for any water piping system.

3 Applicable Codes
- IDEM 327 IAC 8-3.2-18 Rule
- ANSI / AWWA B300 Hypochlorites
- ANSI / AWWA C651 Disinfecting Water Mains
- ANSI / AWWA C600 Installation Of Ductile Water Mains And Their Appurtenances
- ANSI / AWWA C605 Underground Installation Of PVC Pressure Pipe And Fittings For Water
- Indiana State Plumbing Code (latest edition adopted by the State)

4 Disinfectant Monitoring Methods
4.1 The disinfectant level will be monitored by at least one of the following methods:
- Dipstick Method
- Colormetric Method

5 Potable Water for Flushing
5.1 Water for testing shall be arranged for by the Contractor with the Owner’s Representative.
5.2 Potable water for flushing, chlorinating, pressure testing, etc. must be supplied through a horizontally mounted reduced pressure type backflow preventer, so as to protect the potable water system from the cross connection.
5.3 The Contractor shall furnish all necessary equipment, piping, pumps, fittings gauges, etc. and personnel to properly conduct the testing.

6 Chlorination
6.1 Hypochlorites shall be certified by NSF/ANSI 60 per AWWA B300 Section 4.4.2
6.2 Sodium Hypochlorite: The disinfectant used for sanitizing plumbing parts and materials that directly contact potable water will be NSF/ANSI 60 approved bleach which has a chlorine concentration of 5.25%.
6.3 Calcium Hypochlorite: Chlorination granules that are specifically for municipal water treatment containing approximately 65% chlorine by weight and are readily soluble in water.
Note: Do NOT use chlorine tablets or granules intended for swimming pool disinfection, as this material is extremely difficult to eliminate from the pipe after the desired contact time.
6.4 The Contractor shall supply all valves, backflow preventers, chlorine, sodium sulfite, gauges, and all other equipment required to complete this procedure.

7 Draining Of Working Area
7.1 The Contractor shall provide and operate pumps or other equipment necessary to drain and keep excavations, pits, trenches, etc., free of water.
7.2 The Contractor shall be responsible for the proper treatment and discharge of all testing, drainage and other water from the construction and repair site or as the result of construction and repairs. This treatment and discharge shall be in accordance with federal, state, and local regulations and ordinances.

8 Procedure for new sections of underground pipe

8.1 Disinfect The New Piping And Fittings.

8.1.1 Chlorine dosing, water addition and testing must be witnessed and approved by an Authorized University Employee.

8.1.2 The slug method is typically the preferred method at Purdue University. Refer to AWWA Standard C651, Section 4.4: Methods of Chlorination.

8.1.3 Calcium hypochlorite granules are placed in the piping as it is installed, the piping is completely filled with water to eliminate air pockets and the piping is flushed to remove particulates.

8.1.4 Chlorinating the Piping: Refer to the “Purdue University Water Works Table of Chlorinating Dosages” in this Guideline. The target level is 200 ppm free residual chlorine when the water temperature is above 48°F but at no time may the free residual chlorine level exceed 400 ppm. The main must be disinfected at zero pressure (0 psi) by gauge for three hours.

8.2 Flush the Non-Potable Water from the Pipe and Fittings.

8.2.1 This procedure must be witnessed and approved by an Authorized University Employee or Designated Representative.

8.2.2 Flushing must be through an unrestricted outlet so that the pressure is never above 20 psi applied to any portions of the water system not under repair.

8.2.3 Flowing water velocities, from the flushing, must be greater than one foot per second (1 FPS) and less than two and a half feet per second (2.5 FPS).

8.2.4 Flush six (6) minutes for every 100 feet of pipe from the farthest block valve to the repair point.

8.2.5 This step must be done in conjunction with Section 8.4 below.

8.3 Neutralize the Chlorine Remaining in the Disinfecting Water.

8.3.1 This procedure must be witnessed and approved by an Authorized University Employee. Refer to AWWA Standard C651 Section 4.5.2 Disposing of Heavily Chlorinated Water. As the disinfecting solution is flushed from the main it must react with granular technical grade sodium sulfite (Na2SO3).

8.4 Test for the Absence of Disease Indicator Bacteria; Total Coliforms:

8.4.1 This procedure shall be performed by an Authorized University Employee.

8.4.2 Refer to AWWA Standard Methods for the Examination of Water and Wastewater.

8.4.3 During the testing period, the work area shall be safe and protected from unauthorized access.

8.4.4 Free residual chlorine concentration shall be measured and reported for all samples. Two samples shall be taken; one of the potable water used for flushing just prior to the backflow preventer, and the second of the water from the repaired main and fittings. Another set of two samples at the same locations shall be taken 24 hours later.

8.4.5 No further work on the new pipe and fittings will be permitted until two sequential indicator bacteria tests (Total Coliform, Fecal Coliform) results are reported as “ABSENT”. Indicator bacteria testing shall be expected to take seven (7) days.

8.4.6 Written record, signed by the appropriate Purdue employee, of the indicator bacteria testing results shall be supplied to the Water Works Manager.

8.4.7 In the event two sequential indicator bacteria tests are not reported as “ABSENT”, repeat previous sections of this guideline until such results are obtained.

8.5 Flush The New Piping And Fittings To Remove All Loose Materials.

8.5.1 This procedure must be witnessed and approved by an Authorized University Employee or Designated Representative.

8.5.2 See AWWA Standard C651 Figures 1 & 2 and Table 3.

8.5.3 Flushing must be through an unrestricted outlet so that minimum pressure is applied to any portions of the water system not
under repair. Flowing water velocities, from the flushing, must be greater than two and a half feet per second (2.5 FPS) and less than ten feet per second (10 FPS).

8.5.4 Flush two (2) minutes for every 100 feet of pipe from the farthest block valve to the repair point.

8.5.5 At no time shall pressure be above 20 psi.

8.5.6 Flushing shall be to the nearest Authorized University Employee approved storm water drain.

9 Procedure for repaired sections of underground pipe

9.1 General

9.1.1 Disinfections will take place by using a chlorine concentration of 200 ppm with a contact time of three hours.

9.1.2 Refer to the Purdue pipe diameter to length chlorination dosage chart for the correct combination of bleach measured in ounces or gal.lions. The chart also includes a reference for mixing 200 ppm chlorine solutions for submerging and surface disinfecting.

9.2 Reinstating Drained Systems, Major Repair or Renovation, and Cross Connection Repair:

9.2.1 Flood the affected water system with the 200 ppm chlorine solution.

9.2.2 Calculate the chlorine concentration by using the attached chart and protect the existing distribution system from potential back flow. Make sure the disinfectant is distributed throughout the system by checking for bleach odor at the outlets.

9.2.3 Valve off and allow to stand at zero pressure for three hours.

9.2.4 Submerge smaller plumbing materials which come in contact with potable water into a container with 200 ppm chlorine solution with a contact time of three hours. Any accumulation of dirt or contamination should be removed prior to submerging. These containers should be used for no other purpose.

9.2.5 The existing plumbing fixtures to which the sanitized hardware is to be attached should be thoroughly sprayed, swabbed, or soaked with a 200 ppm chlorine solution prior to connection.

9.2.6 Contact the Authorized University Employee so that the disinfectant level can be monitored.

9.2.7 Flush the system.

9.2.8 A bacterial water sample will be taken at the discretion of the Authorized University Employee.

9.3 Taps

9.3.1 Before the process of cutting and making a tap into the potable water system is initiated all surface dirt and contamination should be removed. A liberal application of a 200 ppm chlorine solution must then be applied to the tap site and to the cutting equipment.

9.4 Repair Clamps

9.4.1 If the water line remains live, and the pressure in the line remains above 20 psig at all times during the repair, then disinfection with chlorine will not be required. If the pressure drops below 20 psig at any time then the disinfection process will be followed.

9.5 Temporary Feeds or Bypass Lines

9.5.1 The type of plumbing materials being used for the construction of a bypass will determine the disinfection process. Smaller plumbing materials can be submerged while hoses should be flooded. Use the 200 ppm chlorine solution with a contact time of 3 hours for both procedures. Apply liberal amounts of a 200 ppm chlorine solution to the existing plumbing connection points. Temporary lines must be equipped with a back flow device so that the main water distribution system is protected.

10 Disinfection and flushing tables

10.1 Measuring Reference

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Ounces</th>
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<tr>
<td>Half Teaspoon</td>
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10.2 200 ppm Concentration Reference

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<thead>
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<th>Bleach</th>
<th>Water</th>
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</thead>
<tbody>
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<td>0.5 Oz.</td>
<td>1 Gallon</td>
</tr>
<tr>
<td>5.0 Oz.</td>
<td>10 Gallons</td>
</tr>
</tbody>
</table>

10.3 Sodium Sulfate required neutralizing 200 ppm chlorine per 100 lin. ft. of pipe

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>6”</td>
<td>0.47</td>
</tr>
<tr>
<td>8”</td>
<td>0.83</td>
</tr>
<tr>
<td>10”</td>
<td>1.30</td>
</tr>
<tr>
<td>12”</td>
<td>1.88</td>
</tr>
<tr>
<td>14”</td>
<td>2.55</td>
</tr>
</tbody>
</table>
### Chlorinating with 5.0% bleach dosages

<table>
<thead>
<tr>
<th>Pipe Dia. (in)</th>
<th>Lin. Dia.</th>
<th>10'</th>
<th>25'</th>
<th>50'</th>
<th>75'</th>
<th>100'</th>
<th>300'</th>
<th>1000'</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.144 Oz.</td>
<td>0.288 Oz.</td>
<td>0.432 Oz.</td>
<td>0.58 Oz.</td>
<td>1.7 Oz.</td>
<td>5.744 Oz.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.224 Oz.</td>
<td>0.576 Oz.</td>
<td>1.152 Oz.</td>
<td>1.728 Oz.</td>
<td>2.304 Oz.</td>
<td>6.896 Oz.</td>
<td>1.436 Pint</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>0.512 Oz.</td>
<td>1.296 Oz.</td>
<td>2.592 Oz.</td>
<td>3.872 Oz.</td>
<td>5.168 Oz.</td>
<td>15.52 Oz.</td>
<td>1.616 Qt.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.912 Oz.</td>
<td>2.304 Oz.</td>
<td>4.592 Oz.</td>
<td>6.896 Oz.</td>
<td>9.2 Oz.</td>
<td>1.724 Pint</td>
<td>2.873 Qt.</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>1.44 Oz.</td>
<td>3.584 Oz.</td>
<td>7.184 Oz.</td>
<td>10.77 Oz.</td>
<td>14.37 Oz.</td>
<td>1.347 Qt.</td>
<td>1.122 Gal.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2.064 Oz.</td>
<td>5.168 Oz.</td>
<td>10.34 Oz.</td>
<td>15.52 Oz.</td>
<td>1.293 Pint</td>
<td>1.939 Qt.</td>
<td>1.616 Gal.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.68 Oz.</td>
<td>9.12 Oz.</td>
<td>1.149 Pint</td>
<td>1.724 Pint</td>
<td>1.149 Qt.</td>
<td>3.447 Qt.</td>
<td>2.873 Gal.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8.272 Oz.</td>
<td>1.293 Pint</td>
<td>1.293 Qt.</td>
<td>1.939 Qt.</td>
<td>2.586 Qt.</td>
<td>1.939 Gal.</td>
<td>6.464 Gal.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>14.7 Oz.</td>
<td>1.149 Qt.</td>
<td>2.298 Qt.</td>
<td>3.447 Qt.</td>
<td>1.149 Gal.</td>
<td>3.447 Gal.</td>
<td>11.49 Gal.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1.436 Pint</td>
<td>1.796 Qt.</td>
<td>3.591 Qt.</td>
<td>1.347 Gal.</td>
<td>1.796 Gal.</td>
<td>5.387 Gal.</td>
<td>17.95 Gal.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1.034 Qt.</td>
<td>2.586 Qt.</td>
<td>1.293 Gal.</td>
<td>1.939 Gal.</td>
<td>2.586 Gal.</td>
<td>7.757 Gal.</td>
<td>25.85 Gal.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1.408 Qt.</td>
<td>3.519 Qt.</td>
<td>1.76 Gal.</td>
<td>2.639 Gal.</td>
<td>3.519 Gal.</td>
<td>10.558 Gal.</td>
<td>35.19 Gal.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>1.839 Qt.</td>
<td>1.149 Gal.</td>
<td>2.298 Gal.</td>
<td>3.447 Gal.</td>
<td>4.596 Gal.</td>
<td>13.789 Gal.</td>
<td>45.96 Gal.</td>
<td></td>
</tr>
</tbody>
</table>

Chlorine dosage of 200 ppm may be used for dosage times of 3 hours when water temperature > 48 F.
1 General

1.1 The storm and sanitary sewer systems are separated on the majority of campus. However due to constraints, certain sections of the campus remain as combined sewers. Sanitary sewers discharge to the West Lafayette waste water treatment plant.

1.2 Materials and installations shall be in accordance with the following industry and association standards.

1.2.1 INDOT Standard Specifications – Latest Edition

1.2.2 ASTM – Material Specifications

1.2.3 Recommended Standards for Sewage Works Great Lakes – Upper Mississippi River Board of State Sanitary Engineers (10 State Standards) – Latest Edition

1.2.4 Model Specifications for Water & Sewer Main Construction in Indiana – Latest Edition

1.2.5 Environmental Protection Agency (EPA) – National Pollutant Discharge Elimination System (NPDES) Standards

1.2.6 City of West Lafayette Standards, Specifications, & Details- Latest Edition

1.2.6.1 Construction Guidelines and Details (11” x 17”):
http://www.city.west-lafayette.in.us/departments/engineering/11x17_Full Set.pdf

1.2.6.2 Construction Guidelines and Details (24” x 36”):
http://www.city.west-lafayette.in.us/departments/engineering/24x36_Full Set.pdf

1.2.6.3 Standard Policy and Guidelines Manual:

1.2.7 Sanitary Sewer effluent from buildings must meet or exceed West Lafayette treatment standards per city code. See the West Lafayette web page:
http://ordlink.com/codes/westlaf/index.htm

1.2.8 City of Lafayette Sewer Standards, Specifications & Details – Latest Edition

1.2.9 Sanitary Sewer effluent from buildings must meet or exceed:
- West Lafayette treatment standards per city code.
- Indiana Department of Environmental Management (IDEM) Regulations in Indiana Administrative Code, Title 327 – Water Pollution Control Division
- Indiana Plumbing Code
- Indiana Fire Code
- National Sanitation Foundation Standards 60 and 61

1.2.10 New Specifications: In the event new editions supersede any of the herein mentioned standards, the latest edition shall apply.

1.3 Sanitary Sewer Design Conditions

1.3.1 The condition of existing sewer systems must be verified for each project. Purdue will teleview upon request.

1.3.2 A&E Consultants are to provide peak, average and minimum daily sanitary sewer flows for each project. Provide post construction design flow data for use in updating the Purdue Sanitary System flow model

1.3.3 Separation of water mains and sewers shall meet the requirements of IAC 327.

1.3.4 Manholes are to be installed at all changes of direction.

1.3.5 All pipes entering a manhole shall be detailed such that shear planes are eliminated.

1.3.6 Bench walls and flow lines shall be installed where necessary to ensure proper flow through the manhole.

1.3.7 Sewers shall slope in accordance Table 1 – Minimum Sewer Slope per 100 Feet of Run.

<table>
<thead>
<tr>
<th>Sewer Size</th>
<th>Minimum Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>8”</td>
<td>0.45</td>
</tr>
<tr>
<td>10”</td>
<td>0.33</td>
</tr>
<tr>
<td>12”</td>
<td>0.27</td>
</tr>
<tr>
<td>15”</td>
<td>0.20</td>
</tr>
<tr>
<td>18”</td>
<td>0.17</td>
</tr>
<tr>
<td>24”</td>
<td>0.12</td>
</tr>
<tr>
<td>30” – 48”</td>
<td>0.10</td>
</tr>
</tbody>
</table>

1.3.8 Consult Utilities Engineering if an application is believed to be outside of these conditions.
2 Materials & Equipment

2.1 Piping Materials

2.1.1 Sanitary sewers shall be Reinforced Concrete Pipe (RCP), PVC plastic or Ductile Iron as determined with Utilities Engineering. Typically sanitary sewers shall be PVC up to 12” diameter and shall be RCP for 12” and larger.

2.1.2 Reinforced Concrete Pipe (RCP): ASTM C76, Class III in grassy areas and Class IV in paved areas. Joints for circular concrete sewer pipe shall utilize rubber gaskets (ASTM C443).

2.1.3 Ductile Iron Pipe: AWWA C151 Thickness Class 50 with Push-On Joints conforming to AWWA C111.

2.1.4 PVC: ASTM D3034 SDR 35 is suitable for depths up to 15 ft, and SDR 26 for depths greater than 15 ft. Joints shall be gasketed. In some situations, SDR 25 water grade PVC is allowed.

2.2 Manholes & Catch Basins

2.2.1 The minimum diameter of manholes shall be 48”.

2.2.2 Manholes and catch basins shall be constructed of ASTM C478 precast reinforced concrete sections. Joining of pipes to new manholes shall be made thru cored openings with manufactured rubber gaskets or rubber gaskets cast integrally in the manhole wall and located as required.

2.2.3 Castings shall be grey iron unless otherwise indicated. Manhole frame and lid shall be heavy duty with appropriate designation cast in lid. Sanitary manhole lids shall be type “B” self-sealing.

2.2.4 Furnish and install manhole steps meeting the requirements of OSHA for all manholes and catch basins. Steps shall be cast in the concrete.

2.2.5 Provide smooth transition at bottom of manhole where inverts are at different elevations. Drops shall meet the requirements in the 10 State Standards and shall be approved by Owner.

2.2.6 Coat the exterior of manholes per West Lafayette recommendations

2.2.7 Preferred Manufacturers

• East Jordan
• Neenah

3 Installation Guidelines

3.1 Piping

3.1.1 Sewers shall be laid with a minimum slope as noted on the drawings. All sewer grades and pitch shall be established by use of a surveyor’s level and a uniform grade provided in all sewers.

3.1.2 All work shall be in accordance with utility company and OSHA regulations.

3.1.3 All sewer pipe shall be laid to the lines and grades as shown on the Drawings, unless otherwise directed by the Project Manager. All pipes shall be bedded firmly on compacted clean sand bedding or as directed by the Project Manager. Carefully trim to fit the bottom of the pipes for first class pipe laying method. No blocking under pipes will be permitted.

3.1.4 The supporting strength of the pipe is dependent upon the foundation and trench width. To develop normal strength, the pipe shall have a firm uniform foundation under the lower quadrant of the barrel.

3.1.5 All pipes and fittings shall be carefully inspected before being laid and no cracked, broken, or defective pipe or fittings shall be used in the work. All pipe shall be laid with the bell ends upstream. The spigot shall be carefully inserted in the bell in such a manner that there will be no unevenness of any kind along the bottom of the pipes and so that there is a uniform joint space all around. Fill all voids under the bell after the joint is made and before backfilling.

3.1.6 The interior of the sewer shall, as the work progresses, be cleared of all dirt and superfluous materials of every description. During the process of the laying, care shall be taken to protect pipes from disturbance, and the trench shall be kept free from water. All debris shall be promptly and completely removed from the interior of the pipes.

3.1.7 The ends of the pipes shall be protected to prevent the entrance of dirt or other foreign substances. Such protection shall be placed at night or whenever pipe laying is stopped for any reason.

3.1.8 Make connections to existing manholes and structures thru cored openings. All connections shall be made with properly engineered adapter fittings and gaskets that result in a sealed connection to the manholes.

3.1.9 Field cutting into pipe shall not be permitted. Pipe connections to existing pipe shall be made with manufactured connectors approved for the application. Wyes for branch connections must be provided. Wyes must be cut into existing lines and shall be made with manufactured connectors approved for the application.

3.1.10 Each pipe section shall be handled into its position in the trench only in such a manner and by such means as approved. The Contractor will be required to furnish slings, straps and other approved devices for support and proper handling of the pipe.

3.1.11 Provide at least 30” of cover over the top of
the pipe before the trench is wheel loaded. Provide at least 48" of cover before using mobile trench compactors of the hydrohammer or impactor type.

3.1.12 Revise and reset all existing manholes and catch basins, in the area of work as required to meet the grades shown.

3.2 Manholes & Catch Basins

3.2.1 Construct and install manholes, catch basins and other appurtenances as shown on the Drawings to suit invert elevations and with tops to suit final grades.

3.2.2 Where new manholes are located over existing sewers, remove existing sewer pipe as required to install new manholes and make connections with new pipe and fittings as required.

3.2.3 Seal all manholes water tight, per West Lafayette Standards.

4 Testing Guidelines

4.1 Perform all testing in accordance with West Lafayette requirements, Latest edition.

4.2 Test piping systems prior to concealment. Keep written field records of all tests. Each record shall contain, as a minimum, the date of the test, system or subsystem tested, test medium and pressure, duration of test, test results, name and signature of individual performing test, and the name and signature of witness to the test.

4.3 All tests must be done to the satisfaction of the Owner’s representative and local authorities having jurisdiction, before covering. It shall be the responsibility of the Contractor to properly notify the Owner’s Representative and local authorities before the work is tested. Testing shall be performed at a time mutually agreed upon.

4.4 Furnish all instruments required for testing. Contractor shall be responsible for furnishing all equipment necessary for the required tests. Water will be provided and direction for proper disposal of the water upon completion of the tests shall be as directed by the Project Manager.

4.5 Any visible leakage or appreciable pressure drop during the test will be cause for rejecting the test. Additional tests will be required after corrective measures have been taken until satisfactory results are obtained.

4.6 All sanitary sewers constructed of PVC will be subject to a 5% go/no-go mandrel deflection test conforming to 10 State Standards and IDEM standards.

4.7 Test all building sewers and sanitary sewers with standing water test of 10 ft. Water level at the top of the test head shall not drop for at least 15 minutes.

4.8 All sanitary sewers will be subject to a low pressure air test conforming to ASTM F1417 standard.

4.9 Sanitary manholes shall be air tested according to ASTM C1244. Standard test method for concrete sewer manholes shall be the negative air pressure (vacuum) test. Manhole vacuum tests shall include installed casting.

4.10 All sanitary sewers are to be televised using NASSCO standards. A copy of the tape or CD and printed report shall be given to the owner.

4.11 No sanitary discharge shall be allowed into newly constructed mains until the 30 day settlement period has expired, all testing and structure inspections have been completed and passed, and a certified copy of the as-built has been given to the owner without prior approval of the owner.

4.12 Reports shall use typical NASSCO sewer standards but be aware that Utilities Engineering has jurisdiction. Reports shall include:

- Compaction and density
- Excavation and backfill for Utilities
- All quality control tests including:
  - Air pressure/water leakage tests
  - Televising of the sewers
  - Mandrel/deflection tests

5 Rejection of Construction

5.1 Unacceptable conditions will be corrected by the contractor at no additional cost to Purdue, including but not limited to:

- Cracked or faulty pipe
- Debris in line
- Excessive gaps at joints
- Rolled joint gaskets
- Protruding taps
- Improper pipe repair
- Misaligned or deformed pipe
- Root infiltration
- Infiltration or exfiltration
- Failure of standing water test
- Failure of air test
- Failure of manhole test
- Failure of vacuum test
1 General

1.1 The storm and sanitary sewer systems are separated on the majority of campus. However due to constraints, certain sections of the campus remain as combined sewers. The majority of campus storm sewers discharge to an onsite retention pond.

1.2 Materials and installations shall be in accordance with the following industry and association standards.

- ASTM – Material Specifications
- Recommended Standards for Sewage Works Great Lakes – Upper Mississippi River Board of State Sanitary Engineers (10 State Standards) – Latest Edition
- Model Specifications for Water & Sewer Main Construction in Indiana – Latest Edition
- Environmental Protection Agency (EPA) – National Pollutant Discharge Elimination System (NPDES) Standards
- Indiana Department of Environmental Management (IDEM) Regulations in Indiana Administrative Code, Title 327 – Water Pollution Control Division
- Indiana Plumbing Code
- Indiana Fire Code
- National Sanitation Foundation Standards 60 and 61.
- New Specifications: In the event new editions supersede any of the herein mentioned standards, the latest edition shall apply.

1.3 Storm Sewer Design Conditions:

1.3.1 The condition of existing sewer systems must be verified for each project. Purdue will televise upon request.

1.3.2 A&E Consultants are to provide peak and average daily storm sewer flows for each project.

1.3.3 Purdue University Campus has implemented NPDES Phase II Storm Water Standards on all campus projects.

1.3.4 West Lafayette storm water guidelines shall be implemented when evaluating runoff from new project sites.

http://www.westlafayette.in.gov/department/division.php?structureid=93

1.3.5 The A&E Consultants are responsible for filling out all required permit forms and filling out the Notice of Intent for the project.

1.3.6 The NPDES Best Management Practices shall be evaluated to improve storm water runoff quality and reduce quantity to the receiving storm water collection system. Provide post construction design flows for use in updating the Purdue Storm Water flow model.

1.3.7 For parking garages, the top exposed deck may drain directly to the storm sewer, but the covered decks must pass thru an oil-water separator before discharging to the storm sewer system.

1.3.8 Drainage structures shall be designed to handle at least H20 Highway Traffic loading as a minimum.

1.3.9 Separation of water mains and sewers shall meet the requirements of IAC 327.

1.3.10 Manholes are to be installed at all changes of direction.

1.3.11 Bench walls and flow lines shall be installed where necessary to ensure proper flow through the manhole.

1.3.12 All pipes entering a manhole shall be detailed such that shear planes are eliminated.

1.3.13 Sewers shall slope in accordance with the following table:

<table>
<thead>
<tr>
<th>Sewer Size</th>
<th>Minimum Slope (feet per 100 feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8&quot;</td>
<td>0.45</td>
</tr>
<tr>
<td>10&quot;</td>
<td>0.33</td>
</tr>
<tr>
<td>12&quot;</td>
<td>0.27</td>
</tr>
<tr>
<td>15&quot;</td>
<td>0.20</td>
</tr>
<tr>
<td>18&quot;</td>
<td>0.17</td>
</tr>
<tr>
<td>24&quot;</td>
<td>0.12</td>
</tr>
<tr>
<td>30&quot; – 48&quot;</td>
<td>0.10</td>
</tr>
</tbody>
</table>

1.3.14 Consult Utilities Engineering if an application is believed to be outside of these conditions.
2 Materials & Equipment

2.1 Piping Materials

2.1.1 Storm sewers shall be Reinforced Concrete Pipe (RCP), PVC plastic or Ductile Iron as determined with Utilities Engineering. Typically storm sewers shall be ductile iron up to 12” diameter and shall be RCP for 12” and larger.

2.1.2 Reinforced Concrete Pipe (RCP): ASTM C76, Class III in grassy areas and Class IV in paved areas. Joints for circular concrete sewer pipe shall utilize rubber gaskets (ASTM C443).

2.1.3 Ductile Iron Pipe: AWWA C151 Thickness Class 50 with Push-On Joints conforming to AWWA C111.

2.1.4 PVC: ASTM D3034 SDR 35 is suitable for depths up to 15 ft., and SDR 26 for depths greater than 15 ft. Joints shall be gasketed. In some situations, SDR 25 water grade PVC is allowed.

2.2 Manholes & Catch Basins

2.2.1 Manholes and catch basins shall be constructed of ASTM C478 precast reinforced concrete sections. Joining of pipes to new manholes shall be made thru rubber gaskets cast integrally in the manhole wall and located as required.

2.2.2 Castings shall be grey iron unless otherwise indicated. Manhole frame and lid shall be heavy duty with appropriate designation cast in lid.

2.2.3 A Fish logo and the message “Dump No Waste, Drains to River” shall be cast into every storm casting. See West Lafayette City Standards.

2.2.4 Furnish and install manhole steps meeting the requirements of OSHA for all manholes and catch basins. Steps shall be cast in the concrete.

2.2.5 Provide smooth transition at bottom of manhole where inverts are at different elevations.

2.2.6 Coat exterior of manholes per West Lafayette Recommendations.

2.2.7 Downspout boots used to connect exterior downspouts to the storm drainage system shall be of gray cast iron conforming to ASTM A48 Class 30B or 35B.

2.2.8 Preferred Manufacturers

• East Jordan

3 Installation Guidelines

3.1 Piping

3.1.1 Sewers shall be laid with a minimum slope as noted on the drawings. All sewer grades and pitch shall be established by use of a surveyor’s level and a uniform grade provided in all sewers.

3.1.2 All work shall be in accordance with utility company and OSHA regulations.

3.1.3 All sewer pipe shall be laid to the lines and grades as shown on the Drawings, unless otherwise directed by the Superintendent. All pipes shall be bedded firmly on compacted bedding, carefully trimmed to fit the bottom of the pipes for first class pipe laying method. No blocking under pipes will be permitted.

3.1.4 The supporting strength of the pipe is dependent upon the foundation and trench width. To develop normal strength, the pipe shall have a firm uniform foundation under the lower quadrant of the barrel.

3.1.5 All pipes and fittings shall be carefully inspected before being laid and no cracked, broken, or defective pipe or fittings shall be used in the work. All pipe shall be laid with the bell ends upstream. The spigot shall be carefully inserted in the bell in such a manner that there will be no unevenness of any kind along the bottom of the pipes and so that there is a uniform joint space all around. Fill all voids under the bell after the joint is made and before backfilling.

3.1.6 The interior of the sewer shall, as the work progresses, be cleared of all dirt and superfluous materials of every description. During the process of the laying, care shall be taken to protect pipes from disturbance, and the trench shall be kept free from water. All debris shall be promptly and completely removed from the interior of the pipes.

3.1.7 The ends of the pipes shall be protected to prevent the entrance of dirt or other foreign substances. Such protection shall be placed at night or whenever pipe laying is stopped for any reason.

3.1.8 Make connections to new and existing manholes and sewers as approved by the Project Manager. All connections shall be made with properly engineered adapter fittings, gaskets, or
cast-in connectors to result in a sealed connection to the manholes.

3.1.9 Field cutting into pipe shall not be permitted. Pipe connections to existing pipe and manholes must be provided. Wyes for branch connections must be provided.

3.1.10 Each pipe section shall be handled into its position in the trench only in such a manner and by such means as approved. The Contractor will be required to furnish slings, straps and other approved devices for support and proper handling of the pipe.

3.1.11 Provide at least 30” of cover over the top of the pipe before the trench is wheel loaded. Provide at least 48” of cover before using mobile trench compactors of the hydrohammer or impactor type.

3.1.12 Revise and reset all existing manholes and catch basins, in the area of work as required to meet the grades shown.

3.2 Manholes & Catch Basins

3.2.1 Construct and install manholes, catch basins and other appurtenances as shown on the Drawings to suit invert elevations and with tops to suit final grades.

3.2.2 Where new manholes are located over existing sewers, remove existing sewer pipe as required to install new manholes and make connections with new pipe and fittings as required.

3.2.3 Seal all manholes water tight, per West Lafayette Standards.

4 Testing Guidelines

4.1 Perform all testing in accordance with local requirements.

4.2 Test piping systems prior to concealment. Keep written field records of all tests. Each record shall contain, as a minimum, the date of the test, system or subsystem tested, test medium and pressure, duration of test, test results, name and signature of individual performing test, and the name and signature of witness to the test.

4.3 All tests must be done to the satisfaction of the Owner’s representative and local authorities having jurisdiction, before covering. It shall be the responsibility of the Contractor to properly notify the Owner’s Representative and local authorities before the work is tested. Testing shall be performed at a time mutually agreed upon.

4.4 Furnish all instruments required for testing. Contractor shall be responsible for furnishing all equipment, plugs and water necessary for the required tests and for proper disposal of the water upon completion of the tests.

4.5 Any visible leakage or appreciable pressure drop during the test will be cause for rejecting the test. Additional tests will be required after corrective measures have been taken until satisfactory results are obtained.

4.6 All storm sewers constructed of PVC will be subject to a 5% go/no-go mandrel deflection test conforming to 10 State Standards and IDEM standards.

4.7 Test all storm sewers with standing water test of 10 ft. Water level at the top of the test head shall not drop for at least 15 minutes.

4.8 All storm sewers will be subject to a low pressure air test conforming to ASTM F1417 standard.

4.9 Storm sewer manholes shall be air tested according to ASTM C1244. Standard test method for concrete sewer manholes shall be the negative air pressure (vacuum) test. Manhole vacuum tests shall include installed casting.

4.10 All storm sewers are to be televised using West Lafayette standards. A copy of the tape or CD and printed report shall be given to the owner.

4.11 No storm discharge shall be allowed into newly constructed mains until the 30 day settlement period has expired, all testing and structure inspections have been completed and passed, and a certified copy of the as-built has been given to the owner without prior approval of the owner.

4.12 Reports shall use typical NASSCO sewer standards but be aware that Utilities Engineering has jurisdiction. Reports shall include:

- Compaction and density
- Excavation and backfill for Utilities
- All quality control tests including:
  - Air pressure/water leakage tests
  - Televising of the sewers
  - Mandrel/deflection tests

5 Rejection of Construction

5.1 Unacceptable conditions will be corrected by the contractor at no additional cost to Purdue, including but not limited to:

- Cracked or faulty pipe
• Debris in line
• Excessive gaps at joints
• Rolled joint gaskets
• Protruding taps
• Improper pipe repair
• Misaligned or deformed pipe
• Root infiltration
• Infiltration or exfiltration
• Failure of air test
• Failure of mandrel test
• Failure of vacuum test
1 General

1.1 Materials and installations shall be in accordance with the following industry and association standards.

- ASME B31.1 Power Piping Code
- ASTM Materials
- AWWA Water Piping
- AWS Welding

1.2 Design Conditions:

1.2.1 Hydrostatic test pressure shall be as defined for each system in the respective guideline listed above.

1.2.2 Consult Utilities Engineering if an application is believed to be outside of these conditions.

2 Fabrication

2.1 All direction changes and branch connections shall be accomplished with prefabricated fittings. Pipe bends and hot taps will not be acceptable without prior approval of Utilities Engineering.

3 Welding

3.1 All pipe fitters and plumbers must present proof of current ASME certification before doing any welding on this job. All welders shall be approved by the Owner.

3.2 The welders identification symbol (submitted with current ASME Certification) must be stamped on all work welded by this welder. A ¼” stamp die must be used at each weld and the markings are to be clear and deep in the pipe so that the welder can always be identified.

3.3 The Contractor will be required to remove and remake any weld not properly identified with a die stamped identification symbol.

3.4 Non-destructive testing methods may be utilized as deemed necessary by the welding inspector.

4 Testing

4.1 Steam piping shall have an Initial Service Test performed per the requirements of ASME B31.1 – Power Piping Code.

4.2 Chilled Water piping shall have a Hydrostatic Test performed per the requirements of ASME B31.1 – Power Piping Code.

4.3 The Contractor shall furnish, install and maintain all necessary equipment (rated pumps, hoses, barrels, tanks, piping, blind flanges, blanks, fittings, caps, temporary pipe supports, etc., and other apparatus) to achieve test pressures under the specification, code or regulation.

4.4 The Contractor shall furnish, install and maintain all temporary lines from the supply to the system under test and shall remove them after the test is complete.

4.5 Test water shall be diverted as directed by Owner upon completion of the test.

4.6 Vents shall be suitably plugged for piping systems undergoing tests, when required.

4.7 The Contractor shall exercise due and reasonable care in the testing of piping and systems to ensure the safety of personnel. The Contractor shall furnish and install temporary pressure relieving devices for safety.

4.8 If there is a possibility that test media will freeze, a suitable antifreeze shall be added to the test media provided such addition will not affect normal operation.

4.9 Where piping will be adversely affected by water, a substitute fluid may be used with the Owner’s and/or Engineer’s approval.

4.10 One or more calibrated indicating test gages shall be connected directly to the piping as required to coordinate the pressuring operation and shall be mounted to be visible to the test operator controlling the pressure. The gage shall have dials that are calibrated over a range approximately two (2) times the test pressure.

4.11 Tests will not be performed until all anchors, hangers, supports, gages, plugs, bulkheads, blanks, and allied appurtenances are installed and properly tightened. Tests will be made against bulkheads or blanks and not against closed valves unless otherwise specified.

4.11.1 Install temporary spring hanger stops prior to filling pipe with water.

4.12 All flange and weld joints are to be left uncovered, unpainted and exposed during the testing.

4.13 Items installed in the system, but for which testing is not required, shall be isolated. Before applying pressure, all lines or systems shall be inspected to insure that all parts not included in the test are isolated.

4.14 Hammer testing will not be performed on piping during the pressure test.

4.15 The test temperature shall not be less than 60°F for hydrostatic tests; and 70°F for pneumatic tests. The test pressure shall be as stated in the respective section for individual systems. The Contractor shall monitor test medium temperature to ensure system temperature has stabilized prior to beginning test period.

4.16 Flanged pipe pieces removed from the lines to permit installation of blanks shall be tested separately.

4.17 The Contractor shall maintain a log for testing piping systems and shall note date, system, line number,
time and duration of test, test pressure, fluid or gas used, defects encountered during testing, and remedies taken to achieve test conformance, and shall be signed by the person performing the test. Test reports shall be submitted to the Owner in triplicate.

4.17.1 System temperature and pressure shall be recorded at least four (4) times during the test period.

4.18 All testing shall be witnessed by the Owner who shall countersign and receive all test reports.

4.19 After testing, all lines shall be cleaned and flushed to the Owner’s satisfaction.

4.20 The following equipment shall not be subject to the testing procedure:

- Equipment not having a specified test pressure
- Pumps, boilers and compressors
- Tanks
- Expansion Joints
- The inlet side of relief valves

4.20.1 The Contractor shall furnish and install spool pieces and blind flanges to assure equipment protection.

4.21 Valves shall be in the “open” position for the test, unless otherwise specified.

4.22 Automatic control valves shall always be in the open position unless provided with a bypass permitting application of the pressure on both sides.

4.23 Instrument piping, except the piping for locally mounted indicating pressure gauges and for pressure gages used for test, shall be separately tested up to the block valves. Inline instruments shall be tested with the piping.

4.24 Auxiliary lines and systems which are open to the atmosphere downstream of drain and vent valves shall not be pressure tested, unless specified.

4.25 Piping that connects to lines installed by others, shall be isolated from such lines by valves or test blanks located at or near the junctions. When necessary to include parts of such lines in the test, the Project Manager shall be given prior notice so that the test conditions may be mutually agreed upon.

4.26 Testing of two systems may be combined, if the prescribed test media and pressures of both systems are compatible and prior approval is obtained from the Project Manager.

4.27 The test pressure shall not be applied until the piping and its contents reach the same temperature.

4.28 The point of introduction of pressure shall be located upstream of all check valves and upstream of pressure release devices.

4.29 While maintaining the test pressure, all welded, threaded, flanged and packed joints shall be inspected for leaks. Test duration shall allow for complete inspection but shall not be less than three (3) hours.

4.30 Restrictions, such as flow nozzles and orifice plates which interfere with filling, venting or drain shall be removed from the piping.

4.31 Piping and vessels shall be provided with vents at all high points to prevent air pockets when filling. Such vents shall also be opened when emptying to avoid producing a vacuum. Contractor shall furnish and install all necessary vents and drains including valves.

4.32 Pneumatic testing shall be with clean compressed air. The pressure shall be applied gradually.

4.33 While maintaining the pneumatic test pressure, all welded, threaded, flanged and packed joints shall be inspected for leaks using a soap suds test.

4.34 If the source of pressure is higher than the maximum test pressure specified, a relief valve shall be used to guard against over pressurization. The relief valve shall be set to the test pressure specified plus 10 psi.

4.35 Any joint found leaking during a pressure test shall be repaired and retested to the satisfaction of the Project Manager.

4.36 Test blanks, temporary piping, supports, spring hanger pins, etc., shall be removed. The application of paint and insulation to piping and equipment shall be completed.

4.37 Material such as gaskets, bolting, etc., damaged during the test shall be replaced.

5 Cleaning and Flushing

5.1 All piping installed under this work package shall be cleaned and flushed as part of the work after hydrostatic or pneumatic testing.

5.2 The Owner shall furnish the following for cleaning and flushing.

5.2.1 Sufficient source of fresh water, steam and compressed air from existing plant.

5.2.2 Target drain for water used for flushing.

5.3 The Contractor shall furnish and install all temporary valves, hoses and fittings to connect piping systems to water mains and sewers. The Contractor shall also furnish a temporary back-flow preventer (reduced pressure type) at connection(s) to existing water mains.

5.4 The Contractor shall flush all chilled water pipes with potable water to clear out debris.

5.5 The Contractor shall drain all flushing and cleaning
water to the existing storm sewers and/or waste water detention tank at a flow rate not to exceed 500 GPM.

5.6 Piping systems must be maintained in clean conditions at all times. Reasonable precautions shall be taken to prevent entry of foreign material into the piping system.

5.7 Steam Piping

5.7.1 Piping system shall be thoroughly blown out with steam using full line pressure, to assure complete removal of all foreign matter after pressure testing.

5.7.2 All steam lines will be cleaned via a series of steam blows. Source of steam will be from the existing steam systems. All steam blowing must be coordinated and witnessed by the Owner or his representative.

5.7.3 All temporary piping to atmosphere and temporary supports to conduct the steam blow shall be furnished and installed by the Contractor.

5.7.4 The Contractor shall include means to protect valve trim, flow orifices, and other devices which could be damaged by shot and debris. Equipment installed by the Contractor and damaged by steam blows shall be repaired or replaced by the Contractor at no additional charge to the Owner.

5.7.5 Target coupons for steam blows shall be furnished and installed by the Contractor. Target coupons shall be a 1” x 1” bar of brass fitted through square holes in a 4” steel pipe on the discharge of the steam blow. Steam lines will be blown clear until accepted by the Owner.

5.8 Condensate and Non-Potable Water Piping

5.8.1 Individual pipe sections are to be blown clean using compressed air, using a wand or other means prior to assembly. The finished system is to be flushed clean with water.

5.8.2 After blowout, the piping shall be flushed with water a minimum of ½ hour or until approval of the Project Manager is granted before placed in service.

5.9 Temporary Piping

5.9.1 On all piping systems requiring cleaning or flushing, all operating mechanisms such as valves, cylinders, bearings, etc., shall be disconnected. A spool piece shall be installed at these points to allow a continuous circulation of cleaning media or flushing fluid.

5.9.2 Special care shall be taken to insure that materials not compatible with cleaning fluids are protected.

5.10 Cleaning Bypass Items

5.10.1 All pump relief valves, bypass valves and other valves that were closed during flushing shall be removed and thoroughly cleaned.
1 General

1.1 The chilled water distribution system is a central system served by chillers located in the Wade Power Plant and/or the Northwest Chiller Plant.

1.2 Chilled water piping is direct buried in clean sand.

1.3 Operating pressures range from 20 to 100 psi with the norm being approximately 90 psi for supply and 75 psi for return.

1.4 Supply water temperature is approximately 45°F and return water temperature is approximately 60°F.

1.5 Materials and installations shall be in accordance with the following industry and association standards.

- ASME B1.20.1 Pipe Threads, General Purpose (Inch)
- ASME B16.5 Pipe Flanges and Flanged Fittings
- ASME B16.9 Factory-Made, Wrought, Butt-Welding Fittings
- ASME B16.11 Forged Fittings, Socket-Welding and Threaded
- ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
- ASME B31.1 Power Piping Code
- ASTM Materials
- AWWA HDPE Pipe Materials
- AWS Welding

1.6 Chilled Water Design Conditions:

1.6.1 150 PSIG design pressure

1.6.2 100°F design temperature

1.6.3 150 PSIG hydrostatic test pressure for a 2 hour duration. Plus or minus 5 PSIG differential.

1.6.4 Water velocities should not exceed 6 feet per second (fps).

1.6.5 New branch lines serving new or existing buildings shall be HDPE pipe.

1.6.6 New distribution main line materials shall be determined with Utilities Engineering for each project.

1.6.7 Consult Utilities Engineering if an application is believed to be outside of these conditions.

2 Carbon Steel Piping & Components

2.1 Table of materials

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping</td>
<td>ASTM A53, Grade A or B, Electric Resistance Welded (ERW, Type E), Beveled Ends, Standard Weight (STD) Carbon Steel Pipe.</td>
</tr>
<tr>
<td></td>
<td>See Note 1</td>
</tr>
<tr>
<td>Fittings</td>
<td>ASME B16.9, ASTM A234-WPB Wrought Carbon Steel, Standard Weight (STD), Butt Weld Fittings</td>
</tr>
<tr>
<td></td>
<td>See Note 2</td>
</tr>
<tr>
<td>Flanges</td>
<td>ASME B16.5 Class 150, ASTM A105 Forged Steel, Slip On or Weld Neck, Flat Face or Raised Face Flanges.</td>
</tr>
<tr>
<td></td>
<td>Select weld neck for fitting to fitting</td>
</tr>
<tr>
<td>Bolting</td>
<td>ASTM A307 Grade B, Regular Hex Head, Carbon Steel Bolts and Studs, with ASTM A563 Grade A, Heavy Hex, Carbon Steel Nuts.</td>
</tr>
<tr>
<td></td>
<td>See Note 3</td>
</tr>
<tr>
<td>Gaskets</td>
<td>ASME B16.21 Gasket to suit ASME B16.5 Flanges</td>
</tr>
<tr>
<td>Branch Connections</td>
<td></td>
</tr>
<tr>
<td>Main ≥2½&quot; to branch ≤2&quot;</td>
<td>Reducing Tee</td>
</tr>
<tr>
<td></td>
<td>Forged Steel Thread-o-lets</td>
</tr>
<tr>
<td>Main ≥2½&quot; to branch &gt;2&quot;</td>
<td>Butt Weld Equal or Reducing Tees</td>
</tr>
<tr>
<td></td>
<td>Nozzle Weld with Reinforcing as Required</td>
</tr>
<tr>
<td></td>
<td>Forged Steel Weld-o-lets</td>
</tr>
</tbody>
</table>

2.2 Coatings

2.2.1 Underground pipe shall be furnished factory coated with Fusion Bonded Epoxy Coating to provide corrosion protection.

2.2.2 Coating shall be applied to clean pipe in accordance with manufacturer’s established procedures.

2.2.3 Thickness of coating shall be manufacturer’s standard but not less than 20 mils.

2.2.4 At each end 4” surface shall be left uncoated. After field welding, these uncoated surfaces and all fittings shall be blast cleaned to near white metal and brush painted with a two part epoxy coating. COVERED WITH DENSO WRAP SYSTEM.

2.3 Preferred Manufacturers

2.3.1 Factory Applied Coatings

- 3M Scotchkote 6233

...
PHYSICAL FACILITIES
2018 Consultant’s Handbook
Division 33 Utilities
6100 Underground Chilled Water Piping

• DuPont Nap Guard 7-2501

2.3.2 Field Brush Applied Coatings
• 3M Scotchkote 323
• DuPont Nap Gard 7-1861

2.3.3 Alternative coating systems shall require pre-approval of the owner.

3 High Density Polyethylene Pipe (HDPE)

3.1 HDPE pipe shall meet the requirements of ASTM D3035, D3350 and/or F714, and AWWA C901 and/or C906.

3.2 HDPE pipe shall be iron pipe size, DR-11 with a working pressure rating of 160 psig at a water temperature of 73°F.

3.2.1 See Note 4

3.3 HDPE pipe size shall be determined for each specific application. HDPE pipe has significantly smaller inside diameter than steel pipe, therefore it is sometimes oversized to achieve the desired inside diameter. However consideration must be given to connecting the larger HDPE pipe to flanges and fittings of steel pipe.

3.4 HDPE fittings shall be selected to provide a working pressure rating of 160 psig. This may require fittings of the next numerically lower size with a thicker wall. Consider the effect of the reduction in inside diameter on fluid velocity and pressure loss if multiple fittings will be required for an installation.

3.5 HDPE pipe shall be limited to nominal 12” diameter without approval from Utilities Engineering.

3.6 HDPE pipe shall be joined by thermal butt-fusion in accordance with the manufacturer’s recommendations.

3.7 Transitions from steel to HDPE pipe shall be done with a valve.

3.8 HDPE pipe flange joints shall be made using a flange adapter, which is fused to the HDPE pipe. Epoxy coated steel backup rings shall be fitted behind the flange adapter sealing surface for bolting to the mating flange. Backup rings shall be AWWA C207 Class D for 160 psig.

3.9 HDPE pipe shall have four BLUE horizontal color stripes equally spaced around pipe.

3.10 HDPE pipe shall be laid with a trace wire to facilitate future locating.

3.10.1 Trace wire shall be #12 THHN solid copper.

3.10.2 Trace wire shall be affixed to outside of pipe to resist backfill.

3.10.3 Trace wire color code shall follow piping color code.

3.10.4 Trace wire shall be brought into a building junction box and labeled.

3.10.5 An additional valve box shall be installed at the origin of the HDPE piping run to house both supply and return trace wires. No wire terminations shall be in the valve box, simply coil the trace wire in the box.

4 Installation Guidelines

4.1 Piping

4.1.1 Chilled water piping shall be at least 5 feet below grade at all points but not more than 8 feet.

4.1.2 All buried lines shall be spaced 30” apart, outside of pipe to outside of pipe, with clear side spacing to facilitate future repairs or expansion.

4.1.3 Locate supply piping on the North and/or East side.

4.1.4 Cathodic protection shall be discussed with Utilities Engineering for each project.

4.1.5 Coated steel pipe shall not be lifted with chains. Lifting shall be done with straps that will not damage the epoxy coating.

4.1.6 Coated steel pipe shall not be staged on concrete, gravel or other surfaces that can damage the epoxy coating.

4.1.7 Valved drains shall be installed at all piping low points, and shall be sized to adequately drain the lines with respect to time required. In buildings no buried drains

4.1.8 Valved vents shall be installed at all piping high points, and shall be sized to adequately vent the lines during filling and draining. In buildings, no buried vents.

4.1.9 Unions or flanges shall be installed in all piping connections to equipment, valves, controls, instrumentation and miscellaneous specialties, and whenever necessary to facilitate dismantling of piping and removal of items requiring maintenance and repair.

4.1.10 Branch lines shall take-off at horizontal centerline of main or above. Branch lines shall take-off by means of welded fittings.

4.2 Flanges

4.2.1 When bolting steel flanges to flat face iron flanges on valve or pump housings use only flat face flanges so the iron housings do not crack when the bolts are torqued.
4.2.2 When flanges are used to connect HDPE pipe to steel or iron pipe or valves, verify bolt pattern and dimensions, and verify that all components will provide a minimum of 150 psig design pressure for the joint.

5 Notes

1 For pipe up to 10" NPS, standard weight pipe is Schedule 40 pipe. For pipe 12" NPS and larger, standard weight pipe has a larger inside diameter (thinner wall) than Schedule 40 pipe. Schedule 40 pipe may be bid as an alternate to standard weight for 12" NPS and larger pipe. Seamless pipe may also be bid as an alternate to electric resistance welded pipe.

2 ASME B16.9 fittings are rated for pressure and temperature based on the pipe schedule ratings of carbon steel piping. Schedule 40 fittings may be bid as an alternate where allowed for pipe by this guideline. In ASME B31.1, Table A-1, there are two grades of ASTM A234 wrought steel fittings to choose from. Grade WPB has the same tensile and yield strengths as ASTM A53 and A106 Grade B Pipe.

3 Bolts selected from ASME B16.5 as indicated for Low Strength Bolting, Table 1B. Nuts selected as recommended in ASTM A563 Table X1.1, as referenced in ASTM A307.

4 Per ASTM D3035 and F714, there are HDPE materials that are capable of a design pressure of 160 psig with a DR-13.5 pipe thickness. DR-13.5 has a larger inside diameter than DR-11, therefore DR-13.5 pipe can be bid as an alternate provided all pipe, fittings and components will be capable of 160 psig design pressure.
1 General
1.1 Materials and installations shall be in accordance with the following industry and association standards.
- ASME B16.1 Gray Iron Pipe Flanges and Flanged Fittings
- ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
- ASME B31.1 Power Piping Code
- ASTM Materials
- AWWA C509 Resilient Seated Gate Valves for Water Supply Service
- AWWA C515 Reduced Wall, Resilient Seated Gate Valves for Water Supply Service
- AWWA C550 Protective Interior Coatings for Valves and Hydrants
- AWWA C800 Underground Service Line Valves and Fittings
  - AWS Welding

2 Chilled Water Design Conditions
2.1 All valves shall open counter clockwise.
2.2 Consult Utilities Engineering if an application is believed to be outside of these conditions.

3 Valve Boxes
3.1 Furnish and install adjustable 5-1/4” valve boxes on all new valves buried in the ground.
3.2 The boxes shall be cast iron of proper length and with a base suitable for valve size.
3.3 The boxes shall have covers marked “Water”.
3.4 The boxes shall have a 12” concrete ring or square poured around the valve box at grade. The concrete shall be a minimum of 6” thick.
3.5 The boxes shall be sealed at the valve bonnet using a resilient valve box adapter. The adapter shall prevent settling and shifting, center the operating nut and protect the epoxy coating of the valve.

4 Valves on Pipe 2” and Less
4.1 This section only applies to drain and vent valves.
4.2 Valves shall be the same size as the pipe.

5 Valves shall be threaded brass, quarter turn ball valves, or ball-type corporate stops.
5.1 Valves shall have male iron pipe thread on both ends and tee head for slotted key operation.
5.2 Valves shall have a minimum of 12” of schedule 80 brass pipe or ductile iron pipe on either side of valve through the valve box.
5.3 Blow off hydrants shall be used for blow offs, bleach ports, drain and vent valves.

6 Valves on Pipe Greater than 2” and Less than 4”
6.1 Valves on pipe greater than 2” shall be nominal 4” size, meeting the requirements below.
6.2 These valves shall have flanged connections.

7 Valves on Pipe 4” and Greater
7.1 Valves 4” and greater shall be resilient wedge type with non-rising stem to meet or exceed the requirements of the AWWA C509 and C515 Standards.
7.2 The valve body, bonnet and wedge shall be constructed of ASTM A536 Ductile Iron.
7.3 The exterior of the ductile iron wedge shall be encapsulated with EPDM rubber.
7.4 All internal and external ferrous surfaces of the valve body and bonnet shall have a fusion bonded epoxy coating free of visible holidays, complying with the AWWA C550 Standard. This coating shall be applied electrostatically prior to assembly and cover bolt holes and flange to body surfaces.
7.5 The wedge shall be symmetrical and seal with flow in either direction. There shall be no exposed metal seams, edges or fasteners within the water way. The gate when fully open shall result in the full diameter of the water way to be unobstructed and equal to the nominal size of valve. There shall be no recesses to trap debris or obstruct flow when fully open. The valve shall not be used for flow rate control.
7.6 The stem and its nut shall be high strength ASTM B763 Manganese Bronze in compliance with the AWWA C509 and C515 Standards.
7.7 The operating nut shall be constructed of ductile iron. The nut shall have four flats at the
stem connection and shall evenly distribute input operating torque to the valve stem. The nut shall be 2” square AWWA size nut.

7.8 Valves must have thrust washers located above and below the thrust collar.

7.9 All body–to–bonnet and bonnet–to–cover seals shall be pressure energized O-rings. Flat gaskets shall not be allowed. The valve shall have triple O-ring stem seals. Two O-rings shall be located above and one O-ring located below the thrust collar. The lower two O-rings shall provide a permanently sealed lubrication chamber.

7.10 Fasteners shall be hexagonal shaped, Type 304 stainless steel bolts and nuts.

7.11 End connections shall be ASME B16.1 Class 125 flat face flanges.

7.12 Preferred Manufacturer & Model
- American Flow Control Series 2500 Resilient Wedge Gate Valve
- Mueller Series 2360 Resilient Wedge Gate Valve
- United Water Products Model 2010 Resilient Seated Gate Valve

8 Installation Guidelines

8.1 All valve operators shall be no more than 5 feet below grade.

8.2 All valves shall be fully closed and fully opened twice by hand before installation. Any valve that is not operable by hand shall not be accepted and not installed.

8.3 After installation all valves shall be left in the open position.
1 General
1.1 Steam is supplied to campus from the Wade Power Plant located on the South East edge of campus.
1.2 Steam is supplied from the central plant through a high pressure system operating at a nominal 125 psi with a temperature range of 350°F to 600°F, and a low pressure system operating at a nominal 15 psi with a temperature range of 230°F to 475°F.
1.3 Condensate is returned to Wade from campus via gravity and pressurized systems at a recovery rate of 90 to 95% with a temperature range of 100°F to 250°F.
1.4 Steam and condensate piping is networked through campus and to buildings served primarily through an interconnected system of buried 7'x7' steel reinforced concrete walk tunnels.
1.5 Materials and installations shall be in accordance with the following industry and association standards.
   - ASME B1.20.1 Pipe Threads, General Purpose (Inch)
   - ASME B16.5 Pipe Flanges and Flanged Fittings
   - ASME B16.9 Factory-Made, Wrought, Butt-Welding Fittings
   - ASME B16.11 Forged Fittings, Socket-Welding and Threaded
   - ASME B16.20 Metallic Gaskets for Pipe Flanges
   - ASME B31.1 Power Piping Code
   - ASME B36.10M Welded and Seamless Wrought Steel Pipe
   - ASTM Materials
   - AWS Welding

2 Steam & Condensate Design Conditions
2.1 Steam velocities should not exceed 150 feet per second (fps).
2.2 Condensate pipe sizing should be done with tables provided by industry accepted associations, such as ASHRAE.
2.3 For design purposes, new main condensate return piping in the tunnels should be sized as atmospheric pressure, gravity return piping. But when designing new building condensate systems, it cannot be assumed that the main line in the tunnel is atmospheric. Condensate main line back pressure shall be discussed with Utilities Engineering for each project.
2.4 Consult Utilities Engineering if an application is believed to be outside of these conditions.

3 Installation Guidelines
3.1 Piping
   3.1.1 Steam and condensate piping shall be pitched uniformly down in the direction of flow at ¼" per 10 ft.
   3.1.2 Unions or flanges shall be installed in all piping connections to equipment, valves, controls, instrumentation and miscellaneous specialties, and whenever necessary to facilitate dismantling of piping and removal of items requiring maintenance and repair.
   3.1.3 Branch lines shall take-off at horizontal centerline of main or above.
   3.1.4 Automatic air vents shall be designed into the system at high points and in locations where air could accumulate.
3.2 Drip Legs
   3.2.1 Drip legs shall be installed at all low points and changes of elevation in steam piping systems.
   3.2.2 Drip legs in distribution piping shall be installed at maximum intervals of 300 ft. provided the piping is pitched properly. If piping is pitched up, such that condensate flow is opposite of steam flow, drip legs shall be installed at maximum intervals of 150 ft.
   3.2.3 Drip legs shall be full size up to 6” mains, and half size for mains 8” and larger, but never less than 6”.
   3.2.4 Drip leg height from bottom of main to condensate discharge line shall be 1.5 times the diameter, but not less than 8”.
   3.2.5 Provide a 1” blow down fitting with plugged ball valve on the bottom of the drip leg.
3.3 Trapped Condensate
   3.3.1 Trapped condensate lines shall be pitched according to the guidelines above.
   3.3.2 Trapped condensate lines shall be sized according to the appropriate tables.
   3.3.3 Trapped condensate lines shall be designed completely by the design engineer and indicated on plans. The lines shall not be left for
3.3.4 Trapped condensate from the distribution system shall not be piped into the building condensate return systems, but shall be collected in separate receivers in the tunnels and pumped into the main condensate return lines downstream of any building condensate meters. Therefore the building condensate meters will only reflect the actual steam use in the buildings and not the losses from the distribution system.

3.3.5 High pressure trapped condensate shall be discharged into a low pressure steam line or a flash tank to recover the flash steam. High pressure trapped condensate lines are essentially low pressure steam lines and therefore shall be designed as such with the appropriate line size, drip legs, steam traps, slope and prevention of low points or pockets where slugs of condensate can form and prevent the passage of steam. Needs rephrased.

3.4 Threaded Drip Leg Fittings

3.4.1 The condensate discharge shall be a weld-o-let fitting, and the piping shall be welded up to and including the inlet of the first isolation valve. With a toe nipple on discharge side of inlet isolation valve

3.4.1.1 The piping, steam trap, strainer and fittings shall be threaded between the isolation valves.

3.4.1.2 Provide unions at either end of the threaded assemblies to allow removal for maintenance and replacement.

3.4.1.3 The piping and fittings from the outlet of the second isolation valve shall be welded. The whole assembly can be threaded after trap inlet valve.

3.4.2 The blow down fitting on the bottom of the drip leg shall be a weld-o-let fitting, and the piping shall be welded up to and including the inlet of the blow down ball valve. The piping, fittings and plug from the outlet of the blow down ball valve can be threaded.

3.5 Condensate Pumps

3.5.1 The piping and fittings from the inlet of the condensate receiver through the check valve on the pump discharge line shall be threaded and/or flanged connections. See note

3.5.1.1 Provide a union upstream of the receiver inlet to transition from welded to threaded piping.

3.5.1.2 Provide another union downstream of the check valve to transition back to welded piping and fittings. See note

3.6 Isolation Valves

3.6.1 Main or branch isolation valves 4” and larger shall include a bypass line for warm-up. On the top of line, never on the bottom.

3.6.1.1 The bypass shall be 1” for 10” lines and smaller, and shall be 2” for 12” lines and larger.

3.6.1.2 Include two (one not two) globe valves on the bypass line, and a ½” instrument connection with gate valve.

3.6.2 Main or branch isolation valves shall include a 1” drain on either side of the valve with a gate valve.

3.7 Strainers

3.7.1 Strainers shall have a ball valve installed on the blow down connection.

3.7.2 Blow down shall be piped such that discharge does not blow directly toward personnel operating valve, or onto insulation of adjacent piping.

3.5.1 Receiver shall be soft/pad or spring bed mounted to dampen vibrations. Inlet piping has to have a flanged rubber coupling installed to dampen vibrations.

3.5.1.2 Discharge line has to have a flex hose installed in the assembly to dampen vibrations.
## Steam & Condensate Piping Nomenclature

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPS</td>
<td>Low Pressure Steam</td>
</tr>
<tr>
<td>MPS</td>
<td>Medium Pressure Steam</td>
</tr>
<tr>
<td>HPS</td>
<td>High Pressure Steam</td>
</tr>
<tr>
<td>HPSR &amp; TC</td>
<td>High Pressure Condensate or Trapped Condensate Piping connecting high pressure steam traps to other items (e.g. flash tanks, condensate receivers, low pressure steam lines)</td>
</tr>
<tr>
<td>MPSR</td>
<td>Medium Pressure Condensate Piping connecting medium pressure steam traps to other items (e.g. flash tanks, condensate receivers, low pressure steam lines)</td>
</tr>
<tr>
<td>LPSR</td>
<td>Low Pressure Condensate Piping connecting low pressure steam traps to other items (e.g. flash tanks, condensate receivers)</td>
</tr>
<tr>
<td>CP</td>
<td>Pumped Condensate Short runs of piping connecting condensate pumps discharge to condensate return system in the tunnels. CP is typically &lt; 50 psig in the buildings</td>
</tr>
<tr>
<td>CR</td>
<td>Condensate Return Piping in the utility tunnels returning condensate to the power plant. This is an atmospheric pressure, gravity flow system; however these lines are pressurized in multiple locations due to existing lines that are undersized for the current load</td>
</tr>
</tbody>
</table>
5 Low Pressure Steam & Condensate Piping

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping</td>
<td>≤ 2&quot;</td>
<td>ASTM A53 or A106, Grade A or B, Electric Resistance Welded (ERW, Type E) or Seamless (Type S), Square Cut Ends, Schedule 80 Carbon Steel Pipe&lt;br&gt;Threaded pipe is allowed only as designated per this guideline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASTM A53 or A106, Grade B, Electric Resistance Welded (ERW, Type E) or Seamless (Type S), beveled ends, standard weight (STD) carbon steel pipe</td>
<td>Note 1</td>
</tr>
<tr>
<td>Fittings</td>
<td>≤ 2&quot;</td>
<td>ASME B16.11 Class 3000, ASTM A105 forged steel, socket weld&lt;br&gt;ASME B16.11 Class 2000, ASTM A105 forged steel threaded fittings are allowed only as designated per this guideline</td>
<td>Note 3</td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASME B16.9, ASTM A234-WPB wrought carbon steel, standard weight (STD), beveled ends, butt weld</td>
<td>Note 4</td>
</tr>
<tr>
<td>Flanges</td>
<td>≤ 2&quot;</td>
<td>ASME B16.5 Class 300, ASTM A105 forged steel, socket weld, raised face</td>
<td>Note 5</td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASME B16.5 Class 300, ASTM A105 forged steel, weld neck, raised face</td>
<td>Note 5</td>
</tr>
<tr>
<td>Bolts</td>
<td>All</td>
<td>ASTM A193 Grade B7 alloy steel bolts and studs, with ASTM A194 Grade 2H carbon steel nuts</td>
<td>Note 6</td>
</tr>
<tr>
<td>Gaskets</td>
<td>All</td>
<td>ASME B16.20 Class 300 spiral wound gasket to suite ASME B16.5 Flanges, 0.175&quot; thick, Type 304 SS windings with flexible graphite filler (compressed thickness of 0.125&quot; to 0.135&quot;), 0.125&quot; thick carbon steel outer centering ring, 0.125&quot; thick Type 304 SS inner ring</td>
<td>Note 7</td>
</tr>
<tr>
<td>Unions</td>
<td>≤ 2&quot;</td>
<td>ASME B16.11 Class 3000, ASTM A105 forged steel, threaded unions with integral stainless steel seat</td>
<td>Note 8</td>
</tr>
<tr>
<td>Strainers</td>
<td>≤ 2&quot;</td>
<td>ASTM A216-WCB cast steel strainer, with threaded ends, and stainless steel 60-mesh screen</td>
<td>Note 9</td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASTM A216-WCB cast steel strainer, with ASME B16.5 Class 300 raised face flanged ends, and stainless steel standard mesh screen</td>
<td>Note 9</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>Strainers shall be furnished with threaded blow down connection</td>
<td></td>
</tr>
<tr>
<td>Branch</td>
<td>≤ 2&quot; main to ≤ 2&quot; branch</td>
<td>Socket Weld Tee</td>
<td></td>
</tr>
<tr>
<td>Connections</td>
<td>&gt; 2&quot; main to ≤ 2&quot; branch</td>
<td>Butt Weld Reducing Tee&lt;br&gt;Forged Steel Sock-o-let</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot; main to &gt; 2&quot; branch</td>
<td>Butt Weld Equal or Reducing Tee&lt;br&gt;Nozzle Weld with Reinforcing as Required&lt;br&gt;Forged Steel Sock-o-let</td>
<td></td>
</tr>
</tbody>
</table>
# 6 High Pressure Steam & Condensate Piping

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping</td>
<td>≤ 2&quot;</td>
<td>ASTM A53 or A106, Grade A or B, Electric Resistance Welded (ERW, Type E) or Seamless (Type S), square cut ends, schedule 80 carbon steel pipe. Threaded pipe is allowed only as designated per this guideline.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASTM A53 or A106, Grade B, seamless, beveled ends, standard weight (STD) carbon steel pipe.</td>
<td>Note 1</td>
</tr>
<tr>
<td>Fittings</td>
<td>≤ 2&quot;</td>
<td>ASME B16.11 Class 3000, ASTM A105 forged steel, socket weld.</td>
<td>Note 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASME B16.11 Class 2000, ASTM A105 forged steel, threaded fittings are allowed only as designated per this guideline.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASME B16.9, ASTM A234-WPB wrought carbon steel, standard weight (STD), beveled ends, butt weld.</td>
<td>Note 4</td>
</tr>
<tr>
<td>Flanges</td>
<td>≤ 2&quot;</td>
<td>ASME B16.5 Class 300, ASTM A105 forged steel, socket weld, raised face.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASME B16.5 Class 300, ASTM A105 forged steel, weld neck, raised face flanges.</td>
<td></td>
</tr>
<tr>
<td>Bolts</td>
<td>All</td>
<td>ASTM A193 Grade B7 alloy steel bolts and studs, with ASTM A194 Grade 2H carbon steel nuts.</td>
<td>Note 6</td>
</tr>
<tr>
<td>Gaskets</td>
<td>All</td>
<td>ASME B16.20 Class 300 spiral wound gasket to suite ASME B16.5 Flanges, 0.175&quot; Thick, Type 304 SS windings with flexible graphite filler (compressed thickness of 0.125&quot; to 0.135&quot;), 0.125&quot; thick carbon steel outer centering ring, 0.125&quot; thick Type 304 SS inner ring.</td>
<td>Note 7</td>
</tr>
<tr>
<td>Unions</td>
<td>≤ 2&quot;</td>
<td>ASME B16.11 Class 3000, ASTM A105 forged steel, socket weld with integral stainless steel seat.</td>
<td>Note 8</td>
</tr>
<tr>
<td>Strainers</td>
<td>≤ 2&quot;</td>
<td>ASTM A216-WCB cast steel, with threaded ends, and stainless steel 60-mesh screen.</td>
<td>Note 9</td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASTM A216-WCB cast steel, with ASME B16.5 Class 300 raised face flanged ends, and stainless steel standard mesh screen.</td>
<td>Note 9</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>Strainers shall be furnished with threaded blow down connection.</td>
<td></td>
</tr>
<tr>
<td>Branch</td>
<td>≤ 2&quot; main to ≤ 2&quot; branch</td>
<td>Socket Weld Tee</td>
<td></td>
</tr>
<tr>
<td>Connections</td>
<td>&gt; 2&quot; main to ≤ 2&quot; branch</td>
<td>Butt Weld Reducing Tee, Forged Steel Sock-o-let</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot; main to &gt; 2&quot; branch</td>
<td>Butt Weld Equal or Reducing Tee, Nozzle Weld with Reinforcing as Required, Forged Steel Sock-o-let</td>
<td></td>
</tr>
</tbody>
</table>
7 Condensate Return and Pumped Condensate

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping</td>
<td>≤ 2&quot;</td>
<td>ASTM A53 or A106, Grade A or B, Electric Resistance Welded (ERW, Type E) or Seamless (Type S), square cut ends, Schedule 80 carbon steel pipe Threaded pipe is allowed only as designated per this guideline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASTM A53 or A106, Grade B, Electric Resistance Welded (ERW, Type E) or Seamless (Type S), beveled ends, Schedule 80 carbon steel pipe</td>
<td>Note 2</td>
</tr>
<tr>
<td>Fittings</td>
<td>≤ 2&quot;</td>
<td>ASME B16.11 Class 3000, ASTM A105 Forged Steel, Socket Weld</td>
<td>Note 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASME B16.11 Class 2000, ASTM A105 Forged Steel Threaded Fittings are allowed only as designated per this guideline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASME B16.9, ASTM A234-WPB Wrought Carbon Steel, Schedule 80, Beveled Ends, Butt Weld</td>
<td>Note 4</td>
</tr>
<tr>
<td>Flanges</td>
<td>≤ 2&quot;</td>
<td>ASME B16.5 Class 150, ASTM A105 Forged Steel, Socket Weld, Raised Face</td>
<td>Note 5</td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot;</td>
<td>ASME B16.5 Class 150, ASTM A105 Forged Steel, Weld Neck, Raised Face</td>
<td></td>
</tr>
<tr>
<td>Bolts</td>
<td>All</td>
<td>ASTM A193 Grade B7 Alloy Steel Bolts and Studs, with ASTM A194 Grade 2H Carbon Steel Nuts</td>
<td>Note 6</td>
</tr>
<tr>
<td>Gaskets</td>
<td>All</td>
<td>ASME B16.20 Class 150 spiral wound to suite ASME B16.5 Flanges, 0.175&quot; Thick, Type 304 SS Windings with Flexible Graphite Filler (compressed thickness of 0.125&quot; to 0.135&quot;), 0.125&quot; Thick Carbon Steel Outer Centering Ring, 0.125&quot; Thick Type 304 SS Inner Ring</td>
<td>Note 7</td>
</tr>
<tr>
<td>Unions</td>
<td>≤ 2&quot;</td>
<td>ASME B16.11 Class 3000, ASTM A105 Forged Steel, Threaded Unions with Integral Stainless Steel Seat</td>
<td>Note 8</td>
</tr>
<tr>
<td>Branch Connections</td>
<td>≤ 2&quot; main to ≤ 2&quot; branch</td>
<td>Socket Weld Tee</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot; main to ≤ 2&quot; branch</td>
<td>Butt Weld Reducing Tee</td>
<td>Forged Steel Sock-o-let</td>
</tr>
<tr>
<td></td>
<td>&gt; 2&quot; main to &gt; 2&quot; branch</td>
<td>Butt Weld Equal or Reducing Tee</td>
<td>Nozzle Weld with Reinforcing as Required</td>
</tr>
</tbody>
</table>
### 8 Steam & Condensate Design Pressures

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal Pressure</th>
<th>Design Pressure</th>
<th>Design Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPS</td>
<td>15 psig</td>
<td>100 psig</td>
<td>475°F</td>
</tr>
<tr>
<td>LPSR</td>
<td>15 psig</td>
<td>100 psig</td>
<td>475°F</td>
</tr>
<tr>
<td>HPS</td>
<td>125 psig</td>
<td>150 psig</td>
<td>600°F</td>
</tr>
<tr>
<td>HPSR</td>
<td>125 psig</td>
<td>150 psig</td>
<td>600°F</td>
</tr>
<tr>
<td>TC</td>
<td>125 psig</td>
<td>150 psig</td>
<td>600°F</td>
</tr>
<tr>
<td>MPS</td>
<td>125 psig</td>
<td>150 psig</td>
<td>600°F</td>
</tr>
<tr>
<td>MPSR</td>
<td>125 psig</td>
<td>150 psig</td>
<td>600°F</td>
</tr>
<tr>
<td>CR</td>
<td>0 psig</td>
<td>100 psig</td>
<td>250°F</td>
</tr>
<tr>
<td>CP</td>
<td>0 psig</td>
<td>100 psig</td>
<td>250°F</td>
</tr>
</tbody>
</table>
### Notes

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For pipe up to 10&quot; NPS, standard weight pipe is Schedule 40 pipe. For pipe 12&quot; NPS and larger, standard weight pipe has a larger inside diameter (thinner wall) than Schedule 40 pipe. Schedule 40 pipe may be bid as an alternate to standard weight for 12&quot; NPS and larger pipe.</td>
</tr>
<tr>
<td>2</td>
<td>Condensate piping shall be Schedule 80 for all pipe sizes due to the corrosive nature of the condensate.</td>
</tr>
<tr>
<td>3</td>
<td>ASME B16.11 fittings are rated for pressure and temperature based on the pipe schedule ratings correlated to the fitting class. Class 3000 socket weld and Class 2000 threaded fittings are rated as Schedule 80 pipe.</td>
</tr>
<tr>
<td>4</td>
<td>ASME B16.9 fittings are rated for pressure and temperature based on the pipe schedule ratings of carbon steel piping. Schedule 40 fittings may be bid as an alternate where allowed for pipe by this guideline. In ASME B31.1, Table A-1, there are two grades of ASTM A234 wrought steel fittings to choose from. Grade WPB has the same tensile and yield strengths as ASTM A53 and A106 Grade B Pipe.</td>
</tr>
<tr>
<td>5</td>
<td>ASME B16.5 Section 2.5.2 indicates that “At temperatures above 400°F for Class 150 and above 750°F for other class designations, flanged joints may develop leakage problems unless care is taken to avoid imposing severe external loads, severe thermal gradients or both.” Although Class 150 Flanges would be adequate for the temperatures and pressures of the Low Pressure Steam per Table II-2-1.1 for Group 1.1 Materials, the temperatures do exceed 400°F at times and the system is affected by external loads and thermal gradients, therefore Class 300 Flanges shall be selected.</td>
</tr>
<tr>
<td>6</td>
<td>Bolts selected from ASME B16.5 as indicated for High Strength Bolting, Table 1B. The ASTM A194 Grade 2H nuts are the industry standard nut for this bolt.</td>
</tr>
<tr>
<td>7</td>
<td>ASME B16.20 Section 3.2.5 recommends inner ring for flexible graphite filled gaskets, and Section 3.3 recommends inner ring to be same material as winding material, and carbon steel outer guide ring.</td>
</tr>
<tr>
<td>8</td>
<td>Although ASME B16.11 does not specifically identify unions, manufacturers such as Bonney Forge fabricate forged steel unions to this specification.</td>
</tr>
<tr>
<td>9</td>
<td>In ASME B31.1, Table A-1, there are three grades of ASTM A216 cast steel to choose from. Grade WCB meets or exceeds the tensile and yield strengths of ASTM A53 and A106 Grade B pipe.</td>
</tr>
</tbody>
</table>
1 General

1.1 Materials and installations shall be in accordance with the following industry and association standards.

- ASME B16.5 Pipe Flanges and Flanged Fittings
- ASME B16.20 Metallic Gaskets for Pipe Flanges
- ASME B16.34 Valves – Flanged, Threaded & Welding End
- ASME B31.1 Power Piping Code
- ASTM Materials
- AWS Welding

1.2 Valve Design Conditions:

1.2.1 Valves shall be same size as pipe.
1.2.2 All valves shall open counter clockwise.
1.2.3 All main line, branch line and isolation valves on steam and condensate systems shall be gate valves.
1.2.4 Globe valves shall only be used for warm-up bypass lines and where specifically instructed by Utilities Engineering.
1.2.5 Ball valves shall be used for blow-down on drip legs and strainers.
1.2.6 All instrument connections, drains, etc. shall be gate valves unless otherwise instructed by Utilities Engineering.
1.2.7 Consult Utilities Engineering if an application is believed to be outside of these conditions.

2 Gate Valves ½” to 2”

2.1 ASME B16.34 Class 800, ASTM A105 Forged Steel Gate Valve, Union or Bolted Bonnet, Conventional Port, Rising Inside Screw Stem, Solid Wedge Disc, Hard Faced Seats, Spiral Wound Gasket Between Body and Bonnet, Socket Weld Ends.

Note: ASME B16.34 does not specifically list Class 800 valves, however it does allow interpolation between classes, and Class 800 has become an industry standard for valves 2” and smaller. These valves meet all the requirements of ASME B16.34 and have a pressure rating between Class 600 and Class 900.

2.2 Packing gland shall be single threaded nut style.

3 Gate Valves 3” to 18”

3.1 Gate valves shall be designed to seal with flow in either direction.
3.2 ASME B16.34 Class 300, ASTM A216 Grade WCB Cast Steel Gate Valve, Bolted Bonnet, OS & Y, Flexible Disc, Hard Faced Disc and Seats, Butt Weld, Chain operator where noted.

Exception: 6” – 18” Low Pressure Steam (LPS) & Condensate (LPSR) systems may utilize the following valve.

3.3 ASME B16.34 Class 150, ASTM A216 Grade WCB Cast Steel Gate Valve, Bolted Bonnet, OS & Y, Flexible Disc, Hard Faced Disc and Seats, Butt Weld, Chain operator where noted.

3.4 If there are clearance concerns in project design consult with Utilities Engineering.

4 Butterfly Valves 3” to 18”

4.1 Butterfly valves shall be triple offset design providing bi-directional bubble tight seal.
4.2 ASME B16.34 Class 300 Triple Offset Butterfly Valve, Bolted Bonnet, Metal to Metal Seats, Butt Weld, Quarter Turn Operator.

Exception: 6” – 18” Low Pressure Steam (LPS) systems may utilize a Class 150 valve.

5 Globe Valves ½” to 2”

5.1 ASME B16.34 Class 300, ASTM A105 Forged Steel Globe Valve, rising stem, bolted or union bonnet, inside screw stem (ISS), plug type, hard faced, SS trim, socket weld ends

6 Check Valves ½” to 2”

6.1 ASME B16.34 Class 300, ASTM A105 Forged Steel Check Valve, swing type, bolted cap, hard faced, ring joint bonnet gasket, socket weld ends

7 Ball Valves ½” to 2”

7.1 ASME B16.34 Class 300, ASTM A216 Grade WCB, Cast Steel Ball Valve, chrome plated steel ball, reinforced TFE packing, bearing and seats, blow-out proof stem, gland nut, zinc plated
lever, socket weld ends

8 Three-Way Test Valves for Steam Traps
½” to 2”

8.1 High pressure (HPS) & medium pressure steam (MPS) and trapped condensate (TC) systems utilize the following valve and LP traps.

8.2 ASME B16.34 Class 300, ASTM A216 Grade WCB, Three-Way Cast Steel Ball Valve, Chrome plated steel ball, reinforced TFE packing, bearing and seats, blow-out proof stem, gland nut, zinc plated lever, socket weld ends

9 Installation Guidelines

9.1 All valves on buried lines shall be installed in a valve pit.

9.2 All valves shall be fully closed and fully opened twice by hand before installation. Any valve that is not operable by hand shall not be accepted and not installed.

9.3 After installation all valves shall be left in the open position.
PHYSICAL FACILITIES
2018 Consultant’s Handbook
Division 33 Utilities
6302 Steam Expansion Joints, Ball Joints, Anchors, Guides and Supports

1 General
1.1 Materials and installations shall be in accordance with the following industry and association standards.
   - ASME B31.1 Power Piping Code
   - ASTM Materials
   - AWS Welding

1.2 Expansion joints shall be designed for the following pressures and temperatures:
   1.2.1 High and low pressure steam: 150 PSIG, 600°F
   1.2.2 Condensate return: 100 PSIG, 250°F
   1.2.3 Consult Utilities Engineering if an application is believed to be outside of these conditions.

2 Slip Type Expansion Joints
2.1 Slip type expansion joints are the preferred type of expansion joints for all steam and condensate applications. Bellows type expansion joints may be used in safety relief valve discharge piping applications only.

2.2 All slip type expansion joints shall be selected for the appropriate traverse, with minimum 2” pre-compression.

2.3 Expansion joints shall be furnished with weld ends.

2.4 Steam expansion joints shall have a welded low point drip leg. The drip leg shall include a 1” welded connection on the bottom for manual blow down and rodding out, and another 1” connection about 3” up from the bottom for steam trap connection. Condensate expansion joints are not to have the drip leg.

2.5 If an anchor is provided with the expansion joint, the anchor base plate shall be shipped separate from the structural assembly, and the height of the assembly oversized by 1-1/2” to allow field adjustment for proper alignment of the joint.

2.6 If an anchor is not provided with the expansion joint, heavier expansion joints, typically 6” and larger, require a sliding support under the expansion joint to prevent cocking the slip. Consideration should be given to making this a guided support as well. Follow manufacturers’ recommendations.

2.7 Expansion joints shall be designed to inject packing under full line pressure. The packing cylinders on the expansion joint shall be furnished with an integral stainless steel shut off valve and must be accessible after installation.

2.8 Expansion joints shall be factory packed for the intended service with flake graphite injectable packing.

2.9 Sliding slip, stuffing box and traverse chamber shall be fabricated of ASTM A106 seamless pipe. Sliding slip shall be plated with a hard chrome material.

2.10 Guide insert materials shall be selected for the proper temperature range of the application. Non-metallic inserts typically are limited to 500°F, and metallic inserts necessary for applications above 500°F.

2.11 Expansion joints shall be provided with removable custom fitted insulated jackets.

2.12 Installation guidelines:
   2.12.1 Expansion joint and piping shall be properly aligned within the tolerance allowed by the manufacturer. Proof of proper alignment shall be made available to Owner upon request. In the case of replacing an existing joint, it cannot be assumed that the existing alignment was correct. The existing joint shall be removed, the piping properly aligned, and then the new joint installed and adjusted for proper alignment.

   2.12.2 Anchors, guides and supports shall be properly spaced per the manufacturers’ instructions and ASME B31.1 requirements. Refer to other sections of this guideline for anchors, guides and supports.

   2.12.3 Valves or other heavy accessories should not be installed in the pipe run between the expansion joints and the first guide. Where this is not possible, the valve or accessory must be supported on a sliding support.

   2.12.4 When welding, ground both sides of the expansion joint to prevent electrical arcing and subsequent damage of the sliding and sealing surfaces.

   2.12.5 Pipe shall be restrained to maintain travel on existing expansion joints when cutting an existing steam line.

   2.12.6 Install two 1” welded connections in piping adjacent to joint for pressure and temperature instrument connections

   2.12.7 Installation in a manhole:
2.12.7.1 Installations using buried conduit system with expansion joints installed in a manhole or vault require guiding at the manhole wall. Properly sized and installed gland and link seals are considered adequate guiding.

2.12.7.2 Consideration should be given to installation of a “moment” guide within 10 ft. of the manhole wall. Moment guides should not be attached to the manhole wall.

2.12.7.3 When a manhole is used, provide power ventilation, an electrical receptacle and lighting inside the manhole.

2.13 Preferred Manufacturer & Model Number

2.13.1 Advanced Thermal Systems (ATS) Thermal Pak Series TP2 Slip Type Expansion Joints

3 Ball Joints

3.1 Ball joints shall be integral socket/retainer design.

Note: Designs using threaded retainer caps or bolted retainer flanges have disadvantages including requiring larger installation clearances and possibility of over tightening during installation or maintenance which can lead to freezing the ball in its socket.

3.2 Ball joints shall be furnished with weld ends.

3.3 Ball joints shall be designed to inject packing under full line pressure. The packing cylinders on the ball joint shall be furnished with an integral stainless steel shut off valve.

3.4 Ball joints shall be factory packed for the intended service with flake graphite injectable packing.

3.5 Pressure retaining components shall be carbon steel meeting ASTM requirements as specified in ASME B31.1. Ball sphere shall be plated with a hard chrome material.

3.6 Ball joints shall be provided with metal compression seals.

3.7 Ball joints shall be provided with removable custom fitted insulated jackets.

3.8 Installation guidelines:

3.8.1 Ball joints shall be installed per manufacturers’ recommendations with proper distances between ball joint centers.

3.8.2 Ball joints installed in the vertical position shall have the male ends pointed down.

3.8.3 Anchors, guides and supports shall be properly spaced per the manufacturer’s instructions and ASME B31.1 requirements. Refer to other sections of this guideline for anchors, guides and supports.

3.8.4 Valves and other heavy accessories should not be installed in the expansion link between the ball joints.

3.8.5 Cold positioning should be determined by the design engineer and included in the design drawings to allow proper installation. Consider thermal growth of the expansion link between the ball joints.

3.8.6 When welding, ground both sides of the ball joints to prevent electrical arcing and subsequent damage of the sealing surfaces.

3.9 Preferred Manufacturer & Model Number

3.9.1 Advanced Thermal Systems (ATS) Thermal Pak Series P2 Flexible Ball Joints

4 Anchors

4.1 Anchors shall be constructed of ASTM A36 structural carbon steel.

4.2 The anchor base plate shall be shipped separate from the structural assembly, and the height of the assembly oversized by 1-1/2” to allow field adjustment for proper alignment of the joint.

4.3 If a pipe spool is provided, it shall be fabricated of ASTM A106 seamless carbon steel pipe of the appropriate schedule for the anchor forces and piping system. The ends of the spool piece shall be machined and beveled for welding.

4.4 Installation guidelines:

4.4.1 When possible, the anchor base plate shall be imbedded in the concrete walls or floors of the tunnel, and the structural assembly welded to the base, with no bolts necessary in the installation.

4.4.2 When installing to an existing tunnel wall, two steel plates shall be used, one on the outside of the wall and one on the inside of the wall bolted together through the wall. The structural assembly is then welded to the base plate.

4.4.3 In all bolted installations stainless steel fasteners shall be used, of the dimensions recommended by the anchor manufacturer. The gap between the fastener and the base plate
holes shall be no more than the gap recommended by the anchor manufacturer. Disc spring washers shall be used to maintain the design tension in the fasteners after thermal expansion.

4.4.4 Buried anchors shall have steel “ears” welded to the piping through which to transmit the force of expansion. The steel “ears” shall be imbedded in concrete. Concrete anchors shall be designed and load bearing soil compaction shall be capable of withstanding all anchor forces.

4.4.5 Anchors and adjacent piping shall be properly insulated.

4.5 Preferred Manufacturer & Model Number

4.5.1 Advanced Thermal Systems (ATS) Figure 702 Pre-Engineered Anchors

5 Guides

5.1 Guides shall be fabricated of ASTM A36 structural carbon steel.

5.2 All guides shall be low friction sliding guided supports.

5.3 Low friction sliding guides shall include two \( \frac{1}{2} \)" thick graphite plates creating the sliding surfaces.

5.4 Installation guidelines:

5.4.1 In order to maintain concentric alignment of piping as it expands into and out of expansion joints, two guides shall be employed into each joint, and on both sides of double expansion joints. One guide will not be acceptable as it will simply act as a fulcrum, not a guide.

5.4.2 Guides shall be properly spaced per the manufacturers’ instructions and ASME B31.1 requirements.

5.4.3 Steel guide bases shall be welded to the structural support steel. Bolted assemblies can loosen over time with thermal expansion and contraction.

5.4.4 Guides and adjacent piping shall be properly insulated.

5.5 Preferred Manufacturer & Model Number

5.5.1 Advanced Thermal Systems (ATS) Figure 100-W & 101-W Low Friction Graphite Pipe Guides

6 Supports

6.1 Supports shall be of the low friction sliding design, rigidly supported from the bottom. Roller supports and trapeze-style supports are not acceptable as rollers tend to bind and trapeze-style supports force the pipes to move up and down as they swing.

6.2 Supports shall be fabricated of ASTM A36 structural carbon steel with two \( \frac{1}{2} \)" thick graphite plates creating the sliding surface.

6.3 Installation guidelines:

6.3.1 Supports shall be properly spaced per the manufacturers’ instructions and ASME B31.1 requirements.

6.3.2 Steel support bases shall be welded to the structural support steel. Bolted assemblies can loosen over time with thermal expansion and contraction.

6.3.3 Supports and adjacent piping shall be properly insulated.

6.4 Preferred Manufacturer & Model Number

6.4.1 Advanced Thermal Systems (ATS) Figure 200-W & 201-W Low Friction Graphite Pipe Supports
1 General
1.1 Materials and installations shall be in accordance with the following industry and association standards.

- ASME Boiler and Pressure Vessel Code
- ASME B31.1 Power Piping Code
- ASTM Materials
- AWS Welding

2 PRV Station & SRV Design Conditions:
2.1 Although the High Pressure Steam system is nominally 125 PSIG, the actual pressure can fluctuate depending on the season. Size the PRV system assuming a reduced supply pressure of 125 PSIG.
2.2 PRV Stations located in the steam distribution system to feed the low pressure system from the high pressure system shall be single stage units.

2.2.1 The load at each of these stations shall be divided between three PRVs adjusted to operate sequentially.

Note: This will also allow continuous operation while one PRV is being serviced.

2.3 PRV Stations located in building lateral tunnels to provide low and/or medium pressure steam to buildings and back feed the LP main shall be two stage units. The intermediate steam pressure shall be determined based on building needs and to reduce the noise level of the PRV Station as much as possible.

2.3.1 The load at each of these stations shall be divided between two sets of PRVs using the 1/3 – 2/3 sizing configuration

2.4 SRV Set Pressures
2.4.1 Low Pressure Steam SRVs shall be set to relieve at 20 PSIG.

2.4.2 Medium Pressure Steam SRVs set pressure shall be determined with Utilities Engineering for each project.

2.5 SRV capacity shall be determined in accordance with ASME BPVC and ASME B31.1 – Power Piping Code.

2.6 Multiple SRVs may be provided in parallel, as required, to handle maximum flow.

2.7 Consult Utilities Engineering if an application is believed to be outside of these conditions.

3 Materials & Equipment
3.1 Pressure Reducing Valves
3.1.1 PRVs shall be pilot-operated.

3.1.2 Cast Steel body, ASME B16.5 Class 300 flanged end connections, with optional stainless steel tubing.

3.1.3 PRV shall be furnished with appropriate silencer or muffling orifice plate(s) to meet noise level requirement of ≤85 db at 10 ft.

3.1.4 Preferred Manufacturers
- Spirax Sarco 25P
- Spence
- Boylston

3.2 Safety Relief Valves
3.2.1 SRV’s shall be spring loaded pop safety relief valve design.

3.2.2 Cast Steel Body, Trim selected for operating conditions, ASME B16.5 Class 300 Flanged Inlet and Class 150 Flanged Outlet, Optional Tungsten Spring

3.2.3 SRV orifice shall be sized for maximum flow.

3.2.4 Preferred Manufacturers
- Kunkle
- Consolidated 1905R 6-150# x 8-150#
- Farris
- Lonergan
- Spirax Sarco

3.3 Separators
3.3.1 Separators shall be baffle type.

3.3.2 Separators shall be carbon steel with ASME B16.5 Class 300 Flanged End Connections.

3.4 Gauges
3.4.1 Pressure

3.4.1.1 4½” iron case, Bourdon type pressure gauge complete with siphon and ball valve. Pressure range is to be indicated on plans.

3.4.2 Temperature

3.4.2.1 4-1/2” iron case, temperature gauge with insertion well. Temperature range is to be 750°F unless otherwise indicated on plans.

3.4.2.2 Temperature gauges shall include an indicator that displays maximum temperature that has been reached.
4 Installation Guidelines

4.1 Pressure Reducing Valves

4.1.1 PRV Stations shall be designed with components staggered and spaced to provide adequate space for maintenance and removal.

4.1.2 PRVs shall have minimum 15” vertical clearance on top and bottom of the valve.

4.1.3 PRV Stations shall have an isolation valve on either side of the assembly to allow isolation for maintenance or removal.

4.1.4 Each pressure regulator shall be matched with one separator, unless otherwise directed by Utilities Engineering.

4.1.5 Provide pressure and temperature gauges on the high pressure supply header, low pressure discharge header and on the intermediate header if applicable.

4.1.6 Provide plugged ¾” thread-o-lets on supply and discharge for future temperature and pressure transmitters. (Total of 4)

4.2 Safety Relief Valves

4.2.1 SRVs shall have minimum 15” vertical clearance on top of the valve.

4.2.2 SRVs shall have a bellows type expansion joint on the discharge line with appropriate condensate drainage.

4.3 Insulation

4.3.1 All components shall be provided with removable custom fitted insulated jackets except SRV.
1 General
1.1 Materials and installations shall be in accordance with the following industry and association standards.
   - ASME B1.20.1 Pipe Threads, General Purpose (Inch)
   - ASME B16.5 Pipe Flanges and Flanged Fittings
   - ASME B16.11 Forged Fittings, Socket-Welding and Threaded
   - ASME B31.1 Power Piping Code
   - ASTM Materials
   - AWS Welding

2 Design Conditions:
2.1 Steam traps shall be sized for full operating flow.
2.2 Traps shall be selected based on manufacturer’s recommendations for the specific applications.
2.3 Thermodynamic disc steam traps shall be used to trap the high pressure steam mains. The high pressure trapped condensate line shall discharge to the low pressure main where available.
2.4 The design engineer shall consider functionality, efficiency of operation, initial cost, life span, location, size and maintainability of traps, and select the best option for the application.
2.5 The design engineer shall specify steam traps including all features and options necessary on the design specifications or drawings. Do not leave it up to the contractor to select steam traps.
2.6 Consult Utilities Engineering if an application is believed to be outside of these conditions.

3 Steam Traps
3.1 Steam trap bodies and trim shall be suitable for the pressure classification for which they are designed, but not less than 100 PSIG.
3.2 Steam traps shall be fabricated of materials of an ASTM Specification that complies with the requirements of ASME B31.1 Power Piping Code.
3.3 End Connections
   3.3.1 2” and under to be ASME B16.11 Class 2000 Threaded

4 Installation Guidelines
4.1 Steam traps shall be located 12” below the devices they serve.
4.2 Steam traps, strainers, and valves shall be piped such that they are accessible for maintenance.
4.3 Steam traps shall have an isolation valve on either side of the trap arrangement to allow isolation for maintenance and removal.
4.4 All steam traps shall have a strainer installed upstream.
4.5 All steam traps shall have a three-way test valve installed downstream. Test port shall be piped such that discharge does not blow directly toward personnel operating valve or onto insulation of adjacent piping.
1 General
1.1 Materials and installations shall be in accordance with the following industry and association standards.
   - ASME Boiler and Pressure Vessel Code
   - ASME B31.1 Power Piping Code
   - ASTM Materials
   - AWS Welding

2 Design Conditions
2.1 Capacity of new condensate pumps shall be determined with Utilities Engineering for each project.
2.2 Capacity of receiver shall be determined with Utilities Engineering for each project. Discharge pressure of pumps shall be a minimum of 50 psig and determined with Utilities Engineering for each project.
2.3 Pumps shall be capable of pumping 210°F condensate without cavitation.
2.4 Condensate receiver inlet shall be lower than the discharge of lowest steam trap in the system. If a pit is required for the pump, design the pit such that it is not a confined space.
2.5 Condensate return systems shall be designed with a common header that all pumps discharge into. In no case shall a pump discharge to another receiver.
2.6 Consult Utilities Engineering if an application is believed to be outside of these conditions.
2.7 Piping should not be run below grade.
   **Note:** A number of University buildings in the past were designed with piping under the basement slab running to a sunken area holding the condensate pump. Without exception the below grade pipes have premature failure and numerous leaks.

3 Condensate Pumps
3.1 Mechanical pumps are the preferred design for Utilities Distribution.
3.2 Pumps shall be duplex type, with controls that automatically alternate between pumps.
3.3 Pressure powered and vacuum pumps shall not be used unless specifically requested by Utilities Engineering.
3.4 Pump shall be flanged or threaded to allow removal for maintenance or replacement.

3.5 Receiver shall be cast iron (steel), and include threaded connections for temperature gauge and pH transmitter.

3.6 Preferred Manufacturers
   - Shipco
   - Hoffman HC Series
   - Domestic

4 Gauges
4.1 Pressure: 4½” iron case, Bourdon type pressure gauge complete with siphon and gauge cocks. Pressure range is to be indicated on plans.
4.2 Temperature: 4½” iron case, temperature gauge with insertion well. Temperature range is to be 750°F unless otherwise indicated on plans.

5 Installation Guidelines
5.1 Condensate pumps and receivers shall be mounted and piped with vibration isolation. Pump should be mounted on a spring frame with air gap between floor and bottom of pump.
5.2 Pumps shall be piped together with isolation valves such that one pump can be removed for maintenance or replacement while the other pump remains in operation.
5.3 Provide a check valve on the discharge of each pump to prevent back flow through pump into receiver.
5.4 Provide a balance valve (e.g. a manual globe valve) on the discharge of each pump.
   **Note:** This is to set the pump to run on an appropriate operating point on the curve
5.5 Provide pressure gauges on the discharge line of each pump.
5.6 Pumps shall be oriented to provide adequate space for maintenance as well as best egress path through tunnels.
5.7 Pressure power condensate pumps shall be provided with removable custom fitted insulated jackets.
1 General
1.1 Materials and installations shall be in accordance with the following industry and association standards.
   - ASME Boiler and Pressure Vessel Code
   - ASME B31.1 Power Piping Code
   - ASTM Materials
   - MICA – Midwest Insulation Contractors Association

2 Design Conditions:
2.1 All insulation materials and installations shall comply with the MICA National Commercial & Industrial Commercial Insulation Standards.
2.2 All steam and condensate piping shall be provided with insulation. Fiberglass insulation with All Service Jacket (ASJ) and PVC Jacket as specified herein shall be provided with the following exception: Insulation at tunnel intersections, changes of direction, or other areas on which the piping will regularly be walked or stepped by personnel shall be calcium silicate with Aluminum Jacket. The calcium silicate shall be supplied in the same thickness as required for fiberglass in the table below.
2.3 Removable blanket insulation shall be provided on all equipment including expansion joints, valves, etc.
2.4 All components of the insulation system, including facings, mastics and adhesives, shall have a fire hazard rating not to exceed 25 for flame spread, and 50 for fuel-contributed and smoke-developed. Ratings to be determined by Underwriter’s Laboratories (UL) or other approved testing laboratory in accordance with ASTM E84, NFPA 255 and UL 723 requirements.
2.5 Consult Utilities Engineering if an application is believed to be outside of these conditions.

3 Fiberglass Insulation
3.1 Fiberglass insulation is required on steam vent piping.
3.2 Fiberglass insulation for piping shall be heavy density, molded fiberglass. The insulation may be single piece “snap-on” or two or more piece sectional insulation as required for larger sizes.
3.3 Pipe and fitting insulation fiberglass material data:
   - Density 3-1/2 lb./ft³, 650°F or greater rating
   - K Factor 0.25 at 100°F
   - Flame Spread 25 max (composite rating)
   - Smoke Developed 50 max (composite rating)
   - Fuel Contributed 50 max (composite rating)
3.4 Table of required insulation thickness in inches with PVC outer jacket for piping:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>HPS, MPS, LPS &amp; Steam Vents</th>
<th>Pumped Condensate</th>
<th>Trapped Condensate</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2&quot;</td>
<td>2½&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>3&quot;</td>
<td>4&quot;</td>
<td>1&quot;</td>
<td>1½&quot;</td>
</tr>
<tr>
<td>4&quot; to 8&quot;</td>
<td>4&quot;</td>
<td>1&quot;</td>
<td>---</td>
</tr>
<tr>
<td>10&quot; to 18&quot;</td>
<td>4&quot;</td>
<td>1½&quot;</td>
<td>---</td>
</tr>
</tbody>
</table>
3.5 All fiberglass insulation shall include a factory and/or field applied all service jacket consisting of high density white Kraft paper bonded to aluminum foil and reinforced with fiberglass yarn. The piping shall be covered with PVC jacketing and the piping system shall be rated so as to meet all building codes for occupied buildings.
3.6 Fittings shall be insulated with pre-formed fiberglass pieces. The fittings shall be covered with PVC insulated fitting covers sized to fit snugly and match pipe insulation thickness.
3.7 All fiberglass insulation shall be installed per manufacturer’s recommendations.

4 Hydrous Calcium Silicate Insulation
4.1 For use only at tunnel intersections, changes of direction or other areas on which the piping will regularly be walked or stepped by personnel.
4.2 Material Data:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>14 lb./ft³</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>60 PSI (ASTM C203)</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>200 PSI (5% Compression)</td>
</tr>
<tr>
<td>Linear Shrinkage</td>
<td>1.1% maximum</td>
</tr>
<tr>
<td>Flame Spread</td>
<td>0 (ASTM E84)</td>
</tr>
<tr>
<td>Fuel Contribution</td>
<td>0 (ASTM E84)</td>
</tr>
<tr>
<td>Smoke Developed</td>
<td>0 (ASTM E84)</td>
</tr>
<tr>
<td>Chloride Content</td>
<td>per ASTM C795</td>
</tr>
<tr>
<td>Asbestos Free</td>
<td>AF Identity System</td>
</tr>
<tr>
<td>K Factor</td>
<td>0.42 at 200°F (ASTM C177, C335 and C518)</td>
</tr>
<tr>
<td>Temperature Rating</td>
<td>1200°F</td>
</tr>
<tr>
<td>Standard Specification</td>
<td>ASTM C533 Type 1</td>
</tr>
</tbody>
</table>

4.3 Pipe insulation shall be moisture resistant with a smooth finish.

4.4 Pipe insulation shall be pre-formed half-sections in nominal 3'-0" lengths.

4.5 Fitting insulation shall be scored block insulation and/or segmented to insure proper fit.

4.6 Jacket shall be field applied aluminum.

4.7 Insulating cement shall meet same criteria as preformed sections.

4.8 Installation Guidelines

4.8.1 Pipe shall be insulated with pre-formed sections.

4.8.2 Fittings shall be insulated with mitered sectional pipe insulation or with pre-formed fitting covers. Block and segmented insulation shall be cut and trimmed for an accurate fit.

4.8.3 Gaps in block insulation shall be filled with insulating cement applied in layers not to exceed 1-1/2". Additional layers shall be placed after the preceding layer(s) have cured.

4.8.4 Two layered insulation where required shall have the inner layer thickness equal to half the specified thickness, or ½" less than the outer layer where this is not practical.

4.8.5 Staggered joint construction shall be used for all systems.

4.8.6 Multiple layer systems shall have staggered joints in both directions.

4.8.7 All voids, chipped corners or other openings in insulation sections or blocks shall be filled.

4.8.8 Tie wires shall be No. 14 black wire. At least four (4) wires shall be used per three (3) feet of length. Wires shall be placed prior to jacketing and shall be at right angles to the pipe axis. Diagonally wound wires are not acceptable.

4.8.9 End wires shall be placed 3" from the end of each insulation section in addition to the tie wires.

4.8.10 End and tie wires shall be tightly twisted together and pressed into the insulation so as to leave no projection visible on the finished surface.

4.8.11 Bolt on type support rings shall be furnished and installed by the insulation contractor on all vertical multiple layer piping insulation with a rise exceeding three feet.

4.8.12 Fittings less than 3" may be insulated with troweled-on high temperature insulating and finishing cement applied in layers not to exceed 1-1/2" thick. Each layer shall be reinforced with chicken wire.

Note: Utility piping in tunnels, steam pits and trenches less than 3" shall be insulated with fiberglass unless specifically called out on drawings as calcium silicate.

4.8.13 Control valves, expansion joints and other equipment requiring regular maintenance or access shall be insulated with removable blanket. Fiberglass insulation in pre-formed sections shall be supplied for all other valves (shut-off, drain, vent, etc.)

4.8.14 A field applied PVC jacket shall be applied to all calcium silicate insulated piping and fittings as the base bid unless noted.

5 Insulation Blankets

5.1 Insulation Covers for up to 500°F System

5.1.1 Insulation Core: 2" Type E needled fiberglass, 6-7 lbs. density with a k Factor of 0.26 at 100°F

5.1.2 Inner, Outer & Gusset Jacketing: 17 oz./sq.yd. Teflon coated fiberglass cloth

5.1.3 Thread: Teflon coated fiberglass

5.1.4 Fastening Devices: Belts made of jacketing material with S.S. double D rings.
5.1.5 Identification Tags: 304 S.S. tag embossed with description of item & Purdue Item Number

5.2 Insulation Covers for over 500°F System

5.2.1 Insulation Core: 2” Type E needled fiberglass, 6-7 lbs. density, with a K factor of 0.26 at 100°F.

5.2.2 Outer Jacketing (Cool Side): 17 oz./sq.yd. silicone impregnated fiberglass cloth

5.2.3 Inner Jacketing (Hot Side) & Gussets (Sides/Edges): 18 oz./sq.yd. high temperature pure fiberglass cloth rated to 1200°F.

5.2.4 Inner & Gusset Casing: 304 S.S. Mesh, 0.008” diameter

5.2.5 Thread: 304 S.S., 10 ply

5.2.6 Fastening Devices:

5.2.7 1.5” Wide straps made of outer jacketing material and fastened with S.S. double D rings.

5.2.8 Identification Tags: 304 S.S. embossed with description of item & Purdue Item Number.

5.3 The covers have to be fabricated in one piece whenever possible, including bonnet being attached to the valve body jacket. The jacket will be sewn inside-out and then turned correct side out before inserting the insulation core. Thus, all seams are inside seams except the final closing seam, which will be a finished outside closing seam. Gussets will be separate pieces sewn to the inner (hot face) and the outer (cold face) jacket surfaces. Identification tags will be riveted to the outer jacket.

5.4 Blankets must fit tight to the component and to Purdue Representative’s satisfaction.

5.5 Manufacturer must provide a conditional five (5) year warranty against defects in design, workmanship and materials for each cover.

6 Jacketing

6.1 Jacket shall be the All Service Jacket (ASJ) (ASJ for Fiberglass only) covered with PVC Jacket. Minimum PVC thickness shall be 0.030 inches. The flame spread/smoke developed rating shall be 25/50.

6.3 Removable insulation blankets as used on expansion joints and valves shall use the flexible, commercially supplied jacket integral with the blanket.

6.4 Jacketing and insulated fitting covers shall be secured with tack, tape or adhesive as approved by Purchasers representative.

6.5 Contractor shall furnish and install the jacketing over the steam and condensate piping and the valve insulation systems specified herein.

6.6 Fire rated insulation and jacket shall be provided at all fire rated wall penetrations.

7 Noise Control Insulation

7.1 Pressure regulating valves shall be supplied with insulation for the purposes of noise reduction, as well as heat conservation and burn protection. This insulation shall be removable, for maintenance access and manufactured and/or approved by the Pressure Regulating Valve Manufacturer.

8 Installation Guidelines

8.1 Insulation shall be installed so that it fits snugly and securely around all pipes, fittings and equipment. There shall be no gaps in insulation coverage and all seams shall be sufficiently taped or sealed to prevent excessive heat from escaping.

8.2 All PVC jacketing shall be warrantied for a period of not less than one year from the time of installation against melting, burning, cracking or deformation caused by excessive heat due to gaps in the insulation coverage.
1 References

- ASTM A48 – Gray Iron Castings
- ASTM C478 – Pre-cast Reinforced Concrete Manhole Sections
- ACI 318 – American Concrete Institute
- ASTM C891 – Installation of Underground Precast Utility Structures
- NEMA TC 8 – Extra-Strength PVC Plastic Utilities Duct for Underground Installation
- NEMA TC 9 – Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation
- NFPA 70 – National Electrical Code

2 Pre-Cast Manholes

2.1 The quality of components is to be that represented by:

- Manhole: Hartford Concrete Products, Inc. - Pre-Cast Vault
- Frame & Cover: Neenah Foundry - #R-1740-F
- Stanchion: Underground Devices Inc. - CR 36
- Cable Arms: Underground Devices Inc. - RA 14 & 20
- Cable Rack Assemblies: Underground Devices Inc.

2.2 Construction

2.2.1 Manhole will be constructed of steel reinforced concrete

2.2.2 Manhole will be complete with manhole cover and ring, 14” diameter sump indentation located adjacent the manhole opening, cable pulling rings, and other appurtenances as required.

2.2.3 Manhole will be waterproof construction

2.2.4 Mortised joint seals or PVC pre-molded water stops shall be installed at the junction of base and walls

2.2.5 Provided with a heavy-duty cast iron frame and cover with nominal 48” opening with a 22” smaller access cover centered in larger cover

2.2.6 Frame and cover shall have open pick holes

2.2.7 Label cast in lid shall read “ELECTRIC”

2.2.8 The Contractor shall permanently weld identification number/letter labels on the manhole lids

2.2.9 Provide cast concrete grade rings without steps as needed to elevate cover to approximately 1” above finish grade. Cast iron adjusting rings may be used to trim final elevation.

2.2.10 Precast manholes shall be provided with hot-dipped galvanized pull-in irons mounted on the ceiling and on each wall. One removable pulling eye shall be installed in the floor, centered under the manhole opening.

2.2.11 Contractor to provide stanchions and cable arms of a glass reinforced nylon material having a combination high mechanical strength, thermal resistance, corrosion resistance and dielectric strength.

2.2.11.1 The stanchions shall be 72" long (2-36") and incorporate multiple cable arm mounting holes.

2.2.11.2 Cable arm length shall be a minimum of 14”.

2.2.11.3 Mounting hardware shall be 316 stainless steel.

2.2.12 Cable racks shall be mounted on each wall of the manhole to adequately support cables.

2.2.12.1 Additional racks shall be mounted not more than twelve (12) inches from corners at duct entrances.

2.2.12.2 Racks shall be spaced not more than forty (40) inches between racks on the walls.

2.3 Installation

2.3.1 Ensure that the soil materials and compaction criteria used for the manhole conforms to the specifications and that the proper elevation for installation has been determined and verified prior to setting manhole.

2.3.2 An eight-inch thick layer of washed pea gravel shall be placed in the excavation to set the new manhole on manholes shall be set level and plumb.

2.3.3 Contractor shall furnish, securely install and properly bond all reinforcing steel, metal hardware, and cast iron frame with #4 AWG solid soft drawn bare copper.

2.3.4 Manhole shall be grounded

2.3.5 Contractor shall properly backfill and compact soil around the manholes after they
have been inspected and approved.

2.4 Design Conditions: Manholes shall be specifically designed for the following conditions and specifications.

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground water level</td>
<td>3'-6&quot; below surface</td>
</tr>
<tr>
<td>Dry earth density</td>
<td>100 lbs. / ft³</td>
</tr>
<tr>
<td>Saturated earth density</td>
<td>120 lbs. / ft³</td>
</tr>
<tr>
<td>Live load</td>
<td>AASHTO H-20-S16 truck</td>
</tr>
<tr>
<td>Live load impact</td>
<td>2'-0&quot; I = 20%</td>
</tr>
<tr>
<td>Earth cover</td>
<td>Min. 2'-0&quot; – Max. 5'-0&quot; for Electrical Manholes</td>
</tr>
<tr>
<td>F’c</td>
<td>4,500 PSI with grade 60 reinforcing steel</td>
</tr>
<tr>
<td>Fy</td>
<td>60,000 PSI</td>
</tr>
<tr>
<td>Codes &amp; Standards</td>
<td>AASHTO Load factor design for manholes</td>
</tr>
<tr>
<td></td>
<td>ASTM C-857</td>
</tr>
<tr>
<td></td>
<td>ACI Code 318 (USD) where applicable for manholes</td>
</tr>
</tbody>
</table>

3 Cast-in-Place Duct Bank

3.1 Construction

3.1.1 Concrete and related work shall be mixed, placed, and cured in accordance with the “Building Code Requirements for Reinforced Concrete”, ACI-318.

3.1.2 Concrete shall develop an ultimate compressive strength of 4000 P.S.I. in 28 days with a maximum slump of 6 inches at time of placing. The top aggregate size shall be ½" to ensure good placement between embedded items.

3.1.3 Color top layer of concrete encasement red by heavily sprinkling with red oxide cement coloring while still wet (color to the satisfaction of the Owner).

3.1.4 The number, size and arrangement of conduits in the cast-in-place underground duct bank sections shall be as indicated in the Program.

3.1.4.1 Outer encasement of concrete shall be 3" minimum with 1½" between conduits.

3.1.4.2 Conduit spacers shall be PVC, sized to allow for the full separation of conduits as indicated on the drawings and spaced a maximum of eight (8) feet on centers. No conduits, wood stakes, etc. shall be used to separate conduits in the duct bank.

3.1.4.3 Conduit and fittings used in the construction of this cast-in-place underground duct bank shall conform to Section 2.4 of this specification. Make all joints and connections in conduit using fittings designed for the purpose bonded permanently and watertight using solvent cement.

3.2 Quality; the quality of components and construction is to be that represented by:

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lid and Frame</td>
<td>ASTM A48, Class 30B. Cast iron construction, machined flat bearing surface with removable lid</td>
</tr>
<tr>
<td>PVC Duct</td>
<td>NEMA TC-8 Type – DB Nominal size 5”</td>
</tr>
<tr>
<td>PVC Fittings</td>
<td>NEMA TC-9</td>
</tr>
<tr>
<td>Underground Warning Tape</td>
<td>3 inches wide plastic tape, colored red with suitable warning legend describing buried electrical lines</td>
</tr>
<tr>
<td>Reinforcing bars</td>
<td>ASTM A615 Grade 60, deformed type</td>
</tr>
<tr>
<td>Reinforcing bar concrete cover</td>
<td>ACI-318</td>
</tr>
<tr>
<td>Lap splices</td>
<td>Class B according to ACI-318 for the respective steel grade and concrete ultimate strength</td>
</tr>
</tbody>
</table>

3.3 Installation

3.3.1 Duct runs should slope from buildings to manholes and from manhole to manhole a minimum of three inches (3") in one hundred feet (100').

3.3.2 A three inch thick 4000 PSI concrete base shall be poured to form a solid surface to set new duct bank on. Within the base shall be #4 Rebar ties at intervals of not greater than eight feet (8'). Each tie shall be used to secure down the conduit spacers. The base shall be the full width and length of the duct bank and shall have
a minimum of 24 hours set up time prior to constructing duct bank. Grades shall be checked after pouring to assure proper slope and drainage.

3.3.3 A minimum distance between top of duct bank and final grade surface of 2 feet 6 inches is preferred, for all points of all duct runs, but some exceptions will be granted to avoid serious conflicts with existing utilities, and for obtaining correct grades, where necessary. Final depth must be approved by the owner if less than 2 feet 6 inches.

3.3.4 Where curves are necessary in duct run (both vertical curves and horizontal curves) design to the least curvature practical, and without any abrupt changes in the direction of the ducts.

3.3.5 Install 4-#4 continuous reinforcing bars (one in each corner of duct bank) throughout the length of duct bank runs. Provide crossties as required to form these bars in place. 3.3.6 The minimum-bending radius for underground conduits shall be 48” with no more than a combined total of 90 degrees of directional change per run without owner’s approval.

3.3.6 The entire length of excavation between manholes or between manholes and buildings must be excavated to its design depth before installing any duct, to determine all interferences and adjust elevations accordingly, if necessary.

3.3.7 Where the duct bank enters a manhole, provide reinforcement in the duct bank base. Provide extra reinforcement where duct bank crosses a roadway, an excavation, and unstable or compacted earth.
1 References
1.1 NFPA 70 National Electric Code
1.2 IEEE C2 National Electric Safety Code
1.3 ANSI C57.12.28 American National Standard for Switchgear and Transformers – Pad-Mounted Equipment – Enclosure Integrity
1.4 ANSI C57.12.70 American National Standard Terminal Markings and Connections for Distribution and Power Transformers
1.5 IEEE C57.12.00 General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
1.6 IEEE C57.12.26 Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors

2 General Requirements
2.1 Voltage
   • 12.47 KV Primary system voltage
   • 2400 V Primary system voltage
2.2 Building transformers located within a building vault are to be substation type and are to be flange connected to the primary disconnecting means and throat / busway connected to the secondary switchgear.
2.3 Pad mounted transformers may be used where there is no building electrical vault with owner approval.
2.4 Sample Specifications can be provided for Liquid Filled Unit Sub-Station Transformers and PadMount Liquid Filled Transformers

3 Grounding
3.1 The transformer shall have a 4/0 copper 600 v insulated green colored grounding conductor installed between the Xo bushing and a grounding pad.
3.2 The transformer shall have the two diagonally opposing ground pads connected by separate 4/0 bare copper conductors through PVC conduit sleeves inserted through the foundation pads to the grounding grid.
3.3 All grounding connections shall be copper, 2-hole, compression lugs.
3.4 The low voltage termination spades shall have an adequate number of holes to accept an additional number of ANSI two-hole lugs to accommodate the additional grounding and bonding conductors. Additional cable supports shall be provided when applicable to relieve pressure from the transformer phase and neutral bushings. The engineer of record shall determine the number of ANSI two-hole lugs required and increase the size of the termination spade accordingly.

4 Testing
4.1 All specified testing reports shall be submitted and review by the Energy and Utilities electrical engineer prior to transformer energization.
1 References
1.1 ANSI/IEEE C37.71 - Subsurface Load Interrupting Switches.
1.2 ANSI/IEEE 386 Separable Connections and Bushings.
1.3 ANSI/Z55.1 - Gray Finishes for Industrial Apparatus and Equipment.
1.4 IEEE C37.20.3

2 General Information
2.1 Power fuses shall be utilized to provide primarily short circuit protection for cables and transformers. The fuse rating shall be selected to appropriately provide 125 percent of the transformers full-load rating continuously, sustain no damage from magnetizing in-rush currents, and provide protection against thermal damage from internal or secondary faults. The interrupting rating shall be sufficient to quickly and safely interrupt fault currents and prevent extensive damage to equipment.

3 Medium Voltage Switch Ratings
3.1 The quality of components is to be that represented by G & W Electric Co load break with integral ground ("GRAM" style switch).

<table>
<thead>
<tr>
<th>3.1.1 Ratings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System Voltage</td>
<td>12.47 kV, three phase, 3 wire, 60 Hz, grounded</td>
</tr>
<tr>
<td>Maximum Design Voltage</td>
<td>15 kV</td>
</tr>
<tr>
<td>Basic Impulse Level</td>
<td>95 kV</td>
</tr>
<tr>
<td>Rated Continuous Current</td>
<td>600 amperes</td>
</tr>
<tr>
<td>Fault-Close Rating</td>
<td>40/64 kA asymmetrical</td>
</tr>
<tr>
<td>Momentary Current Withstand</td>
<td>40/64 kA asymmetrical</td>
</tr>
</tbody>
</table>

3.2 The quality of components is to be that represented by G & W Electric Co load break switch with integral ground and fault interruption ("VGNI" style switch).

<table>
<thead>
<tr>
<th>3.2.1 Ratings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System Voltage</td>
<td>12.47 kV, three phase, 3 wire, 60 Hz, grounded</td>
</tr>
<tr>
<td>Maximum Design Voltage</td>
<td>15 kV</td>
</tr>
<tr>
<td>Basic Impulse Level</td>
<td>110 kV</td>
</tr>
<tr>
<td>Rated Continuous Current</td>
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</tr>
<tr>
<td>Fault-Close Rating</td>
<td>40/64 kA asymmetrical</td>
</tr>
<tr>
<td>Momentary Current Withstand</td>
<td>40/64 kA asymmetrical</td>
</tr>
</tbody>
</table>

4 Switch Construction
4.1 Switch shall have bottom cable entrances and shall be 600 ampere, apparatus bushings.
4.2 Switches shall have entranceways and switched ways as called for on the drawings.
4.3 Switch internal bus and wiring shall be copper, shall not require field contact alignment before energizing, shall have a compression spring operator with position indicator pad lockable in any position and shall be operated from outside the tank by a removable, breakaway handle.
4.4 Tank shall be 1/4" stainless steel, welded lid, corrosion resistant, primed and painted with no external aluminum parts.
4.5 Tank shall withstand 15 PSIG internal and 14 PSIG external without affecting switch performance.
4.6 Tank shall include gas filling valve and pressure gauge, four lifting eye provisions, viewing windows to permit inspection of the switch contacts in the open position for each way, one 1/2" - 13 grounding provision for the tank and each switch way.
4.7 Tank shall have single line diagram and stainless steel nameplate attached with stainless
steel mechanical fasteners.

4.8 Tank shall be factory filled with SF6 gas and AC hi-pot tested prior to shipment.

4.9 A bolted, galvanized steel channel frame with galvanized enclosing panels to allow clearance below the tank, shall be supplied as requested for each switch.

4.10 Switch is to be of waterproof construction

5 Switch Factory Finishes

5.1 Clean surfaces before applying paint.

5.2 Apply corrosion-resisting primer to all surfaces.

5.3 Apply finish coat of vinyl paint to 3 mils thick.

5.4 Finish Color: ANSI Z55.1; Type 61 - Light Gray.
1 References
1.1 NFPA 70 National Electric Code
1.2 IEEE C2 National Electric Safety Code
1.3 IEEE C37.20.3 Metal-Enclosed Interrupter Switchgear
1.4 ANSI C57.12.28 Switchgear & Transformer – Pad-Mounted Equipment - Enclosure Integrity

2 Load Interrupter Switchgear
2.1 The quality of components is to be that represented by S & C Electric Co.
2.2 Provide an Incoming Termination section with surge protection and copper bus connection.
2.3 Provide a switch and fuse combination section for each transformer, flange connected to the transformer, with a transition section if necessary.
2.4 Load interrupter switch shall be a three-pole, single-throw, metal-enclosed type with manual stored energy operator which shall simultaneously disconnect or connect ungrounded conductors. The moveable blade of the switch shall be de-energized when in the open position. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability.
2.5 A ground bus shall extend the width of the switch enclosure and shall be bolted directly thereto. Connect frame of unit to ground bus and provide for attachment to ground grid at each end.
2.6 The door shall have an inspection window to allow full view of the position of the three switch blades.
2.7 Switch shall have provision for padlocking in the open and closed positions.
2.8 Switch shall be fused, with fuses mounted on a single frame below switch.
2.9 Fuse rating shall be appropriate to provide 125 percent of the transformer full-load rating, sustain no damage from magnetizing in-rush current, and provide protection against thermal damage.

2.10 Switch & fuse integrated ratings

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Maximum Voltage (KV)</td>
<td>13.8</td>
</tr>
<tr>
<td>Rated Withstand Impulse BIL (KV)</td>
<td>95</td>
</tr>
<tr>
<td>Continuous and Load Interrupting Current (A)</td>
<td>600</td>
</tr>
<tr>
<td>Short-Circuit Interrupting Current (kA rms Sym)</td>
<td>34.6</td>
</tr>
<tr>
<td>Duty-Cycle Fault-Close Current (kA Asym)</td>
<td>40</td>
</tr>
</tbody>
</table>

3 Pad Mounted, Metal-Enclosed Switchgear
3.1 The quality of components is to be that represented by:
   3.1.1 “PMU Pad-Mounted Switchgear” per specification 662-451 as modified for PMU features as manufactured by the S & C Electric Co.
3.2 The basic configuration for one transformer is PMU-5 and for two is PMU-7.
3.3 The switchgear shall be configured with one incoming compartment for radial-feed, equipped with air-insulated, load-interrupter switch. The outgoing compartment shall be provided with fused disconnects.
3.4 Switches shall be provided with a manual, handle-type operator utilizing a stored-energy (spring-driven) mechanism to simultaneously open or close all phases.
3.5 The switchgear shall be configured so that the switch actuator is padlockable, but may be accessed without opening the switch compartment doors.
3.6 Fused compartments shall be disconnect non-load break type hook-stick removable.
3.7 Switchgear enclosures shall be of freestanding, self-supporting construction provided with separate incoming and outgoing compartments configured for bottom cable entry. Enclosures shall be of live-front construction, provided with a hinged door for access to each compartment.
### 3.8 Switch & Fuse Integrated Ratings

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Maximum Voltage (KV)</td>
<td>13.8</td>
</tr>
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<td>Rated Withstand Impulse BIL (KV)</td>
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<tr>
<td>Continuous and Load Interrupting Current (A)</td>
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</tr>
<tr>
<td>Short-Circuit Interrupting Current (kA rms Sym)</td>
<td>25</td>
</tr>
<tr>
<td>Duty-Cycle Fault-Close Current (kA Asym)</td>
<td>40</td>
</tr>
</tbody>
</table>
1 References
1.1 NFPA 70 National Electric Code
1.2 IEEE C2 National Electric Safety Code
1.3 IEEE C37.46 Standard Specifications for Power Fuses and Fuse Disconnecting Switches
1.4 IEEE C37.47 Standard Specifications for Distribution Fuse Disconnecting Switches, Fuse Supports, and Current-Limiting Fuses

2 General Information
2.1 Power fuses shall be utilized to provide primarily short circuit protection for cables and transformers. The fuse rating shall be selected to appropriately provide 125 percent of the transformers full-load rating continuously, sustain no damage from magnetizing in-rush currents, and provide protection against thermal damage from internal or secondary faults. The interrupting rating shall be sufficient to quickly and safely interrupt fault currents and prevent extensive damage to equipment.

3 Expulsion Type Power Fuses
3.1 The quality of components is to be that represented by
   - S & C Electric type SM-5S or SM-5SS
3.2 Fuses shall be of the solid-material type and shall utilize refill-unit-and-holder or fuse-unit-and-end-fitting construction with readily replaceable refill unit or fuse unit.
3.3 Disconnect style mountings shall be used for switchgear rated up through 600 MVA at 13.8 kV. Non-disconnect style mountings for power fuses shall be used only where higher ratings are required.
3.4 Fusible elements shall be non-aging and non-damageable construction.
3.5 Melting time-current characteristics shall be permanently accurate with a maximum total tolerance of 10% in terms of current.
3.6 Power fuses shall be capable of detecting and interrupting down to minimum melting current, under all realistic conditions of line-to-line or line-to-ground voltage, and shall be capable of handling the full range of transient recovery voltage severity associated with these faults.
3.7 All arcing accompanying power fuse operation shall be contained within the fuse, and any arc products and gases evolved during fuse operation shall be vented through exhaust control devices that shall effectively control fuse exhaust.
3.8 Blown-fuse indicators shall provide visible evidence of fuse operation while installed in the fuse mounting.
3.9 Expulsion-type power fuses shall be 13.8KV, E-rated, with an Interrupting Rating (kA sym) of 34.6kA

4 Electronic Power Fuses
4.1 The quality of components is to be that represented by
   - S & C Electric
4.2 Electronic power fuses shall utilize an expendable interrupting module and a reusable control module.
4.3 The interrupting module shall consist of a main-current section and a fault-interrupting section. These sections shall be arranged coaxially and contained within the same housing. The main-current section shall carry current under normal operating conditions while the fault-interrupting section shall operate only under fault conditions. It shall not carry current continuously and shall not determine the time current characteristic (TCC) minimum operating curve shape.
4.4 The fusible-element section shall not be subject to damage due to current surges.
4.5 All arcing accompanying operation of the electronic power fuse shall be contained within the interrupting module and fuse operation shall be silent, without any exhaust.
4.6 The control module shall continuously monitor the line current through an electronic sensing circuit, be self-powered with the capability to supply power for operating the sensing logic circuits, and to actuate the interrupting module during a fault.
4.7 Blown-fuse indicators shall provide visible evidence of fuse operation while installed in the fuse mounting. Fuse mounting shall be disconnect style.
4.8 Electronic power fuses shall have time-current characteristics that are permanently accurate.
4.9 Electronic power fuses shall be 13.8KV, Continuous rated for 600A, with an Interrupting Rating (kA sym) of 40kA.

5 Current-Limiting Power Fuses
5.1 The quality of components is to be that represented by:
   - Cutler Hammer type HLE
   - GE type EJO-1
   - Cooper type NX
5.2 Current-Limiting type power fuses shall be
constructed with pure silver fuse elements, high purity silica sand filler, and a glass resin outer casing.

5.3 Disconnect style mountings shall be used for switchgear rated up through 600 MVA at 13.8 kV. Non-disconnect style mountings for power fuses shall be used only where higher ratings are required.

5.4 Fusible elements shall operate in such a manner as to substantially limit the peak let-through current by interrupting the fault before the first current peak is attained.

5.5 Melting time-current characteristics shall be permanently accurate with a maximum total tolerance of 10% in terms of current.

5.6 Current-limiting fuses shall be capable interrupting all currents from the rated interrupting current down to the minimum continuous melting current in no less than one hour.

5.7 All arcing accompanying operation of the current-limiting power fuse shall be contained within the fuse and operation shall be silent, without any exhaust.

5.8 Blown-fuse indicators shall provide visible evidence of fuse operation while installed in the fuse mounting.

5.9 Current-limiting fuses shall be 15.5KV, E-Rated, with an Interrupting Rating (kA sym) of not less than 38kA.
1 Grounding Cable Material

1.1 The ground cable shall be soft drawn stranded bare copper size and number as shown on the Drawings.

2 Tap Material

2.1 The main taps for equipment connections shall be #2/0 soft drawn stranded, tinned, annealed, bare copper cable or as shown on the Drawings.

2.2 The taps for manhole cover, cable drain shield adapters from elbows, and concrete reinforcement shall be #4 soft drawn bare copper.

3 Manhole Grounding

3.1 Have a minimum of two (2) ¾” by 10’ ground rods.

3.2 All #4/0 neutral conductors inside a manhole shall be bonded together using #4/0 neutral conductor. This conductor “bus” shall be used as the grounding point for all local grounds.

3.3 Electrical equipment mounted inside a vault, such as switches, shall be grounded by #2/0 copper conductor(s).

3.4 A #4 solid copper conductor shall ground the manhole cover ring. The ring shall be drilled and tapped to accept a ¼”-20 threaded screw.

3.5 The connectors and terminals shall be bolted to the electrical equipment using Stainless Steel bolts, flat washers, lock washers, and nuts, or by connectors supplied with the electrical equipment.

3.6 All cable drain shield adapters shall be grounded using #4 solid copper conductor. Elbow, cap, and extension surface grounds may be attached within connectors used to ground drain shields.

3.7 The concrete reinforcement shall be grounded using #4 solid copper conductor attached to each provided re-bar grounding tab inside the manhole.
PHYSICAL FACILITIES
2018 Consultant’s Handbook
Division 33 Utilities
8000 Utility Tunnels

1 Tunnel Design
1.1 Cast in Place concrete or Precast concrete shall be provided. Corrugated metal pipe, poly or other prefabricated units are not permitted.
1.2 Precast tunnel systems shall consist of a three-sided, bottom and sides section with a removable top assembled to form a completely enclosed tunnel.
1.3 Precast concrete units shall be tested and conform to the current edition of the American Concrete Institute Standard ACI-711, Section 301.
1.4 Tunnel top should integrate the sidewalk surface where applicable.
1.5 Tunnel lifting hooks for precast tunnels shall be recessed and the joints shall be properly sealed and watertight.
1.6 Pipe support steel and anchor plates shall be provided in the precast tunnel top at regular intervals not to exceed 8'-0" on center.
1.7 Concrete mix designs for tunnels shall include a Crystalline waterproofing admixture (Xypex®) at the dosage specified by the manufacturer.
1.8 All tunnels shall be designed in accordance with AASHTO LRFD Bridge Design Specifications and for AASHTOHL-93 vehicle loading.

2 Soil Conditions
2.1 Soil conditions shall be determined for each application by a Geotechnical Engineer registered in the state of Indiana.
2.2 All backfill adjacent to precast trenches, concrete utility tunnels and other underground concrete structures subject to vehicular loading shall be flowable fill.

3 Tunnel Gaskets
3.1 Manufacturer shall flexible plastic gaskets for all joints in the installation.
3.2 Manufacturer shall also provide a sufficient quantity of primer to adequately prepare joints for installation under wet conditions.

4 Tunnel Manhole Frames and Lids
4.1 Manhole frames and lids shall be selected for each application with Purdue approval.

5 Tunnel Top Waterproofing Standards
5.1 Underground/Buried Tunnel: 60 mil nominal thick Elvaloy KEE based thermoplastic membrane reinforced with a 5.0 oz. weft inserted knit polyester fabric integrally bonded to an Active Polymer Core (APC).

5.1.1 Heat-welded seams
5.1.2 Wrap membrane down sides of tunnel to the top of the footing.
5.1.3 Warranty: Special Manufacturer’s Warranty: A written non-prorated waterproofing warranty, covering both materials and labor, in which manufacturer agrees to repair or replace waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.

5.1.3.1 Warranty Period: 15 years from date of Substantial Completion.
5.1.3.2 Warranty shall include removal cost, subsequent system repair, and replacement of the overburden, paving, etc. at manufacturer’s expense for repairs resulting from the loss of water tightness due to failure of the waterproofing system, if necessary.
5.1.3.3 Warranty shall be a ‘no dollar limit’ warranty.
5.1.3.4 Contractor is responsible for installing the system as required to achieve the manufacturer’s warranty requirements.

5.2 Drainage Panels
5.2.1 A three-dimensional polypropylene drainage core with a woven geotextile adhered to one side to allow water passage while restricting soil particles. Composite includes a thin polyethylene sheet on the back of the drainage core.
5.2.2 Minimum compressive strength of 18,000 psf (ASTM D1621)
5.2.3 Minimum flow of 1.34 gpm/ft width at 3600 psf sustained for 300 hours, and hydraulic gradient of 0.01 (ASTM D4716)
5.2.4 Filter fabric shall have a permeability coefficient of 0.015 cm/sec

5.3 Exposed Tunnel Top: Liquid applied traffic coatings complying with ASTM C 957.
5.3.1 Minimum dry film thickness of 55 mil
5.3.2 Color as selected by the Owner
5.3.3 Provide uniformly graded washed silica sand of particle size, shape and minimum hardness recommended by the manufacturer spread to refusal to achieve a slip-resistant finish
5.3.4 Acceptable manufactures include:
5.3.4.1 Autogard: Neogard
5.3.4.2 Sikalastic: Sika
5.3.4.3 Pecora Deck 800: Pecora
1 General

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

2 Summary

2.1 This section includes the protection and trimming of existing trees that interfere with, or are affected by, execution of the Work, whether temporary or permanent construction.

2.2 Related Sections include the following: (Only use these, or modifications thereof, if relevant to project).

2.2.1 Division 2 Section "Site Clearing" for removal limits of trees, shrubs, and other plantings affected by new construction.

2.2.2 Division 2 Section "Earthwork" for building and utility trench excavation, backfilling, compacting and grading requirements, and soil materials.

2.2.3 Division 2 Section "Exterior Plants" for tree and shrub planting, tree support systems, and soil materials.

3 Descriptions

3.1 Protected Tree: Any tree that the Campus Arborist, in agreement with the site Construction Superintendent, has designated to be of high value because of its type, age, or other professional criteria.

3.2 Root Zone: The ground area surrounding each tree containing its root system, defined by a radius equal to the trunk diameter at breast height (dbh) in inches multiplied by 1.5 feet per inch. For example, a 10 inch dbh tree would have a root zone extending 15 feet from the trunk in all directions.

3.3 Protected Root Zone (PRZ): The part of the Root Zone of a Protected Tree which must be protected from construction damage. The Protected Root Zone for other existing plants may be indicated on the Landscape Protection Plan.

3.4 Landscape Protection Plan: A plan that identifies areas of plant preservation and methods of protection within the Protected Root Zones. The methods may consist of fencing, mulching, etc.

3.5 Compaction: Increased soil density. This results in death of existing roots and/or greater difficulty for new roots to develop. Damage may be caused by many agents, including the use of heavy equipment, concentrated foot traffic, and storage of heavy materials under or around trees.

3.6 Damage: Shall include any of the prohibited practices listed below and as determined solely by the Owner.

3.7 Prohibited Practices: Shall include, but are not limited to:

- Breaking of branches, scraping of bark, or unauthorized cutting.
- Nailing or bolting into trees or using trees as temporary support in any way (including cabling around any part of the tree).
- Unauthorized filling, excavating, trenching, or use of augers within Protected Root Zones.
- Compaction of or driving over Protected Root Zones.
- Storage of any materials or vehicles within Protected Root Zones.
- Dumping of construction waste or materials within Protected Root Zones.
- Disposal of liquid waste or contaminants in an area which may impact protected trees or their Protected Root Zones.
- Unauthorized removal or relocation of Protected Trees.
- Removal of tree protection barricades or construction fencing prior to completion of project.
- Any other practices listed on the Landscape Protection Plan.

4 Submittals

4.1 Product Data: For each type of product indicated.

5 Quality Assurance

5.1 Preconstruction Conference: The University may call a preconstruction conference to review project requirements, including tree protection and trimming, prior to start of construction.

5.2 Before tree protection and trimming operations begin, Contractor will meet with Owner’s representative to review tree protection and trimming procedures and responsibilities.

5.3 On-going Site Inspection
5.3.1 The Campus Arborist will monitor the construction site throughout the construction process. Violations and damages will be handled according to construction department guidelines and specifications stated in the contract or Landscape Protection Plan.

5.3.2 The Campus Arborist will notify the construction inspector of any breach of the contract or Landscape Protection Plan. At this time the contractor will stop and/or correct whatever practice led to the breach.

5.3.3 If a breach of contract occurs, damages will be assessed according to the Tree Appraisal Schedule listed in the landscape protection plan. (Damages are established based on the pre-established value of the affected tree and the amount of both short and long term damage done to that tree. The Campus Arborist shall perform the damage assessment.)

5.3.4 The Contractor shall immediately contact the Owner’s representative should protected trees be compromised in violation of agreed upon specifications. Failure to communicate promptly could result in damages of up to 100% of the appraised value.

6 Products — Materials

6.1 Chain-Link Fence: Metallic-coated steel chain-link fence fabric of 0.120 inch (3 mm) diameter wire; a minimum of 72 inches (1200 mm) high; with 1.9 inch (48 mm) diameter line posts; 2-3/8 inch (60 mm) diameter terminal and corner posts; 1-5/8 inch (41 mm) diameter top rail; and 0.177 inch (4.5 mm) diameter bottom tension wire; with tie wires, hog ring ties, and other accessories for a complete fence system.

6.2 Organic Mulch: Shredded hardwood bark, free of deleterious materials.

7 Execution—Preparation

7.1 Temporary Fencing: Install 6-foot high, non-moveable, temporary, chain link fencing around Protected Root Zones where indicated on plans to protect remaining trees and vegetation from construction damage. Maintain temporary fence and remove when construction is complete.

7.1.1 Provide access for landscape maintenance equipment.

7.2 Protect tree root systems from damage caused by runoff or spillage of noxious materials while mixing, placing, or storing construction materials. Keep Protected Root Zones free of ponding, eroding, or excessive wetting caused by dewatering operations.

7.2.1 Mulch Protected Root Zones where indicated on plans to minimize compaction.

7.2.2 Apply 12-inch (300-mm) average thickness of organic mulch. Do not place mulch within 6 inches (150 mm) of tree trunks.

7.2.3 Mechanical equipment can be used to place and remove mulch as long as it operates only on previously placed mulch.

7.3 Do not store construction materials, debris, or excavated material inside Protected Root Zones. Do not permit vehicles or persistent foot traffic within Protected Root Zones; prevent soil compaction over root systems.

7.4 Maintain fence enclosed Protected Root Zones in pre-construction condition and free of weeds and trash.

7.5 Do not allow fires within protected root zones.

8 Excavation

8.1 Install shoring or other protective support systems to minimize sloping or benching of excavations adjacent to Protected Root Zones.

8.2 Do not excavate within Protected Root Zones, unless otherwise indicated.

8.3 Where utility trenches are required within Protected Root Zones the Owner should be consulted. Tunneling under or around roots by drilling, auger boring, pipe jacking, or digging by hand may be required.

8.3.1 Root Pruning: Cut roots with sharp pruning instruments; do not break or chop only after consulting with Owner and Owner is satisfied with contractor’s qualifications to perform the work.

8.4 Regrading

8.4.1 Grade Changes: Where new finish grade is indicated below or above existing grade around trees, slope grade beyond Protected Root Zones. Maintain existing grades within Protected Root Zones.

8.5 Tree Pruning

8.5.1 All tree pruning before, during, and after construction activity, will be performed by Owner.

8.6 Tree Damage, Repair, and Replacement
8.6.1 Immediately notify Owner of trees damaged by construction operations.
8.6.2 Repairs and replacements will be handled by Owner.

8.7 Disposal of Waste Materials
8.7.1 Burning is not permitted.
8.7.2 Disposal: Remove excess excavated material and displaced trees per Owner's direction.
1 General
1.1 The bidding requirements, contracting requirements, and applicable parts of Division 1 - General Requirements, as listed in the Table of Contents, shall be included in and made a part of this Section.

2 Summary
2.1 Provide firestop systems consisting of a material, or combination of materials installed to retain the integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, and/or hot gases through penetrations, blank openings, construction joints, or at perimeter fire containment in or adjacent to fire-rated barriers in accordance with the requirements of the Building Code for this project.

2.2 Firestop systems shall be used in locations including, but not limited to, the following:
- Penetrations through fire-resistance-rated floor and roof assemblies requiring protected openings including both empty openings and openings that contain penetrations.
- Penetrations through fire-resistance-rated wall assemblies including both empty openings and openings that contain penetrations.
- Membrane penetrations in fire-resistance-rated wall assemblies where items penetrate one side of the barrier.
- Joints in fire-resistance-rated assemblies to allow independent movement.
- Perimeter Fire Barrier System between a rated floor/roof and an exterior wall assembly.
- Joints, through penetrations and membrane penetrations in Smoke Barriers and Smoke Partitions.

2.3 All firestopping shall be in accordance with this section, and all disciplines of firestopping (mechanical, electrical and general) shall be by the same subcontractor.

3 Related Work
3.1 Examine Contract Documents for requirements that affect Work of this Section. Other Specification Sections that relate directly to Work of this Section include, but are not limited to:
- Division 3 - Concrete; Concrete work
- Division 4 - Masonry
- Division 5 - Metals
- Division 7 - Thermal and Moisture Protection
- Division 8 - Openings
- Division 9 - Finishes
- Division 21 – Fire suppression
- Division 26 - Electrical

4 References
4.1 Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

4.1.1 American Society for Testing and Materials (ASTM)
- E 84 Test Method for Surface Burning Characteristics of Building Materials
- E 119 Test Method for Fire Tests of Building Construction and Materials
- E 136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°F
- E 814 Fire Tests of Through-Penetration Fire Stops

4.2 Factory Mutual (FM) Research
- FM Approval Standard of Firestop Contractors – Class 4991

4.3 Underwriters Laboratories, Inc. (UL)
- UL 263 Fire Tests of Building Construction and Materials
- UL 723 Surface Burning Characteristics of Building Materials
- UL 1479 Fire-Tests of Through-Penetration Fire Stops
- UL 2079 Tests for Fire Resistance of Building Joint Systems

5 System Performance Requirements
5.1 Penetrations: Provide and install firestopping systems that are produced to resist the spread of fire, and the passage of smoke and other gases according to requirements indicated, including but not limited to the following:

5.1.1 Firestop all penetrations passing through fire resistance rated wall and floor assemblies and other locations as indicated on the drawings.

5.1.2 Provide and install complete penetration firestopping systems that have been tested and approved by third party testing agency.
- F-Rated Through-Penetration Firestop Systems: Provide through-penetration firestop systems with F ratings indicated, as determined per ASTM E 814, but not less than one hour or the fire-resistance
rating of the construction being penetrated.

- **T - Rated Through-Penetration Firestop Systems**: Provide firestop systems with T ratings, in addition to F ratings, as determined per ASTM E 814, where indicated by Code.
- **L – Rated Through-Penetration Firestop Systems**: Provide firestop systems with L ratings, in addition to F and T ratings, as determined per UL 1479, where indicated by Code.
- **W – Rated Through-Penetration Firestop Systems**: Provide firestop systems with W Water Resistance ratings, in addition to F, T and L ratings, as determined per UL 1479, where indicated.

5.2 **Perimeter Fire Containment Systems**: Provide interior perimeter joint systems with fire-resistance ratings indicated, as determined per ASTM E 2307, but not less than the fire-resistance rating of the floor construction.

5.3 **Fire-Resistive Joints**: Provide joint systems with fire-resistance ratings indicated, as determined per UL 2079, but not less than the fire-resistance rating of the construction in which the joint occurs.

5.4 For firestopping exposed to view, traffic, moisture, and physical damage, provide appropriate firestop systems for these conditions.

5.5 Where there is no specific third party tested and classified Firestop System available for particular firestop configuration, the firestopping contractor shall obtain from the firestop manufacturer an Engineering Judgment (EJ) or Equivalent Fire Resistance Rated Assembly (EFRRA) for submittal.

6 **Submittals**

6.1 **General**: Submit in accordance with Section 01300

6.2 Submit Manufacturers Product Data Sheets for each type of product selected. Certify that Firestop Material shall be asbestos free and complies with local regulations.

- Certification by firestopping manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOC’s) and are nontoxic to building occupants.

6.3 Submit system design listings, including illustrations from a qualified testing and inspection agency that is applicable to each firestop configuration

- Where there is no specific third party tested and classified Firestop System available for particular firestop configuration, the firestopping contractor shall obtain from the firestop manufacturer an Engineering Judgment (EJ) or Equivalent Fire Resistance Rated Assembly (EFRRA) for submittal.

6.4 Submit contractor qualifications as noted in “Quality Assurance” article.

6.5 Firestop Penetration Log: The firestopping subcontractor shall provide a log listing the location of each protected penetration, the firestop system manufacturer, and the listed system. Reference the identification labels required in Section 3.08.

6.6 SDS for each product to be used shall be provided to the individual responsible for site coordination of SDS information.

7 **Quality Assurance**

7.1 Fire-Test-Response Characteristics: Provide firestopping System Design Listing by a testing and inspection agency in accordance with the appropriate ASTM Standard(s) per article 1.04. A qualified testing and inspection agency may be UL, FM Research, Intertek Testing Services, Omega Point Laboratories (OPL) or another agency performing testing and follow-up inspection services for firestop materials that is acceptable to the authority having jurisdiction.

7.2 Contractor Qualifications: Acceptable contractors shall meet at least two (2) of the following criteria:

7.2.1 FM Approved in accordance with FM Standard 4991 – Approval of Firestop Contractors.

7.2.2 UL Qualified Firestop Contractor.

7.2.3 Shown to have successfully completed not less than 5 comparable scale projects. Demonstrating successful completion includes, but is not limited to providing:

- Letters of reference from the building owner and design firm attesting to the contractor’s performance on the project in question.

7.2.4 Completion of the manufacturer’s certified product installation training for each manufacturer of firestopping installed. A
manufacturer’s willingness to sell its firestop system products to a contractor or to an installer engaged by the contractor does not, in itself, confer qualification on the buyer.

7.3 Single Source Responsibility: Obtain firestop systems for each kind of penetration and construction condition indicated from a single primary firestop systems manufacturer.

7.3.1 Materials of different manufacture than allowed by the tested and listed system shall not be intermixed in the same firestop system or opening.

7.3.2 Tested and listed firestop systems are to be used before an Engineering Judgment (EJ) or Equivalent Fire Resistance Rated Assembly (EFRRA) is installed.

8 Delivery, Storage, And Handling

8.1 Deliver firestopping products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer.

8.2 Store and handle firestopping materials in accordance with manufacturers written instructions.

9 Project Conditions

9.1 Environmental Conditions: Install firestopping in accordance with manufacturers written instructions.

9.2 Ventilation: Ventilate per firestopping manufacturers' instructions or Safety Data Sheet (SDS)

10 Sequencing And Scheduling

10.1 Project coordination is essential to inform and educate all the parties involved with the firestopping process of their role and how they can affect firestopping on the project. A pre-construction meeting shall be scheduled and required for all parties involved prior to the start of construction. Attendance is mandatory for those contractors/subcontractors performing firestopping work as well as those for whom the firestop contractor has been subcontracted.

11 Environmental Regulations

11.1 All materials shall be asbestos free and comply with local VOC Regulations.

11.2 If required, hazardous disposal of firestop materials shall be strictly observed as noted on the individual SDS.

12 General Firestopping Products

12.1 Systems listed by approved testing agencies, as identified in part 1 above, may be used, providing they conform to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance.

12.2 Available Products: Subject to compliance with requirements, through-penetration firestop systems that may be incorporated into the work include, but are not limited to, those systems indicated on the drawings.

12.3 Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:

- Specified Technologies Incorporated
- 3M Fire Protection Products
- RW Grace
- Tremco
- Or owner approved equal

13 Execution Examination

13.1 Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of firestopping. Notify the responsible party or parties of any unsatisfactory conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

14 Execution Preparation

14.1 Priming: Prime substrates where recommended by firestopping manufacturer using that manufacturer’s recommended products and methods. Confine primers to areas of bond. Do not allow spillage and migration onto exposed surfaces.

14.2 Masking Tape: Use masking tape to prevent firestopping from contacting adjoining surfaces that will remain exposed upon completion of Work. Remove tape as soon as it is possible to do so without disturbing the firestopping seal with substrates.

14.3 Verify that system components are clean, dry, and ready for installation.

14.4 Verify that field dimensions are as shown on the Drawings and as recommended by the manufacturer.
15 Installing Penetration Firestops

15.1 General: Comply with the “System Performance Requirements” article in Part 1 and the through-penetration firestop manufacturer’s installation instructions and drawings pertaining to products and applications indicated.

15.1.1 Coordinate with other trades to assure that all pipes, conduit, cable, and other items, which penetrate fire rated construction, have been permanently installed prior to installation of firestop assemblies.

15.1.2 Schedule the work to assure that partitions and all other construction that conceals penetrations are not erected prior to the installation of firestop and smoke seals.

15.2 Install forming/damming materials and other accessories in accordance with manufacturers written instructions.

15.3 Install fill materials for through-penetration firestop systems by proven techniques to produce the following results:

- Completely fill voids and cavities formed by openings, forming materials, accessories, and penetrating items.
- Install materials so they contact and adhere to substrates formed by openings and penetrating items.
- For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces.

16 Installing Firestop Joint Systems

16.1 General: Comply with the “System Performance Requirements” article in Part 1 and with the firestop manufacturer’s installation instructions and drawings pertaining to products and applications indicated.

16.1.1 Install joint fillers to provide support of firestop materials during application and at the position required to produce the cross-sectional shapes and depths of installed firestop material relative to joint widths that allow optimum sealant movement capability and develop fire-resistance rating required.

16.2 Install systems by proven techniques that result in firestop materials

16.2.1 Directly contacting and fully wetting joint substrates.

16.2.2 Completely filling recesses provided for each joint configuration,

16.2.3 Providing uniform, cross-sectional shapes and depths relative to joint width that optimize movement capability.

16.3 Tool non-sag firestop materials immediately after their application and prior to the time skinning or begins. Form smooth, uniform beads of configuration indicated or required to:

- Produce fire-resistance rating
- Eliminate air pockets
- Ensure contact and adhesion with sides of joint

17 Installing Perimeter Fire Barrier Systems

17.1 General: Comply with “System Performance Requirements” article in Part 1 and with the firestop manufacturer’s installation and drawings pertaining to products and applications indicated.

17.2 Install metal framing, curtain wall insulation, mechanical attachments, saing materials and firestop materials as applicable within the system design.

18 Field Quality Control

18.1 The inspector shall advise the contractor of any deficiencies noted.

18.2 Do not proceed to enclose firestopping with other construction until inspection agency has verified that the firestop installation complies with the requirements.

18.3 Where deficiencies are found, repair or replace the firestopping so that it complies with requirements of tested and listed system design.

19 Cleaning

19.1 Clean off excess fill materials and sealants adjacent to openings and joints as work progresses. Use methods and cleaning materials approved by manufacturers of firestopping products and or assemblies in which openings and joints occur.

19.2 Protect firestopping during and after curing period from contact with contaminating substances. If damage caused by others, owner and general contractor to instruct firestop contractor to make appropriate repairs and charge to appropriate trades.

20 Labeling

20.1 Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently
to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:

- Contractor’s name, address and phone number
- Through-penetration firestop system designation of applicable testing and inspecting agency
- Date of installation
- Through-penetration firestop system manufacturer’s name
- Installer’s name
1 General
1.1 Provide UL listed and FM approved fire pump complete with pump, driver, controller and accessories in accordance with all requirements of NFPA 20 and FM Global Engineering Data Sheet 3-7.
1.2 Related Requirements:
- Section 21 10 00 Water-Based Fire-Suppression Systems.
- Basic Mechanical Requirements.
- Basic Materials and Methods.
- Electrical Requirements.

2 Fire Pump Products
2.1 Horizontal split case, bronze fitted, centrifugal type, with suction and discharge connections in the lower half of the case.
2.2 The pump shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total head. The shut off head shall not exceed 120 percent of rated head for split case pumps, or more than 140 percent for end suction pumps.
2.3 Impeller: Cast bronze, enclosed type, dynamically balanced, keyed to shaft and locked in position.
2.4 Wearing rings: Renewable cast bronze locked in position.
2.5 Bearings: Grease lubricated type with external mounted grease fittings.
2.6 Stuffing Boxes: Deep seal type with split packing glands.
2.7 Shaft: Carbon steel with bronze shaft sleeves.
2.9 Coupling: Pump shall be directly connected to motor by flexible coupling. Coupling guard shall be provided.
2.10 Baseplate: Mount and level pump and motor on and bolt to a one piece cast iron bedplate with drip rim.

2.11 Motor: Open drip proof, ball bearing type. Locked rotor current shall not exceed the values specified in NFPA 20.
2.12 Provide a complete set of UL listed and FM approved fire pump fittings, suitable for capacity and service conditions, including but not limited to the following:
2.12.1 Casing (circulation) relief valve. Valve shall be set below the shut-off pressure at minimum expected suction pressure. Valve shall allow sufficient circulation to prevent the pump from overheating when operating with no discharge.
2.12.2 Suction reducer and discharge increaser when required.
2.12.3 Automatic air release valve.
2.12.4 Suction and discharge gauges.
2.12.5 3-way, [flush] [free standing], [polished brass] outside pump test hose valve manifold, complete with 2½" rough brass hose gate valves with cap and chain. Cast brass plate lettered “Pump Test Connection.”
2.13 Tests
- The pump shall be hydrostatically tested to twice the working pressure but not less than 250 PSI.
- The pump unit shall be given a complete factory performance test. Furnish characteristics curves prepared from the test results. Include curves and test results in the Operation and Maintenance Manuals.
- Provide a field performance test and obtain approval of the installation by the Owner.
2.14 Project requirement:
- [X,XXX] GPM at [XX] PSIG at 100% of standard pump rating.
2.15 Pump Rating:
- [X,XXX] GPM at [XX] PSIG.
- [XX] HP, [XXX]/60/3, 1760 RPM.
2.16 Pump shall be Peerless [4AEF11] or owner approved equal.

3 Fire Pump Controller
3.1 Provide a fire pump controller as indicated and specified below and comply with the requirements of NFPA 20.
3.2 Factory assembled, wired and tested motor control equipment, UL listed and FM approved for
fire pump purposes. Enclose all equipment in approved drip tight enclosures. Combined manual and automatic type incorporating the following:

3.2.1 Disconnect switch: Normal source and emergency source. Externally operable.
3.2.2 Circuit breaker: Normal source and emergency source. Symmetrical amp interrupting capacity of 100,000 amps withstand rating.

3.2.3 (If connecting to an emergency source:) Automatic transfer switch: Electrically operated, mechanically held switch including the following:
   - Form C engine contacts.
   - 0.5 to 6 second power outage override.
   - 0-30 minute retransfer timer.
   - By-pass switch.
   - Test switch- Solid state control panel shall include 0 to 5 minute engine cool down timer and a 0 to 5 minute adjustable transfer to emergency timer. Switch shall be rated 150 amps at [460]/60/3

3.2.4 (If connecting to a generator:) Provide a generator start circuit from the fire pump controller's generator start remote contacts to the generator. Upon loss of normal power, the fire pump controller shall tell the generator to start.
3.2.5 Motor starter: Shall be [primary reactor reduced voltage] [across the line] start. Starter shall be capable of being energized automatically through the pressure switch or manually by means of an externally operable handle.
3.2.6 The controller shall have two independent pressure transducers. One shall be for the fire pump controller and one shall be for the suction pressure. The digital pressure switch shall have start and reset settings that can be set to the nearest 1.0 psi. These settings shall be readable through the door.
3.2.7 All transducers, pressure switches, and all related pressurized wet parts shall all be mounted externally to the side of the controller. They shall also be mechanically protected from damage. No water pressure connection of any kind shall be provided inside the controller enclosure.
3.2.8 Running period timer: Set to keep motor in operation for a minimum period of time when started automatically.
3.2.9 Restart time delay: To ensure that 3 seconds elapse between stopping and restarting motor.
3.2.10 Control circuit: Fully supervised.
3.2.11 Pilot Lights:
   - Power On.
   - Phase Reversal.
   - Transfer Switch Normal.
   - Transfer Switch Emergency.
   - Emergency Isolating Switch Open.

3.2.12 Alarm contacts: Normally open and normally closed remote contacts for the following alarms:
   - AC Power Failure.
   - Phase Reversal.
   - Pump Running.
   - System Trouble.
   - Transfer Switch Normal.
   - Transfer Switch Emergency.
   - Emergency Isolating Switch Open.

3.2.13 Automatic controller: Equipped to start fire pump automatically or manually and wired for manual shutdown.
3.2.14 Pressure recorder. Paperless.

3.3 All printed circuit boards, low voltage field connections, and the HMI display shall be located in a separate compartment of the main enclosure with its own access door. All connections to this compartment from other sections of the enclosure shall be routed through sealed fittings. No voltages above 50 volts shall be present in this compartment so site personnel can access these components without the use of high incident energy Personal Protective Equipment (PPE).

3.4 The fire pump controller shall be comprised of modular chassis with plug-in printed circuit boards, relays, and connectors. These plug-in parts shall be securely latched or locked in place.
3.5 Control power shall be 24 VDC and shall be derived from 3 independent, electrostatically shielded, control power transformers with redundant isolated rectifier circuits.

3.6 A Human Machine Interface (HMI) shall be provided to set up the controller and display the status but shall not be relied on for the controller operation. The accuracy of the display shall be 2 percent or 2 digits and shall be traceable to the National Institute of Standards and Technology.

3.7 The starting and running functions controller shall operate independently of the HMI and shall even operate with the HMI damaged or disconnected.
3.8 The HMI shall be a 5.7 inch, 64 K color touch screen interface that simultaneous displays all 3 phase voltages and currents, the System Pressure, Start/Reset settings, Manual/Auto Stop setting, and the Weekly/Monthly test setting. It
shall also display the starting sequence and pump running status.

3.9 It shall also capture the pump acceptance test values for the following flow condition when the save button is pressed. At 0%, 25%, 50%, 75%, 100%, 125%, and 150% flow, the HMI shall save the time and date, discharge PSI, suction PSI, L1-L2, L2-L3, L3-L1 line voltages, and L1, L2, L3 line currents. The saved values shall be plotted to show the pump curve.

3.10 In addition, the HMI shall be capable of enabling or disabling remote or deluge start, auto testing, minimum run timing, setting sequence timing, and acceleration timing.

3.11 Further, it shall display the following alarms: AC Volts Low, AC Failure, CB Trip, Fail to Start, Load Shed, Lockout, Low Discharge Pressure, On Demand, Motor Overload, Over Pressure, Phase Reversal, PhaseSmart, 8 Pump House Trouble inputs, Pump Run, Single Phase Running, and Transducer Failure.

3.12 A password protected Setup Assistant screen is provided to quickly access the pressure start/reset settings, the sequence, accelerate time settings, the remote/deluge start settings, and the weekly/monthly test settings.

3.13 A Setup summary screen accessible to anyone is available to view all the controller settings.

3.14 A Remote alarm contact testing screen shall be provided to operate each remote alarm contact individually to facilitate remote alarm testing.

3.15 The Alarm Silence shall be provided with a 24 hour auto re-sounding function.

3.16 The internal Data Recorder shall download directly through an external USB waterproof adapter to a USB drive. No codes, settings, or menu operations shall be required. Once the USB is inserted, the data recorder shall recognize the USB drive and indicate “USB Active”. The file shall then be automatically transferred and indicate “USB OK”. The USB drive can then be removed.

3.17 The Data Recorder shall record the system pressure every hour or every time the pressure changes by 5 psi. It shall also record all 3 phase voltages and currents on every alarm event and every 5% change from the previous reading. In addition, all active alarms and the starting sequence shall be recorded.

3.18 A test valve solenoid shall be provided on the outside of the enclosure to facilitate local pressure drop testing or auto testing. It shall include a y-strainer to protect the valve from debris.

3.19 Anytime the test valve is operated, either through the local pressure drop test button or through the auto testing function, the transducer shall be tested. If the pressure reads greater than 10 psi while the valve is open, a Transducer/DVS failure alarm shall activate. If the transducer is disconnected, the pump shall start.

3.20 Phase Smart logic shall be provided to assure that the controller will not start the fire pump under single phase conditions when the voltage on any phase is lower than 65% of the rated motor voltage.

3.21 A control system shall be provided to assure that the controller will not start the fire pump motor under single phase conditions when the voltage on any phase is lower than 65% of the rated motor voltage. However, if the motor is already running when a phase loss occurs, the controller shall keep the motor running.

3.22 The Power Available signal shall indicate when the controller line voltage is less than 85% of the controller rated voltage on any or all phases.

3.23 An audible alarm shall be provided to supervise the Emergency Isolating switch in the open position.

3.24 A mechanical interlock shall be provided between the normal and emergency isolating switches to prevent opening of the normal source until after the emergency source is opened.

3.25 The manufacturer’s published warranty certificate for the entire controller shall be submitted to show that it covers parts and labor for a period of 2 years from startup date and parts for a period of 5 years. In addition, a guarantee shall be provided to cover parts damaged by transient voltage surges, including lightning, up to a maximum of $5,000 for a period of 5 years.

3.26 An Underwriters Laboratories certificate of compliance verifying electromagnetic compatibility (EMC) with other equipment and immunity from other equipment shall be submitted.

3.27 Controller shall be provided in a dust-tight NEMA 12 enclosure with drip-hood. NEMA 4 operators. Enclosure shall be painted with red baked enamel paint.

3.28 Line Terminal connections shall be sized to
accommodate wire sizes shown on Electrical Drawings.

3.29 Manufacturers
- The controller shall be Master Control Systems EC Series or owner approved equal.

4 Jockey Pump
4.1 Pump
4.1.1 Peripheral turbine or centrifugal type pump.
4.1.2 Cast iron body with bronze self-centering enclosure impeller keyed to shaft.
4.2 Shaft: 416 stainless steel with mechanical seal and water slinger to protect bearing.
4.3 Motor: Open, drip proof type.
4.4 Provide pump fittings, suitable for capacity and service conditions, including but not limited to the following:
- Isolation valves on both sides of pump.
- Suction and discharge gauges.
- Pressure relief valve.
- Coupling.
- Foundations: Reinforced concrete of required for alignment.
4.5 Centrifugal multistage jockey pump driven by a [1.0] HP [460] volt, 3 phase, 60 cycle ODP motor. Grundfos Model [CR3-6] or owner approved equal.

5 VFD Jockey Pump Controller
5.1 Provide jockey pump controller as indicated and specified below and complying with the requirements of NFPA-20.
5.2 The controller shall consist of a motor disconnect switch, VFD, pressure transducer, and a MAN, OFF, AUTO selector switch. The Manual mode shall command the VFD to run at the set pressure.
5.3 The jockey pump controller shall be built strictly in accordance with UL-508A and shall be listed by Underwriters Laboratories Inc.
5.4 The controller shall be rated for use in an ambient temperature ranging from +4.5 to 50 degrees Celsius.
5.5 The manufacturer of the VFD shall be the same as that used in the variable speed fire pump controller for the installation.

5.6 The variable frequency drive shall provide a through the door display to adjust the system pressure setting and the proportional, integral, differential loop to within 1% of the pressure set point. Further, it shall be able to accelerate an already spinning motor and shall allow deceleration of the motor without causing a motor over-voltage shutdown.
5.7 The pressure transducer provided to sense the system pressure for the VFD shall be the same as the pressure transducer used in the fire pump controller.
5.8 The pressure transducer shall be plumbed to the outside of the enclosure using a 1/2 inch FNPT brass bulkhead fitting.
5.9 The controller shall be provided in a drip-tight, vented, NEMA2 enclosure with a drip hood.
5.10 Manufacturers: Master Control Systems or owner approved equal.

6 Execution — Fire Pump
6.1 Check and certify final alignment after installation and prior to operation.
6.2 Pipe all drains from baseplate, reliefs, etc., to floor drain.
6.3 Provide all suction and discharge isolation valves and check valves required for the system including pump bypass piping to utilize street pressure.

7 Fire Pump Controller
7.1 Provide for relief of pressure to the pressure actuated switch, to test the operation of the controller and pump.
7.2 Connect pressure sensing line between pump discharge check valve and discharge control valve.
7.3 Multiple pumps shall each have separate sensing line connected to each controller.

8 Jockey Pump
8.1 Level and align pump and motor after installation.
8.2 Pipe all drains and relief valves to floor drain.
9 Jockey Pump Controller

9.1 Set controller to start jockey pump at 5 psi higher than fire pump start point.

9.2 Connect pressure sensing line between pump discharge check valve and discharge control valve.

10 Pump Testing

10.1 Listed fire pump(s) shall meet the test requirements of NFPA-20 and Purdue University. Prior to the final acceptance of the fire pump installation, a complete operational check shall be made under simulated emergency conditions.

11 Suction Pressure Regulating Valve

11.1 Provide a Suction Pressure Regulating Valve for the fire pump as described in the Job Scope specified elsewhere. The valve is to be installed in the discharge line of the fire pump upstream of the backflow device. The device shall be FM approved for its intended use and installed per FM requirements. Pilot control lines to be 1/2 brass. Suction Pressure Regulating Valve to be a Watts figure 116-1FM or approved equal.
1 General

1.1 Provide all material, labor, engineering and operations for the installation of complete and operable fire suppression systems as shown in the job scope and as specified herein.

1.2 Provide all equipment and materials including pipes, valves, fittings, sprinkler heads, fire department connections, backflow preventer, pipe supports, specialties and accessories necessary for a complete and approved fire suppression system.

1.3 Provide a fire service main from the water main into the building, valves, hydrants and components as described in the job scope and/or shown on the Drawings. Make all connections to utilities as required to serve the fire suppression system. Flush the fire service main before connecting to the fire suppression system.

1.4 This Contractor shall be completely responsible for the design, layout, submittals, installation, testing, certification and acceptance of the fire suppression system by the IDHS Division of Fire and Building Safety.

1.5 This Contractor shall be responsible for any damage to the work of others, to the building and to property of others caused by leaks in the fire suppression system. This Contractor shall pay for necessary replacement of work or damaged property during installation and testing period.

1.6 Apply and pay for all permits and fees required for work under this section.

2 Related Requirements

2.1 Section 28 46 00 Fire Detection and Alarm

2.2 Basic Mechanical Requirements

2.3 Basic Materials and Methods

3 Wiring

3.1 All wiring will be provided under the Fire Detection and Alarm Division, unless otherwise indicated. The Fire Detection and Alarm Division will provide all wiring from workflow switches, supervisory switches and alarm bell. Coordinate for proper operation. The Fire Detection and Alarm Division will provide an alarm bell on the exterior of the building.

4 Submittals

4.1 An action submittal for the fire suppression system shall be submitted to the Owner for review and approval prior to system installation and shall include all of the following information.

4.1.1 Hydraulic calculations and shop drawings with riser diagram and system layout showing the actual location of all components. Obtain approval from the IDHS Division of Fire and Building Safety.

4.1.2 Manufacturer's product data sheets for all equipment and materials including pipes, couplings, fittings, valves, sprinkler heads, backflow preventers, fire department connections, pipe supports, specialties and accessories. Indicate which products will be used in the project.

4.2 A closeout submittal for the fire suppression system shall be submitted to the Owner after the system installation is complete and shall include as-built drawings, as-built hydraulic calculations and Operation and Maintenance Manuals for the fire suppression system. These documents should reflect all changes made since the approved action submittal.

4.3 Provide spare parts to the Owner as specified

4.3.1 Provide spare sprinkler heads of each type and temperature rating installed on the project.

4.3.2 Provide one sprinkler wrench for each type of sprinkler head installed on the project.

4.3.3 Mount sprinkler head cabinets on wall next to main riser assembly.

4.3.4 Provide a list of sprinkler heads installed on the project in the sprinkler cabinet.

4.3.5 Specialty sprinkler heads shall include extra escutcheons and cover plates.

5 Quality Assurance

5.1 Contractor Qualifications

- Work shall be performed by a contractor regularly engaged in the design and installation of fire suppression systems.

5.2 Regulatory Requirements

5.2.1 System design, installation and materials shall comply with the applicable regulating agencies and organizations, which include, but are not limited to the following:

- Indiana Department of Homeland Security (IDHS) Division of Fire and Building Safety.
• Underwriters Laboratories (UL).
• Factory Mutual (FM).
• Purdue University.

5.2.2 System design, installation and materials shall comply with applicable codes, standards, and regulations, which include, but are not limited to the following:
• Indiana Building Code
• Indiana Fire Code
• National Fire Protection Association (NFPA) Codes and Standards

5.2.3 If there is a conflict or discrepancy between the referenced codes, standards or regulations and the Drawings and Specification, it is the Contractor's responsibility to notify the Engineer and Owner in writing prior to installation.

5.2.4 The Contractor shall assume full financial responsibility for compliance with all applicable codes, standards and regulations. This includes compliance for modification or extension of existing systems. All deficiencies shall be corrected at no additional cost to the Owner.

6 Products — General

6.1 All products, equipment and materials shall be new, UL listed, FM Approved, and installed in accordance with the manufacturer's instructions and its listing or approval.

6.2 All products, equipment and materials shall be rated for the maximum working pressures involved, but not less than 175 PSI cold water pressure, unless noted otherwise.

6.3 Pressure gauges shall be UL listed, 3½" dial type with pressure range of not less than twice the normal working pressure. Provide pressure gauges where shown on the Drawings and as required.

7 PIPE

7.1 Pipe shall conform to ASTM Standards.

7.2 The manufacturer's name or brand, and applicable ASTM Standard shall be marked on each length of pipe.

7.3 Pipe shall have a factory applied protective coating to provide resistance to microbiologically influenced corrosion (MIC).

7.4 Grooves shall be rolled and shall be dimensionally compatible with the coupling. Cut grooves are not acceptable.

7.5 Lightwall pipe is not acceptable.

7.6 Schedule 40
• Black steel pipe, ASTM A135 or A53, joined by welded joints, mechanical grooved couplings, or threaded joints.

7.7 Schedule 10
• Black steel pipe, ASTM A135, joined by welded joints or mechanical grooved couplings.

7.8 The following piping shall be galvanized:
• [Note galvanized pipe on drawings or list areas here:]
• Piping exposed to weather.
• Drain piping open to the atmosphere.
• Piping used in a corrosive atmosphere (where noted on the Drawings).
• Piping inside the building upstream of the backflow preventer shall be schedule 40 galvanized only.
• Existing dry and preaction systems that do not have dry pipe nitrogen inerting.

8 Fittings

8.1 Plain end, pressure fit type fittings are not acceptable.

8.2 Hole cut mechanical tee fittings are not acceptable.

8.3 Galvanized piping shall have galvanized fittings.

8.4 1½" pipe and smaller shall have threaded fittings.

8.5 Threaded

8.5.1 Cast iron in accordance with ASME B16.4 Class 125 or 250.

8.5.2 Malleable iron in accordance with ASME B16.3 Class 150 or 300.

8.6 Flanged

8.6.1 Cast iron in accordance with ASME B16.1 Class 125 or 250.

8.6.2 Gaskets shall be full face of 1/8" minimum thickness, red sheet rubber.

8.6.3 Flange bolts shall be hexagon head machine bolts with heavy semi-flushed hexagon head nuts, cadmium plated, with dimensions in accordance with ASME B18.2.

8.7 Welded

8.7.1 Standard weight, black steel in accordance with applicable ASME and ASTM standards.
8.7.2 The branch fitting diameter shall not exceed half of the nominal pipe size.

8.8 Grooved

8.8.1 Couplings and fittings shall be ductile iron conforming to ASTM A536, minimum 350 psi rated pressure. 5", 6", and 8" couplings shall be a minimum of 300 psi rated pressure.

8.8.2 Short pattern fittings shall be full-flow with flow characteristics similar to standard pattern full-flow fittings.

8.8.3 Couplings shall be rigid type. Flexible type couplings shall be used in locations where vibration attenuation and stress relief are required.

8.9 Braided Flexible Hose

8.9.1 Braided flexible hose fittings shall be either FlexHead or VicFlex.

8.9.2 Braided flexible hose fittings shall only be installed with manufacturer approved brackets.

9 Valves

9.1 General

• All valve sizes shall be compatible with the pipe size.

9.2 Gate Valves

9.2.1 1½" pipe and smaller: OS&Y, bronze, threaded.

9.2.2 2" pipe and larger: OS&Y, resilient-seated, iron body, bronze mounted, flanged or grooved.

9.3 Butterfly Valves

9.3.1 Iron body (lug-style or grooved end), minimum 300 PSI rated pressure, and gear operator with position indicator.

9.4 Check Valves

9.4.1 1½" pipe and smaller: bronze, threaded.

9.4.2 2" pipe and larger: Class 150 or 300, center guided, non-slam type, ductile iron body, stainless steel spring, flanged or grooved.

9.5 Relief Valves

• Relief valves shall not be less than ½" in size and set to operate at 175 PSI or 10 PSI in excess of the maximum system pressure, whichever is greater.

9.6 Ball Drip Valves

• ¾" automatic drain, cast brass, Potter Roemer 5980 Series or approved equal.

9.7 Globe and Angle Valves (Drains and Flow

10 Sprinkler Heads

10.1 Temperature Ratings

10.1.1 Ordinary temperature, except where higher temperature sprinkler heads are required.

10.1.2 Sprinkler heads shall be color coded.

10.1.3 Sprinkler heads located in rooms with electrical switchgear shall be 212° F.

10.2 Sprinkler heads in finished ceilings shall be [white] finish [recessed] pendent type with adjustable two piece escutcheons, unless otherwise noted.

10.3 Sprinkler heads in rooms without finished ceilings and unfinished spaces shall be [plain brass] pendent or upright as required.

10.4 Pendent and horizontal sprinkler heads in areas subject to freezing shall be dry type (walk-in coolers/freezers, cold rooms, loading docks).

10.5 Pendent and horizontal sprinkler heads on dry and preaction systems shall be of the dry type only.

10.6 Horizontal sidewall sprinklers shall be [chrome] finish with [chrome] escutcheons. Horizontal sidewall sprinklers shall be used where shown on the Drawings [and shall include the following areas]:

10.7 Window sprinklers shall be quick response, horizontal sidewall or pendent vertical sidewall with [chrome] finish and [chrome] escutcheons. Tyco Model WS or approved equal.

11 Backflow Preventers

11.1 General

11.1.1 Indiana Department of Environmental Management approved, ASSE listed and USC approved.

11.1.2 Backflow preventers shall consist of two resilient seated full flow isolation valves, two independently operating, spring loaded poppet-type internally epoxy coated cast iron check valves and four resilient seated test cocks for field testing. Stainless steel springs and corrosion resistant materials shall be used throughout.
11.2 Double Check Valve Assembly [If the water utility is from Purdue – West Lafayette]
   - Double check valve assembly shall be a Watts Series LF709, Febco LF850, or approved equal.
11.3 Double Check Detector Assembly [If the water utility isn’t from Purdue – West Lafayette]
   - Double check detector assembly shall be a Febco LF856 or approved equal.

12 Fire Department Connections

12.1 General
12.1.1 [Other than IFPW]: Fire department connections shall be listed, [2] [4] way with 2½” inlets x [4] [6]” outlet complete with clappers, hose threads, caps and chains. Potter Roemer Series or approved equal.
12.1.2 [Indiana University Purdue University Fort Wayne (IFPW) Only]: Fire department connections shall be listed, 5” Storz, 30 degree elbow adapter, with heavy and blind cap.
12.1.3 [Wall] [Base] plates shall have 1” letters and read [“AUTO SPKR”] [“STANDPIPE”] [“DRY STANDPIPE”] [“AUTO SPKR AND STANDPIPE”].
12.2 Wall type shall be [flush] [exposed] with a [polished brass] [polished chrome plated] finish.
12.3 Free standing type shall have cast brass body with [polished brass] [rough brass] [polished chrome plated] finish. [Polished brass] [Polished chrome plated] trim and seamless cover sleeve. Cast brass base plate.

13 Hose Connections

13.1 Non-adjustable pressure regulating angle valve (where pressure is 100 PSI or higher)
13.1.1 1½” hose thread outlet, UL listed, cast brass, 300 PSI rated, brass finish with cap and chain. Potter Roemer 4045 or approved equal.
13.1.2 2½” hose thread outlet, UL listed, cast brass, 300 PSI rated, brass finish with cap and chain. Potter Roemer 4053 or approved equal.
13.2 Angle hose valve (where pressure is less than 100 PSI)
13.2.1 1½”, UL listed and FM approved, cast brass, 300 PSI rated, hose thread outlet, polished brass finish with cap and chain. Potter Roemer 4060 or approved equal.
13.2.2 2½”, UL listed and FM approved, cast brass, 300 PSI rated, hose thread outlet, polished brass finish with cap and chain. Potter Roemer 4065 or approved equal.

14 Dry Pipe Valve Assemblies

14.1 Provide A Complete Dry Pipe Valve Assembly With Accessories And Trim Package Including But Not Limited To Drain Valves, Check Valves, Test Valve, Alarm Pressure Switch, Low-Air Supervisory Switch, Drain Cup, Reset Bar And Pressure Gauges. Provide Accelerator As Required. Viking Or Approved Equal.

15 Deluge Valve Assemblies

15.1 Provide a complete deluge valve assembly with accessories and trim package including but not limited to emergency release, pressure
operated relief valve, drain valves, check valves, test valve, drain cup, pressure gauges. System shall have [hydraulic release] [electric actuation] [pneumatic actuation]. Viking [model e-1] [model e-2] or approved equal.

16 Preaction Valve Assemblies
16.1 Double interlock, supervised, dry system with deluge valve controlled by an electric release system and pneumatic system pressure. The electric detector system must actuate and a sprinkler must operate before water will enter the system. Activation of one without the other shall only sound an alarm. System shall include all valves, trim, accessories and components to provide a complete assembly. System shall be of a fail-safe design on loss of power. Viking Surefire or approved equal.

16.2 Release control panel shall be Viking VFR-400.

16.3 Deluge Valve and Trim

- Deluge Valve.
- Test drain valve.
- Auxiliary drain valve.
- Drain cup.
- Drip check.
- Alarm test shut-off valve.
- Strainer orifice check valve.
- Pressure operated relief valve.
- Priming valve.
- Emergency release. Ball valve with stainless steel enclosure.
- Priming pressure gauge and valve.
- Water supply pressure gauge and valve.

16.4 Water Flow Alarm Trim

- Alarm pressure switch.

16.5 Riser Valves

- Water supply control valve.
- Rubber seat check valve.
- Main system drain valve.

16.6 System Air/Nitrogen Supply Trim

- System pressure gauge and valve.
- Soft seat check valve.
- Air pressure supervisory switch.
- Air maintenance control device.

16.7 Air supply control valve

16.7.1 Release Trim

16.8 Pneumatic actuator.

- Solenoid Valves.

17 Corrosion Prevention
17.1 Wet Pipe Nitrogen Inerting

17.1.1 Nitrogen inerting vents and injection ports shall be ECS PAV-WN or approved equal.

17.1.2 Wet pipe nitrogen inerting procedure components shall be ECS NISK-1 or approved equal.

17.1.3 Handheld gas analyzer shall be ECS PHGA-1.

17.2 Dry Pipe Nitrogen Inerting (Dry and Preaction Systems)

17.2.1 Nitrogen generator shall be ECS PGEN or approved equal.

17.2.2 Air maintenance devices shall be Victaulic 757, Tyco AMD-1, or Reliable A-2.

17.2.3 Dry vent shall be ECS PAV-D or approved equal.

17.3 Corrosion monitoring station shall be ECS ICMS and probe with push button test ECS DCMP-3 or approved equal.

18 Fire Alarm Devices

18.1 Waterflow switches shall be vane type with field replaceable instantly recycling adjustable pneumatic retard and visual indication of activation. Potter VSR or approved equal.

18.2 Valve Supervisory Switches — Die cast enclosure with red enamel finish and tamper resistant screws. Two sets of contacts. Mounting device shall be weatherproof and suitable for indoor or outdoor use. Potter or approved equal.

- Post-Indicator Valves: Potter PCVS-2.

19 Execution Examination
19.1 Verification of Conditions

19.1.1 Examination shall be done before design approval and fabrication. Prefabrication is done at This Contractor’s risk.

19.1.2 Examine the project site and become familiar with the actual job conditions under which the work will be performed.

19.1.3 Coordinate all work and placement of components with other trades.

19.1.4 Verify all dimensions. Be responsible for all measurements, fitting and assembly of all work.
19.1.5 Modify design as required to integrate with actual job conditions, coordination and dimensions.
19.1.6 This Contractor shall be responsible for any redesign and refabricating.

20 Preparation
20.1 The action submittal for the fire suppression system must be approved before work may begin.
20.2 Inspect pipe and fittings for defects and clean all dirt and other foreign matter prior to installation. Damaged pipe and fittings will be rejected.

21 Installation
21.1 General
21.1.1 Contractor shall make all connections to utilities as required to install the system. All connections to utilities and their shutdown shall be arranged with the Owner.
21.1.2 The sprinkler system shall be zoned on a floor-by-floor basis. In addition, systems protecting special hazards shall be zoned separately.
21.1.3 Install chrome plated and other finished components with care so that marring does not occur to the finish.
21.2 Pipe
21.2.1 The Drawings indicate general intent and location. Install piping in the most direct and straight manner as possible.
21.2.2 Install piping high enough to permit relocation of lights without moving ceiling grid.
21.2.3 Conceal piping in finished areas unless otherwise shown on the Drawings.
21.2.4 Install vertical lines plumb and horizontal lines parallel to building lines.
21.2.5 Install horizontal piping pitched to low points and in a manner to make it possible to test and empty entire system. Provide valves at low points to facilitate system drainage.
21.2.6 Protect open pipe ends whenever work is suspended during construction to prevent foreign material from entering.
21.2.7 Protect piping that passes through non-sprinkler areas with fire resistive construction as required by code and approved by the Owner.
21.2.8 This Contractor shall sterilize all piping upstream of fire sprinkler system backflow preventer.
21.3 Pipe Hangers and Supports — Support piping from the structure above with hangers. Sizing, spacing and installation shall be in accordance with NFPA 13, unless otherwise shown on the Drawings or specified herein. Comply with other sections of this specification relating to Basic Mechanical Materials and Methods.
21.3.1 Seismic Performance [New Buildings with a Seismic Design Category “C” or higher]
   • System piping shall be capable of withstanding the effects of earthquake motions determined in accordance with the Indiana Building Code and NFPA 13.
   • [Some existing facilities require seismic bracing.]
21.4 Pipe Sleeves
21.4.1 Provide sleeves for pipes passing through building walls and floors above grade.
21.4.2 The annular spaces between pipe and sleeves shall be sealed with caulking or shall be fire stopped where required.
21.4.3 Provide [chrome plated] escutcheons large enough to cover the pipe sleeve in finished areas.
21.5 Sprinkler Heads
21.5.1 Install sprinkler heads in accordance with the manufacturer's instructions. Heads shall be installed to satisfy all code requirements for head spacing.
21.5.2 Center sprinkler heads in grid or lay-in ceilings in both directions.
   • Exception: In rooms with an area of 150 sq. ft. or less, sprinkler heads may be centered in the grid or tile in one direction only.
21.5.3 Coordinate location of sprinkler heads with ceiling grid, diffusers, light fixtures and other obstructions. Provide additional sprinkler heads which may be required for coordinated ceiling pattern and for centering, even though it may exceed minimum code requirements. Show actual sprinkler head locations in the action submittal and closeout submittal.
21.5.4 Provide sprinkler head guards on heads below 7'6" above the floor or walkway or where sprinkler heads may be exposed or subject to damage.
21.5.5 Protect finishes against scratches, dents and discoloration. Defective items will not be accepted.
21.5.6 Only new sprinklers shall be installed. When a sprinkler head has been removed from the piping for any reason, it shall not be
reinstalled. Install a new sprinkler head that matches the specifications of other sprinkler heads in the same compartment.

21.5.7 Sprinkler head locations shown on the Drawings are for general intent only. This Contractor is responsible for a system layout in accordance with code requirements and Owner specification.

21.6 Main Riser and/or Header Assembly — Provide main riser or header assembly consisting of a backflow preventer, fire department connection, drain valve, pressure gauge, main waterflow switch, and [corrosion monitoring station].

21.7 Backflow Preventers

21.7.1 Install in compliance with state regulations. Mount horizontal, maximum 4 ft. above the floor.

21.7.2 Complete full flow backflow preventer test to ensure proper operation. Inspection shall be performed by a registered inspector in accordance with the Indiana Department of Environmental Management. Submit reports to the Owner and include a copy in the Operation and Maintenance manuals.

21.8 Fire Department Connections — Provide a check valve with ball drip valve in line connecting fire department connection to fire suppression system.

21.9 Inspector’s Test Connections

21.10 Inspector’s test connections shall be installed at the most remote point of each sprinkler system zone. Test connections shall be provided with a 1” pipe and valve. Test pipe shall discharge to the outside through a corrosion resistant orifice of the proper size, where it can easily be seen. Location of discharge shall be as approved by the Owner.

21.11 Sectional Control Assembly — Provide sectional control assembly for each sprinkler zone. Sectional control assembly shall include supervised shut off valve, [check valve], pressure gauge, water flow indicator, test valve, drain valve, sight glass, and restricted orifice union of the proper size

21.12 Drains — Pipe drains to terminate at floor drains or outside the building as shown on the Drawings or as specified. Location of drains to the building exterior shall be approved by the Owner.

21.13 Ball Drip Valves — Locate ball drips in accessible locations and pipe discharge full size to nearest floor drain.

21.14 Fire Alarm Devices — Provide a waterflow switch for each sprinkler zone. Provide a redundant hardwired main waterflow switch upstream of all of the sprinkler zones.

21.15 Valve Supervisory Switches — Provide valve supervisory switches for all water supply shut-off valves.

22 Corrosion Prevention Installation

22.1 Wet Pipe Nitrogen Inerting

22.1.1 Provide nitrogen inerting vents at an accessible, remote high point of each sprinkler zone where the pressure gauge is visible from below. The location of the vents shall be proposed in the action submittal and approved by the Owner.

22.1.2 Provide nitrogen inerting vents at the top of each standpipe or combination riser.

22.1.3 Provide nitrogen injection ports for each nitrogen inerting vent at the riser on system side of the sectional control assembly.

22.1.4 Provide wet pipe nitrogen inerting procedure components which includes a 3/8” rubber hose, a nitrogen cylinder regulator, and brass couplers for quick connection.

22.1.5 Provide handheld gas analyzer to sample the gas concentration during the wet pipe nitrogen inerting procedure.

22.1.6 Provide nitrogen to fully inert all wet pipe sprinkler zones and standpipe or combination risers in accordance with the manufacturer’s wet pipe nitrogen inerting procedure.

22.2 Dry Pipe Nitrogen Inerting

22.2.1 Provide a nitrogen generation system to serve dry and preaction sprinkler systems.

22.2.2 Provide a manual dry vent for each dry/preaction sprinkler system on the system side of the valve.

22.2.3 Provide a separate air compressor if the nitrogen generation system does not meet fast fill requirements. Install tank mounted air compressors on neoprene vibration isolation pads Kinetics Model NGD and 4” concrete pad.

22.3 Corrosion Monitoring Station

22.3.1 Provide corrosion monitoring station on the main sprinkler riser downstream of the double check valve, in an accessible location and in accordance with manufacturer’s instructions. Complete the manufacturer’s procedure to place the corrosion monitoring station in service.
22.3.2 Provide probe with push button test for visual indication of corrosion activity.

23 Wet Pipe Sprinkler Systems

23.1 General

23.1.1 Fire sprinklers shall be provided for the [entire building.] [project area.]

23.1.2 [The following sprinkler zones shall be provided:]

23.1.3 Do not install sprinkler piping or sprinkler heads in elevator shafts or elevator equipment rooms.

23.1.4 Do not install sprinkler heads in transformer vault.

23.1.5 Provide sprinkler heads at all stair landings, except intermediate landings.

23.2 Design Criteria: [Provided by Purdue Fire Protection Engineering] — The system shall be hydraulically calculated to provide [X.XX] GPM/ft² over the most hydraulically remote [X,XXX] ft², including [XXX] GPM hose allowance. Sprinklers shall have a maximum coverage area of [XXX] ft² per head. The design area of operation shall not be decreased, even when allowed by NFPA 13.

23.3 [Paint Spray:] — Provide sprinkler heads in finishing room and for paint spray booth and related exhaust ductwork in accordance with NFPA 33. Maximum 12 ft. sprinkler spacing in ductwork. Use dry type sprinkler heads in ductwork as required. All sprinklers shall be controlled by an accessible and supervised OS&Y sectional control valve.

24 Dry Pipe Sprinkler Systems

24.1 General

24.1.1 [Provide dry pipe sprinkler systems for:]  

24.1.2 Provide a nitrogen/air supply line from the nitrogen generation system. Provide air maintenance device and check valve at connection to the trim work.

24.2 Design Criteria: [Provided by Purdue Fire Protection Engineering]  

24.2.1 The system shall be hydraulically calculated to provide [X.XX] GPM/ft² over the most hydraulically remote [X,XXX] ft², including [XXX] GPM hose allowance. Sprinklers shall have a maximum coverage area of [XXX] ft² per head. The design area of operation shall not be decreased, even when allowed by NFPA 13.

25 Preaction Sprinkler Systems

25.1 General

25.1.1 [Provide double interlocked preaction system for:]  

25.1.2 Provide a nitrogen/air supply line from the nitrogen generation system. Provide air maintenance device and check valve at connection to the trim work.

25.1.3 Emergency release shall be provided at deluge valve. An additional release shall be located in [choose location]. Pipe drain to floor drain located in [choose location].

25.1.4 This Contractor shall provide a completely pre-assembled, pre-wired fire protection valve system that includes trim piping and a release panel. The Electrical Contractor shall be responsible for programming the release panel, setting pressure switch trip points, verifying the proper operation of the preaction system controlled by the releasing panel, and connecting the release panel to the fire alarm system. The fire alarm system will monitor alarm, trouble and supervisory conditions from the release panel. The Electrical Contractor will provide system initiating devices and will terminate associated wiring. Coordinate for proper operation.

25.2 Design Criteria: [Provided by Purdue Fire Protection Engineering]  

25.2.1 The system shall be hydraulically calculated to provide [0.XX] GPM/ft² over the most hydraulically remote [X,XXX] ft², including [XXX] GPM hose allowance. Sprinklers shall have a maximum coverage area of [XXX] ft² per head. The design area of operation shall not be decreased, even when allowed by NFPA 13.

26 Hydraulic Calculations

26.1 General

26.1.1 This Contractor shall prepare hydraulic calculations for the design of the system and submit to the Owner and IDHS Division of Fire and Building Safety for approval before any fabrication or installation is started.

26.1.2 Hydraulic calculations shall include the volume in gallons of all systems installed.

26.2 Flow Test Data: [If the water utility is from Purdue – West Lafayette]  

26.2.1 This flow test data shall be used in the design of the system: Static pressure of [XX] PSI, with a residual pressure of [XX] PSI flowing [X,XXX] GPM.

26.3 Flow Test Data: [If the water utility isn't from
Purdue – West Lafayette

26.3.1 Flow tests shall be performed by This Contractor and verified by local fire department. Make all arrangements and pay for all costs involved.
26.3.2 This Contractor shall use 85% of the flow test pressure data in the hydraulic calculations.

27 Standpipe Systems

27.1 Provide a [Class I] [Class II] [Class III], [automatic-dry] [semiautomatic-dry] [manual-dry] [automatic-wet] [semiautomatic-wet] [manual-wet] standpipe in each stairway in accordance with NFPA 14. The system shall be [pipe sized] [hydraulically designed to provide the required minimum pressure and flow rate].

27.2 Provide a [1½] [2½]” hose valve, 4 ft. above the floor, at the following locations:
- At each intermediate landing between floor levels in every required exit stairway.
- At the highest landing of stairways with stairway access to the roof.

27.3 At each standpipe where stairway does not access the roof, provide a roof manifold when the roof has a slope of less than 4” in 12”. Where lines pass through the roof, provide flashing and counterflashing as required for a watertight installation. Roof manifold is not required if stairway goes to roof.

27.4 All standpipes shall be interconnected at the bottom. Provide isolation valve for all risers.

27.5 Provide drain valves with hose connection at the low point of all standpipes downstream of the isolation valve.

27.6 Provide a ¾” water connection with shut-off valve and check valve for maintaining water within a manual-wet system. Water supply connection shall be made downstream of backflow preventer.

27.7 Provide sign at each hose connection for manual standpipes that reads "MANUAL STANDPIPE FOR FIRE DEPARTMENT USE ONLY".

28 Existing Construction

28.1 General

28.2 Provide all work necessary to accommodate additions and alterations as required to meet code requirements and this Specification.

28.3 Existing Fire Suppression Systems:

28.4 Modify the fire suppression system to accommodate renovations that affect sprinkler spacing or coverage. Relocate existing piping or provide additional sprinkler heads and piping to accommodate new work.

28.5 Only new sprinklers shall be installed. When a sprinkler head has been removed from the piping for any reason, it shall not be reinstalled. Install a new sprinkler head that matches the specifications of other sprinkler heads in the same compartment.

28.6 Piping and sprinkler heads shown on the Drawings and old record drawings are for general information and reference only. This Contractor shall examine the project site for verification.

28.7 Existing fire suppression systems can be shut down and drained by the Owner after the action submittal is approved. Plan work so that the interruption is minimized. Provide temporary caps to isolate piping to areas where work is being performed.

29 Identification

29.1 Identify piping installed in this project, exposed or concealed, with a label.

29.2 Piping shall be labeled close to valves, at changes in direction, at branches, at access panels, before pipes pass through the floor and at entry point into rooms; however, spacing of labels shall not exceed 20 ft. Labels shall be in contrasting colors such as black on white placed in conspicuous location subject to approval by the Owner.

29.3 The label shall consist of an arrow, approximately 6” in length with the width to be determined by letter height, and an abbreviation of the service ("FL" for Fireline). The following letter sizes shall apply:
- Pipe under 1” diameter: Letter Size ½”
- Pipe 1” to 3” diameter: Letter Size 1”
- Pipe over 3” diameter: Letter Size 2”

30 Painting

30.1 All exposed fire suppression piping shall be painted. Except in mechanical, general storage and utility areas, paint shall match interior finish or as specified by Owner. Mechanical, general storage and utility shall be painted red equal to Glidden #4520 or Rustoleum #964.
31 Closeout Activities

31.1 Testing and Acceptance

31.1.1 Perform all operational and acceptance tests required by NFPA 13 and 14. All tests shall be made in the presence of the Owner's representative.

31.1.2 Test all piping hydrostatically at not less than 200 PSI for 2 hours without loss of pressure. Retest piping that fails initial tests after correction of defective work.

31.1.3 Schedule a final acceptance test with Owner at least seven days in advance.

31.1.4 Complete and sign Contractor's Material and Test Certificates. Pay for all inspections by the authority having jurisdiction and obtain approval of the installation. Include copies of the certificates in the Operations and Maintenance Manuals.

31.2 Demonstration

31.2.1 When required approvals of this work have been obtained, schedule to demonstrate to the Owner's fire equipment personnel the operation and maintenance of the systems.

31.2.2 Demonstrate equipment, specialties, and accessories. Review operating and maintenance information.

31.3 Corrosion Prevention Procedures

31.3.1 Complete the manufacturer’s wet pipe nitrogen inerting procedure for all wet pipe fire suppression zones. Each zone shall have at least 98% nitrogen after the final cycle.

31.3.2 Complete the procedure to place the corrosion monitoring station in service.
1 General

2 Related Documents

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

3 Summary

3.1 Purdue University has hired a third party arc flash consultant (AFC) to perform an fault current study, protective device coordination study and arc flash study for this project. The arc flash consultant coordinates with the A/E Electrical Engineer of Record during the study process. The arc flash study process starts during design development and ends no later than building occupancy.

3.2 The study process consists of three arc flash report phases. These are:

3.2.1 “As-Drawn” (during design) which is completed by Final Review Construction Document Submittal. The “As-Drawn” report and back-up files must be reviewed and approved by Purdue before the “Construction” phase report can begin.

3.2.2 “Construction” during the submittal and construction phase to confirm the electrical equipment submitted to be furnished and installed is consistent with the “As-Drawn” phase from the arc flash point of view. Different manufacturers may result in different arc flash study results. The “Construction” report and back-up files must be reviewed and approved by Purdue before the “Final” phase report can begin.

3.2.3 “Final” which is due no later than building occupancy and where the AFC field verifies that the components of the electrical installation are consistent with the design and submittals to ensure an accurate overall arc flash study. The “Final” report and back-up files must be reviewed and approved by Purdue before the Arc Flash labels can be field installed by the AFC.

3.2.4 This contractor shall be responsible to provide the information detailed below to the AFC and to assist the AFC in the field where required in this process to complete the studies.

4 Products (Not Used)

5 Execution

6 “Construction” Phase

6.1 Submit one copy of each electrical distribution system submittal (same as submitted to the A/E Electrical Engineer of Record) directly to the AFC for a simultaneous review by the AFC.

6.1.1 Submit Product Data for over-current protective devices specified in other Division 26 Sections and listed below. Use equipment designation tags that are consistent with A/E contract document drawings, specifications and electrical distribution system one-line diagrams.

6.1.2 Using the contract document drawings and the Electrical Distribution System Diagram, provide the following submittals for this ‘construction’ phase to the AFC:

- Circuit-breaker and fuse-current ratings and types. Include equipment voltage, ampere rating, fault current setting, manufacturer/model number, trip unit number and trip setting.
- Relays and associated power and current transformer ratings and ratios.
- Transformer kilovolt amperes (kVA), primary and secondary voltages, connection type, impedance, and X/R ratios.
- Conduit, Wire and Cables: Indicate conduit material, sizes of conductors, conductor material, and insulation type.
- Motor horsepower and code letter designation according to NEMA MG 1 for all three phase motors 50 HP and larger.

6.2 The AFC will update the arc flash model with project specific information from each submittal and forward any submittal review comments to the A/E Electrical Engineer of Record in a timely manner.

6.3 The A/E Electrical Engineer of Record will incorporate the AFC comments into each submittal review and forward to Purdue for final approval/distribution.

6.4 After each submittal listed in Paragraph 3.1.A.2. is received back from Purdue, submit one copy of each of the final approved submittals during the “construction” phase to the AFC. Electronic submittal of final approved submittals to AFC is acceptable.

7 “Final” Phase

7.1 Prior to substantial completion, submit the following information to the AFC:
7.1.1 Cables Lengths: For each feeder on the contract document’s electrical one line diagram and for all pieces of mechanical equipment with a remote safety switch or starter, provide the cable length. This includes conduit type, cable length, cable size, cable insulation type, number of conductors per phase, and ground conductor size.

7.1.2 Prior to building occupancy the contractor shall set the trip settings of all breakers using information provided by the AFC. This includes obtaining manufacturer’s codes, keys, special equipment and/or service personnel to accomplish setting the trips.

7.2 This Contractor shall assist the AFC in verifying the final installation by opening rooms, panel dead fronts, switches, panel doors, etc. for every piece of equipment.

7.3 The AFC will be responsible for determining the accuracy of all trip settings and provide supporting documentation that this activity has been completed. The supporting documentation shall be a signed and dated letter from the AFC stating that the breaker settings displayed in the protective device settings sheet have been field verified for accuracy. The letter shall be included in the final report.

7.4 The AFC shall send the final report to Purdue for review and approval before field installing any Arc Flash labels for the project in question.

7.5 Once Purdue has approved the final report, the Arc Flash labels may be field installed by the AFC. Note: This needs to occur before Purdue occupies the building.
Note: The A/E must choose all design values in brackets below before using in project specifications

1 General
1.1 Provide all material, labor, engineering and operations necessary for the installation of a complete, operable fire detection and alarm system as shown on the drawings and as specified herein.
1.2 The fire alarm system shall be initially configured by the manufacturer.

2 Related Requirements
2.1 Section 211000 Water-Based Fire-Suppression Systems.

3 Reference
3.1 Abbreviations and Acronyms:
   - FACP - Fire Alarm Control Panel
   - FASP - Fire Alarm Sub-Control Panel
   - FAPS - Fire Alarm Power Supply
   - RAAP - Remote Alarm Annunciator Panel
   - FABC - Fire Alarm Battery Cabinet
   - ANAC - Addressable Notification Appliance Controller

4 Submittals
4.1 An action submittal for the fire alarm system shall be submitted to the owner for review and approval prior to system installation and shall include all of the following:
   - Voltage calculations and shop drawings with riser diagram and system layout showing the actual location of all components including initiating devices, notification appliances with candela ratings, control devices, monitoring devices, FACP, FASP, FAPS, RAAP, FABC, ANAC. Include the number of conductors, zones and conduit sizes.
   - Manufacturer’s product data sheets for all equipment and materials. Indicate which products will be used in the project.
4.2 A closeout submittal for the fire alarm system shall be submitted to the Owner after the system installation is complete and shall include all of the following:
   - Record documentation with all changes made since the approved action submittal.
   - A schedule of circuits and components by function, location and wire code.
   - A sequence of operation including a troubleshooting guide of the system.
   - Provide a “Fire Alarm System Record of Completion” in accordance with NFPA 72.
   - Provide a digital copy of the complete programming for the FACP.
   - All parts, maintenance manuals, keys, and a list of spare devices.
   - Furnish spare devices to the Owner as specified.
     4.9.1 Furnish spare devices of each type installed on the project. The amount of spare devices shall be 6% of the total devices but not less than one device. This includes all notification appliances and initiating devices.
     4.9.2 Furnish one of each type of module installed on this project.

5 Quality Assurance
5.1 Contractor Qualifications
5.1.1 The operation and configuration of the fire alarm system shall be certified by a Fire Protection Engineering Technician. The technician shall be a full-time employee of the system sub-contractor and be National Institute for Certification in Engineering Technologies (NICET) Level II certified, in the technical subfield of Fire Alarm Systems.
5.1.2 Work shall be performed by a contractor regularly engaged in the design and installation of fire alarm systems.

5.2 Regulatory Requirements
5.2.1 System design, installation and materials shall comply with the applicable regulating agencies and organizations, which include, but are not limited to the following:
   - Indiana Department of Homeland Security (IDHS) Division of Fire and Building Safety.
   - Underwriters Laboratories (UL).
   - Factory Mutual (FM).
   - Purdue University
5.3 System design, installation and materials shall comply with applicable codes, standards, and regulations, which include, but are not limited to the following:
PHYSICAL FACILITIES
2018 Consultant’s Handbook Specifications
Division 28 Electronic Safety and Security
4600 Fire Detection and Alarm

- Indiana Building Code (IBC)
- Indiana Fire Code (IFC)
- Indiana Electrical Code (IEC)
- Indiana Mechanical Code (IMC)
- National Fire Protection Association (NFPA) Codes and Standards
- Americans with Disabilities Act (ADA)

5.4 It is the contractor’s responsibility to notify the engineer, architect and owner in writing prior to installation if there is a conflict or discrepancy between the applicable codes, standards or regulations and the drawings or specifications.

5.5 The contractor shall assume full financial responsibility for compliance with all applicable codes, standards and regulations. This includes compliance for modification or extension of existing systems. All deficiencies shall be corrected at no additional cost to the Owner.

6 General Products
6.1 All products, equipment and materials shall be new, listed and installed in accordance with the manufacturer’s instructions and its listing.
6.2 Vendors shall be Simplex or Notifier.
6.3 [West Lafayette Campus] All locks on cabinets and manual pull stations shall be replaced with Fort #415 key lock.

7 Wiring
7.1 General
7.1.1 All fire alarm system wiring shall be sized and installed per fire alarm vendor and manufacturer’s recommendations. The contractor shall verify specific requirements with fire alarm vendor and make necessary changes both in sizes and quantities.
7.1.2 Notification appliance circuits shall be loaded to not more than 75% of the circuit power rating.
7.1.3 Plenum-rated cables shall be approved by the Owner.
7.2 Wiring
7.2.1 12 AWG for AC, power supply connections
7.2.2 14 AWG for DC, power supply connections
7.2.3 12 AWG for DC, Audio/Visual Device Power (non-addressable)
7.2.4 2C/14 AWG UTP for DC, Audio/Visual Device Power (Simplex Addressable)

7.2.5 14 AWG for Discrete Control Circuits
7.2.6 IDNet/Mapnet/FlashScan/Data, and Network Communications (addressable systems) cable shall be 2/c, 18 AWG, solid copper and shielded. Manhattan Cable M39124, West Penn 975 or approved equal. If Simplex 4100ES is used then IDNet+ circuits do not require shielded cable. Unshielded twisted-pair wire shall be 2/c, 18 AWG, solid copper. West Penn 980 or approved equal.
7.2.7 All non-addressable signal and power cabling shall be type FPL, solid or stranded copper. Correct wire gauge indicated above. West Penn 994, 998, Manhattan Cable M39070, M39069, or approved equal.
7.2.8 Speaker cable shall be 2/c, 16 AWG, solid or stranded copper and shielded. Manhattan Cable M39126, West Penn 991 or approved equal.

7.3 Labels
7.3.1 All terminals shall be numbered and match the record documentation designations.
7.3.2 All switches shall be labeled as to function and/or position (“Normal”, “Test”)

7.4 Conductors
7.4.1 Black (Hot) and White (Neutral) for all 120V power wiring.
7.4.2 All fire alarm cable shall have red (positive) and black (negative) conductors with a red outer jacket.
7.4.3 Label each conductor at each termination.
7.4.4 Labels shall be 2, 3, or 4 characters per termination.
7.4.5 Labels shall be Brady adhesive type.
7.4.6 Labels shall be similar to the following or Owner approved designation:
   - Network data/communications loop label : NWK:1
   - Initiating device circuits(conventional) label: Z-1,
   - Initiating device circuits(addressable) label: M plus (loop #) :1 (panel #) – 1 (device #) -1
   - Notification appliance circuits label : A plus (panel #) : 1 (circuit #) -1
   - Notification appliance circuits(voice) label: V plus (panel #) : 1 (circuit #) -1
   - Addressable module label: M plus (loop #) :1 (panel #) – 1 (device #) -1
   - Control relay(conventional) label: CR-1
- Heat detector (conventional) label: HD-1, Heat detector (addressable) label: M plus (loop #):1 (panel #) – 1 (device #) -1
- Smoke detector (conventional) label: SD-1
- Smoke detector (addressable) label: M plus (loop #):1 (panel #) – 1 (device #) -1
- Post indicator valve label: PIV
- Main waterflow conventional label: M-WF

7.5 All fire alarm system wiring (non-addressable and addressable) shall be installed in metallic raceway. Minimum conduit size ¾", minimum Wiremold size #700. Provide raceway capacity for minimum 20% future conductors.

7.6 All junction boxes, covers, and conduit fittings installed above ceilings or in walls shall be red. J-Boxes and covers installed exposed shall be red. Not required for exposed surface raceway, boxes and fittings, i.e. Wiremold. Paint shall be Glidden #7100 “Fire Red”.

8 Panels

8.1 Fire Alarm Control Panel (FACP) and Fire Alarm Sub-Control Panel (FASP):

8.1.1 FACP and FASP shall be Simplex 4100ES or Notifier Onyx NFS2-3030.

8.1.2 FACP and FASP shall be minimum 16” x 36” 6 unit tub, surface or semi-flush mounted.

8.1.3 FACP and FASP shall have an 80 character minimum alphanumeric display to indicate alarm, supervisory and component status messages and shall include a keypad for use in entering and executing control commands.

8.1.4 FASP shall include a CPU and style-7 network communications card for communication, annunciation, and information sharing with the main FACP and FASP.

8.1.5 FACP shall be equipped with modules that visually display red alarm and yellow trouble LEDs for each zoned (non-supervisory) device. The red LED shall be replaced with a different color LED (yellow, amber) when used to indicate supervisory signals. The color shall not be green or common trouble yellow.

8.1.6 Fire Alarm Test Switches

8.1.7 Provide fire alarm test switches in the FACP and FASP.

8.1.8 Provide one switch for each of the following (unless otherwise specified by Owner):
- All building audible/visible signals - defeat.
- Fire alarm receiving equipment circuit - disconnected.
- Standby battery load - disconnected.
- All Fire Evacuation switch with indication of active alarm to fire alarm receiving equipment when activated (FACP). Red LED type only.
- Sprinkler alarm bell - silence.
- Preaction valve - defeat (one per circuit).
- Waterflow switch and pressure switch - defeat (one per zone).
- All magnetic door holders - defeat (one switch to control all magnets).
- All building fans shutdown - defeat (one switch to control all fans).
- All elevator home - defeat (one switch to control all elevator controllers located in the same elevator equipment room).
- Building smoke detectors - defeat (one per zone; zone defined as a single addressable device or a group of non-addressable devices connected to addressable monitor card). Verify with Architect/Owner the exact configuration or specific requirements for project.
- All duct smoke detectors - defeat (one switch to control all detectors).
- All smoke dampers - defeat (one switch to control all dampers).
- Immediate and time delay computer shutdown - defeat (one per circuit).
- Immediate and time delay computer air-conditioning shutdown - defeat (one per circuit).
- Alternative Automatic Fire-Extinguishing Systems – defeat (one per system).
- Communications/Data circuit - disconnect (one switch for each circuit).

8.1.9 If separate circuits are installed for audible and visual signals, then one defeat switch shall be provided for all of the audible and one for all of the visual signals.

8.1.10 Each fire alarm test switch shall have integral LED indicator and labeled as to function, normal and test.

8.1.11 Indicator lights shall be yellow LED type. NOTE: LEDs signify non-normal switch position, when LED is illuminated this will indicate a trouble condition.

8.1.12 Switch in “center” position (Toggle Type), “out” position (Pushbutton Type) - normal operation. (Verify Type with Vendor).
8.1.13 Switch in “down” or “in” position (Toggle Type), “in” position (Pushbutton Type) - (test) - defeat. (Verify Type with Vendor).
- Particular function is inoperative.
- Integral indicator light “on”.
- Trouble signal transmitted to fire alarm receiving equipment.
- All arranged in a horizontal or vertical row.

8.2 Disconnect Switch
8.2.1 Provide two-gang switch box in bottom left hand corner (1½” from side of panel) of FACP and FASP. Provide GRC conduit coupling on incoming conduit connector and chase nipple switch box to couplings as well as attaching box to panel back. Provide ½” chase nipple in top of box for power wiring to FACP and FASP. Switch box shall be Wiremold V5744-2.
8.2.2 Provide single pole red pilot handle switch for 120V internal panel disconnect and 120V 20A duplex receptacle in new switch box. Wire the receptacle ahead of the pilot switch. Single-pole red pilot handle switch shall be Hubbell 1221-PL or approved equal. Duplex receptacle shall be Hubbell 5362 or approved equal.

8.3 Telecommunications [Purdue West Lafayette Campus]
8.3.1 Provide single gang Wiremold j-box with duplex telephone outlet, Panduit #CJ5E88TIW Office White, Category 5E, T568B wiring standard, 8 conductor jack (2 required), Panduit #CEB1W Office White, single opening wall plate, Panduit #CHF2IW-X, Office White snap-in module in top of opening (1 required) and Panduit #CHB2IW-X, Office White, blank fitting in bottom opening (1 required) mounted in FACP under or near pilot light switch and adjacent to 20A duplex receptacle. Locate phone outlet between receptacle and front edge of FACP cabinet. (2” maximum from j-box bottom to cabinet bottom).
8.3.2 Install 1” conduit with two (2) Commscope #5EN5 “gray”, 24AWG, non-plenum category 5E or two (2) Commscope #5E55 “gray”, 24AWG, plenum category 5E cables back to nearest telephone “IDF” or “BDF” location for connections to telephone system. Contact Owner for Purdue designated room number.
8.3.3 This contractor shall notify the Owners Representative as soon as cables have been installed, so arrangements for cable testing and acceptance can be made with the Owners Telecommunications personnel.

8.4 Remote Alarm Annunciator Panels (RAAP):
- RAAP shall be semi-flush or surface mounted with special steel back box.
- RAAP shall be Simplex 4603-9101 or Notifier LCD-80 and include special steel back box.

9 Power Sources
9.1 General
9.1.1 Power supply and automatic battery charger shall be mounted in the FACP and FASP.
9.1.2 “Back Wiring” of receptacles and switches is not approved. "Side Wiring" using formed eyes is the only approved method of connection.

9.2 Safety Switch
9.2.1 Provide a switch secured in either the on or off position labeled “Fire Alarm Power”.
9.2.2 If the EM panel is a circuit breaker panel, a branch breaker may be used instead of the switch as long as a handle tie/lock and critical circuit tag are installed on the branch breaker.

9.3 Batteries
9.3.1 Self-protecting, lightning resistant, surge protection for input and output.
9.3.2 Battery cabinet shall be surface or semi-flush mounted adjacent to FACP and FASP of at least 12” H x 24” W x 6 ¾” D with battery shelf and solid door. Cabinet finish shall match the FACP and FASP. Include a battery load disconnect switch.
9.3.3 Batteries shall be compatible with the system with at least a 2 year warranty.

10 Initiating Devices
10.1 Manual Pull Stations — Manual pull stations shall be Simplex 4099-9004 or Notifier NBG-12LX.
10.2 Smoke Detectors
10.2.1 Smoke detectors shall have pulsating power on LED indicator that locks on to steady burn in an alarm situation.
10.2.2 Photoelectric smoke sensor shall be Simplex 4098-9714 or Notifier FSP-851.
10.2.3 Sensor base shall be Simplex 4098-9792 or Notifier B210LP.
10.3 Duct Smoke Detectors
10.3.1  Duct smoke sensor shall be Simplex 4098-9714 or Notifier FSP-851R.
10.3.2  Duct sensor housing shall be Simplex 4098-9756 or Notifier DNR.
10.3.3  Remote test station shall be Simplex 2098-9806 or Notifier RTS151KEY.

10.4  Heat Detectors
10.4.1  Heat detectors shall be combination rate of rise/fixed temp, rated at 135°F for areas where ambient temperatures do not exceed 120°F.
10.4.2  Heat sensor shall be Simplex 4098-9733 or Notifier FST-851R.
10.4.3  Sensor base shall be Simplex 4098-9792 or Notifier B210LP.

11 Notification Appliances

11.1  General
11.1.1  Wall mounted notification appliances shall be [red].
11.1.2  Ceiling mounted notification appliances shall be approved by the Owner and shall be [white].
11.2  Audible appliances shall be Simplex 4901-9816, Simplex 4901-9817, Simplex 49AO-WRF, Wheelock MT-12/24-R, Gentex GEH3-WR or Notifier equal.
11.3  Visible appliances shall be Simplex 4906-9109, Simplex 49VO-WRF, Wheelock STR, Gentex GES3-WR or Notifier equal.
11.4  Combination Audible/Visible appliances shall be Simplex 4906-9127, Simplex 49AV-WRF, Wheelock HSR, Gentex GEC3-WR or Notifier equal.
11.5  Emergency Voice/Alarm Communication
11.5.1  Speakers shall be dual voltage evacuation, multi-tap type, set according to vendor’s drawings. Speakers shall operate on a 70.7 VRMS notification circuit.
11.5.2  Voice only appliances shall be Simplex 4902, Wheelock ET, or Gentex SSPK-CLPW or Notifier equal.
11.5.3  Combination voice/visible appliances shall be Simplex 4906, Wheelock ET, Gentex SSPK-WLPR or Notifier equal.

12 Auxiliary Input/Output Devices

12.1  General — Auxiliary hardwired control relays shall be Simplex or Notifier as required by the system. Unit shall be fast acting heavy-duty power relay with full floating movable contact carrier to assure ample wipe, high contact pressure and accurate alignment. Contacts shall be rated as required. Relay shall include deformed cold rolled 16 gauge steel enclosure with screw-type cover, if not mounted in FACP.
12.2  Monitor Module:
12.2.1  Addressable zone monitor—module shall be Simplex 2190-9155, Simplex 4090-9001, Notifier FMM-1 or Notifier FZM-1.
12.2.2  Signal Module—Addressable zone signal module shall be Simplex 2190-9161, Notifier FCM-1.
12.2.3  Relay Module—Addressable relay module shall be Simplex 2190-9163, Simplex 4090-9002, Notifier FRM-1.

13 Knox-Box
13.1  Knox-box shall be [surface] [recessed] mount without a tamper switch.

14 Execution General
14.1  Panels shall have transient surge protection built-in or additionally provided. Provide transient surge protection for wiring runs between buildings and any devices mounted on the exterior of the building.

15 System Description
15.1  The fire alarm system shall be modular with the latest compatible version of software from the manufacturer. The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation.
15.2  All active points, spare points and hardware related points shall include numerical identification as well as a text description.
15.3  Network communication between the FACP and FASP shall be accomplished using a class “A” communications loop. A single open, ground or short on the network loop shall not degrade network communications. Communications on the loop shall be passed in the opposite direction to maintain communications throughout all FASP. The status of the communications link shall be reported at the FACP. The network communications wiring shall be installed in separate conduits to provide maximum survivability of the system.
15.4  FACP and FASP shall provide inputs and outputs as follows:
15.5  Initiating Device Circuits (Alarm & Trouble):
Manual Stations  
Smoke Detectors  
Heat Detectors  
Waterflow Switches  
Supervisory Switches (Trouble Only)  
Pressure Switches (Trouble Only)  
Preaction Solenoid Valves (Trouble Only)  
Alternative Automatic Fire-Extinguishing Systems

15.6 Notification Appliance Circuits (Alarm & Trouble):

- Audible/Visible Signals
- Audible Only Signals
- Visible Only Signals
- Sprinkler Bell

15.7 Control Circuits (Alarm & Trouble):

- Door Holder Control
- Smoke Damper Control
- Air Distribution System Fan Shutdown
- Elevator Recall

15.8 Fire Pump Monitoring (Alarm & Trouble):

- Fire Pump Running
- Fire Pump Controller Loss of Normal Power (Trouble Only)
- Fire Pump Controller Loss of Emergency Power (Trouble Only)
- Fire Pump Controller on Emergency Power (Trouble Only)
- Fire Pump Controller Phase Reversal (Trouble Only)

15.9 [Emergency Voice/Alarm Communication]  
An emergency voice/alarm communication system, integral within the FACP, shall include central voice alarm system components complete with microphone, digital voice controller, custom voice message library, pre-amplifier, amplifiers and tone generators. Features to be included:

15.9.1 70.7 volt output amplifiers with battery backup. Amplifiers shall be UL listed. Provide power to drive all speakers plus 50%. Equally balance all amplifiers. Provide one backup amplifier for every three amplifiers provided. This amplifier shall automatically take over in the event any of the three primary amplifiers fail.

15.9.2 The message shall be custom as designated by the Owner. The words of the message shall be professionally recorded and digitized.

15.9.3 There shall be a designated message for the following: FIRE ALARM EVACUATION

15.9.4 The fire alarm evacuation message shall be initiated automatically.

15.9.5 Voice communications circuits shall be supervised.

16 Installation

16.1 Initiating Devices — General

16.1.1 All initiating devices shall have individual zone addresses.

16.1.2 Final connections of equipment, devices and wiring shall be made under the direct supervision of the manufacturer’s representative.

16.2 Manual Pull Stations

16.2.1 Manual pull stations shall be mounted at 4’ above finished floor.

16.2.2 Manual pull stations shall be surface mounted using Simplex 2975-9178, Notifier SB-10 or semi-flush mounted using Simplex 2099-9813 trim plate, Notifier BG-TR trim ring. Simplex 2099-9814 back ring may be used to surface mount Simplex manual stations to a Wiremold box.

16.3 Smoke Detectors

16.3.1 Smoke detectors should not be located in direct airflow or closer than 36” from an air supply diffuser or return air opening.

16.3.2 Each elevator recall smoke detector, upon activation of alarm, shall home per the Indiana Elevator Safety Code.

16.3.3 The Contractor shall install all conduits, wiring, boxes, etc. for the elevator shaft smoke detectors, unless otherwise noted. However, a blank cover shall be installed on the box instead of the smoke detector and base. The wires shall be tagged in the FACP and the opposite end for future connection. The smoke detector(s) and base(s) shall be turned over to the Owner. If this detector is to control elevator shaft fire damper, this contractor shall install all conduit, wiring and make connections necessary. In this application this detector shall be on a separate zone and have its own defeat switch in FACP.

16.4 Duct Smoke Detectors

16.4.1 Provide duct smoke detectors in accordance with the IMC.

16.4.2 Each duct smoke detector, upon activation of alarm, shall shut down all operational capabilities of the respective air distribution system in accordance with the listing and labeling of appliances used in the system.

16.4.3 The sampling tube shall match duct size.

16.4.4 Provide a remote control station mounted at most 6’ above finished floor with
indicator lights and key test switch in the immediate area near detector.

16.4.5 Duct detectors, remote test stations and indicator lights shall have legend tags denoting which fan unit they serve and the type (conventional or addressable) of the detector.

16.5 Notification Appliances

16.5.1 Provide appropriate back-boxes, adapter plate, and skirts for mounting, supplied by the manufacturer.

16.5.2 Notification appliances, at all outdoor, freezer, or wet locations, shall be installed in weatherproof back-boxes.

16.5.3 All visible notification appliance circuits shall be synchronized to comply with ADA recommendations regarding photo-sensitive epilepsy.

16.6 Auxiliary Input/Output Devices

16.6.1 All signal, monitor, control and relay modules shall be mounted in appropriately sized lift-off-cover JIC type boxes in an accessible location at a maximum of 6’ above finished floor. Where modules are installed above ceiling grids, the location shall be marked on the grid.

16.6.2 All remotely mounted discrete input/output cards shall be installed in J-boxes such that all switches, fuses, LEDs shall be visible and readily accessible.

16.7 Fire Suppression Systems

16.7.1 Coordinate with the fire suppression contractor to provide all necessary wiring for fire suppression systems.

16.7.2 Provide all wiring for waterflow switches. Main waterflow switches shall be hardwired back to the FACP. Provide separate zone circuit wiring to each switch to actuate fire alarm system.

16.7.3 Provide all wiring for supervisory switches. Each supervisory switch shall have a separate zone circuit. Each supervisory switch shall cause a “trouble signal only” if the valve is turned, the unit is removed from its mounting, or housing cover is removed. The FACP shall have indications that distinguish between valve closed and circuit trouble.

16.7.4 Provide all wiring for fire suppression system releasing panels.

16.7.5 Provide a weatherproof alarm bell mounted 10 to 15 feet above grade on the exterior of the building. The alarm bell shall be supervised and actuated by any flow switch through the FACP. Alarm bell shall be 10” 24VDC vibrating type equipped with any options required for the particular location and system. Alarm bell shall be Wheelock MB-G10-24-R.

16.8 Door Release Devices

16.8.1 Magnetic door holders shall be UL 228 listed. Units shall be either wall or floor mounting as indicated on the drawings and be complete with matching door plate (finish to match door hardware). Units shall operate at 24VDC and develop a minimum of 25 lbs. holding power.

16.9 Smoke Dampers

16.9.1 Smoke dampers shall be close upon actuation of a smoke detector or detectors installed in accordance with one of the design methods in the IMC.

16.10 Alternative Automatic Fire-Extinguishing Systems

16.10.1 Wet-chemical systems, dry-chemical systems, foam systems, carbon dioxide systems, halon systems, clean-agent systems shall be connected to the fire alarm system in accordance with the owner’s instructions, the drawings and specifications.

16.11 Connection to Fire Alarm Receiving Equipment [Purdue West Lafayette]:

16.11.1 The fire alarm system shall be capable of transmitting all alarm, trouble and supervisory signals to the Owner’s existing Digitize 3505 Prism LX directly without damage.

16.12 Connection to Fire Alarm Receiving Equipment [Off Site]:

16.12.1 Provide form “C” dry relay contacts for interface to off-site alarm monitoring equipment. Provide for separate alarm, trouble, and supervisory output.

16.12.2 Provide an integral serial digital alarm communicator transmitter (DACT) for connection to central station monitoring.

16.13 Knox-Box

16.13.1 Provide a Knox-Box on the exterior of the building. The installation location shall be approved by the Owner.

17 Supervision

17.1 All Initiating devices and notification appliances shall cause a trouble signal if the device circuitry is broken or the device is removed.

17.2 Power supplies shall cause a trouble signal
if the main or any auxiliary power supply fails.

17.3 All modules shall cause a trouble signal if the device is removed from the circuit.

17.4 The connecting circuit from the FACP to the fire alarm receiving equipment shall cause a trouble signal if the connecting circuit is open or wire to wire short.

17.5 Upon activation of a supervisory device or any of the above listed conditions, the respective trouble LED shall be lit on the FACP and indicated on the display in the FACP, FASP and RAAP.

18 Closeout Activities

18.1 Acceptance Test Preparation
   18.1.1 Verify that the fire alarm system is installed in accordance with the drawings, specifications and the code.
   18.1.2 Test the function of the fire alarm system with the manufacturer’s representative.

18.2 Acceptance Test
   18.2.1 Schedule an acceptance test with the Owner at least seven days in advance.
   18.2.2 The fire alarm system acceptance test will fail if the contractor has not completed the acceptance test preparation.
   18.2.3 Demonstrate the operation of the complete fire alarm system including but not limited to annunciators, initiating devices, notification appliances, emergency control function interfaces, fire suppression system components and connection to fire alarm receiving equipment.
   18.2.4 Acceptance test failures will be rescheduled.

18.3 System Acceptance
   18.3.1 The fire alarm system acceptance shall be coordinated with fire suppression system acceptance.
   18.3.2 The Owner’s Fire Equipment Services personnel shall be given instruction for operating and testing the fire alarm system immediately upon system acceptance.
   18.3.3 Provide the closeout submittal to the Owner upon completion of the fire alarm.