

Management Services

# Facilities Planning and Development

*Consultant Procedures and Design Guidelines*



2010.01

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## 1.0 ORIENTATION

### 1.1 INTRODUCTION

This manual is for use by design consultants providing services to the University of Missouri and describes the minimum design and submittal criteria for University projects. The manual has the following sections.

**Section I, Orientation**, describes the general business relationship between the consultant and University.

**Section II, Planning and Contract Document Development Guidelines**, lists University codes, standards, design review, drawing, and project manual requirements.

**Section III** presents **Design Guidelines** to be used in the design of University facilities.

**Section IV** presents **Outline Specifications and Details** to be incorporated in specifications and construction documents.

**Appendices** follow the sections with additional information supporting this document.

#### 1.1.1 The University of Missouri

The University of Missouri System (UM) is made up of four campuses (Columbia, Kansas City, Rolla, and St. Louis). Each campus has a separate administration. Design and construction projects are typically funded and administered by campus administration.

The University Board of Curators shall approve the hiring of Architects and Engineers Hiring consultants when the fees are more than \$500,000. The Board of Curators also approves schematic plans on projects with construction cost of more than \$5,000,000, project designs on design/build project with construction cost of more than \$5,000,000, material changes to the exterior of buildings or campuses, and final plans, if there are substantial changes from Board approved schematics.

## 1.2 AGREEMENTS BETWEEN THE UNIVERSITY AND CONSULTANT

- 1.2.1 The University **Project Manager** [PM] is the **Owner's Representative** while completing the agreement between the University and the consultant. All instructions and approvals come to the consultant from the PM.
- 1.2.2 The University uses the University of Missouri Standard Consulting Agreement as the contract between the consultant and the University for Design Services. Review this document carefully; the University allows no exceptions to this agreement form. A copy can be found at <http://www.umsystem.edu/ums/departments/fa/management/facilities/guidelines/> . Agreements for non-design services, geotechnical services and land surveyor services are also available there. .
- 1.2.3 The consultant will provide all basic services noted in the agreement form. On major projects, the University will hire a code consultant to audit the design and assist the University in its role as the Authority Having Jurisdiction. The University may also hire other consultants as necessary.
- 1.2.4 Renovation projects normally include a review of existing conditions as a part of the basic services. The University will make all existing documentation available to the consultant.
- 1.2.5 On major projects, the University will stipulate the maximum design fee in the Request for Proposals. On other engagements, the consultant will be asked for a fee proposal.
- 1.2.6 **Fee proposals** should include the consultant's perception of the University's project scope of work and recommended scope of services. The consultant will include proposed fee and estimate of reimbursable expenses, project schedule, and University provided information.
- 1.2.7 . The PM will tell the consultant the expected fee structure [lump sum, not to exceed, or percentage of construction cost] and what exceptions may apply.
- 1.2.8 **Reimbursable and non-reimbursable expenses** are described in the agreement. The consultant should discuss any potential reimbursable expenses with the PM before the proposal is submitted. Reimbursable expenses shall be approved in advance by the PM, will be paid at cost, and must be accompanied by supporting documentation and/or receipts. For agreements paid as a percentage of construction cost, the cost to reproduce and distribute bidding documents is reimbursable, but all miscellaneous expenses like copying, long distance telephone, faxes, overnight mail, computer usage/plotting, and mileage and included in the percentage fee. Reimbursable expenses for travel have limits; the PM will give the consultant a schedule. .

- 1.2.9 The consultant's proposal shall identify **project milestones** and include two weeks for University review of submittals. The PM will provide the consultant with any University schedule requirements.
- 1.2.10 All **design review meetings** should be included in the consultant's basic services fee. Also, basic services include a prebid meeting, a pre-construction meeting, a punch-list inspection, and a final inspection.
- 1.2.11 The number of proposed **construction observation trips** should be identified by the consultant as a part of basic services during construction. The consultant shall discuss the preferred method for additional trip payment with the PM before submitting a proposal. If a per trip unit cost for additional construction trips is used, a trip refers to one person on site for one day and includes the issuance of any related meeting minutes and site visit reports.
- 1.2.12 Unless requested to provide services involving **asbestos containing materials [ACM]**, the University will provide the consultant with the specification for ACM removal. The consultant assumes no design responsibility for work related to ACM removal.
- 1.2.13 The University requires a minimum of **\$1,000,000 professional liability insurance**. The PM will tell the consultant if additional professional liability insurance is required. Additional coverage may be required on major projects and/or projects that present unusual risks. The PM may require this as a reimbursable expense. The consultant may be asked to detail their current professional liability coverage and costs in determining the additional cost to the university.
- 1.2.14 The consultant shall submit proof of the required insurance with the signed agreement. The University will not execute the agreement or approve payments without approved insurance.
- 1.2.15 The University and/or the PM will provide instructions on how to submit payment requests. The process can vary from campus to campus. The university will not process payments unless an executed agreement is on file. In general, invoices must include a detail of the work completed, summarize the total bill for services to date, and note the amount of the current request

### 1.3 DESIGN PROCESS AND APPROVAL

#### 1.3.1 Project Management

1.3.1.1 The University's Project Manager [PM] is the Owner's Representative during the design of the project. All instructions and approvals come to the consultant from the PM. Services rendered but not requested by the PM will not be compensated.

#### 1.3.1

1.3.1.2 The PM manages the total project budget and requires the consultant to manage the construction budget.

1.3.1.3 The PM will manage internal University approvals and instruct the consultant accordingly.

1.3.1.4 The consultant should insist on the timely owner provided information and approvals. The University asks the consultant to notify the PM of owner related delays before the schedule is jeopardized.

1.3.1.5 The consultant must notify the PM immediately if the consultant believes additional services are requested by the University. This also applies to abandoned work. A fee must be negotiated and the agreement adjusted immediately.

#### 1.3.2 Meetings and Shareholders

1.3.2.1 University projects normally involve many academic, student, and service groups as shareholders in a project. The PM arranges for and coordinates the consultant's contact with these groups. Meetings are scheduled by the PM's office.

1.3.2.2 Campus Facilities Management organizations provide in-house design & construction related services at each campus. The PM will arrange for and coordinate the consultant's contact with these groups.

1.3.2.3 Meeting minutes are kept by the consultant and reviewed by the PM before issue. Meeting minutes should be issued to all participants within five working days.

1.3.2.4 The University asks the consultant to respect the University's time and conduct effective, productive meetings. The consultant should review meeting agendas with the PM in advance.

#### 1.3.3 Submittals

1.3.3.1 The University asks the consultant to provide timely and complete submittals. The University will review the consultant's work for program conformance and

constructability. Incomplete and/or poor quality submittals waste University and consultant time. The PM is authorized to reject incomplete submittals.

- 1.3.3.2 The consultant is responsible for the management and performance of their subconsultants. Delay of a subconsultant's part of a submittal is considered an incomplete submittal from the consultant.
- 1.3.3.3 Delay of a project due to incomplete submittals is the responsibility of the consultant.
- 1.3.3.4 Detailed submittal requirements are described in Section II.
- 1.3.3.5 The consultant will allow two weeks of University review time between submittal of review documents and the review meeting. The University considers the milestone achieved only when the review is complete.
- 1.3.3.6 Final review documents should be ready to issue for bid. Do not include the pre-printed UM bidding documents [Advertisement for Bids, General Conditions, Information for Bidders, Bidders Statement of Qualifications, Prevailing Wage Rates] to avoid those reproduction costs.
- 1.3.3.7 The University will supply the consultant with an electronic copy of the bid form and special conditions. The PM will work with the consultant to tailor these for the project. The PM will supply the pre-printed Division 1 bidding documents when the consultant is instructed to advertise the project.

#### 1.3.4 Electronic Documents

The University requires electronic files of design drawings to interface with campus facilities management software. The consultant should coordinate the format and media with the PM. All contract documents and studies shall be furnished to the University in an electronic format, in addition to a hard copy format.

#### 1.4 BIDDING

- 1.4.1 The PM coordinates the **advertisement** after the final review documents are approved. The PM sets the advertisement date.
- 1.4.2 The PM will instruct the consultant on how the campus will distribute plans and what the consultant will do to support that effort. The PM will provide the following documents for the bidding documents:

- One copy of the advertisement for bids
- One copy of the list of plan rooms
- Information for Bidders
- General Conditions of the Contract for Construction
- Bidder's Statement of Qualifications
- Bidder's Statement of Qualifications for Asbestos Abatement (if required)
- MBE/WBE Participation Requirements
- Prevailing Wage Rates

- 1.4.3 The University will distribute plans and maintains the planholder list. The PM will tell the consultant if the university will use a third party reprographics firm to copy and distribute bidding documents.

- 1.4.4 **Addenda** are part of the contract documents and will be expeditiously distributed to all planholders and plan rooms at least 72 hours before the bid opening. The consultant plays a key role regardless how the addenda are distributed: by the consultant, by the university, or by a third party reprographics firm. The consultant shall prepare addenda for the PM to approve. Addenda will be distributed as outlined in the University of Missouri Information for Bidders, which is then incorporated in the contract for construction.

1. If addenda are mailed, it must be mailed at least seven (7) days before the bid date. If addenda must be issued six (6) days or less before the bid date, either the bid date is extended or the consultant must verify each plan holder has a copy of the addenda at least 72 hours before the bid opening. If addenda are faxed, the consultant shall verify that each plan holder has received a copy of the addendum at least 72 hours before bid opening.
2. If the bid form is revised by addenda, the revised bid form must be printed on different colored paper to distinguish the revisions.
3. In addition to issuing addenda to plan holders, copies of addenda must be placed in each set of the bidding documents that have not yet been issued to a campus distribution point.

- 1.4.5 The PM assisted by the consultant, will hold a **prebid meeting** if required by the agreement. Plan holders are invited to attend to ask questions about the drawings and specifications and to inspect the project site. The consultant will be asked to describe the project and point out important facets of the work and schedule. Simple clarifications can be made in response to questions. Other questions will be recorded and clarified by addenda. Questions requiring interpretations by the consultant will be answered by addenda.
- 1.4.6 To assure an adequate number of bids is received:
1. The consultant will review the local bidding climate prior to the preparation of bidding documents. The size and composition of projects will be considered to encourage competitive bidding. If it appears a conflict among projects will occur in the bidding market, the rescheduling of the bids will be considered if time permits and if this rescheduling can result in additional bids.
  2. The consultant will review the bidders list after the project has been on the market for seven (7) to ten (10) days to determine if there is adequate interest in the project. The consultant will contact several prospective bidders to assure an adequate number of bids will be received (minimum of three).
  3. If little interest is shown in the project, the consultant will contact potential bidders and determine the cause.
- 1.4.7 The campus construction administrator will conduct a **public bid opening**. The consultant will attend the bid opening if required by the agreement.
- 1.4.8 The Consultant performs the **Bid Evaluation** to determine if the bids are responsive and the bidders responsible. The PM reviews the M/WBE goal. The Consultant's review and analysis includes, but not limited to:
1. A thorough analysis of the "Bidder's Statement of Qualifications" to determine if the low bidder is responsible [qualified].
  2. A thorough analysis of the low bidder's breakdown of cost against the scope of work to determine if the bid is responsive.
  3. An analysis and explanation of the bid spread
  4. A comparison & analysis of the consultant's prebid construction estimate to the low bid and the average bid.
  5. An analysis and explanation of why there were variations in the bids

## 1.5 CONSTRUCTION

- 1.5.1 Once the contract is awarded, the **Owner's Representative** is no longer the PM. The construction project manager (CPM) is now the Owner's Representative. All instructions and approvals come to the consultant from the CPM. Services rendered but not requested by the CPM will not be compensated. This includes site visits.
- 1.5.2 **Communications** during construction, including letters, memos, directives, etc., flow through the CPM with the exception of shop drawings which are submitted directly to the consultant. The CPM will review communications with the consultant and the contractor at the pre-construction meeting.
- 1.5.3 The CPM will schedule the **final inspection**. The consultant, owner, and contractor must inspect the work, system by system and room by room, if appropriate, making a record of deficiencies or corrections required to fully comply with the contract documents.
- 1.5.4 The consultant must prepare a final **punch list**, by room, system, or area, and send the requested number of copies to the owner's representative, who will make them available to the contractor. The consultant must field verify completion of punch list.
- 1.5.5 The University will not make final fee payment until all outstanding items, including the **Record Drawings** in the format required by the University, have been received. .

2.0 PLANNING & DEVELOPMENT GUIDELINES

2.1 INTRODUCTION

- 2.1.1 The consultant shall use the planning information in this section to plan and develop University facilities.
- 2.1.2 The criteria represent minimum levels of performance, quality, and/or standardization that are sometimes different from those accepted in private and commercial industry. This is in recognition that these facilities must be cost effective over the life of the facility, while supporting the academic and research missions of the University.
- 2.1.3 The planning and development criteria compliment the Design Guidelines. The consultants shall familiarize themselves and be responsible for implementing all criteria and guidelines.
- 2.1.4 The consultant shall plan facilities with consideration given to serviceability and maintainability of these facilities.

## 2.2 GENERAL

2.2.1 Design submittals shall, as a minimum includes items in this section and Table 1 below.

2.2.2 The consultant shall

2.2.2.1 Develop and economically justify designs within the prescribed budget and space allocations.

Design to obtain the lowest life-cycle cost consistent with a high quality facility.

Design to harmonize architecturally with the buildings upon the University campus and/or as instructed by the PM.

cooperate mutually with the owner and with any other such consultants employed by the owner.

2.2.3 Provide an experienced Architectural or Engineering Project Manager capable of effectively coordinating a multi-disciplined team and with experience in the communication and administrative skills necessary for that role. The same manager will be used for both design and construction unless approved by the University.

2.2.4 Design to the University's Codes and Standards as listed in section 2.4 of this manual.

2.2.5 Make all correspondence between the University and the consultant during the design phase through the PM.

2.2.6 Make project design presentations to the Board of Curators for projects as required by the PM. See section 1.1.1.

2.2.7 Identify any construction alternates included in the design as additional to base bid design. The University typically includes construction alternatives to protect the budget.

Table 1 Minimum Design Review Submittal Requirements

	Section Number Reference	Description	S D	D D	C D
General	2.7.1	Schematic Design Brochure	x		
	2.3; 2.7.2.5; 2.8.1.7	Energy Report		x	x
	2.7.2.2,	Quantative Cost Estimate	x		
	2.8.1.7	Design Summary		x	
	2.7.2.3	Description of Construction	x		
	2.8.1.7; 2.9.4	Specifications		x	x
	2.8.1.8	Detail Cost Estimate		x	x
	2.7.2.4; 2.7.1.9; 2.9.2.3	Construction Schedule	x	x	x
Architectural	2.9.3.21	Demolition		x	x
	2.5; 2.7.2.1; 2.8.1.2	Floor Plans	x	x	x
	2.8.1.3; 2.9.3.18	Roof Plan and System	x	x	x
	2.7.2.1; 2.8.1.4	Building Sections & Elevations	x	x	x
	2.8.1.2.5	Fixtures Locations		x	x
	2.8.1.2.6	Built-in Features		x	x
	2.8.1.5	Interior Finish Schedule		x	x
	2.4.4	Building Accessibility (ADA)	x	x	
	2.6; 2.7.1.4; 2.8.1.7.2	Area Tabulation	x	x	x
	2.8.1.7.2	Code Summary	x	x	x
Civil	2.8; 2.9	Demolition/Excavation		x	x
	2.7.2.1; 2.8.1.1; 2.8.2.3	Site Plan	x	x	x
	2.8.1.1; 2.8.2.3	Existing Structures		x	x
	2.8.1.1; 2.8.2.3	Existing Topography	x	x	x
	2.8.1.1; 2.8.2.3	Final Topography		x	x
	2.8.1.1	Drainage Method		x	x
	2.8.1.1; 2.8.2.3	Exterior Elements		x	x
	2.8.1.1	Grade Elevations	x	x	x
	2.4.4; 2.8.1.1	Site Accessibility (ADA)	x	x	x
	2.8.1.1	Walkways, Drives, etc.	x	x	x
	2.8.1.1; 2.8.2.2, 2.8.2.3	Existing Underground Utilities	x	x	x
	2.8.1.1; 2.8.2.3	New Underground Utilities		x	x
	2.8.1.1; 2.8.2.3	Staging Area		x	x
2.8.7.2	Design Calculations		x		

	Section Number Reference	Description	S D	D D	C D
Structural	2.8.2.4; 2.9.3.19	Design Loading	x	x	x
	2.8.2.4; 2.9.3.19	Grid Reference		x	x
	2.8.2.4; 2.9.3.19	Junctions at Floor, Roof, Wall		x	x
	2.8.2.4; 2.9.3.19	Construction & Expansion Joints			x
	2.8.2.4; 2.9.3.19	Special Jacking & Lifting		x	x
	2.8.2.4; 2.9.3.19	Concrete Protective Cover			x
	2.8.2.4; 2.9.3.19	Anchor Bolts			x
	2.8.2.4; 2.9.3.19	Special Connections Details			x
	2.8.2.4; 2.9.3.19	Shoring			x
	2.8.2.4; 2.9.3.19	Construction Sequence		x	x
	2.8.2.4; 2.9.3.19	Bolt Torque			x
	2.8.2.4; 2.9.3.19	Connection Capacity			x
	2.8.2.4; 2.9.3.19	Rebar Type & Location			x
2.8.7.2	Design Calculations		x		
Mechanical	2.8.2.5; 2.9.3.21	Demolition		x	x
	2.8.2.5; 2.9.3.20	Pipe Routing & Location		x	x
	2.8.2.5; 2.9.3.20	Water, Sanitary, Gas Isometrics		x	x
	2.8.2.5; 2.9.3.20	Ductwork Routing & Location		x	x
	2.8.2.5; 2.9.3.20	Equipment Location		x	x
	2.8.2.5; 2.9.3.20	Equipment Schedules		x	x
	2.8.2.5; 2.9.3.20	Plumbing Fixtures		x	x
	2.8.2.5; 2.9.3.20	Air Handling & Conditioning Units			x
	2.8.2.5; 2.9.3.20	Boilers, Chillers, Cooling Towers			x
	2.8.2.5; 2.9.3.20	Heat Exchangers, Pumps, Fans			x
	2.8.2.5; 2.9.3.20	Steam Traps, VAV Boxes, Tanks			x
	2.8.2.5; 2.9.3.20	Air Devices & Fume Hoods			x
	2.8.2.5; 2.9.3.20	Airflow Diagrams w/rates			x
	2.8.2.5; 2.9.3.20	Waterflow Diagrams w/rates			x
	2.8.2.5; 2.9.3.20	Control Diagrams w/Sequence		x	x
	2.8.7.2	Design Calculations		x	

	Section Number Reference	Description	S D	D D	C D
Electrical	2.8.2.6; 2.9.3.21	Demolition		x	x
	2.8.2.6	Power & Control Wiring			x
	2.8.2.6	Lighting			x
	2.8.2.6	layout and wiring		x	x
	2.8.2.6; 2.9.3.20	fixture schedule and type			x
	2.8.2.6	details			x
	2.8.2.6	Distribution Diagrams		x	x
	2.8.2.6	primary service		x	x
	2.8.2.6	secondary service			x
	2.8.2.6; 2.9.3.20	Utilization Schedule		x	x
	2.8.2.6; 2.9.3.20	Substation & motor control center			x
	2.8.2.6; 2.9.3.20	lighting and power panels			x
	2.8.2.6; 2.9.3.20	telephone panels			x
2.8.7.2	Design Calculations		x		

## 2.3 ENERGY

- 2.3.1 The energy conservation criteria contained in this section shall be followed by the consultant.
- 2.3.2 Facility designs shall include energy conservation features that can be economically justified on life cycle cost criteria. Principal considerations are first cost, operational cost, maintenance cost, climatic conditions, site configuration, building orientation, building functional arrangement, building envelope, and mechanical systems as applicable to minimize the use of fossil fuels.
- 2.3.3 Develop an energy budget for new building, building additions, and renovations based on the following:
1. Building function and classification, and information received from the PM.
  2. Latest edition of ASHRAE Standard 90
- 2.3.4 Building envelope and mechanical and electrical systems shall meet the minimum requirements of ASHRAE Standard 90.
1. The consultant shall document compliance at the conclusion of schematic design, design development, and contract document phases.
  2. If the design does not achieve compliance, then redesign is required.
- 2.3.5 The consultant shall develop an energy conservation report for each new building, building addition, or renovation (see section II.G for format and requirements):
1. When total energy consumption is expected to exceed the 500 million BTU per year or the building is larger than 10,000 gross square feet
  2. Included as a part of the schematic design, where final selection of energy conservation features is made
  3. Updated during the design development and contract document phases
  4. For new buildings, additions, or renovations of existing buildings where total energy consumption is less than 500 million BTU per year, An energy conservation report is not required unless requested by the Project Manager (PM)
1. 5. An energy analysis comparing at least three (3) different alternatives is required

2.3.7 Use of computer programs and other methods for energy analysis is required with the following parameters:

1. Hour-by-hour simulations and energy analyses

- (1) Heated and cooled buildings
- (2) Heated buildings equal to or greater than 20,000 gross square feet
- (3) The preferred computer energy analysis programs are TRACE, CARRIER E20-II HAP. BLAST and DOE II may also be used
- (4) Use of any other computer program for energy analysis requires approval by the PM

2. Modified bin method

- (1) Heated buildings less than 20,000 gross square feet

2.3.8 Specific criteria listed in this manual supersede both BOCA and ASHRAE requirements

#### 2.4.1 BUILDING CODES AND STANDARDS FOR UNIVERSITY FACILITIES

#### 2.4.2 Basic Building Code Policy

2.4.2.1 All University facilities shall comply with the International Code Council [ICC] Codes.

2.4.2.2 Codes and standards required by accreditation agencies, such as the Joint Commission for Accreditation of Hospitals (JCAHO) will also be used unless the ICC requirements are more stringent.

2.4.2.3 In the event that special design features and/or construction systems are not covered in the ICC codes, the applicable edition of the National Fire Protection Association [NFPA] family of standards and/or the NFPA 101 Life Safety Code shall be used.

2.4.2.4 **Codes** that apply to University design & construction.

1. ICC International Building Code and reference standards
2. ICC International Fire Code
3. ICC International Plumbing Code
4. ICC International Mechanical Code
5. NFPA 70 National Electric Code (NEC)
6. Americans with Disabilities Act Accessibility Guidelines (ADAAG) and American National Standards Institute (ANSI) 117.1 Guidelines for Accessible & Useable Buildings & Facilities.
7. NFPA 101 Life Safety Code (as noted in 2.4.1 above)
8. American Society of Mechanical Engineers (ASME) Safety Code of Elevators and Escalators A17.1 (1996) and other codes as adopted by The Missouri Division of Fire Safety, Elevator Safety Unit.

2.4.2.5 **Standards** that apply to University design & construction.

1. National Fire Protection Association (NFPA) standards
2. Missouri Standard Specification for Highway Construction, Missouri State Highway Commission
3. American Concrete Institute (ACI)
4. American National Standards Institute (ANSI)
5. American Refrigeration Institute (ARI)
6. American Society for Testing and Materials (ASTM)
7. Underwriter's Laboratories, Inc. (UL), Federal Specifications
8. National Electrical Manufacturers Association (NEMA)
9. Williams Steiger Occupational Safety and Health Act of 1970 (OSHA)
10. American Society of Heating Refrigeration & Air Conditioning Engineers (ASHRAE)

**2.4.2.6 Automatic Fire Suppression Systems.** All new buildings will be designed with automatic fire suppression systems throughout. Exceptions to this requirement may be granted by the UM Director of Facilities Planning & Development for facilities such as garages, temporary facilities, etc. Work to existing facilities will be designed to meet code. However, it is highly recommended to provide automatic fire suppression systems as a part of major renovation projects.

**2.4.2.7 The Authority Having Jurisdiction [AHJ]** as referred to in the building codes is the UM Director of Facilities Planning & Development, University of Missouri System. All requests for the AHJ will be made through the Project Manager to the UM Director of Facilities Planning & Development.

### 2.4.3 Design Procedures

**2.4.3.1** The University's general policy is not to deviate from the adopted codes. Consultant must certify in writing on the contract document that the project has been designed in compliance with the University codes, see section 3.0 Contract Documents for additional information.

**2.4.3.2** The Consultant shall perform a project code analysis before the completion of design development, but preferably during the schematic design phase. The Consultant shall reference applicable codes and editions and note the occupancy, construction type, egress conditions, and other information necessary. The Consultant is encouraged to use drawings to illustrate conditions. The code analysis will note any potential nonconforming construction. The Consultant may employ a Code Consultant to augment their design team. Failure of design work to meet the established University basic building code will result in redesign at no cost to the Owner.

**2.4.3.3** The University may employ an Independent Code Consultant to review designs for code compliance. This does not relieve the Consultant from responsibility to design to code. On major projects, a follow-up code analysis will be performed on design development and contract documents submittals.

### 2.4.4 Variance Procedures

**2.4.4.1** Consultant must request approval of any code variances in writing through the University Project Manager (PM) to the UM Director of Facilities Planning & Development. The University AHJ will issue a written ruling on all requests. A code variance request must include:

1. An explanation of the situation, the applicable codes, and the reason why code compliance is not possible. Copies of referenced codes, informational sketches, drawings, calculations, and other supporting material should be attached to the request.

2. A discussion and recommendation related to the impact on building use and occupant safety.
3. A discussion and recommendation of equivalent systems available and cost implications of each.

#### 2.4.5 Code Change Administration

2.4.5.1 Changes to the ICC Code will be implemented by the January 1 following issuance. Changes to the NFPA, and other listed standards, will be adopted similarly as the ICC code. Revisions to ADAAG will be implemented immediately.

2.4.5.2 Projects with Design Development approval will not be required to incorporate subsequent code revisions, with the following exceptions:

1. Projects where construction does not begin within 18 months of approval of design development documents or within 12 months of approval of final construction documents will be revised to incorporate subsequent code revisions.
2. Changes, which significantly improve the access, health, and safety of building occupants, will be incorporated into all projects.

2.4.5.3 The University will notify Consultants engaged in University design work of any code revisions in writing. The Consultant shall promptly advise the University Project Manager of any implications of a code revision to the design work. Any resulting abandoned work resulting from a University code revision may be eligible as an additional service under the Consultant's agreement.

## 2.5 STANDARD FLOOR AND ROOM NUMBERING

### 2.5.1 General

1. At MU, the Office of Space Planning and Management will provide all newly assigned room numbers. Provide MU with an electronic copy of your plan drawings.
2. At UMKC, UMSL, and MUS&T, the consultant in accordance with the following procedure will assign room numbers. At the initial design phase and throughout the design and construction phases, room numbers will comply with these guidelines.
3. The definitions used here facilitate general understanding of floor and room and do not always conform to NFPA or ICC code definition.
4. Include numbers in the project drawings. Room numbers must be shown correctly on drawings before advertisement for bids.

### 2.5.2 Floor Designators

1. First floor - lowest floor having a grade level entrance or exit.
2. If there is no floor at grade level, the first floor above grade is the first floor.
3. The floor immediately below the first floor is the basement floor.
4. Floors below the basement are to be called the first sub-basement, second sub-basement, etc. as needed.
5. Floors above the first floor are to be called second floor, third floor, etc., as needed.

### 2.5.3 Numerical Designation of Rooms by Floor

1. Sub-basement rooms - label by alpha indicators only.
2. Basement rooms - label with numbers 0-99.
3. First floor rooms - label with numbers 100-199.
4. Second floor rooms - label with numbers 200-299.
5. Third floor rooms - label with numbers 300-399, etc., as needed.

### 2.5.4 Alpha Prefixes and Suffixes for Numeric Room Designators

1. For large buildings with over 100 rooms per floor, reference to magnetic north and, where appropriate, to building north, must be shown on drawings. Assign appropriate alpha character N, E, W, S, as prefix to numeric indicator. This allows for 400 unique assignable alphanumeric prefix.
2. For remodeling or for very large buildings with over 400 rooms per floor, the 26 letters of the alphabet may be used as suffix to numeric indicators. Conventions for application are as follows:
  - (1) Wall or doorway will distinguish between new room and existing parent room.
  - (2) No alpha suffix derived room area will be created that is not in contact physically with existing parent or alpha suffix derived parent room.
  - (3) Rooms with internally derived alpha suffix rooms inside will be marked with word "complex" after parent room number.
  - (4) Rooms will be marked with tactile letter signs at 5 foot height located on wall adjacent to door on opposite side from hinge, as stated in ANSI part A117.1 (1971), in order to coincide with section 504 of the Rehabilitation Act of 1973 specifications.
  - (5) Certain types of rooms will be marked as to function as well as room number such as Rest Rooms and Mechanical Rooms.
  - (6) Assigned alpha numeric system will provide for 10,800 unique alpha numeric indicators per floor and will require designators of not more than six elements (1 alpha, 4 numeric, 1 alpha) even in buildings over 10 floors.

#### 2.5.5 Room Area Definition

1. All areas in every building must follow this convention and be marked accordingly. Any area separated from an adjacent area by a full floor to ceiling partition and/or has a highly differentiated function from that adjacent area will be labeled as a discrete entity. This will be characterized by a building unique numeric or alphanumeric code to indicate its uniqueness.
2. In the case of low walls, see-through partitions, wire cages, or no walls at all, the above convention implies the possible application of unique designators within larger open areas. (Example: stack and reading areas within Ellis Library.)

#### 2.5.6 Numbering Rooms

1. If floor has 100 or less rooms per floor:
  - (1) Starting from an entrance, apply numeric designators in clockwise (counter clockwise-MUS&T) direction to each individual room area.

- (2) Where hallways are present, in some cases, use of even/odd designators may be used to further differentiate sides of hallways and eliminate confusion
- (3) Where intermediate hallways or isolated rooms are encountered, numbers are to be assigned in the clockwise (counter clockwise-MUS&T) sequence at the first entrance to the hallway or isolated area.

2. If floor has more than 100 rooms per floor:

- (1) Follow the above convention after having used alpha prefix designators in accordance with magnetic orientation to building.
- (2) Use alpha suffix designators if more than 400 rooms per floor or if remodeling of present rooms creates new room areas to be designated use of the clockwise (counter clockwise-MUS&T) and odd/even conventions described above.
- (3) Rooms not accessible from a corridor or common area will be numbered by the use of an alpha suffix. The prefix and the number will be the same as the room through which common access is available. For example, rooms accessible through room E101 will be numbered E101A, E101B, etc.
- (4) Rooms not accessible from a corridor or common area and are at a different level than the room which provides access will be called mezzanines. Mezzanines will be numbered described above.
- (5) If a room is subdivided into more than one room and the new rooms created are accessible from the corridor or common areas, and if room numbers in the appropriate sequence are not available for use, the original room number will be retained and numerical suffixes (-1, -2, -3, etc.) will be used for each new room created.
- (6) For remodeling projects requiring new room numbers, the starting point for numbering will be in vertical alignment with the starting point of numbering on adjacent floor(s).
- (7) Rooms spanning more than one floor will be numbered according to the main level entrance to the room if one entrance is on the main level. If no entrance is on the main level, the room will be numbered according to the entrance closest to the main level.
- (8) The main corridor will be numbered 100, 200, 300, etc. on the first, second, third, etc. floors. Other corridors, stairwells, vestibules, and elevators will be numbered using the number of the main corridor with the addition of an alpha suffix, applied in a clockwise fashion.
- (9) The consultant shall obtain written approval of the room numbering at Design Development and notify the Project Manager of any desired changes as they occur prior to issuance of Construction Documents.

## 2.6 BUILDING AREAS DEFINITIONS

### 2.6.1 Gross Area

1. Gross Area is the sum of the floor areas of the building included within the outside faces of exterior walls for all stories or areas having floor surfaces. Gross area is gross square feet (GSF).
2. Calculate gross area by measuring from the outside face of exterior walls, disregarding cornices, pilasters, buttresses, etc., which extend beyond the wall face. Gross area includes basements (except unexcavated portions), attics, garages, enclosed porches, penthouses, mechanical equipment floors, lobbies, mezzanines, balconies (inside or outside) utilized for operational functions, and corridors, provided they are within the outside face lines of the building. Stairways, elevator shafts, mechanical service shafts, and ducts count as gross area on each floor through which the shaft passes. Exclude open courts and light wells, or portions of upper floors eliminated by rooms or lobbies rising above single-floor ceiling height.

### 2.6.2 Net Assignable Area

1. Net Assignable Area is the sum of all areas on all floors of a building assigned to, or available for assignment to, an occupant, including every type of space functionally usable by an occupant (except spaces defined as custodial, circulation, mechanical, and restroom areas). Net assignable area is assignable square feet (ASF).
2. Calculate assignable area by measuring from the inside finishes of surfaces that form the boundaries of the designated areas. Do not include unusable areas having less than 6'6" clear headroom. Include space subdivisions for offices, classrooms, laboratories, seminar and conference rooms, libraries, file rooms, storage rooms, etc., including those for special purposes (e.g., auditoriums, cafeterias, TV studios, faculty and student locker and shower rooms, maintenance and repair shops, garages), which can be put to useful purposes in accomplishment of the institution's mission. Deductions are not made for columns and projections necessary to the building.

### 2.6.3 Nonassignable Area

1. Nonassignable area is the building area that is not available for assignment to building occupants but is necessary for the general operation of the building. By definition, nonassignable area consists exclusively of the following: circulation, custodial, mechanical, and restroom areas. Calculate nonassignable area the same as assignable area.

2.7 SCHEMATIC DESIGN PHASE

2.7.1 Board of Curators Report

For major construction projects, the PM will direct the consultant to produce and present a Schematic Design Report to the University's Board of Curators. The report is distributed to Board members, University administrators, and other officials and may be used in conjunction with development activities by the University. It is imperative this document be succinct, accurate, and of professional quality. The following outline should be used in developing the report along with any supplementary directions given by the PM.

1. Provide a one to two page Executive Summary summarizing the size and scope of the project, estimated costs, and general programmatic information identifying programs and activities directly benefiting the University.
2. Provide background information on the history of the project; the programs benefitting from the project; and problems it will solve, e.g. space shortages, obsolete facilities, future growth. Describe other parameters affecting definition of the problem, such as master planning issues, existing structural limitations, and site conditions. Typical subheadings might include Project Background, Space Program, Planning Issues, and Design Objectives.
3. When the project is a Master Plan or is part of a multi-phase development, include a summary of the planning associated with the total project. The summary should describe how the project fits into the overall objectives and parameters of the master plan, and may include conceptual plans and other available drawings, and projected costs.
4. Include a table of assignable square footage that clearly illustrates the proposed assignments of space and use the column headings shown below.

Department/ <u>Type of Space</u>	Current <u>Assignments</u> *	Proposed Assignments		
		<u>Renovated</u>	<u>New</u>	<u>Total</u>

\* If available or applicable

5. Prepare a presentation rendering at the direction of the PM for university approval.
6. Provide a concise presentation of the proposed Schematic Design solution. The narrative should focus on important features of the design addressing the project statement outlined in the introduction. Include a general description of proposed materials and building systems. Also explain how the design accommodates future

modifications (flexibility) and expansion (expandability). Typical subheadings might include Site Plan, Interior Design/Building Organization, Architectural Solution, Exterior Design/Building Appearance, and Future Expansion.

7. Schematic design drawings (photographically reduced) should include site plan(s), floor plans, primary elevations, at least one primary building section, and any other drawings necessary to adequately convey important features of the proposed building.
8. Use the following Project Cost Estimate with approved costs from the PM.

Construction Cost (Approved Estimate)	\$
New Construction (if applicable)	\$
Renovation (if applicable)	\$
Site Development (if applicable)	\$
Construction Contingency (By Owner)	\$
Other Construction Costs (By Owner)	\$
Consultant Fees (By Owner)	\$
Other Consultant Costs (By Owner)	\$
Project Management (By Owner)	\$
Other Project Costs (By Owner)	\$
Total Project Costs	\$
Construction Cost Per GSF	\$/GSF

9. Use the following project schedule outline of project schedule milestones:

Consultant Selection	(date)
Schematic Design Approval	(date)
Contract Award (if known)	(date)
Construction Complete (if known)	(date)

For projects with unknown construction awards and completes (usually due to funding), indicate the construction period in months.

10. Include an Outline Specifications using the following outline as a guide. This is a brief summary of building systems and materials proposed in the schematic design. Allow no more than 2 pages. Typical headings are: Sitework, Structure, Building Shell, Finishes, Furnishings and Equipment, Conveying Systems, Mechanical Systems, Life safety Systems, Electrical Systems, Building Controls, Telecommunications, Information Technology

## 2.7.2 Schematic Design Submittal

1. Schematic design drawings must include site plans, floor plans, roof plan, primary elevations, at least one primary building section, and any other drawings necessary to adequately convey important features of the proposed building. Include a code summary on the schematic plans.
2. Project Cost Estimate
  - 2.1 Submit a written quantitative estimate of construction developed from complete schematic plans and outline specifications.
  - 2.2 Break down the construction estimate into the major architectural, civil, structural, mechanical, and electrical building components by labor and material for major divisions of work.
  - 2.3 Use the format shown in the appendix as a guideline.
  - 2.4 Include and identify your design contingency.
  - 2.5 Provide a life cycle cost analysis of the proposed roofing system.
  - 2.6 For projects at MU, the consultant should exclude from the construction cost estimate the following construction related services and procedures which are performed directly by MU Campus Facilities: asbestos testing, energy management equipment, meters and transformers, fire extinguishers, HVAC testing and balancing, keys and locks, landscaping and signage. The PM will develop the budget for these items and will review the scope of work performed by MU Campus Facilities with the consultant.
3. Description of construction. Provide a description of:
  - 3.1 Construction, i.e., structural system, wall system, roof design, waterproofing, exterior, and interior finishes, etc.
  - 3.2 Plumbing, air conditioning, heating and ventilating systems, including controls, ducts, filtration, and piping. Include appropriate code references to be followed in design.
  - 3.3 Electrical services, including voltage, number of feeders, and whether feeders are overhead or underground. Provide a specific description of items to be served by emergency power and describe consideration for special areas.
  - 3.4 Fire protection system required for building occupancy.
4. Provide estimate for construction period and lead time for special items.
5. Energy Report: furnish an energy consumption report consisting of calculations (including any computer printouts) and a written summary of the results and clearly indicate assumptions. Include the following as a minimum.
  - 5.1 Identification of analysis methods: include loads and building systems analysis.

- 5.2 Building energy consumption
- 5.3 Energy budget determination
- 5.4 Methodology of life cycle costing analysis.
- 5.5 Description of major energy conservation features selected, such as building envelope U-values (or R-values), type of fenestration and percent of gross wall area, type of air handling system, reheat systems, automatic system control features, lighting levels and controls, etc.
- 5.6 Estimates of building energy consumption (see below for energy conversion values) is subdivided as follows:
  1. Energy consumption per month by energy type. Including maximum demand per month
  2. Total monthly and annual energy consumption (BTUs)
  3. Annual energy consumption (BTUs) per building system, i.e., lighting, HVAC, hot water, equipment, etc.
  4. Annual energy consumption per square foot of building space (BTU/GSF/year)
  5. Energy conversion values, from 10 CFR Part 436 are:

Electricity	3,412 BTU/KWHr
Fuel Oil (#2)	137,000 BTU/gallon
Natural Gas	1,030,000 BTU/1000 cubic feet
Liquefied Petroleum Gas (LPG) propane	21,560 BTU/pound
Coal	24,500,000 BTU/short ton
Steam (80% boiler and 15% line loss)	1,390 BTU/pound
  6. Discuss energy metering: include types of metering and compatibility with existing or projected energy monitoring and control systems (EMCS).

## 2.8 DESIGN DEVELOPMENT PHASE

### 2.8.1 General Requirements

#### 1.0 Site Plan:

Overall dimensions of the proposed building(s) or work area including alternatives. Indicate reference to a benchmark and baseline.

Location and extent of existing structures on the site within 300 feet measured from the exterior walls of the proposed building. Identify structures and streets by proper names.

Existing and proposed contours.

Method of general drainage of the site as affected by the proposed building.

Indication of exterior elements; e.g., outdoor facilities, streets, service drives, parking areas, disabled access, paved areas, covered walks, landscape development, stairs, pools, retaining walls, terraces, etc. Include any elements to be demolished. At MU, final landscape design is done by the campus with input from the consultant.

Section(s) through site, to explain changes in level in the proposed building as related to the site.

Underground campus utilities and structures.

Small-scale campus map indicating project location on title sheet.

Appropriate scale for project location, staging, limits, and parking areas.

#### 2.0 Floor Plans:

2.1 Locations, sizes, and space numbers of programmed spaces and other required gross areas, including corridors (width), stairs, toilets, janitors' closets, mechanical spaces, storage rooms, etc.

2.2 Location of doors and windows. Indicate door swings. Indicate fire separation.

2.3 Overall dimensions of each major area of the building(s).

2.4 Provisions for making facilities accessible to persons with disabilities.

2.5 Location of plumbing fixtures such as lavatories, floor drains, water closets, urinals, service sinks, drinking fountains, fire hose cabinets, fire extinguishers, and sprinkler systems.

2.6 Indicate principal built-in features such as fixed auditorium seats, kitchen equipment, display cases, counters, shelves, lockers, etc.

2.7 Indicate extent of any demolition work.

2.8 Use the scale listed later in these requirements.

- 3.0 Roof Plans and Roof Details
  - 3.1 A roof plan and detail of existing conditions (reroof) or other components and penetrations (new).
  - 3.2 Photographs of overall roof condition and show locations of inspection openings (reroof project only).
  - 3.3 An outline of the method of reroofing.
  - 3.4 A narrative report discussing major design features and options (reroof).
  - 3.5 Identification of existing components and methods of attachment.
  - 3.6 Simple sketches showing method of detailing new system.
  - 3.7 Consultant must submit to the Project Manager (PM) calculations used to determine control and expansion joint width and spacing, including long bands of windows.
  
- 4.0 Elevations and Sections
  - 4.1 Exterior elevations for the building must show windows, doors, window vents, stairs, platforms, retaining walls, etc. Indicate grades, paved areas, etc.
  - 4.2 Indicate floor heights and windowsill heights.
  - 4.3 Include longitudinal and transverse sections for each major area, indicating floor elevations, finish exterior grades, ceiling heights, pipe tunnels, unexcavated areas, basement and areaways, rooflines, and parapets.
  - 4.4 Include small-scale plan or diagram to indicate section lines for each elevation and section (see scale requirements).
  - 4.5 Include larger scale (1/4" = 1'0") indication of special design features with notes related to materials and design.
  - 4.6 Various floor and grade elevations including those for interior and exterior stairways, walls, terraces, walks, etc.
  
- 5.0 Interior Planning
  - 5.1 The following space types must be thoroughly dimensioned to illustrate details clearly:
    - (a) Classrooms and lecture halls
    - (b) Kitchens and related service areas
    - (c) Laboratories and any other programmed spaces
    - (d) Toilet and locker rooms
  - 5.2 Include an interior finish schedule that indicates, in general terms, floor, wall, and ceiling finishes together with special items of finish.
  - 5.3 Indicate location of moveable items of furniture and equipment listed in the space description sheets. Differentiate from built-in furniture and equipment.
  - 5.4 See scale requirements later in this section.

- 6.0 Area Tabulation - Tabulate net assignable square foot (NASF) and overall gross square foot (GSF) areas. Show space-by-space comparison of preliminary assignable area with program assignable areas. Tabulate by floor and include totals for the building.
  
- 7.0 Outline Specifications and Design Summary
  - 7.1 Specifications must be in outline form using CSI format.
  - 7.2 Provide a design summary documentation in an indexed report format with all assumptions and references stated. Include:
    - (a) Architectural design calculations (including occupancy classifications, type of construction, fire resistive ratings, exiting calculations, allowable building height and area, toilet fixture calculations and any unusual provisions or exceptions applicable to the project)
    - (b) Structural design calculations (including live load, roof load, snow load, wind load, lateral soils load, and seismic load calculations. Also include any unusual provisions, special loads, or exceptions applicable to the project)
    - (c) Mechanical design calculations (including building loadings, equipment sizing, steam pipe stress analysis, annual energy usage and any unusual provisions or exceptions applicable to the project)
    - (d) Electrical design calculations (including fault current calculations, transformer loading, circuit sizing, building energy usage and any unusual provisions or exceptions applicable to the project)
    - (e) Civil design calculations (including storm drainage, sanitary sewer, domestic water service and any unusual provisions or exceptions applicable to the project)
    - (f) Basis of design equipment and material information (e.g. catalog material, charts, tables, performance curves, etc.)
    - (g) Update energy conservation report and life cycle costing
    - (h) Verification of compliance with University standards, guidelines, and codes
  
- 8.0 Cost Estimate
  - 8.1 Submit a written quantitative estimate of construction developed from complete design development plans and specifications. Use the format in the appendices.
  - 8.2 Show estimated contractor overhead and profit, unit costs applied and materials and labor quantities.
  
- 9.0 Construction Phasing Schedule - Provide a construction-phasing schedule in bar chart and/or outline (narrative) form.

### 2.8.2. Design Drawings

- 1.0 Scale
  - 1.1 Plot, site, & utility plans can be either 1" = 10' or 1" = 20' scale.
  - 1.2 Building floor plans and roof plans will be 1/8" or 1/4" = 1'.
  - 1.3 Details will be drawn at 1/2", 1", or 1 1/2" = 1'.
  
- 2.0 Existing Utilities Capacity - Show verified capacity at points of connection to existing utilities.
  
- 3.0 Plot Plan
  - 3.1 Indicate routing of outside utility lines from point of connection to existing utilities to the building.
    - a. Show existing utilities including those underground.
    - b. Show existing and final topography of site.
    - c. Show proposed site access, staging areas, and project limits.
  
- 4.0 Structural Plans
  - 4.1 Include the design loadings (dead, live, wind, snow, seismic), material specifications and design stresses (steel, concrete, masonry, soil bearing, etc.) assumed during the design, plus assembly stresses where applicable.
  - 4.2 When structures employ a beam-column framework, a grid reference system using alphabetic and numeric symbols will be utilized. When additions are made to existing structures, the original reference system will be extended where practical.
  - 4.3 Detail junctions between floors, roof, and exterior wall to assure continuity and load path.
  - 4.4 Drawings will clearly dimension and accurately describe non-standard details and construction requirements. Included but not limited to:
    - Construction and expansion joint details
    - Special jacking and lifting procedures`
    - Protective cover (concrete)
    - Anchor bolt material and projection
    - Special connection details
    - Shoring requirements
    - Construction sequence
    - Bolt torque
    - Concrete reinforcing details
    - Connection capacity
    - Water stops, etc.
  - 4.5 Type and location of rebar splices.

- 5.0 Mechanical
- 5.1 Plumbing Plans
  - a. Indicate all required demolition.
  - b. Indicate locations of main wastes and vents, as well as service mains, including water, air, gas, vacuum, etc.
  - c. Indicate pieces of equipment, showing location and required piping connections, including pumps, tanks, generators, etc.
  - d. Provide equipment schedules for plumbing fixtures.
  - e. Provide isometrics for water, sanitary, and gas piping.
- 5.2 Heating, Ventilating, Air Conditioning and Piping Plans
  - a. Indicate all required demolition.
  - b. Indicate service mains, including steam, return, hot water, chilled water, condenser water, etc.
  - c. Indicate air moving equipment and double line duct runs to all outlets including supply and exhaust fan systems, fume hoods, etc.
  - d. Indicate pieces of equipment, showing locations and required piping connections including pumps, tanks, converters, etc.
  - e. Provide equipment schedules indicating sizes, capacities and operating characteristics.
  - f. Provide air and water flow diagrams for supply and exhaust air, and water distribution systems. Diagrams are to indicate flow rates in mains and branches to assist in balancing.
  - g. Control schematics and sequence of operations.
- 5.3 Large Scale Drawings of Equipment Rooms
  - a. The scale should be no smaller than  $\frac{1}{4}'' = 1'0''$ .
  - b. Indicate layout of equipment to assure adequate space allowance.
  - c. Include elevations of built-up fan units to assure proper air flow and access to component parts of the units.
  - d. Show pump layout and piping runs.
- 5.4 Fire Protection
  - a. Show pipe runs, sprinkler locations, pumper connections, and test connections.
  - b. Show coverage rate of sprinklers.
  - c. Show any special equipment, Halon, CO<sub>2</sub>, etc.
  - d. Show control schematic.
- 6.0 Electrical Plans
- 6.1 All required demolition.

- 6.2 Show the power and control layouts on one set of drawings and the lighting layouts on a different set of drawings using standard symbol conventions. Show all conduit sizes and the size and number of conductors.
- 6.3 Provide single line electrical distribution diagrams showing primary service to substations and secondary service to distribution switchboards, motor control center, and panel boards for power and lighting. Show all conduit sizes and the size and number of conductors.
- 6.4 Indicate the point of connection to external utilities, i.e., high voltage, telephone, and signal systems.
- 6.5 Indicate and provide utilization schedule for each load center unit substation, motor control center, distribution and switchboards, telephone equipment rooms, and closets.
- 6.6 Indicate type and locations of lighting fixtures in typical offices, laboratories, corridors, examination rooms, etc., and use a schedule for detail.
- 6.7 Indicate fault current at all manholes.

## 2.9 CONTRACT DOCUMENTS

### 2.9.1 Introduction

1. The consultant shall prepare the contract documents that consist of the project manual, the drawings, and addenda.
2. The term "Project Manual" refers to the written portion of the contract documents.
  - a. Bid forms (Bid for Lump Sum, Bidders Statement of Qualifications, MBE/WBE Evaluation)
  - b. General Conditions for Construction Contract
  - c. Special Conditions
  - d. Prevailing Wage Rates
  - e. Specifications
3. The term "Drawings" refers to the graphic portrayal of elements included within the scope of the contract documents.
4. There should be no duplication between portions of the contract documents; instead, they should be complementary.

### 2.9.2 General

1. The consultant shall develop the Contract documents to be complete and ready for seals and signatures. Contract document originals will be sealed, signed, and dated by the consultant of record prior to printing of bid documents.
2. The consultant shall make all corrections to drawings and specifications identified during design development and subsequent intermediate reviews in the contract documents.
3. The consultant shall provide a final logic bar chart schedule for project construction and identify the critical path. The schedule will include purchase and delivery activities and durations for all major equipment and building components.
4. The consultant shall provide a revised, detailed construction estimates will be submitted. These estimates will become the basis for the University estimate to be used at bid opening. The estimates will include separate estimated costs for any construction alternates included in the bid documents but not part of the base bid. Follow the cost estimate format in the appendix.
5. During the construction bidding, the consultant will accept and reply to all contractor inquiries relating to clarification and interpretation of the plans and

specifications. These questions and answers will be formally documented, and those that identify significant change or clarification will form the basis of a formal contract addendum prior to actual contract award. The consultant will participate in all pre-bid meetings and publish minutes of those meetings.

### 2.9.3 Drawing Format

1. The following are minimum requirements for projects involving construction of new facilities, or renovations of or additions to existing facilities.
2. Completed tracings, whether hand drawn or CADD produced, will be of excellent quality for the production of good duplicates and microfilming.
3. A scale of  $\frac{1}{4} = 1'0"$  or  $\frac{1}{8} = 1'0"$  is preferred for building floor plans, elevations, and sections.
4. A scale of  $1" = 10'$  or  $1" = 20'$  is acceptable for site plans and utility plans. Location plans and plans showing contractor access routes may be smaller.
5. Details will be drawn  $\frac{1}{2}"$ ,  $1"$ , or  $1\frac{1}{2}" = 1'0"$ .
6. A graphic scale will be required on drawings.
7. Drawing size will be D size sheets (24" x 36"), unless otherwise directed by Project Manager (PM). The consultant will contact the PM for CADD requirements.
8. Drawings will be segregated into disciplines (Architectural, Civil, Structural, Mechanical, Plumbing, Electrical).
9. Pertinent information will be shown only on discipline drawings applicable to that Division of work. If information must be located on drawings of a different discipline, drawings will be cross-referenced.
10. HVAC equipment and electrical equipment schedules will be included on the drawings. Door, window, and room finish schedules may be included on the drawings or in the project manual.
11. Manufacturer and product names will be referenced in equipment schedules on the drawings.
12. Symbols and abbreviations used on drawings will be explained and shown on legends.

13. Design details will be shown on the drawings, not in the specifications.
14. Each drawing sheet will display the following:
  - a. Advertisement/issue date
  - b. Title of the project
  - c. An individual sheet title
  - d. Alphanumerical number indicating discipline and sheet number
  - e. Scale
  - f. The seal of a professional architect or engineer registered in the State of Missouri, signed and dated.
  - g. Campus project number
15. Title sheet in each set of drawings will contain the following:
  - a. Consultant will certify the following on the title sheet of the drawings:

"I hereby certify these drawings and/or specifications have been prepared by me, or under my supervision. I further certify that to the best of my knowledge these drawings and/or specifications are as required by and in compliance with the Building Codes of the University of Missouri".

\_\_\_\_\_Signature
  - b. Title of the project and project number
  - c. Owner's name: (University of Missouri - Campus Name, For The Curators of the University of Missouri)
  - d. Consultant's name
  - e. Drawing index
  - f. Site location plan
  - g. Advertisement/issue date
  - h. Professional architect/engineer seal, signed and dated
  - i. Code review data
16. Sections and details will be numbered and cross-referenced.
17. Project construction limits, construction fencing, and contractor access will be clearly shown on the site plan drawings. Included will be any required tree protection.
18. Roofing
  - a. The roof plans shall include all features and elements of the roof, including roof slope and drainage, all penetrations and mechanical equipment. On reroofing projects, clearly indicate items to be demolished

and/or removed, existing materials to remain and new materials and construction. The following items should be shown on the roof plans, accurately located, and drawn to scale.

- Mechanical units, exhaust fans, vents
  - Piping, conduit, and related supports
  - Roof walkways, screens, hatches, and ladders.
  - Roof drains, overflow drains, and scuppers
  - Miscellaneous penetrations
  - Expansion joints and area divided curbs
  - Gutters and downspouts
  - Valley, ridges, saddles and crickets
- b. The drawings shall include complete details of roof system and components including:
- Each roof perimeter condition
  - Each penetration condition, including vent flashing
  - Each roof-related sheet metal fabrication
  - Equipment curbs, skylight curbs, and roof hatches
  - Roof expansion joints and area dividers
  - Piping & equipment supports
  - Typical roof drain and overflow drain including sumps and flashings
  - Scuppers
- c. Roof flashing details shall indicate following components:
- Roof deck and wall substrate and other adjacent materials
  - Insulation including separate layers and vapor retarders
  - Roof and flashing membrane
  - Cant strips, if applicable
  - Flashing attachment, if applicable
  - Counterflashing and reglets
  - Sealants
  - Wood nailers and blocking, including adequate attachment
19. Structural construction drawings shall include structural loadings and details (floor, roof, cross-sectional, etc.)
20. Mechanical & Electrical construction drawings shall include:
- a. Double line drawings for ductwork and equipment room piping. All other piping may be single line. Show ductwork on separate sheets, not with utilities. Show location of all dampers and valves.
  - b. Completed equipment, lighting, and power panel schedules
  - c. All details, cross-sectional and elevation views
  - d. Air and water flow (balancing) diagrams
  - e. Control schematic, point listing, and sequence of operation

- f. Show equipment schedules and sequence of operation information on mechanical drawings.
  - g. Identify circuits and show equipment schedules on electrical drawings.
21. The consultant, at the direction of the PM, will incorporate drawings that illustrate the location of any expected asbestos containing materials. The consultant will not be responsible for the identification and removal of asbestos.

#### 2.9.4 Project Manual and Specifications

1. Language of the project manual will be brief and consistent.
  - a. Do not repeat information contained in either the General Conditions or the Special Conditions in any other section.
  - b. Do not repeat information contained in the specifications on the drawings (except in equipment schedules).
2. Consultant will use the CSI numbering system as directed by the PM.
3. Titles of unused divisions will remain in the table of contents with parenthetical notation on each to state "(Not Used)." No reference shall be made to unused divisions in the body of the specifications.
4. There shall be no blank spaces between paragraphs or within sentences within sections in the specifications. The end of each section should be marked "End of Section".
5. The architect or engineer seal of professional registration in the State of Missouri shall be affixed to the cover sheet of the specifications, signed, and dated.
6. Provide the University Original copies of the specifications in a computer file format acceptable to the PM. If the PM allows paper, it shall be of such quality as to be satisfactorily scanned to PDF electronic files. White paper of sufficient weight to prevent ghosting shall be used for all specification pages to increase contrast.
7. No allowances shall be provided in the contract documents unless approved by the project manager.
8. The term "Contractor" shall be used throughout the specifications in the context defined in the General Conditions.
9. The General Conditions cover all one-year guarantees. Guarantees other than one year will be stated at the end of the applicable section. Do not repeat one-year

guarantees in the specifications. Guarantees or warranties greater than one year will be stated in the Special Conditions.

10. As stated in the General Conditions, local building permits, inspections, etc. will not be required for work located on University property except when connections are made to city utilities and at drives and sidewalks adjoining city streets.
11. Only the "Owner", "Owner's Representative", "Architect", and "Contractor" will be referred to in the specifications.
12. Design details, sketches, and drawings will not be included in the specifications.
13. Specifications will indicate the type and quality of material to be used. To the greatest extent possible, all colors will be identified in the specifications.
14. A minimum of three manufacturers will be listed and the words "or approved equal" will be stated. Proprietary items may be specified only with the University's approval. Criteria will specify critical parameters which will identify what constitutes an approved equal.
15. If asbestos containing materials are expected to be removed during the construction of the project, the University's Asbestos Removal Specifications will be incorporated into Division 2 of the specifications. The current edition of the University Asbestos Removal Specification can be found at the FPD Website.
16. Consultant will list all required submittals, shop drawings, operation manuals, warranties, and certifications in the Submittals section of the Special Conditions in Division 1.
17. The geotechnical report will be included as part of the contract documents, and clearly marked For Reference Only, in General Requirements, Division 1.

### 3.0 DESIGN GUIDELINES

#### 3.1 Introduction

- 3.1.1 This section contains information to be used by consultants in the design of University facilities.
- 3.1.2 The criteria represent minimum levels of performance, quality and/or standards, which are sometimes different than those, accepted in private and commercial industry. This is in recognition that these facilities must survive longer than normal service lives, without undue cost to the users and taxpayers, while still supporting academic and research missions of the University of Missouri.
- 3.1.3. Users are alerted that the Consultant Procedures & Design Guidelines sections 3.0, Design Guidelines, and 4.0, Outline Specifications & Details, are migrating towards a new structure modeled on Construction Specifications Institute 2004 division numbers and titles. During the transition, users are advised to search for topics broadly.
- 3.1.4. Any conflicts between the requirements in listed reference documents will be resolved by the Project Manager.

## 3.2 ARCHITECTURAL

### 3.2.1. General

3.2.1.1 The following information is provided as a guide in establishing architectural requirements and should not be construed to limit the consultant from proposing more cost effective alternates.

3.2.1.2 Facilities will be designed per the latest edition of ADAAG. See section II.D, Code Requirements.

- (1) In all new construction, all public entrances to the building will be accessible to persons with disabilities. The main entrance will be provided with one door, or set of doors, that is power operated. At MU, if an entrance to the building other than the main entrance is located closer to the parking designated for persons with disabilities, that entrance will also be power operated.

These items should be regarded as a minimum requirement. The design team should evaluate the need for after hours use of the facility which may require accessible entries. If the expected users of the building include a larger than normal percentage of persons with disabilities, other entrances to the building will also be power operated.

- (2) In existing structures, a minimum of one entrance will be accessible to persons with disabilities. That entrance will be power operated. The accessible entrance will be either the main entrance or entrance closest to parking designated for persons with disabilities. In existing structures, any design for construction in the vicinity of an entrance should evaluate the possibility of making that entrance accessible. Whenever it is physically and economically feasible, all entrances should be made accessible.

3.2.1.3 The building, addition, or renovation will meet the requirements as defined in Section II.D, Codes Requirements.

3.2.1.4 Finished floor height will be expressed on contract documents as actual elevation based on University of Missouri's datum, not on an arbitrary one.

3.2.1.5 Design of animal rooms will comply with "Federal Regulations, Title 9, Subchapter A, Animal Welfare 43FR56217" and the Public Health Service Regulations contained in DHEW Publications # (NIH)78-23, and the latest ALAC standards.

3.2.1.6 The consultant will plan access for servicing and maintenance of equipment. Minimize rooftop equipment and roof penetrations by consolidating equipment in mechanical penthouses.

### 3.2.2 Fire Protection

- 3.2.2.1 Facilities will be constructed of fire resistant materials.
- 3.2.2.2 Floors and floor/wall assemblies will at least equal the requirements of the designated User Group, as defined in the latest edition of ICC Code.
- 3.2.2.3 Doors at facility perimeter will have a rating commensurate with the wall system in which they are located.
- 3.2.2.4 A five-pound ABC multipurpose fire extinguisher (provided by the Owner on MU projects) will be provided in each laboratory room or area. Emergency showers and eye-washers will be provided as required.
- 3.2.2.5 Fire extinguisher cabinets will be included in Class A corridors. Cabinets may be recessed or semi-recessed models. Fire hoses will not be provided; however, standpipes and standard two and one half inch (2-1/2") fire department connections are required.
- 3.2.3 Building Envelope
- 3.2.3.1 The building envelope will comply with the latest edition of ASHRAE/IES Standard 90.
- 3.2.3.2 Exterior wall insulation may be semi rigid, blanket batt type, glass fiber, unfaced, complying with ASTM C665 and the following ASTM E84 values:
- (1) Flame spread less than 25
  - (2) Smoke development and fuel contributed less than 50
- 3.2.3.3 Perimeter foundation walls, walls below grade, and perimeter slab on grade, will be provided with closed-cell, extruded polystyrene insulation board.
- 3.2.3.4 All foundations walls with accessible or occupied space on one side and soil on the other will be waterproofed below grade.
- 3.2.3.5 Drain tiles are to be installed at footings and tied to sanitary or storm sewer system as allowed by local municipalities. Down spouts will be tied into storm sewers (in lieu of foundation drain tiles) and will not discharge on grade. Refer to IV.E.2.e. for additional information.
- 3.2.3.6 Crawl spaces will have concrete floor slabs, floor drains, ventilation and lighting.
- 3.2.3.7 Exterior building materials will be selected to maintain and/or compliment the harmonious nature of the campus. Care will be given to provide a consistent image to the historical character of the campus. Materials should be practical, maintenance free, durable, and cost effective.
- (1) Exterior walls systems of brick veneer over block backup are preferred. The Project Manager must approve the use steel stud backup.

- (2) Exterior insulation and finish systems [EIFS] stucco, and plaster will not be used as the primary finish of a building or renovation. The allowed use is for small areas or soffits with the approval of the Project Manager.
- (3) The use of curtain walls, spandrel panels, etc. is generally limited to public and vertical circulation areas. The project manager must approve other applications.

3.2.3.7 At MU, door and window frames installed in buildings on the "white campus" will be medium bronze color. Door and window frames installed in buildings on the "red campus" will be cream color. Doors installed in buildings on the "red campus" will be red color. Doors and windows installed in other areas of the campus will be one of the above colors. In existing structures, the color will match the color of the existing windows and/or doors if that color is one of the above. If the color is something other than one of the above colors, the Owner will decide which color to install.

3.2.3.9 At MU, windows installed in areas normally occupied by people will be operable, except in those areas required by code to maintain a specific air balance. Screens will not be supplied with windows.

3.2.3.10 At MU, glazing in windows on the red campus will have a light bronze tint.

### 3.2.4 Roofing

3.2.4.1 From the pre-approved systems, the consultant will select roof systems which are suitable for the facility. To evaluate possible systems, the consultant will consider the following design parameters:

- (1) Life of the roof system. Preferred systems and associated useful lives include:
 

Built Up	
Conventional	20 years
Coal Tar	20 years
Single Ply	
Fully-adhered EPDM	15 years
Modified Bitumen (SBS)	20 years
Slate	50 years
Cement/Clay Tile(UMKC)	50 years
Composition shingles	25 years
Metal	
Preformed architectural	
Structural standing seam	
Architectural – custom fab	
- (2) If other systems, such as PVC, TPO, CSPE/Hypalon, mechanically-attached EPDM, APP type modified bitumen are, in the opinion of the consultant, the most appropriate system. It will be evaluated by the project team.
- (3) Initial (first) cost of the roof system and additional building costs required for recommended roof system.
- (4) Maintenance costs and requirements.

- (5) Energy costs associated with recommended roof system.
- (6) Building height/roof slope/wind resistance requirements
- (7) Present and future use of building, including specific uses in the building that could affect the roof system.
- (8) Local environmental issues/contaminants and pollutants
- (9) Life expectancy of building
- (10) Structural properties of roof superstructure
- (11) Type of roof deck
- (12) Slope/drainage
- (13) Vapor retarder requirements (See VB7-13)
- (14) Roof traffic/access and penetrations
- (15) Code/Insurance requirements and restrictions
- (16) Aesthetics
- (17) HVAC internal pressures
- (18) Application issues, such as staging, access, building use and occupancy, etc.

3.2.4.2 After establishing design parameters, Systems should be evaluated by the consultant based upon:

- (1) Minimum established UM standards (refer to Section IV, Division 4.7)
- (2) A choice of roof systems with properties, that, considering all factors, are best suited to the project
- (3) Requirements for a total system warrant

3.2.4.3 The consultant will follow these roofing guidelines when designing the roofing system:

- (1) Use only recommended roofing systems as identified in Paragraph 4.b above and detailed in Section IV, Division 4.7.
- (2) Single-ply ballasted roofs and spray foam roofing system will not be installed.
- (3) Light weight concrete will not be used as a means to create slope on new buildings. On re-roofs, it may be used to repair existing decks.
- (4) New buildings should have ¼" foot slope and this should be accomplished by sloping the structure..
- (5) If an existing roof has less than ¼" foot slope a serious evaluation will be done to determine if achieving ¼" foot is feasible. If additional slope is required on re-roofs, tapered insulation should be used.
- (6) Coal tar roofs shall not exceed 1/8" foot slope.
- (7) Use crickets, saddles, and edge strips to direct water flow away from parapets and penetrations. Backslope is to be confirmed during detailing.
- (8) Overflows are required by code. Overflows shall not be piped into the primary roof drain system. Highly visible and dependable systems such as scuppers and "daylighted" drains are preferred.
- (9) Provide roof walkways to and around rooftop equipment and other areas as directed by the owner.
- (10) At the design development phase, a review should be undertaken by the consultant to include vapor retarder requirements deck type, expansion joint locations and details, salvageability of existing roof insulation, drainage, roof

access, roof contaminants, fire rating, and wind uplift factors, and all other applicable parameters.

- (11) Existing roof decks will be checked by a registered structural engineer if roof loads are in question.
- (12) For re-roof projects, an evaluation will be done by the consultant and the owner to determine if a roof survey by nuclear meter or other means may be performed. Core samples will be taken and results recorded and evaluated.
- (13) Roof access will be evaluated, and roof access hatches, ladders and other components will be installed as required by the owner.
- (14) Avoid complex flashing details. Minimize use of pitch pans or sealant pockets. Maintain minimum 8" flashing height, 12" is preferred.
- (15) Minimize roof penetrations. If structural penetrations are unavoidable, use round or square structural steel shapes to facilitate flashing. Equipment supports for rooftop mounted equipment shall be a minimum 14" height. Use prefabricated equipment supports where possible. Equipment support frames or stands shall provide following working clearances:

Width of Equipment	Height of Legs
Up to 25"	14"
25-37"	18"
37-49"	24"
49-61"	30"
Over 61"	48"

### 3.2.5 Doors, Windows, Curtain Walls, and Glass

3.2.5.1 All exterior glass systems will be insulated, double pane glass with aluminum thermal break frame construction. No steel framing should be exposed to the exterior.

3.2.5.2 Replacement windows will be aluminum. In restoration projects, wood windows may be allowed.

3.2.5.3 All new construction and major renovations will use low-E glazing. Glazing on window replacement projects will be evaluated on a life cycle cost basis to determine viability of the low-E type.

3.2.5.4 Minimum door size shall be 3'0" in width and 7'0" in height.

### 3.2.6 Finishes

#### 3.2.6.1 Floor Finishes:

- (1) Lobby & Public Areas: Hard durable surfaces requiring minimum maintenance such as ceramic tile, slate, quarry tile (non-slip), marble chip epoxy filled tile, VCT, Terrazzo, seamless vinyl or rubber flooring.
- (2) Classrooms: VCT or sheet vinyl. Carpet will be limited to spaces with programmatic needs such as sound dampening.
- (3) Auditoriums & Lecture Halls: VCT, stained sealed concrete, or epoxy in seating areas and carpeting in aisles.
- (4) Laboratories: Sheet vinyl, VCT (Dry labs only), epoxy, rubber flooring or sealed concrete based on program requirements.
- (5) Offices & Conference Rooms: Carpet. Consider carpet tiles in high traffic areas and as approved by the project manager.
- (6) Mechanical Rooms, Janitor closets, storage rooms: Sealed concrete.
- (7) Stairwells: Hard surfaced floors with slip resistant covering.
- (8) Computer Labs: VCT, carpet, or carpet tile.
- (9) Corridors: VCT in classroom and lab buildings. Carpet in office buildings and suites.
- (10) Food Preparation & Service: Non-slip Quarry tile or epoxy coating.
- (11) Animal quarters: Epoxy coating
- (12) Hospital & Clinic application & exam rooms: Sheet vinyl, rubber flooring and VCT in procedure rooms.
- (13) Restroom: Ceramic floor tile.
- (14) Certified sustainable flooring products should be used where practical.

3.2.6.2 At MU, consistently wet areas or wash down areas (such as cage and cart wash areas, kitchens, etc.) should have the following wall system: concrete masonry unit wall with 1/8" fiberglass panel bonded to the wall with mastic and nylon anchors.

3.2.6.3 Water resistant drywall will be used in intermittently wet areas (such as restrooms, wash rooms, custodial closets, etc.).

3.2.6.4 Public stairways in academic buildings should have very durable wall finishes (such as CMU or concrete) and floor finishes.

3.2.6.5 All mechanical rooms will have sealed concrete floors and masonry or concrete walls.

3.2.6.6 Restrooms will have a ceramic tile wainscot with a minimum of 54" in height and will have ceramic tile floors.

3.2.6.7 For high use areas, consideration should be given to the use of modified acrylate copolymer multi-color coating similar to Zolotone or Polomyx.

3.2.6.8 In general, wallcovering should be used only in private offices, conference rooms, or other low traffic areas. Wall covering should not be used in corridors. For conference rooms and similar areas, consider chair rails to prevent wall damage. All wall covering

will be commercial grade. Vinyl wall covering will be Type II. Ease of cleaning and serviceability will be criteria for selection

3.2.6.9 Thin coat veneer plaster provides a good durable finish and is particularly useful when matching existing plaster walls.

3.2.6.10

Acoustical wall panels will be used sparingly. The need for a chair rail will be considered and panels will be terminated a minimum of 4" above the finished floor.

3.2.6.11

If carpet is used, consideration should be given to soil hiding characteristics like yarn fiber, color, pattern and yarn density.

3.2.6.12

Avoid mixing floor coverings within one room unless dictated by program needs.

3.2.6.13

Wall and ceiling access doors

- (1) Access will be supplied for all concealed valves or other equipment that may require operation or adjustment.
- (2) Access doors will have a minimum size of 24" x 24" if possible.
- (3) Both mechanical and architectural drawings will note the need for access doors, number of doors needed, and general locations. Exact locations are not desired. Design should require access doors be located to allow access to valves or other equipment.

3.2.6.14

Entry mats, at all main building entrances, roll-up (removable), recessed, floor mats will be installed. At MU, use linked tread type floor mats. Size and exact location of mats should be of sufficient size to handle foot traffic, but not exceed manufacturer's maximum size recommendation for removal and cleaning.

3.2.7 Furnishings

3.2.7.1 Furnishings such as carpet, wall coverings, furniture and cabinets will comply with "Fire Spread Ratings Requirements" contained in NFPA101 Life Safety Code and other pertinent ANSI standards.

3.2.7.2 Specify prefabricated, stock cabinets, and benches to encourage competitive bidding.

3.2.7.3 Furniture in public areas will be fastened to the structure where justified by safety and/or security concerns.

3.2.7.4 Signs will be installed on the wall adjacent to the latch side of the door whenever possible. If wall space is not available on the latch side of the door, coordinate placement of the sign with the PM. Meet all other requirements of ADAAG when choosing an alternate placement.

Mounting height will be 60" above the finished floor to the centerline of the sign.

Mount signs 2" from door trim.

Do not mount signage on or above doors.

At MU, the consultant should confirm whether signs are to be provided by the campus or specified by the consultant.

3.2.7.5 Preferred standard window treatment is 1" horizontal mini-blinds. These should be bid and budgeted as a part of the construction contract.

### 3.2.8 Conveying Systems

3.2.8.1 All elevators shall be inspected by state certified inspectors and certified by the State of Missouri before final acceptance.

3.2.8.2 Passenger elevators are preferred to be hydraulic. Hydraulic elevators shall be used for four stories or less. Elevators serving more than four floors shall be electric traction.

3.2.8.3 Where an elevator pit is required, the pit will have a sump pit, a sump pump with an alarm connected to the Building Automation System, and no floor drain.

3.2.8.4 Elevators will be wired and equipped with telephone and supplied with a vandal proof instrument.

3.2.8.5 For each installation, designer will evaluate expected usage of elevator to determine the need for vandalism-resistant construction. At MU, controls shall always be vandalism-resistant.

3.2.8.6 At MU, the following shall apply to the Vertical Platform Lifts.

- (1) The use of vertical platform lifts is prohibited in new construction. Possible exceptions include access to performing areas in assembly occupancies or to provide access to incidental occupiable spaces and rooms which are not open to the general public and which house no more than five persons.
- (2) Lifts may be used in existing facilities built prior to 1991 as part of an accessible route and only when the use of an elevator or ramp is not feasible.
- (3) Lifts shall comply with ADAAG and ASME A18.1 – 1999 and Addendum 2.10.1a Safety Standard for Platform Lifts and Stairway Chairlifts.
- (4) Lifts shall be installed such that all lift enclosure walls are securely attached to

- adjacent walls, structure, or supplemental structural supports as required for stability and proper operation of the unit.
- (5) The use of vertical lifts is preferred over the use of inclined (stair) lifts.
  - (6) The lift platform should be fully enclosed whenever possible. The minimum platform size is 36" x 54".
  - (7) Lifts shall allow unassisted entry, operation, and exit. Operating controls shall be large push-button or paddle controls.
  - (8) The preferred drive type is recirculating ball screw. The minimum weight capacity is 750 lbs.

### 3.2.9 Ceiling Systems

3.2.9.1 Provide sound attenuation at partitions and ceilings between major areas. Review criteria for acoustical separation with the PM.

3.2.9.2 Suspended ceiling systems will be designed with a 2' x 2' grid pattern in most areas. Other sizes may be considered as approved by the Project Manager. Use of a 2' x 2' grid in public corridors, auditoriums, lecture halls, and other areas subject to frequent above ceiling access or upgraded appearance should be considered. Reveal edge tiles may be used in selected areas with approval of the PM. Concealed spline or tongue and groove ceiling systems will not be used.

3.2.9.3 Drywall ceilings should be limited to consistently wet areas (such as cage and cart wash areas, kitchens, biosafety Level 3 or larger facilities) and soffits in special public areas. Access must be maintained to the plenum space.

### 3.2.10 Architectural; Telephone and Data Rooms

#### 3.2.10.1

All telephone and data network topology will conform to EIA/TIA Building Telecommunications Wiring Standards.

#### 3.2.10.2

##### Telephone and Data Rooms

- (1) All telephone and data rooms should not be considered as potential locations for ancillary electrical equipment as well as basic termination of cable/wire/fiber.
- (2) Size: minimum size requirements - 5' x 6' with door opening out or 5' x 8' with door opening into the room.
- (3) Ceiling height: minimum 8' to ceiling grid or cable distribution system.
- (4) Doorways: minimum size requirements - nominal 3' W x 6'-8" H. Must be equipped with a locking door. Handle to have a knurled finish.
- (5) Location: minimum of one telephone/data room will be located on each floor. One room should be allocated for every 10,000 gross square feet of floor area. Distance limitations or other considerations may require more than one room. Rooms should be located as close to the core of the structure as possible and

should be vertically stacked in multiple story buildings. Average cable runs should not exceed 150' with no single cable run exceeding 295'.

- (6) Floor finish: install vinyl composition tile or use a concrete sealer.

### 3.2.10.3 Telephone and Data Equipment Rooms

- (1) Telephone and data equipment rooms are special purpose rooms that serve space and environmental needs of large pieces of telecommunications and data equipment and may not be required in all buildings. The need for these rooms should be discussed with Campus Telecommunications and Campus Computing.
- (2) Size: minimum size requirements - 15' x 15' (225 net square feet).
- (3) Ceiling height: minimum 8'-6" to ceiling grid or cable distribution system.
- (4) Doorways: minimum size requirements - nominal 3'W x 6'-8"H. Must be equipped with a locking door (may be integrated with building security system. Handle to have a knurled finish.
- (5) Floor finish: install vinyl composition tile or use a concrete sealer.
- (6) Floor loading: minimum 100 lbs/sf equipment load.
- (7) Power: each closet must have a minimum of two 110V AC duplex outlets. Outlets must be separately fused, 20 amp, 3-wire grounding and on a non-switched circuit. Outlets should be located below the termination board location, if known.

3.2.10.4 Construction cost will include installation and termination of telephone/data cabling and conduit/raceways to the main telephone room and to all outlets.

### 3.2.11 Janitor Closets

3.2.11.1 Each floor of a building will have a minimum of one custodial closet per 20,000 sf. The main floor closet may be combined with a central storage closet. The closet will be 60-80 sf and rectilinear. Custodial closets will serve that specific use only and will not contain building systems equipment or roof hatches.

Furnish with the following:

- (1) 24" x 24" floor mounted mop sink with stainless steel edge caps, vandal proof drain, stainless steel splash plates, and a hose connection with a vacuum breaker.
- (2) Two duplex electrical outlets (GFCI).
- (3) 16 lineal feet of shelving that is 18" deep, 14" between shelves, with the lowest shelf being 20" above the floor. The shelves should be of sturdy construction, capable of holding bulk cleaning supplies with ledge to prevent items from rolling off.
- (4) A locking storage cabinet 2'W x 20"D x 6'H.
- (5) Ladder and mop/broom hangers mounted on one wall.
- (6) Lighting at the 20' candle level. The light fixture(s) shall have safety guards.
- (7) A floor drain.

3.2.11.2 Each building will have a central storage closet on the main floor, accessible to the main corridor, and as close as practical to access doors and an elevator. The size of the room will be a minimum of 144 sf. The door will be a minimum of 36" with a storeroom function lockset. The door should open outward if allowed by code. Buildings 50,000 sf and larger should consider an adjacent storage room to accommodate specific storage requirements. Central storage closets will serve that specific use only and will not contain building systems equipment or roof hatches. Furnish with the following:

- (1) 24" x 36" floor mounted mop sink with stainless steel edge caps, vandal proof drain, stainless steel splash plates, and a hose connection with a vacuum breaker.
- (2) Two duplex electrical outlets (GFCI).
- (3) 36 lineal feet of shelving that is 18" deep, 14" between shelves, with the lowest shelf being 20" above the floor. The shelves should be of sturdy construction, capable of holding bulk cleaning supplies.
- (4) A locking storage cabinet 2'W x 20"D x 6'H.
- (5) Ladder and mop/broom hangers mounted on one wall.
- (6) Lighting at the 20' candle level. The light fixture(s) will have safety guards.
- (7) A floor drain.
- (8) Telecom-data telephone in each

### 3.2.12 Loading Dock Facilities

#### 3.2.12.1

For new construction and building additions, consultant should review loading dock facility requirements with the PM.

#### 3.2.12.2

Potential needs to be addressed could include:

- (1) Trash dumpster/compactor equipment
- (2) Recycling containers (paper, cardboard, cans). All buildings will have accommodations for recycling containers and material. Those areas can be alcoves, closets, or rooms suitable for such storage, near a building service entrance or preferably at an exterior covered loading dock.
- (3) Truck dock bays (at grade and/or at loading height)
- (4) Service vehicle parking (two minimum)
- (5) Receiving area
- (6) Holding areas (hazardous materials, chemicals)

### 3.2.13 Restrooms

#### 3.2.13.1

Toilet partitions will be either floor supported-overhead braced or floor and ceiling supported. At MU and UMKC only, partitions and screens are to be solid polymer plastic resin.

#### 3.2.13.2

Accessible toilet stalls will be designed to meet current requirements of ADAAG.

#### 3.2.13.3

One restroom liquid all purpose soap dispenser will be installed at each washbasin. At MU, dispensers will be provided and installed by the campus. At UMKC, dispensers will be supplied by the University and installed by the contractor. Dispensers at UMKC will primarily be countertop mounted with reservoir below counter.

#### 3.2.13.4

At MU and UMKC, built-in receptacles are not desired. An alcove is preferred to accommodate a freestanding waste can. At UMKC waste receptacles will be supplied and installed by UMKC if freestanding. Built-ins, if used, will be supplied and installed by the contractor.

#### 3.2.13.5

At UMKC paper towel dispensers shall be supplied by the University and installed by the contractor.

#### 3.2.13.6

At UMKC feminine napkin dispensers shall be planned for with proper backing in the wall. Units will be supplied and installed by the University as needed.

### 3.3 CIVIL

#### 3.3.1 General

3.3.1.1 The following information is provided as a general guideline in establishing civil engineering design requirements.

#### 3.3.1.2 Subsurface Investigations

- a. The University will be responsible for providing record location information of the Owner's underground utility lines and structures.
- b. The Owner will assist with location of, but will not be responsible for location of, underground facilities owned by public utility, municipal corporation, or other persons.

#### 3.3.1.3 Soils Investigations

- a. If investigative soils analysis is required during project design, Owner will retain a soils engineer.
- b. The soils engineer, in consultation with the Owner and consultant, will determine number, sizes, depth, and proposed location of borings and/or pits. In general, there will be one boring for every 2,000 square feet of building footprint, with a minimum of four soil borings. To the extent possible, borings should be located near the location of proposed footings/piers.
- c. Boring information will be shown, with dimensions, on a plot plan to be submitted in two (2) copies by the consultant to the Owner at least five (5) working days prior to proposed sampling.
- d. The plot plan will show:
  - (1) A graphic scale, north arrow, and location of existing buildings and trees
  - (2) Above and below ground service/utility lines (both utility company and Owner-owned lines)
  - (3) Pavement areas and established benchmark(s) with elevation(s) noted
  - (4) Existing site features, not specifically mentioned, impacting boring or pit locations.
  - (5) The soils/geotechnical report will be included as an informational item of the bidding documents in the general requirements, Division 1.

#### 3.3.1.4 Storm Drainage

- a. This section applies to stormwater conveyance systems outside the footprint of buildings. Building systems are covered in Section III.3.5, Mechanical Systems.
- b. Trunk storm sewers are defined as the primary spine(s) of the piping system and generally carry the flow from more than one site.
- c. Stormwater systems shall be designed using the actual time of concentration. The worst case of complete development, per the current Master Plan, or current conditions shall be used for calculation of offsite flow.

- d. Generally the Rational Formula shall be used for areas under 200-acres. Runoff coefficients shall consider percentage of impervious area and average site grade (slope).
- e. Return periods will be 25 years with actual time of concentration (duration) for all building sites, pedestrian malls, streets, quadrangles, and Trunk Storm Sewers.
- f. Return periods will be ten (10) years with actual time of concentration (duration) for parking lots, park space, and open areas.
- g. Project Manager (PM) will establish "return periods" for all other areas.
  - a. Return period must satisfy governing municipality's regulations.
- h. No ponding is allowed on paved areas. Detention basins shall be labeled on the drawings.
- i. Designer will compare above return periods with those required by the local municipality. Coordination with municipality may be required and should be reviewed with the PM. Any discrepancies will be discussed with the project manager.
- j. All buildings and structures will be developed such that no entry of water through entrances, window wells, area ways, basements, drains, etc. will occur during a minimum hundred year storm. Design should maintain positive drainage away from building entrances.
  - a. Connections to building drains shall be designed to prevent surcharge from the storm sewer for the 100-year storm.
  - b. Sidewalk grade shall be set to prevent surface from collecting and channeling surface drainage.
- k. Particular attention will be paid to bicycle and wheelchair safety in the design of storm drainage systems. Grate bars will be placed perpendicular to direction of traffic flow. Grates in pedestrian areas should be sized to avoid catching heels of shoes.
- l. At MU, a modified version of the City of Columbia standard curb inlet is used for all work not in the public right-of-way.
- m. At MU only, storm drains, except small area drains, shall be reinforced concrete pipe (RCP) conforming to ASTM C76 or AASHTO M170, Class 3 minimum, and 12" or larger.
- n. At MU only, piping for small area drains in courtyards, small yard areas, and building area ways may be 8" or larger.
- o. At MU only, storm drains less than 36" in diameter shall run on a straight line and grade between structures. Horizontal and vertical bends are permitted in 8" and 10" lines provided a cleanout is included. The deflection should utilize a wye with the cleanout as an upstream extension of the downstream line's alignment.
- p. Consultants shall use the Missouri Department of Natural Resources document "Protecting Water Quality – A field guide to erosion, sediment and storm water best management practices for development sites in Missouri and Kansas" and the EPA guidance "Storm Water Management for Construction Activities" as Best Management Practice guidelines for the preparation of site plans and construction details relative to erosion control on construction sites.

### 3.3.1.5 Sanitary Sewers

- a. Sanitary sewers shall be designed in accordance with the standards and requirements of the Missouri Department of Natural Resources and local requirements (MSD, City of Columbia, Rolla, or Kansas City).
- b. Sewer systems shall be designed to carry traffic loads in all locations.
- c. Sewer piping installation shall include granular bedding with fines and backfill within the pipe envelope.
- d. The minimum service line size shall be 6". The minimum sewer line shall be 8".
- e. Sanitary sewer pipe material shall be as described in Section IV, Outline Specifications and Details.
- f. Pre-cast concrete manholes shall comply with ASTM C478 or ASTM C76, Class 3. Cast-in-place manholes shall be detailed in the construction documents.
- g. Cleanouts may be used at the end of a sewer line where the distance to the downstream manhole is 150-feet or less. Cleanouts are required on service lines outside a building footprint and at horizontal or vertical bends in a service line. The deflection should utilize a wye with the cleanout as an upstream extension of the downstream line's alignment.

### 3.3.1.6 Site Exterior Equipment

- a. Exterior equipment, such as ground mounted transformers, air conditioning units, etc., will be located and landscaped/screened to be aesthetically compatible with surrounding area and adjoining buildings.

### 3.3.1.7 Roadways, Parking Lots, and Walkways

- a. All curbs will be Portland cement concrete.
- b. Pavements shall be designed to accommodate the Design Vehicle for the pavements use. The minimum lane width shall be 10-feet, excluding curb and shy distance (concrete pavements), curb and gutter (asphalt pavements), or striping. Curve radii and intersection radii shall accommodate the Design Vehicle's design speed and turning movements.
- c. Paved walks less than eight feet wide will be designed with a cross slope of two percent to facilitate drainage. Walks equal to or greater than eight feet wide will have a minimum slope of one percent. It is desired to maintain positive drainage away from walks so surface water does not cross them.
- d. All sidewalks will have a minimum width of 7'. Where a sidewalk abuts to a road or driveway, minimum width is 9'. Walks adjacent to roads or driveways will not have grass strips between sidewalk and road or driveway. A medium broom finish will be applied perpendicular to traffic flow. All brooming directions will be shown on the drawings and described in the specifications. Sidewalks abutting a curb line shall be pinned to resist differential movement. Include expansion joint where needed.
- e. At MU, all accessible parking spaces will be "universal spaces." Parking spaces, other than disabled, will typically be 9' in width. No compact car spaces will be permitted.

- f. At MU locations where a parking lot abuts to lawn areas, a mowing strip will be incorporated into the design of the parking lot. A mowing strip is a strip of pavement, 18"-24" in width, on the lawn side of the curb or parking bumpers allowing the lawn to be mowed while parking spaces are occupied.
- g. At MU, accessible ramps adjacent to buildings will have a snow melt system installed, controlled by the Energy Management Control System. At MU, curb cuts for disabled access will use the campus standard detail. (See standard detail in appendix.)
- h. Preferred material for sidewalks, ramps, and other paved, exterior walking surfaces is concrete. All materials must be slip resistive.

### 3.3.1.8 Water Distribution System

- a. All piping shall conform to AWWA standards and the requirements of the MoDNR.
- b. MU Only: All water meters will be located inside buildings. See Section IV, Outline Specifications and Details for information concerning water meters.
- c. The preferred material for water distribution systems is C-900, PVC with ductile iron fittings wrapped in plastic. At MU the Project Manager will provide details.
- d. Fire hydrants shall be provided in accordance with the requirements of the local fire district or department. Hydrants shall be provided with an auxiliary valve, installed with the streamer directed toward a street or drive, and with hydrant base flange 6" above finished grade. MU Project Manager will provide details.

### 3.3.1.9 Landscape

- a. Preservation of existing trees and landscaping will be a primary consideration. At MU, all landscaping materials, installation, and landscape design is provided by the campus. Grading should be at 6" below finish grade to allow for topsoil placement by the campus.
- b. Finished lawn areas will have a finished slope no steeper than one (1) foot vertically to three (3) feet horizontally. Steeper areas will be covered with ground covers or modified with walls or other treatments. At MU, all landscaped areas shall have a finished slope no steeper than one(1) foot vertically to three and one-half (3.5) feet horizontally. Walls may have to be used to reduce steeper areas to this standard.
- c. Selection of landscape plant materials will be based on plant hardiness and on growth success within the area used.
- d. A planting schedule will be provided and timed in relation to planting season and on University's acceptance of the project.
- e. Specific treatments will be identified for project limit lines or edges.
- f. The following planting schedules will be used:
  - (1) Spring schedule
    - (a) Trees (Deciduous and Coniferous Evergreen): Will be planted between March 15 - May 15
    - (b) Shrubs: same as trees
    - (c) Ground covers and herbaceous perennials: same as trees

- (d) Turf: will be seeded (sodded) between April 1 and May 15
- (2) Fall schedule
  - (a) Trees (Deciduous): will be planted between October 15 and December 15
  - (b) Trees (Coniferous Evergreen): will be planted between September 1 and October 30
  - (c) Shrubs: will be planted between September 15 and December 15
  - (d) Ground covers and Herbaceous Perennials: will be planted between September 15 and October 15
  - (e) Turf: will be seeded between August 25 and October 1; will be sodded between September 1 and November 15

### 3.4 STRUCTURAL

#### 3.4.1 General

- a. The following information is provided as a guide for designing structural support systems. All load criteria will be in accordance with the latest edition of BOCA.
- b. Load criteria for all structural systems will be noted on the drawings.
- c. Separate additions from existing structures with an expansion joint.
- d. Do not transfer vertical loads through horizontal expansion joints.
- e. Gypsum roof decking will not be used. Preferred roof decking material is steel or concrete.
- f. All roof decks will be designed with a minimum slope of 1/4" per foot. Positive slope for drainage will be provided by the roof deck rather than tapered insulation (except at crickets and around equipment pads).

#### 3.4.2 Foundations

- a. Subsurface design requirements will be based on a current geotechnical investigation from which soil profiles, design parameters, compaction requirements, and foundation design options are established.
- b. In instances where concrete duct banks, steam tunnels, and other concrete masses join foundation walls, steel pins for reinforcing steel anchoring will be attached to the foundation walls through use of epoxy capsules similar in material and quality to those supplied by Hilti. Other penetration requirements are found in V.B.15.I.B and V.B.16.I.A.
- c. Penetrations of foundation walls by direct burial cable and/or small diameter penetrations shall be sleeved or core drilled, and shall be sealed through the use of 3M Scotchcase 2114, or equal sealant.

#### 3.4.3 Floor Loading

- a. Floor loadings will be increased as required to meet equipment loadings and conditions specified by equipment manufacturer.
- b. If live load reduction is used, it will be in accordance with the latest edition of BOCA and must be noted on the drawings.

#### 3.4.4 Roof Loadings

- a. Minimum roof load design will comply with live load or snow load, whichever is greater.
- b. Roof service loading will be increased as required for external equipment, ducting, and supported utility requirements.

#### 3.4.5 Wind Design

- a. Every building and structure will be designed and constructed to resist prescribed wind effects. Wind will be assumed to come from any horizontal direction. Wind effects will be analyzed in at least two mutually perpendicular horizontal planes.
- b. Exposure category "B" will be used for all campuses.

### 3.4.6 Precast Concrete Design Criteria

- a. The architect will specify allowable deflections to be used in the design of the panels to maintain integrity of the panel.
- b. Panels will be designed with adequate structural integrity to permit handling, transportation, storage, and erection.
- c. Waterproofing materials are discouraged on new concrete surfaces.

### 3.4.7. Masonry

- a. Design and construction guidelines and technical notes of the Brick Institute of America (BIA) will be followed for brick and the Masonry Advisory Council (MAC) for concrete masonry unit (CMU) construction.
- b. Use of stone coping for modification to existing facilities with stone coping will be allowed. Use of stone coping for design effect will require specific approval from the PM.
- c. Masonry units will not be used for foundations walls below grade.
- d. Waterproofing materials are discouraged on new masonry, or stone surfaces. Use will require project manager approval.
- e. The designer will evaluate the expected movement for each wall and require adequate expansion joints to accommodate the movement.

## 3.5 MECHANICAL SYSTEMS

### 3.5.1 General Mechanical Guidelines

#### 3.5.1.1 General Design

- (1) Heating and cooling system loads for the purpose of sizing systems and equipment will be determined in accordance with procedures described in the latest edition ASHRAE Handbook, Fundamentals.
- (2) Indoor design temperature and humidity conditions for general comfort applications will be in accordance with the comfort criteria established in the latest edition of ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy or Chapter 8 of ASHRAE Fundamentals Handbook.
- (3) Outdoor design conditions will be selected from the latest edition of ASHRAE Fundamentals Handbook, or from data obtained from the National Climate Center or similar recognized weather source.
  - (a) Heating design temperature will be no lower than the 99% dry-bulb.
  - (b) Cooling design temperature will be 95°db, 78°wb and for cooling towers 80°wb.
- (4) Winter humidification and summer dehumidification are not required in general comfort applications.
- (5) Ventilation systems will be designed to provide outdoor air ventilation rates in accordance with section 6.1.3 of the latest edition of ANSI/ASHRAE Standard 62.
- (6) Supply/return air systems will be designed in accordance with the latest edition of ASHRAE Fundamentals Handbook.
- (7) Piping systems will be designed in accordance with the latest edition of ASHRAE Fundamentals Handbook.
- (8) HVAC equipment will have a minimum efficiency at the specified rating condition, not less than the values shown in ASHRAE 90.
  - (a) Compliance with minimum efficiency requirement specified for HVAC equipment will include compliance with Integrated Part-Load Value (IPLV) as well as standard or full-load requirements.
- (9) MU, UMKC, MS&T Only: steam and chilled water are preferred systems.
- (10) All penetrations through firewalls, or floor or roof decks will have fire stopping material installed at the penetrations and will be shown on the drawings.

#### 3.5.1.3 Equipment

- (1) Major equipment will be provided with adequate pressure, temperature, and flow indicators at time of installation to establish unit performance.

- (2) Equipment will be provided with bearings lubricated for life by the manufacturer or built in automatic lubrication system where possible. Where periodic lubrication is needed, specification will require lubrication points to be readily accessible for lubrication.
- (3) Electric heating systems will not be used.
- (4) Access doors will be provided to coils, filters, motors, belts etc.
- (5) Vibration and sound transmission from mechanical equipment will not exceed ASHRAE sound criteria.
- (6) All HVAC equipment will be located to facilitate accessibility, maintainability and replacement.
- (7) All coils within air handling units, chillers, and heat exchangers will be capable of being pulled without obstruction of equipment, pipes, conduit, etc., or requiring removal of any other coil in the same unit.
- (8) All mechanical equipment/systems will be installed on a 4" minimum concrete housekeeping pad, and where required, steel support framing as required to allow proper housekeeping, drainage, and access.
- (9) Where exterior equipment is to be located above a roofing system, adequate space will be provided below equipment to allow for roof maintenance as specified by NRCA Roofing Manual. Avoid multiple roof top penetrations.
- (10) All motors will be high efficiency.
- (11) No motors will be designed to operate in the service factor.
- (12) Motors will be designed to operate continuously at all speeds with variable speed drives having carrier frequency of 12 KHZ or higher without large fluctuations in amps drawn at any single speed.
- (13) Equipment pits, whenever possible, will be drained by gravity to storm or sanitary lines (local authority approval). Where gravity drainage is not possible, a sump with a pump will be installed. The sump will have an alarm installed, connected to the building automation system whenever possible, to alert maintenance personnel whenever the water level rises and before the water overflows the pit. Where the building automation system is not available, a local alarm will be installed.
- (14) The MU campus steam system operates at 35 to 65 psi. Typical maximum design should be at 70 psi, 450 deg F. Minimum design 35 psi, 300 deg F. system should be able to handle 400 degree F. steam at a minim pressure of 55 psig at the building entrance.
- (15) MU Only: The campus pumped condensate system operates with a pressure that varies from 25 to 60 psig. The Owner will verify the condensate system pressure for each installation.
- (16) MU Only: All condensate pumps must be capable of handling high temperature condensate (210 degrees F.).
- (17) MU Only: Condensate tanks must be sized at a minimum of three times the calculated peak flow in gpm.
- (18) MU Only: A pressure gauge is to be installed on the system side of the condensate pump discharge check valve.

- (19) MU Only: Pressure powered pumps shall be used.

#### 3.5.1.4 Insulation

- (1) All insulation will comply with ASHRAE 90.1.
- (2) Insulation containing asbestos is prohibited. All new insulation shall be marked "Asbestos Free" or "Non-Asbestos Insulation".
- (4) Provide insulation on equipment, pipes, and ducts where:
  - (a) Heat transmitted will significantly affect ambient temperatures in controlled spaces.
  - (b) Heating or cooling effects will be significantly affected due to heat flow into or out of pipes or ducts.
  - (c) Condensation will occur as a result of surface temperature approaching dew point of the ambient air.
  - (d) Significant energy loss would result from heat transfer.
  - (e) Personal injury may result (external surface temperature is 150°F or greater).

### 3.5.5 Refrigerant Cooling Systems

#### 3.5.5.1 General Design Guidelines

- (1) All mechanical room installations will comply with ASHRAE 15.
- (2) Waste water cooled units are not acceptable.
- (3) All roof mounted condensing units will be designed to 115°F outside air temperature.

#### 3.5.5.2 Material

- (1) All valves will be full port. Provide isolation valves on each side of driers. Provide check valves on the discharge of compressors. Discharge from all relief valves will be piped to exterior of the building.
- (2) Insulate suction and hot gas bypass in all locations and discharge lines if exposed in occupied areas. For units above 5 tons, use 1" fiberglass insulation. For smaller units, use 1/2" closed cell foam insulation, minimum. All insulation on exterior piping will be protected by an aluminum jacket.

### 3.5.6 Water Cooling Systems

#### 3.5.6.1 General Requirements

- (1) Chilled water will be provided by:
  - (a) Making use of existing chilled water distribution system and existing chiller;
  - (b) Providing new chiller, but using the existing distribution system as much as possible; or
  - (c) Providing new chiller with new chilled water distribution system.

- (d) MU Only: Coordinate with EMO prior to beginning design.
- (2) All new chilled water systems will be Primary/Secondary systems with pressure independent 2-way control valves. The secondary systems will have variable speed pumps and 2-way pressure independent control valves.
- (3) Condensing water systems will be equipped with automatically controlled water treatment and blowdown systems designed to control scale buildup, corrosion, and concentration of dissolved solids.

### 3.5.6.3 Equipment

- (1) Equipment selection will comply with ASHRAE Standard 90.
- (2) Chillers
  - (a) MU Only: The type of chiller to be installed will be determined by the EMO for chillers larger than 100 tons.
- (3) Water treatment
  - (a) MU Only: Designer will coordinate design of water treatment system with EMO.

### 3.5.7 Steam and Hot Water HVAC Systems

#### 3.5.7.1 General

- (1) Heating system will be equipped with treatment system designed to control scale buildup and corrosion, and boiler blowdown control. Condensate treatment will be included where applicable.

#### 3.5.7.3 Medium and Low Pressure Steam (above grade)

- (1) Medium pressure steam is defined as having 15-60 PSI. Low pressure steam is below 15 PSI.
- (2) All drawings will show drip legs and specifications will require drip legs for all risers.
- (3) Pressure Reducing Valves (PRV)
  - (a) All PRVs will be installed with isolation valves, a bypass loop with a globe valve in the bypass, and pressure gauges on both sides of the PRV. All PRVs will be located and configured to allow ready accessibility for maintenance. Whenever possible, provide a minimum clearance of 24" in all directions. No PRV will be located more than 8' above floor level. Designer will evaluate the feasibility of using wall-mounted PRVs.
- (4) MU Only: Building systems (AHU, HX) will be designed for a maximum operating pressure of 15 psig. Sizing of control valves, PRV, traps, etc., will be based on a delivery pressure setting of 5-7 psig.

#### 3.5.7.4 Hot Water

- (1) Pumps
  - (a) All pumps will be installed in easily accessible locations and will have isolation valves installed on each side of the pump.
  - (b) All pumps will have mechanical seals.

- (c) Base mounted, centrifugal pumps will be installed with a pressure gauge manifold and a suction diffuser/strainer. Pipe vibration isolators will be stainless steel. Designer will evaluate the need for vibration isolation on the pump.
- (2) Air Venting
  - (a) Automatic air vents are not preferred. If used, they must be readily accessible.
  - (b) Hose bibbs will be installed for manual air vents at all high points of the hot water systems.
  - (c) Air separators are required on all systems. Centrifugal type air separators are preferred.

### 3.5.8 Air Handling Systems

#### 3.5.8.1 General Requirements

- (1) Variable Air Volume (VAV) systems are preferred.
- (2) Economizer cycles are preferred but should be evaluated on a cost/benefit basis. If an economizer cycle is used, a return air fan is suggested to prevent over pressurization of the conditioned space.
- (3) All systems using 100% outside air should be evaluated for use of heat recovery systems.
- (4) Pitot tube test port stations will be provided in all locations as required to determine fan system or zone air volumes.
- (5) Air handling units will consist of factory fabricated components.
- (6) A drawing will be mounted near the air handling unit showing as-built locations of all fire dampers, balancing dampers, VAV boxes, coils, and other equipment in the ductwork served by that unit. The drawing will be protected by glass or other suitable material.
- (7) Large systems are preferred over small multiple systems.
- (8) The location of outside air intakes will be carefully considered to prevent intake of exhaust from other systems, equipment or parking areas. Where possible, intakes should not be located at or below ground level to minimize maintenance problems from leaves and grass clippings.

#### 3.5.8.2 Air Handling Units

- (1) Air handling unit sections will be factory fabricated. Desired air handling unit features include:
  - (a) Full-sized access sections between all coil and filter sections. Access sections will have an electric light;
  - (b) Hinged access doors will be provided on all units to provide access to filters, coils, fans, dampers, etc. Door handles will be used on these doors. Bolted panels are not acceptable except on very small units.
  - (c) Side loading or upstream loading filter banks.
- (2) Exterior units will be designed specifically for outdoor installation. All piping will be within the unit enclosure.

- (3) For new construction, and existing buildings where possible, locate all air handling units inside the building or in a penthouse. Rooftop and above ceiling locations are not preferred. VAV boxes should be located in corridors or other common areas whenever possible.
- (4) All units will provide thorough mixing of outside and return air. Blow-through units are preferred over draw-through units for 100% outside air units. Designer will evaluate the need for engineered mixing boxes, blenders, or other methods to prevent stratification of the air.
- (5) Sufficient space will be maintained between heating and cooling coils so air stratification is eliminated.
- (6) Filters will comply with ASHRAE Systems and Equipment Handbook, Chapter 25, Table 2.

#### 3.5.8.3 Fans

- (1) Fans will be selected to provide highest efficiency and lowest noise characteristics practical while meeting specific system requirements. Recommended level is 85db, five (5) feet from the unit.
- (2) Fan type and characteristics will be selected to assure stable nonpulsing performance in required operating ranges. Air foil fan wheels are preferred.
- (3) Variable speed drives will be considered for fans having 5 HP or larger motors.
- (4) Fan motors up to 15 HP, fans with belt drives will be provided with adjustable pulley sheaves. Midpoint of adjustment will be at design condition.
- (5) Fans with motors larger than 15 HP, fixed non-adjustable drives in which motor pulleys of different diameter can be used, will be provided.
- (6) The motor selected will have adequate fan/impeller inertia capacity and torque capability to bring the fan to full operating speed in less than 20 seconds. Appropriate starting devices and overload relays to tolerate this time period will be selected.
- (7) Fans will comply with AMCA Standard 210 and ASHRAE Standard 51.

#### 3.5.8.4 Coils

- (1) Coils will be certified by ARI STD. 410.

#### 3.5.8.5 Filters

- (1) Filters will comply with ASHRAE.
- (2) Final filter efficiency is a minimum of 60% or per ASHRAE, which ever is more stringent.

#### 3.5.8.5 Dampers

- (1) Outdoor air intake dampers will conform to AMCA Standard 500. The air leakage rating across the damper when closed will not exceed 6 cfm/sq.ft. at 4" water column static pressure differential.
- (2) Volume dampers will be opposed blade.
- (3) All balancing dampers will lock in position.

- (4) Position of all dampers will be marked on the shaft of the damper by use of a groove or saw kerf.
- (5) Fire dampers will be in accordance with NFPA 90A and with a UL approved fusible link.

#### 3.5.8.6 Ductwork

- (1) All main and branch ductwork will be constructed of galvanized sheet metal per SMACNA. Construction will include the use of duct sealant.
- (1) Fabrication and installation of the turning vanes will conform to latest SMACNA Standards.
- (2) Maximum leakage for all duct systems is 3%. All ducts will be tested per SMACNA.
- (4) All branch duct takeoffs will use the 45 degree design and will have a balancing damper installed in each branch as close to the main duct as practical. No splitter dampers or air extractors will be used.
- (5) Only external insulation will be used. Insulation containing asbestos is prohibited. In mechanical rooms or other places where ductwork is exposed, rigid fiberglass insulation will be used. Rigid fiberglass insulation will be a minimum of 2" thick and will be glued and pinned.
- (6) Flexible ductwork will have a maximum length of 6' and will be properly supported. Provide a typical support detail on the drawings- Flexible ductwork will only be used for connecting the branch duct to the diffuser. In no case will flexible ductwork be used upstream of VAV boxes.
- (7) Use of Ductliner will be minimal and primarily for sound attenuation.

#### 3.5.8.7 Diffusers

- (1) Diffusers with integral dampers will not be used.
- (2) Perforated diffusers will not be used.
- (3) In a suspended ceiling installation, it is preferred diffusers use a 24" x 24" mounting plate. A small diffuser mounted in a large ceiling tile is not acceptable.
- (4) Diffusers for VAV systems will be specified with consideration given to air dumping at low velocities.

#### 3.5.8.8 All turning vanes will be airfoil type.

#### 3.5.8.9 Fume Hoods and Laboratory Systems

- (1) General Requirements
  - (a) All systems, whether new or replacement, will be designed using VAV hoods and constant volume exhaust fans with plenum boxes and barometric dampers. If the complete exhaust-supply system cannot be installed at time of fume hood installation, at a minimum, VAV controllers for the new equipment will be installed. This may require a constant velocity type fume hood be installed. If so, select the fume hood for future modification to a VAV type fume hood. Minor modifications to

- existing fume hoods not increasing makeup air problems or cause other imbalances are exempt from this requirement.
- (b) All fume hood systems will be designed according to ANSI Z9.5. MU Only: Design face velocity will be 100 FPM at full sash.
  - (c) Perchloric and radioactive systems will be completely separate from other exhaust systems.
  - (d) VAV systems (supply, return, and hoods) are required. Constant volume exhaust fans are preferred.
  - (e) Exhaust systems will be designed in accordance with the latest edition of the Industrial Ventilation Manual by the American Conference of Government Industrial Hygienist.
  - (f) For all fume hood installations or alterations, the balance of make-up air to exhaust air for the affected zone or building will be evaluated. Fume hoods that will cause or aggravate an imbalance between the make-up air and exhaust air will not be installed unless the imbalance is corrected. The preliminary design for a project may proceed on the basis of existing drawings and/or balance data. The final design must be based on actual test data.
  - (g) Manifold central exhaust systems are preferred over individual exhaust systems where feasible.
  - (h) Supply air diffusers will not be located in front of a fume hood. Design per ASHRAE guidelines.
  - (i) Fume hood shall be located out of traffic ways, preferably in corners with one foot from the perpendicular wall.
- (2) Fume Hoods
- (a) All fume hoods will be equipped with a face velocity monitor and markings on the front of the hood indicating maximum sash opening height and sash height for maximum air flow.
  - (b) MU Only: All fume hoods must be certified by MU Environmental Health and Safety before use.
  - (c) MU Only: All fume hoods will have half-sash locks with alarms. Alarms may have a user override but, if the override is used, will alarm again after four minutes.
  - (d) All fume hoods will have flow indicators with low flow alarms.
  - (e) MU Only: Vertical sashes are preferred. The use of horizontal sashes is discouraged.
- (3) Ductwork
- (a) All fume hood and laboratory exhaust system ductwork will be constructed with 304 stainless steel and will be of welded construction unless other materials are required by the uses of a particular system.
  - (b) Exhaust ductwork through occupied areas will be under negative pressure and exhaust fans will be located on the roof.

## (4) Controls

- (a) Control fume hood exhaust, room exhaust, and room supply airflows with a VAV scheme to maintain a constant fume hood face velocity of 100 FPM and to provide climate comfort control for the room occupants.
- (b) MU Only: Control equipment will be Phoenix, Tech Air or approved equal. Airflow control devices will be venturi type valves.
- (c) Any control system used will have a response time of 1 second or less.
- (d) Use a proximity sensor to reduce face velocity to 70-80 FPM when no one is in the immediate vicinity of the front of the fume hood.
- (e) Use sash position type of control design, not air pressure differential.

## 3.5.8.10 Animal Quarters

- (1) Design parameters for animal quarters will include 100% outside air, 100% exhaust, heat recovery on exhaust air, and a 50% safety factor on total heat load.
- (2) Verify required space temperatures with ultimate user of the space.
- (3) Where available, use steam for all preheat coils. Use a freeze-proof design on all coils.

## 3.5.8.11 Auditoriums

- (1) Design of air handling systems for auditoriums should consider use of CO<sub>2</sub> monitors and occupancy monitors to control the amount of outside air required.
- (2) Generally it is preferred auditorium systems be separate from other building systems.
- (3) Submit acoustic calculations for mechanical equipment. Particular attention will be given to low frequency vibrations.

## 3.5.9 Control Systems

## 3.5.9.1 General Requirements

- (1) MU Only: All control systems will be installed as follows:
  - (a) Contractor is responsible for providing, installing and connecting all sensors, pneumatic actuators, control valves, control dampers, electrical components and all interconnecting pneumatic tubing and electrical wiring between these devices and up to the Direct Digital Controller (DDC).
  - (b) DDC controllers consist of Johnson Controls METASYS controllers, type NAE, DX, AHU, VAV, VMA or UNT controllers. Owner will provide Johnson Controls METASYS controllers for the contractor to install.
  - (c) After all equipment has been installed, wired and piped, Owner will be responsible for all termination connections at the DDC controller's and for checking, testing, programming and start-up of the control system. Contractor must be on site at start-up to make any necessary hardware adjustments as required.
- (2) All mechanical equipment is to be tied into the campus central control system.
- (3) All DDC system equipment and protocol will be BACNet compatible.

- (4) Design will include a complete sequence of operation, schematic, and point listing of all mechanical control systems on the design drawings.
- (5) System alarms/messages will be indicated through the control system when applicable and specifically indicated in the controls sequence.
- (6) The following control features will be incorporated into the sequence of operation where applicable and justified.
  - (a) Operational Schedules
  - (b) Economizer Cycle
  - (c) Demand Control
  - (d) Temperature Reset
  - (e) Variable Air Quantities (supply/exhaust)
  - (f) Fan Speed Control
  - (g) Deadband Control
- (7) Use of pneumatic actuators with electronic sensors and controls is preferred. If electric actuators are used, they will be industrial and/or heavy duty.
- (8) All safeties, including freeze-stats, smoke detectors, high static detectors, outside air EPs, etc. will be hard wired in series with the motor controllers.
- (9) As much as practical, place controllers in a central, easily accessible location inside a protective cabinet. The designer will evaluate the need for a cabinet for individual controllers.
- (10) For areas having variable occupancy loads such as auditoriums, gymnasiums, classrooms, etc., consideration should be given to control of outside air volume through use of CO<sub>2</sub> monitors.
- (11) Contractor will furnish as-built reproducible control drawings. (Note: the consultant furnishes all other reproducible as-built drawings.)

### 3.5.9.2 Equipment

- (1) Actuators
  - (a) Pneumatic actuators are preferred.
  - (b) The use of positioners is preferred.
  - (c) For damper applications, use a minimum of one actuator for each 25 square feet of damper area.
  - (d) For valve applications, size valves, and actuators for full close and full open with a maximum of 18 pounds of air pressure.
  - (e) Actuators for outside air dampers and pre-heat coils will have a spring return.

## 3.6.6 Electrical; Communications

## 3.6.6.1 Telephone and Data Systems

- (1) General Guidelines
  - (a) The design of all communications systems will be coordinated and approved with campus Telecommunications.
  - (b) In general, the contractor will install wall boxes and any required conduit.
  - (c) A minimum of one voice and one data cable will be installed for every 100 sf. of office area. At UMKC all system installers and contractors shall be Belden CSV's.
- (2) Telecommunications Closets and Equipment Rooms
  - (a) All telecommunications closets should not be considered as proprietary and no other utility service distribution shall be housed in these rooms. Spaces will comply with EIA basic standards.
    - i) Size: minimum size requirements - 5' by 6' with door opening out or 5' by 8' with door opening into the room.
    - ii) Ceiling Height: 8' minimum ceiling height.
    - iii) Doorways: minimum measurement of 3' wide by 6' 8" high. These measurements do not include a doorsill or center post.
    - iv) Location: a minimum of one telecommunications closet will be located on each floor. Distance limitations or other considerations may require more than one closet. Closets should be located as close to the core of the structure as possible and should be stacked one above the other in multiple floor buildings. One closet should be allocated for every 10,000 sq. ft. Average cable runs should be 150 horizontal feet with no single cable run exceeding 295 feet.
    - v) Dust and static: install tile and/or seal concrete.
    - vi) Power: each closet must have a minimum of two 110V AC duplex outlet. Outlets must be separately fused, 20 amp, 3-wire grounding and on a non-switched circuit. Outlets should be located below the termination board location, if known.
    - vii) Grounding: ability to attach to building ground must be provided.
    - viii) Lighting: minimum equivalent of 538 lux measured at 4' above finished floor.
    - ix) Conduit/Cores: each closet must be constructed with a minimum of 2"-4" cores equipped with sleeves extending a minimum of 1" above finished floor. Two additional 4" cores are required for each additional 10,000 square feet per floor.
    - x) Environment: temperature ranges 60°F to 80°F; humidity ranges 20% to 60% relative; heat dissipation 750 to 5,000 BTU's per hour per cabinet.
    - xi) Security: all closets must be equipped with locking doors, handles must be knurled.
  - (b) At UMKC, specific requirements for these spaces will be supplied by the UMKC Telecommunications Department.
- (3) Telecommunications Equipment Rooms

- (a) Equipment rooms are special purpose rooms serving space needs for large pieces of telecommunications and computing equipment and may not be required in all buildings. The need for equipment rooms will be discussed with Campus Telecommunications. Equipment rooms are connected to all building distribution media and are required to have exacting environmental standards due to the nature of the equipment housed in the room. These rooms will meet the following requirements:
  - i) Size: minimum size requirements - 15' x 15' (225 square feet).
  - ii) Ceiling height: minimum 8'-6" .
  - iii) Floor: dust must be kept to a minimum. Tile floors and/or seal concrete. Floor loading minimum 100 lbs./sf. for equipment.
  - iv) Environment: temperature ranges 60°F to 80°F; humidity ranges 20% to 60% relative; heat dissipation 750 to 5,000 BTU's per hour per cabinet.
  - v) Electrical: each manufacturer's equipment is different. The following are requirements generic to all systems' requirements:
    - a) Dedicated branch circuits (unique, non-shared phase conductor, neutral conductor, equipment grounding conductor)
    - b) Sharing or daisy-chaining of any conductors is prohibited
    - c) Isolated grounding
    - d) Dedicated feeder
  - vi) Lighting: minimum equivalent of 538 lux measured at 4' above finished floor.
- (4) Telecommunications Service Entrances
  - (a) Telecommunication facilities must enter and terminate in an area providing optimum utilization for end user requirements. All entrances will be underground, in conduit.
  - (b) Sizing of underground entrance facilities fluctuates with many variables but minimum conduits required for a building entrance will be as follows:
    - i) Two-4" conduits per 200,000 square feet of usable office space.
    - ii) One spare conduit for each 2 conduits to be used.
    - iii) No more than 2 - 90° bends between pulling points.
    - iv) All ends of metallic conduit must be reamed and brushed.
    - v) All conduits will have a pull string installed.
    - vi) Metal sleeves through foundation walls must extend a minimum 20' beyond the wall.
  - (c) A pathway should be available from building entrance to the Telecommunication Equipment Rooms. This should be part of any initial installation, but also provide a path or conduit system for future expansion. The same should be provided between Telecommunication Equipment Rooms within the same building.
- (5) Pathways (interior)
  - (a) Pathways must support cables and provide protection. Pathways should be planned to facilitate original installation of voice/data cabling as well as ongoing maintenance, additions, and relocations. For new construction and

in renovations where possible, cable trays or conduit for horizontal distribution will be installed in corridors. In renovations of existing facilities, existing conduits or other pathways may be used.

#### 4.0 OUTLINE SPECIFICATIONS & DETAILS

##### 4.1. Introduction

This section contains information to be used by consultants in the preparation of project specifications.

The criteria represent minimum levels of performance, quality and/or standardization that should be enhanced by the consultant and made project specific.

The individual guidelines are grouped under the applicable CSI divisions.

Users are alerted that the Consultant Procedures & Design Guidelines sections 3.0, Design Guidelines, and 4.0, Outline Specifications & Details, are migrating towards a new structure modeled on Construction Specifications Institute 2004 division numbers and titles. During the transition, users are advised to search for topics broadly.

## 4.2 SITE WORK

### 4.2.1 Excavation and Backfill

1. All activities will be contained within construction boundaries indicated on site plan. Specified excavation requirements, precautions, and protective systems will be observed at all times.
2. Movement of trucks and equipment on Owner's property will be in accordance with Owner's instructions.
3. Topsoil will be stripped from the construction site and stockpiled in designated area. At MU, topsoil will be stripped and disposed of legally off site.
4. Trenches will not be backfilled until all required tests are completed and the utility systems, as installed, conform to requirements specified by the contract documents.
5. Rock quantities anticipated to be removed in classified excavation as a part of the base bid will be either stated in Division 2 or on the bid form. Add/deduct unit prices for rock removal will be included on the Bid for Lump Sum Contract Form. Relatively accurate estimates of rock removal are important for defining accurate construction estimates.
6. For purposes of identifying and measuring rock, which may be encountered during classified excavation, the following definitions will be used. The definitions are based on minimum equipment requirements, which must be equaled or exceeded by the contractor. If the contractor chooses to use equipment of lesser size, capacity, or power than specified for excavating purposes, the contractor will assume all responsibility for the cost and method of removal of material resembling rock, which cannot be removed with their equipment. Therefore, contract unit prices submitted by the contractor for rock excavation will only be applicable if the contractor's equipment equals or exceeds equipment requirements specified below:
  - a. **Open Excavation**  
Rock excavation in open excavations will include removal and disposal of any sound and solid mass, layer or ledge, regardless of origin, which cannot be effectively loosened or broken down in multiple passes in opposite directions.  
  
A late model crawler-type tractor rated with at least 170 net flywheel horsepower, equipped with a hydraulic ripper with one digging point of standard design and size, and with tractor operating in low gear.
  - b. **Pit and/or Trench Excavation**

Rock excavation in trenches and pits will include removal and disposal of any sound and solid mass, layer or ledge, regardless of origin, which cannot be excavated and removed by a 3/4 cubic yard capacity hydraulic backhoe, rated at not less than 90 net flywheel horsepower, and 30,000 pound drawbar pull.

c. Drilled Pier Excavation

- (1) Weathered rock/shale pier excavation is defined as any material that cannot be drilled or removed with conventional earth augers and requires the use of rock augers for drilling.
- (2) Rock excavation is defined as any sound and solid mass, layer or ledge, regardless of origin, which cannot be drilled with conventional earth augers or underreaming tools and requires alternate drilling methods for removal, such as special core barrels, air tools, and/or other methods of rock excavation. (The minimum size drill rig is one with a rated positive crowd force of 37,000 pounds and a continuous torque rating of 25,000 foot pounds).

7. Disposal on Owner ' s designated site (use as directed by the Project Manager [PM]): contractor will remove excess suitable fill materials from project site and dispose of materials on the Owner's designated site. The distance contractor will have to haul materials for disposal will be in the contract documents. Contractor will level off fill materials at dump site. Unsuitable fill will be disposed of legally off the Owner's property.
8. Disposal off-site (use as directed by PM): contractor will remove excess suitable and unsuitable fill materials from project site and dispose of legally off the Owner's property.
9. Consultant will specify inspection and testing requirements and will include procedures for evaluation of test data. All bearing soil and backfill will be inspected and tested immediately prior to placement of reinforcing steel and concrete and at the discretion of the Owner ' s representative and the soils engineer. Owner will retain the services of an engineering inspection and testing firm. Contractor will be responsible for coordinating and scheduling inspections.
10. On MU projects, rough grade for the contractor will be 6" below finish grade. Topsoil and finish grading will be by the Owner.
11. Backfill and subgrade compaction will conform to geotechnical engineer recommendations. For projects without a geotechnical report, the following criteria shall be specified:
  - a. Bearing soil for spread footings, pad footings, and slabs on grade shall be compacted to a minimum of 95% of maximum density at optimum

- moisture content (-2% to +4%) standard proctor. Excavation to undisturbed soils is not considered adequate.
- b. Backfill for foundations shall be compacted to a minimum of 88% and a maximum of 92% of maximum density under landscaped areas and a minimum of 95% of maximum density under other areas at optimum moisture content ( $\nabla$  2%) standard proctor. Backfill shall be installed in no more than 12" lifts. Specific soils or situations may require smaller lifts.
  - c. Backfill for trenches should be well graded granular materials  $\frac{3}{4}$ " to 1" clean material vibrated in lifts.
12. Proof rolling shall be specified for areas to be paved and shall conform to the geotechnical engineer's recommendations. For projects without a geotechnical engineer's recommendation, the following criteria will be specified:

All areas to be paved that are of sufficient size to permit the required equipment shall be proof rolled prior to placement of the aggregate base course. Proof rolling shall consist of passing/driving a loaded, 20-ton, tandem dump truck over the prepared subgrade soil with a maximum allowable displacement of 1". Any areas that displace more than 1" shall be compacted until this criterion is met, or those areas may be excavated and backfilled with compacted Type 1 Aggregate for Base. All proof rolling shall be performed in the presence of the Owner's Representative.

#### 4.2.2 Demolition

1. PM will designate material removed by demolition that is to remain on the University's property before completion of final review documents.
2. Materials acquired through demolition, other than those required to complete the construction project and designated for return to Owner, will become the property of the contractor and will be removed from the site and off University property in accordance with the Owner's instructions. The material will be disposed of in a legal manner.
3. All asbestos materials are to be removed before general demolition.

#### 4.2.3 Hazardous Materials

##### 4.2.3.1 Asbestos Containing Materials

1. The University will furnish the consultant a completed asbestos removal specification. These are to be inserted into Division 2 and will be considered a part of the contract documents. Asbestos specifications will be furnished after the final contract documents review meeting along with the advertisement (See Appendix E - Asbestos Removal Specifications).
2. The University will retain an asbestos consultant through a separate agreement to develop and provide the survey and abatement documents. Consultant should coordinate with the asbestos consultant in the development of contract documents.
3. Asbestos consultant should be listed as a special consultant to the Owner in the Special Conditions. The asbestos abatement specifications should be listed in the project manual table of contents.

##### 4.2.3.2 Lead Based Paint – See Appendix 16a

##### 4.2.3.3 Miscellaneous Hazardous Materials

1. PCB containing material may be present in existing fluorescent light fixture ballasts. PCB containing ballasts shall not be discarded in the regular trash or demolition debris. PCB containing ballasts not salvaged shall be removed from the fixture and turned over to the Owner for disposal at no cost to the Contractor. Fluorescent light fixtures containing non-PCB ballasts may be salvaged. These ballasts must have a label that specifies no PCB, Non-PCB, or PCB Free. The contractor must properly remove the light fixtures intact and relocate them as directed by the Owner.
2. Mercury Vapor Fluorescent Lamps may be salvaged if the Contractor removes the fixture without breaking the tube and removes them from the site as directed by the Owner. If fluorescent tubes are not to be reused, they must be recycled. The contractor shall remove the tubes fixtures undamaged, pack them securely in tube boxes, and ship them to a fluorescent tube recycler. Fluorescent lamp tubes shall not be discarded in the regular trash or demolition debris. (See Appendix 16b)
3. Mold growth may be present existing building materials. Use standard mold remediation (“clean-up”) techniques to properly control and dispose. Report unusual or severe mold growth to Project Manager. Reference EPA Publication 402K81001, March 2001.

##### 4.2.3.4 Acid Dilution Underground Tanks shall not be used.

## 4.2.4 Asphalt and Portland Cement Concrete Paving

1. Asphalt/Portland cement concrete pavement, will be designed according to the following guidelines:
  - a. Roadway: (rigid and flexible) AASHTO Guidelines for the Design of Pavement Structures, 1986
  - b. Parking Lot:  
Rigid - Portland Cement Association  
Flexible - The Asphalt Institute
  - c. Walkways will have a minimum compressive strength of 4000 psi for 28 days.
  - d. All exposed concrete (including precast concrete) will be air entrained according to the Chart in Division 3 in this standard..
  - e. Flint and chert will be limited to 1% maximum, by weight of the coarse aggregate, in all exposed concrete (cast-in-place or precast). Lignite will be limited to 0.07%, by weight of the fine aggregate in all exposed concrete. Some applications may be required to be lignite free (project manager will advise).
2. Asphalt surfaced parking lots will have a minimum cross section of 3" of asphalt surface prime coat, 6" of crushed stone Type 1 aggregate for base, and an underlayment of geotextile fabric.
3. Concrete surfaced parking lots will have a minimum cross section of 6" of concrete and 4" of Type 1 aggregate for base. The concrete will be Portland cement concrete with a heavy broom finish. All joints will be shown on the plans and will be sealed with traffic grade caulking.
4. All concrete walks and drives will be reinforced with a (MU only: #3 rebar at 18" centers each way) 6x6/10x10 welded wire fabric or rebar. At MU, dowels shall not be epoxy coated. Steel shall be at the approximate mid-point of the concrete depth.
  - a. Concrete strengths will be specified in accordance with actual requirements. Concrete mix will be specified with minimum cement content, as well as maximum water/cement ratio.
  - b. Fibers (non-asbestos) can be used in addition to steel to control shrinkage cracking.
5. Consultant will specify inspection and testing requirements and will include procedures for evaluation of test data. For UMSL and UMKC projects, the contractor will retain services of a concrete testing firm. For MU and MUS&T projects, the University will retain services of a testing firm. Contractor will be responsible for scheduling the tests. Contractor will be required to notify the

Owner ' s representative a minimum of 48 hours prior to all placement of concrete.

Specifications will require strength, air entrainment, temperature, and slump tests, and will indicate allowable limits for each measure. Strength tests will require 4 cylinders (3 to be broken and 1 spare). Test results will be specified to be sent directly to the contractor, architect, and the Owner ' s representative.

Concrete will be tested at the minimum rate of one test for the first 25 cubic yards [CY] placed each day, and one test for each additional 50 CY placed. Concrete may be tested more often at the discretion of the Owner ' s representative.

Test data from concrete cylinder breaks will be evaluated using procedures of the American Concrete Institute (latest edition of ACI 214) to determine if the compressive strength of the concrete tested is acceptable.

6. All concrete walks and drives will be constructed on a minimum of 4" of compacted crushed stone base course. Gradation of the crushed stone will be as required for Type 1 aggregate.
7. Sand will be from local sources meeting ASTM C-144 for mortar and ASTM C-33 Size 67 for concrete. If matching of color is necessary, sand for mortar and concrete will be from the following sources:
  - MU - Missouri River
  - UMSL - Meramec River
  - UMKC - Kaw River
  - MUS&T - Meramec River/Little Piney
8. At MU only, driving surface pavement patches for utility cuts will include 8" of concrete with #4 transverse bars (to the patch centerline) at 18" maximum centers and 2-#4 longitudinal bars. Patch will extend 1-foot minimum outside the trench. Patch surface shall be concrete with abutting concrete paving or 2" of asphaltic concrete/tack coat with abutting asphalt surface.
9. Joints and Concrete Flatwork
  - a. Expansion joints shall be installed to provide for thermal expansion of concrete pavements. Generally expansion joints shall be provided at the PC and PT of curves where the deflection angle is greater than 30E and intersections. If required for load transfers, expansion joints will be detailed with dowel bars to allow load transfer and expansion of the concrete slabs. Non-extruding expansion joint material will be used with expansion joints.

- b. Portland cement concrete flatwork will be isolated from manholes, existing walls, etc., by use of expansion joints.
  - c. Contraction joints shall be tooled during finishing or sawed within 18-hours of concrete placement. If the joint edge ravel, stop, do not proceed until concrete has sufficient cure to saw without damage. Refer to 4.3.3 for further requirements.
  - d. Construction joints will be located at expansion joint locations wherever possible. Construction joints at other locations will be keyed.
  - e. All joints will be sealed with traffic grade, non-asphalt, non-extruding sealant.
  - f. Joint spacing and joint detail will be shown on the drawings.
10. Paint colors will be white for general lot striping, yellow for no parking areas, and blue for accessible spaces and areas. Lead bearing substance paints are prohibited.

#### 4.2.5 Site Utilities

##### 4.2.5.1 Storm Sewers

1. Storm sewer pipe shall be reinforced concrete pipe conforming to ASTM C76 or AASHTO M170, Class 3 minimum, and asbestos-free.
  - a. Joints shall be flexible rubber gasket conforming to ASTM C443 or ASTM C361.
  - b. The minimum pipe size for storm drains is 12”.
2. Area drain piping shall be 8” or larger. Pipe shall be:
  - a. Ductile iron conforming to ASTM A746 with cement lining conforming to ANSI/AWWA C104/A21.4, and asphaltic coating on the interior and exterior conforming to ANSI/AWWA C110/A21.10, and asbestos-free.
  - b. Polyvinyl chloride (PVC) conforming to ASTM D2241, PVC 1120, DR 21, PR 200 (SDR-21).
3. Perforated pipe for subgrade drains shall be SDR-35 or Schedule 40 PVC. Pipe shall be installed in a geotextile envelope with clean rock. Perforated pipe in a ‘sock’ is not acceptable.
4. Inlets and junction boxes may be cast-in-place or precast conforming to ASTM C478.
  - a. Storm manholes (junction boxes) shall use a Deeter 1247, Neenah R-1642, or exact equal frame and lid. The lid shall be lettered with the words ‘Storm Sewer’ or ‘Storm Drain’.

- b. Structures over 3-feet from lid to lowest flow line shall include steps. Steps shall be Neenah 1980-J, Deeter 1606, M.A. Industries PS2-PF, or equal.

#### 4.2.5.2 Sanitary Sewers

1. Sanitary sewers shall be constructed in accordance with the standards and requirements of the Missouri Department of Natural Resources and local regulatory agency (MSD, City of Columbia, Rolla, or Kansas City).
2. Sewer piping installation shall include granular bedding and backfill within the pipe envelope.
  - a. Trench backfill in yard areas shall generally be soil compacted, in continuous layers not exceeding 8" in compacted depth, to 90% Standard Proctor Density.
  - b. Trench backfill under pavements shall generally be granular material compacted, in continuous layers not exceeding 8" in compacted depth, to 95% Standard Proctor Density.
  - c. Maintain -2% to +4% optimum moisture content for cohesive soils. For cohesionless soils, maintain moisture at less than +4% of optimum moisture content.
3. The minimum service line size shall be 6". The minimum sewer line shall be 8".
4. Sanitary Sewer Pipe shall be:
  - a. Ductile iron conforming to ASTM A746 with cement lining conforming to ANSI/AWWA C104/A21.4, and asphaltic coating on the interior and exterior conforming to ANSI/AWWA C111/A21.11, and asbestos-free.
  - b. Polyvinyl chloride (PVC) conforming to ASTM D2241, PVC 1120, DR 35, PR 200 (SDR-21). Joints shall conform to ASTM D3033/D3034, Type 1, Grade 1.
5. Manholes shall be pre-cast concrete conforming to ASTM C478 or ASTM C76, Class 3.
  - a. Joints shall conform to ASTM C361 or ASTM C443.
  - b. Pipe openings shall be provided with flexible connectors designed to produce a positive watertight connection for pipes entering the manhole. Connectors shall be A-LOK or equal.
  - c. Grade rings shall conform to ASTM C478.
  - d. Waterproofing shall consist of two coats of asphaltic pitch conforming to ASTM D449, and shall be asbestos-free.
  - e. Standard frame and lid shall use a Deeter 1247, Neenah R-1642, or exact equal frame and lid. The lid shall be lettered with the words 'Sanitary Sewer'. Watertight frames and lids shall be used in areas with high infiltration potential and in Regulatory Flood Plains.

- f. Manhole steps shall be Neenah 1980-J, Deeter 1606, M.A. Industries PS2-PF, or equal.
6. Cleanouts are required on service lines outside a building footprint and at horizontal or vertical bends in a service line. The deflection should utilize a wye with the cleanout as an upstream extension of the downstream line's alignment.
    - a. Cleanout material shall be cast iron.
    - b. Frame and casting shall be Neenah R-1976, Deeter 1830, or equal. Casting shall be anchored by a 2' x 2' x 8" thick concrete pad, 6" below finished grade. Separate concrete from pipe with two layers of Building Paper.
    - c. End of line cleanouts shall use long radius bends and include a concrete cradle under the bends. PVC shall not extend above grade.

#### 4.2.5.3 Waterlines

1. Waterline pipe shall conform to AWWA standards and the requirements of the MoDNR.
2. Waterline pipe installation shall include granular backfill within the pipe envelope. Granular or soil bedding shall be provided.
  - a. Provide 36" minimum cover.
  - b. Trench backfill in yard areas shall generally be soil compacted, in continuous layers not exceeding 8" in compacted depth, to 90% Standard Proctor Density.
  - c. Trench backfill under pavements shall generally be granular material compacted, in continuous layers not exceeding 8" in compacted depth, to 95% Standard Proctor Density.
  - d. Maintain -2% to +4% optimum moisture content for cohesive soils. For cohesionless soils, maintain moisture at less than +4% of optimum moisture content.
3. MU Only: All water meters will be located inside buildings. See Division 15 specifications for building piping and metering.
4. Valves will be installed with a vertical piece of PVC pipe and a cast iron valve box cover, with lid marked 'Water'. Casting shall be anchored by a 2' x 2' x 8" thick concrete pad, 6" below finished grade. At MU only, Project Manager will provide details.
5. The preferred material for water distribution systems is C-900, PVC with ductile iron fittings. At MU only, the Project Manager will provide details.

6. All joints shall be restrained. In addition to joint restraints, bends shall include stainless steel tie rods and reaction backing. At MU only, Project Manager will provide details.
7. Fire hydrants shall be provided in accordance with the requirements of the local fire district or department. For MU, fire hydrants shall be Mueller Super Centurion 250. At MU only, Project Manager will provide details.
8. Waterlines shall be provided with a tracer wire, with outlet at valve boxes, and warning tape. At MU only, Project Manager will provide details.

4.2.5.4 Gas Mains and services shall have a minimum of 24" of cover.

4.2.5.5 Refer to Division 15 for utilities within a building envelope.

#### 4.2.6 Landscape

1. Owner will be notified prior to grade changes during backfilling and prior to the establishment of the "rough grade" (existing grade prior to application of top soil or growing medium for turf or other plants).
2. Owner will be notified prior to applying top soil or growing medium for turf or plants for the purpose of establishing the finish grade.
3. Soil or growing medium for turf or plants will be examined and approved by the Owner as to its physical properties, fertility level, and weed content before application.
4. Planters will be checked for adequate drainage by the Owner before filling. Planters will be filled with specific soil mixtures. For MU projects, tree grates within the City of Columbia right-of-way are required to be 3' x 5'.
5. Landscape plant materials will be in accordance with the American Association of Nurserymen's Standards.
6. Landscape installer will provide typewritten instructions to the Owner for the maintenance of plant materials for one full year. Instructions will be submitted upon completion of planting.
7. Landscape plants will be maintained by the contractor for a thirty (30) day period following planting.

#### 4.2.7 Site Furnishings

1. Bicycle racks will be as manufactured by Brandir International, Inc., New York, New York.
2. Trash receptacles will be Model TR-29-R with fiberglass lid and plated bag rack as manufactured by Architectural Precast, Inc., Columbus, Ohio.
3. MU Only: Ash urns will be model AT-12-R as manufactured by Architectural Precast, Inc., Columbus, Ohio, or approved equal.
4. MU Only: Benches will be model UB-614, 6', redwood, as manufactured by Victor Stanley, Dunkirk, Maryland, or approved equal. Benches will be in ground mount with a concrete pad.
5. MU Only: Picnic tables will be model CP-2R as manufactured by Victor Stanley, Dunkirk, Maryland, or approved equal. Tables will be in ground mount with a concrete pad.

END OF SECTION

4.3 CONCRETE

4.3.1 This section applies to all building systems concrete work and cast-in-place site structural concrete outside building envelopes.

4.3.1.1 Mix Design and Materials

1. Concrete strengths will be specified in accordance with actual requirements. Concrete mix will be specified with minimum cement content, as well as maximum water/cement ratio.
2. All exposed concrete (including precast concrete) will be air entrained according to the following:

<u>Maximum Aggregate Size</u>	<u>Average Total Air Content</u>	<u>Total Air Content Range</u>
3/8"	7.5%	6.5% - 9.5%
1/2"	7.0%	6.0% - 9.0%
3/4"	6.0%	5.0% - 8.0%
1"	6.0%	5.0% - 8.0%

3. Flint and chert will be limited to 1% maximum, by weight of the course aggregate, in all exposed concrete (cast-in-place or precast). Lignite will be limited to 0.07%, by weight of the fine aggregate in all exposed concrete. Some applications may be required to be lignite free (Project Manager [PM] will advise).
4. The use of calcium chloride and/or flyash in concrete mixes will not be permitted.
5. All accessories touching the exposed surface of the concrete or come in contact with soil will be coated with plastic or epoxy to prevent rust.
6. Precast concrete
  - a. Fabricator must show compliance with the following codes and standards:
    - (1) ACI-318 "Building Code Requirements for Reinforced Concrete"
    - (2) CRSI "Manual of Standard Practice"
    - (3) Prestress Concrete Institute MNL117, "Manual for Quality Control for Plant and Production for Architectural Precast Concrete Products."
  - b. The Fabricator will have a minimum of three (3) years successful experience in the fabrication of precast concrete units similar to the units required for this project. Fabricator will guarantee the connections and will submit their design to the consultant for review.
  - c. The Erector will have a minimum of two (2) years successful experience erecting similar precast units.

- d. Shop drawings shall be prepared by a Registered Professional Engineer licensed to practice in the State of Missouri.

#### 4.3.2 Testing

1. Consultant will specify inspection and testing requirements and will include procedures for evaluation of test data. For UMSL and UMKC projects, contractor will retain the services of a concrete testing firm. For MU and MUS&T projects, the University will retain services of a testing firm. Contractor will be responsible for scheduling the tests. Contractor will be required to notify the Owner's representative a minimum of 48 hours prior to all placement of concrete.
2. Specifications will require strength, air entrainment, temperature, and slump tests, and will indicate allowable limits for each measure. Strength tests will require four (4) cylinders (3 to be broken and 1 spare). Test results will be specified to be sent directly to the contractor, architect, and the Owner's representative.
3. Concrete will be tested at the minimum rate of one test for the first 25 CY placed each day, and one test for each additional 50 CY placed. Concrete may be tested more often at the discretion of the Owner's representative.
4. Test data from concrete cylinder breaks will be evaluated using procedures of the American Concrete Institute (latest edition of ACI 214) to determine if the compressive strength of the concrete tested is acceptable.

#### 4.3.3 Placement

##### 4.3.3.1 Joints and Concrete Flatwork

1. Contraction joints shall be tooled during finishing or sawed within 18-hours of concrete placement. If the joint edge ravel, stop, do not proceed until concrete has sufficient cure to saw without damage.
  - a. Contraction joints shall have a minimum depth of 1/4 of the pavement thickness and a minimum width of 1/8".
  - b. Transverse contraction joints will be provided at a maximum of 2.5 times the pavement thickness (in inches) in feet for street pavements and 2.0 times for all other pavements.
  - c. Longitudinal joints shall have a maximum separation of 12 feet for streets and 9 feet for sidewalks.
  - d. The ratio of slab width to length should not exceed 1.67 for street pavements and 1.25 for all other pavements.
  - e. Some variance in spacing will be permitted to achieve desired architectural effect.

2. Concrete flatwork will be isolated from columns, existing walls, etc., by use of non-extruding expansion joint material.
3. Base course and underslab drainage system for slabs will conform to geotechnical engineer recommendations. For projects without a geotechnical report, slabs will be constructed on a minimum 4" base of 3/4"-1" clean rock with a plastic vapor barrier.
4. MU Only: all slabs below grade shall have a sump hole. Provide an electrical outlet by the sump hole. The campus will provide the sump pump.
5. Slab flatness and levelness will be within 1/8" in 10'. ASTM E1155 will not be used to specify flatness and levelness unless the particular use requires a high level of accuracy. Areas having floor drains will have positive slope to the floor drain. Amount and direction of slope for floor drains will be indicated on the drawings.
6. Construction joints will be located at expansion joint locations wherever possible. Construction joints at other locations will be keyed.
7. Joint spacing and joint detail will be shown on the drawings.

#### 4.3.4 Exposed Concrete

1. All exposed concrete will conform to the applicable sections of V.B.3A.
2. Exposed concrete intended as a finish material shall be clearly defined in the drawings and specifications. Areas to be addressed should include special formwork, form liners, acceptable defects (if any), surface repairs and surface treatments (i.e.: sandblast, rubbing, etc.)

END OF SECTION

#### 4.4 MASONRY

##### 4.4.1 Brick and Block Masonry

1. Design and construction guidelines and technical notes of the Brick Institute of America (BIA) will be followed for brick and the Masonry Advisory Council (MAC) for concrete masonry unit (CMU) construction.

Particular emphasis is placed upon the following BIA sections:

- a. Articles 21, 21A, 21B, 21C/Brick Masonry Cavity Walls.
    - (1) Tie Spacing (4.5 square feet per tie, maximum 24" on center vertical, and maximum 36" on center horizontal).
    - (2) Movement Joints (Articles 18 and 18A).
    - (3) Flashings (placement, protrude 1/4" beyond face of wall and form a drip).
    - (4) Weeps (24" on center with tubes, 16" on center with wicks, located above flashings).
    - (5) Air Space (2" minimum kept clean of mortar droppings).
  - b. Article 28B/Brick Veneer Steel Stud Panel Walls
    - (1) Tie Spacing (2 square feet per tie, maximum 18" on center vertical, and maximum 24" on center horizontal).
    - (2) Movement Joints (Articles 18 and 18A).
    - (3) Flashings (placement, protrude beyond face of wall and form a drip).
    - (4) Weeps (24" on center with tubes, 16" on center with wicks, located above flashings).
    - (5) Air Space (2" minimum, kept clean of mortar droppings).
2. Brick allowances are discouraged. Allowances will be specified for brick only if specific selections cannot be made.
  3. All brick (including that incorporated into the face of architectural precast panels) will comply with ASTM C216 and will have a rating of "no efflorescence" when tested according to ASTM C67.

Lab certification of brick will be based on samples taken from bricks produced for the project and will be approved prior to delivery. At MU, the Owner will retain an independent testing agency that will randomly test brick delivered to the site for compliance.

4. Brick used as paving material must be paving grade and will be set in a concrete base with an asphalt leveling course.

##### 4.4.2 Stone Masonry

1. Limestone will be supplied following the guidelines of the Indiana Limestone Handbook, current edition.
2. Coping stones will be secured with stainless steel anchors and pins and will have a continuous rubber membrane flashing beneath the stones that extends flush to the surface of the wall, but not past the exterior surface. All head joints of coping stones will have joint sealant installed rather than mortar or grout.

#### 4.4.3 Mortar, Flashing, Weep Holes, and Anchors

1. Mortar for Masonry Units and Manufacture of Masonry Units will conform to ASTM Standards on Masonry - 1990 Edition. In particular, C91-89 (Standard Specification for Masonry Cement) and C270-89 (Standard Specification for Mortar for Unit Masonry) will apply.
2. All shelf angles, fasteners, and other metal objects incorporated into masonry walls will be hot dipped galvanized. On MU projects, fasteners will be stainless steel.
3. All flashings should extend 1/4" beyond the face of wall. In-wall flashings should be composite copper asphaltic felt. Through-wall flashings shall be stainless steel. Weeps shall be installed above each flashing.
4. Wall ties will be hot dipped galvanized steel, of a material, construction and movement quality equal to Hohmann & Barnard, Inc., DW10 Box Wall Tie.
5. At load bearing joints of different types of materials (brick and stone, brick and concrete, etc.), mortar will be raked back a sufficient depth to allow the installation of backer rod and sealant. Sealant installation details will comply with the manufacturer's recommendations.

END OF SECTION

## 4.5 METALS

### 4.5.1 Structural Steel

1. If the AISC "Code of Standard Practice for Steel Buildings and Bridges" is used or referenced, the specifications will modify that code by deletion of the following sentence in paragraph 4.2.1: "This approval constitutes the Owner's acceptance of all responsibility for the design adequacy of any detail configuration of connections developed by the fabricator as a part of their preparation of these shop drawings."
2. Specifications will clearly state the responsibility for the design of steel connections. The responsible party must seal the connection designs.
3. Certified (AWS D1.1) welders will be used on structural work.
4. Consultant should consider use of twist-off Legume bolts and load indicator washers for field structural connections.
5. Pre-engineered metal building roof purlins will be adequately braced on the compression flange to resist all design loads. Purlin slide clips commonly used with standing seam systems will not be considered an effective brace for the purlin. Separate purlin bracing such as threaded rods or sag angles must be provided in addition to the slide clips.

### 4.5.2 Testing

1. Consultant will specify inspection and testing requirements and will include procedures for evaluation of test data. For UMSL and UMKC projects, the contractor will retain the services of a structural steel testing firm. For MU and MUS&T projects, the University will retain the services of an independent testing firm to test all steel connections. Contractor will be responsible for scheduling tests. Contractor will be required to notify the Owner's representative a minimum of 48 hours prior to the time testing is needed.
2. Test results will be specified to be sent directly to the contractor, architect and the Owner's representative.

#### 4.5.3 Miscellaneous Metals

1. At exterior guardrails and handrails that are not a significant part of a building ' s architecture, construction will consist of fully welded hot dipped galvanized steel pipe (galvanize only the lower 18" on MU projects). Infill panels will consist of vertical balusters. Support posts will be set in sleeves oversized 1" cast into the walk. On MU projects, railings will be painted black with high gloss enamel paint. Non-shrink non-metallic grout will be used and will slope to drain.
2. Specifications will require a mock up panel for all welded railings, grilles and similar architectural metal elements.

END OF SECTION

#### 4.6 WOOD & PLASTICS

##### 4.6.1 Rough Carpentry

1. Fire retardant lumber, used where required by code, will be in accordance with American Wood Preservers Association standards.
2. Where wood is in contact with ground or moisture, a material suitable for such application shall be used, however CCA is not recommended.

##### 4.6.2 Architectural Millwork and Cabinetry

1. All architectural millwork and cabinetry will meet Architectural Woodwork Institute standards, and finish shall be free of lead bearing substances.
2. The use of more durable solid surfacing materials for windowsills is encouraged. Plastic laminate on solid wood or exterior grade plywood is acceptable. Standard particleboard is not acceptable.
3. Countertops should minimize seams. On MU projects, plastic laminate countertops should have a plywood substrate. Sprayed on glue application for plastic laminate is not recommended.

END OF SECTION

#### 4.7 THERMAL & MOISTURE PROTECTION

##### 4.7.1 General

1. Materials used for moisture protection will comply with specifications contained in the appropriate American Society for Testing and Material standards.
2. All roofing materials shall be asbestos free.
3. Roof manufacturer approval process:

All roof systems are pre-approved by the University. This is an internal process, consisting of the following:

- a. Roof manufacturer submits the following information to the UM Roofing Committee:
  - (1) Roof system technical data
  - (2) List of approved regional installers
  - (3) List of regional projects completed over the last three years  
detailing:
    - (a) Roof area and cost
    - (b) Project owner and contact person
    - (c) A/E design firm and contact person
- b. The UM Roof Management Committee, with the assistance of the UM roof consultant, evaluates all aspects of the proposed system.
- c. If necessary, the manufacturer meets with committee to review submitted materials and respond to questions.
- d. UM Roofing Committee in consultation with UM roof consultant approves or rejects the roof manufacturer. In addition, updated listings are included in the most current version of the Consultant Procedures and Design Guidelines

##### 4.7.2 Roofs

1. Design Standards include:
  - a. Factory Mutual (FM) I90 wind requirements for roof system approval.
  - b. Underwriters Laboratory (UL). UL labels are required for each membrane, with top side fire rating meeting ASTM E108 Class A.
  - c. National Roofing Contractors Association (NRCA), Roofing and Waterproofing Manual, 4th Edition - 1996.
  - d. Sheet Metal and Air Conditioning Contractor 's Association International (SMACNA), Architectural Sheet Metal Manual, 5th Edition - 1993.
  - e. American Society for Testing and Materials (ASTM) standards for polymer-modified bitumen: D5147, D6162, D6163, and D6164.

2. Consultants will base roof specifications on the University of Missouri's Design Guidelines. The systems/manufacturers are prequalified:

EPDM

Carlisle Corporation  
 Firestone Building Products Company – Performance Roof Systems  
 Versico, Inc. *(App Derby Gum tentative acceptance)*

CSPE

JPS Elastomerics Corporation  
 Burke Rubber Company

CPA

Duro-Last Roofing, Inc.  
 Seal-Dry/USA, Inc.

PVC

Sarnifil Corporation (limited application due to proprietary product nature)

Built-Up Roofing Systems/Coal Tar

Allied Signal Inc.  
 Koppers Industries Inc.

Built-Up Roofing Systems/Asphalt

Johns-Manville  
 Tamko Asphalt Products Inc.  
 U.S. Intec

Modified Bitumen SBS

Garland Company Inc.  
 Johns-Manville  
 Tamko  
 Siplast  
 US Intec Inc.  
 Firestone Building Products Company

Metal Roofing Systems

Atas Aluminum Corporation	Monarch
Butler Manufacturing Company	VSR
Centria	SRS
MBCI	Lok-Seam
Steelex Systems, Inc.	CF/SD
Vincent Metals	System 1

3. Recommended Roof Membrane and Insulation Assemblies

## a. Built-up asphalt (BUR)

Membrane: four plies of Type IV glass felts in Type I or Type III asphalt moppings. Coal tar roof assemblies shall be considered with existing no slope roofs or new low slope roofs (less than 1/4" per foot). Type VI felt can be used in lieu of Type IV felt. On nailable substrates, a coated base sheet should be employed with three plies of Type IV. Base sheets should not be utilized under other circumstances.

Insulation: R-20 minimum rigid polyisocyanurate or extruded polystyrene (as part of roof manufacturer's approved system and included in the total system warranty). Mechanically fastened except over concrete deck or vapor retarder. Extruded polystyrene is preferred if approved by the manufacturer.

The insulation specified shall be compatible with the application method required and the other materials of the roofing system and shall be included in the total system warranty.

It is required that insulation be installed in more than one layer with staggered joints. Use of a recovery board is not considered a layer.

Substrate Board: 3/4" thick organic fiberboard or perlite for exterior fire rating Class A. Built-up roofs should never be installed directly over polyisocyanurate. Substrate board to be installed with staggered joints and adhered in asphalt as part of total roof system.

Surfacing: flood coat with surface granulating or a fibrated aluminum coating for Class A rating.

Base Flashings: mineral surfaced modified bitumen sheets. Polyester fabric and modified mastic applies to top edge and side laps. Where deck-wall movement is likely (metal deck, masonry walls), use SBS type with polyester reinforcement only. Install in two components within 20' of corners and expansion joints. Avoid APP type at non-nailable substrates. Use SBS type with polyester reinforcement at low profile expansion joints and control joints. Use SBS type with granule surfacing and polyester reinforcement as walkways.

Anchor membrane with non-ferrous termination bars and stainless steel fasteners at wall/deck transition. Termination bars to be covered with a reglet and counter-flashing even if not required by manufacturer's warranty.

## b. SBS Type Modified Bitumen Sheet System

Membrane: to consist of a base sheet, interply sheet and cap sheet of SBS type sheets bonded with hot asphalt or approved adhesives. Hot asphalt is encouraged where roof accessibility is not a problem. A special fire rated sheet may be necessary to meet Class A requirements. Polyester or fiberglass reinforcement is allowable per manufacturer's roof systems. Standard test methods for sampling and testing Modified Bitumen material shall comply with ASTM D-5147, D-6162, D-6163, D-6164.

Insulation: R-20 minimum rigid polyisocyanurate or extruded polystyrene (as part of roof manufacturer's approved system and included in the total system warranty). Extruded polystyrene is preferred if approved by the manufacturer.

The insulation specified shall be compatible with the application method required and the other materials of the roofing system and shall be included in the total system warranty.

It is required that insulation be installed in more than one layer with staggered joints. Use of a recovery board is not considered a layer.

Substrate Board: 3/4" thick organic fiberboard or perlite for exterior fire rating Class A (as part of roof manufacturer's approved system). Modified bitumen roofs should never be installed directly over polyisocyanurate. Substrate board to be installed with staggered joints and adhered in asphalt as part of total roof system.

Surfacing: ceramic granule surfaced cap sheet, white in color, unless otherwise recommended.

Base Flashings: SBS material furnished and installed per roof manufacturer's recommendations. Use SBS type with polyester reinforcement only. Install in two components within 20' of corners and expansion joints. Avoid APP type at non-nailable substrates. Use SBS type with granule surfacing and polyester reinforcement as walkways.

Anchor membrane with non-ferrous termination bars and stainless steel fasteners at wall/deck transition. Termination bars to be covered with a reglet and counter-flashing even if not required by manufacturer's warranty.

Surfacing: ceramic granule surfaced cap sheet, white in color, unless otherwise recommended.

- c. EPDM (non-reinforced)

-Fully adhered

Membrane: minimum 60 mil thick EPDM non-reinforced sheet. Use tape or continuous contact adhesive seams as supplied and approved by manufacturer.

Insulation: R-20 rigid polyisocyanurate or high-density fiberboard (as part of roof manufacturer's approved system and included in the total system warranty). Polyisocyanurate will have special facers designed for EPDM adhesion and must be approved or manufactured by primary membrane manufacturer. High-density fiberboard is for overlay system to be used only under special conditions. Attach insulation with mechanical fasteners with caps that lock onto screws over metal and wood decks. Adhere with asphalt over concrete and vapor barriers. Substrate must be free of contaminants prior to membrane applications.

The insulation specified shall be compatible with the application method required and the other materials of the roofing system and shall be included in the total system warranty.

It is required that insulation be installed in more than one layer with staggered joints. Use of a recovery board is not considered a layer.

Surfacing: none; use fire rated Class A system for exterior fire resistance.

Base Flashings: 60 mil EPDM. Continue field membrane up walls and curbs. Use details that minimize uncured rubber. Anchor membrane with non-ferrous termination bars and stainless steel fasteners at wall/deck transition. Termination bars to be covered with a reglet and counterflashing even if not required by manufacturer's warranty.

UM Standards for EPDM (listed in Table 1)

TABLE 1  
UM STANDARDS - EPDM  
NON-REINFORCED

ASTM Test	Property	UM
D751	Adhered membrane thickness (mils)	60
D751 <sup>1</sup>	Mech. fasted membrane thickness (mils)	60
D412 <sup>2</sup>	Tensile strength (psi)	1600

D412	Elongation at break (%)	500
D2137	Brittleness point (BF)	-60
D624	Tear resistance (lb-f/in)	220
E96	Water absorption (% max)	3
D573	HEAT AGING TESTS: (% original)	90
	Years as manufacturer of membrane	5
	Years company in business	5
	Number of squares installed in USA	10,000 min.
	Roof installer manufacturer approval	Required
	UL Class A	Required
	Wind uplift	FM I-90
<sup>3</sup>	Seaming overlap (contact cement)	3"

<sup>1</sup>60 mil reinforced membrane for mechanical fastened roofs.

<sup>2</sup>For unreinforced membrane only. Breaking strength for reinforced membrane per ASTM D751 to be 140x150 lbf (minimum).

<sup>3</sup>Taped seams require minimum 4" overlap.

- d. CSPE (reinforced)  
- Fully adhered

Membrane: minimum 45 mil thick polyester reinforced sheet. Use heat welded seams with membrane installed using continuous contact adhesive as supplied and approved by the manufacturer.

Insulation: R-20 minimum. Most insulation types are acceptable substrate (as part of roof manufacturers approved system and included in the total system warranty). Obtain written membrane manufacturer approval.

The insulation specified shall be compatible with the application method required and the other materials of the roofing system and shall be included in the total system warranty.

It is required that insulation be installed in more than one layer with staggered joints. Use of a recovery board is not considered a layer.

Substrate Board: not required

Surfacing: not required

Base Flashings: 45 mil thick CSPE or special coated metal and all as supplied and approved by roof manufacturer.

Anchor membrane with non-ferrous termination bars and stainless steel fasteners at wall/deck transition. Termination bars to be covered with a reglet and counter-flashing even if not required by manufacturer's warranty.

UM Standards for CSPE (listed in Table 2)

TABLE 2  
UM STANDARDS - CSPE  
REINFORCED

ASTM Test	Property	UM
D5019	Membrane thickness (mils)	45
D2136	Low Temperature Flexibility BF	-40
D5019	Breaking strength (min. lbf)	225
D5019	Tear strength (min. lbf)	90
D5019	Ply adhesion (min. lbf/in)	10
D5019	Dimensional change %	2
E96	Water absorption (% max.)	3
	HEAT AGING TESTS:	
D750	Tensile (% original)	90
D750	Low Temperature Flexibility (% original)	90
D750	Elongation (% original)	90
	Years as manufacturer	5
	Years company in business	5
	Number of squares installed in USA	10,000 min.
	Roof installer manufacturer approval	Required
	UL Class A	Required
	Wind uplift	FM I-90
	Heat welded seams	Required

- e. PVC (reinforced)
  - Fully Adhered
  - Mechanically Fastened (where applicable)

Membrane: minimum 45 mil thick fabric reinforced sheet with heat weld seaming.

Insulation: R-20 minimum rigid polyisocyanurate or high-density fiberboard (as part of roof manufacturers approved system and included in the total system warranty).

The insulation specified shall be compatible with the application method required and the other materials of the roofing system and shall be included in the total system warranty.

It is required that insulation be installed in more than one layer with staggered joints. Use of a recovery board is not considered a layer.

Substrate Board: not required

Surfacing: not required

Base Flashings: special coated metal or reinforced sheet and accessories provided by primary manufacturer.

Anchor membrane with non-ferrous termination bars and stainless steel fasteners at wall/deck transition. Termination bars to be covered with a reglet and counter-flashing even if not required by manufacturer's warranty.

UM Standards for PVC (listed in Table 3)

TABLE 3  
UM STANDARDS - PVC  
REINFORCED

ASTM Test	Current Standards	UM
D751	Membrane Thickness (mils)	45
D751	Breaking strength min. (lbf/in)	230
D638	Elongation at break (%)	20
D2136	Low temperature flexibility BF	-40
D570	Water absorption (% max)	2
D570	Water absorption (% max.)	3
	HEAT AGING TESTS:	
D638	Tensile (% original)	90
D638	Low temperature flexibility (% original)	80
D638	Seam strength % tensile	85
D638	Elongation (% original)	90
D2565	Accelerated weathering (hours)	7500
D1004	Tear resistance (lbf)	12
	Years as manufacturer	5
	Years company in business	5
	Number of squares installed in USA	10,000 min.
	Roof installer manufacturer approval	Required
	UL Class A	Required
	Wind uplift	FM I-90
	Heat welded seams	Required

## f. Slope &amp; Drainage

In new construction, the roof will have a minimum design slope of 1/4" per foot. In reroofing, the roof should have a minimum slope of 1/8" per foot. Tapered insulation may be necessary to achieve required slope. Use crickets, saddles and edge strips (tapered at 2 times slope) to direct water from penetrations and parapet walls.

Locate roof drains at projected low points. All roofs shall have overflow systems of either a separate and independent overflow piping system which daylight or overflow parapet scuppers.

## 4. Metal Roofing-Structural Standing Seam (SSR)

Structural metal roofing shall meet UL90 uplift rating. Roofing shall be pre-engineered metal running perpendicular to purlins supports and insulated by a glass batt directly beneath the roofing and over the purlins. Sheets shall have a steel or aluminum core (minimum 22 gauge) and corrosion protection provided by a "Kynar" coated finish. Slope should be no less than 1" per foot. Ice guards are required on eaves over sidewalks

## 5. Slate

Slate material shall be Type S1 slate as specified by ASTM C406 (90-110 year performance life). Natural slate may be installed in slopes as shallow as 3" per foot, provided adhered polyethylene reinforced bitumen sheet underlay is installed (5" per foot slope is preferred minimum). Use copper nails and ridge caps. Ice guards are required on eaves over sidewalks.

Use of artificial slate requires PM approval.

## 6. Asphalt Shingles

Asphalt shingles shall be fiberglass seal-tab type with minimum 25-year warranty. Minimum roof slope shall be 4" per foot with one layer of 15 lb. asphalt saturated felt underlay (30 lb. at MU) (3" per foot may be used with 2 layers of underlay). Provide a galvanized sheet steel drip edge at eaves and gable rakes. Shingles shall be nailed, not stapled.

## 7. Roof Deck

A registered structural engineer shall design roof decks. The design consultant shall determine expected wind uplift conditions for the building roof and determine suitability of the recommended system for these conditions.

Roof deck material shall be a minimum 20-gauge metal deck or a cast in place concrete deck. Wood or wood fiber cement decks shall not be used. Slope to drains shall be designed into the structural system whenever possible.

Concrete decks shall provide a sufficient drying period to avoid containment of residual water. Lightweight concrete shall not be used. Avoid mechanical attachment to decks/parapets. Adhesive or mop-in is preferred.

All wood curbs, blocking, subfascias, etc. should be preservative treated material.

## 8. Vapor Retarders

Roof consultant shall investigate and recommend whether a vapor retarder is required. Vapor retarders may be necessary when interior relative humidity is expected to rise above 45%, and the outside average January temperature is below 40°F. The vapor retarder is a layer of low permeability material to prevent moisture migration from entering the roofing system. The vapor retarder shall be installed on the warm/humidity side. Vapor retarders can consist of polyethylene sheets, laminated sheets, or multiple courses of asphalt and felts.

## 9. Roof Replacement

When roof replacement is necessary, it should not always require a complete removal of the existing roof. Factors in making a determination of roof replacement vs. roof overlay include:

- a. Moisture content in existing insulation. If more than 20%-30% of the existing insulation is wet, total tear-off is recommended.
- b. Structural analysis is required where a roof overlay results in additional imposed load on the structure. A licensed structural engineer shall confirm roof loading capacity.
- c. Roofing inspection with destructive sampling. A sufficient number of at least 2" diameter core samples should be taken to verify construction of existing roof system. These cores will indicate signs of deterioration and presence of moisture and delaminations. Core samples may also detect presence of asbestos when submitted to a laboratory for testing. Proper asbestos abatement procedures must be taken to remove this material. All holes left from the sample removal must be repaired with like materials. It is not recommended to take samples from single ply roofing systems,

- especially if they are still under warranty (a recover installation may require samples).
- d. Condition of the existing roof surface. Proper placement of roof overlays may require the use of a substrate board for improved "U" value of roof assembly, prevention of elevation irregularities, and separation of non-compatible materials. Substrate board can prevent elevation irregularities at the board joints.
  - e. Suitability for attachment. A roof overlay will employ a substrate board that is mechanically attached to the deck component. If attachment cannot meet code requirements, roof replacement will be necessary.

## 10. Warranties & Certification

Roof manufacturer and roof installer will provide the following items:

- a. The University of Missouri Roofing System Manufacturers Certification.
- b. Roofing contractor [installer] will guaranty all materials furnished and work performed under the roofing system contract against defective workmanship for a period of thirty-six (36) months after final completion as provided in the construction documents. See Special Conditions for certification sample. The system may include the following components:
  - (1) Roofing membrane (built-up felts or single-ply), slate, shingles, or metal roofs
  - (2) Flashing and counterflashing
  - (3) Insulation
  - (4) Vapor barrier
  - (5) Fasteners and adhesives
  - (6) Sealants and caulking
  - (7) Ballast and ballast stops
  - (8) Walkway mats & pavers
  - (9) Roof hatches, pitch pans and equipment curbs
  - (10) Gutters, downspouts, and fascia panels
  - (11) Roofing accessories, as required making a complete roofing system
  - (12) Coping

Note: Warranted roof system components are to be identified in the construction documents. Roof materials and accessories must be part of the approved system.

- c. Roofing manufacturer will provide a total system warranty for the roofing system furnished under this contract against leaks and defective materials and workmanship for a minimum period of fifteen (15) years after final completion as provided in the contract. This warranty will run concurrently with the roofing contractor/installer thirty-six (36) month guaranty. This warranty will cover labor and materials for the complete roofing system and the watertight integrity and performance of the roofing system installed which includes all components identified under the

- roofing contractor/installer 36-month warranty. Manufacturer will be liable for full replacement cost of the roof system; therefore warranty shall be a no-dollar limit warranty. The roofing contractor or subcontractor shall provide the Owner with an Application for a Roof Warranty. Warranty shall not exclude coverage as a result of winds less than 38, 54, 63, or 72 mph (review with project manager).
- d. Roofing contractor and roofing manufacturer accompanied by a designated University representative will perform, at no additional cost to the Owner, an annual inspection of the complete roofing system installation through the (36 month) contractor's warranty period. This inspection will include a written detailed evaluation of the roofing system including system failures and maintenance recommendations. All roofing system failures and defects will be repaired/corrected by the contractor at no additional cost to the Owner within thirty (30) days from date of annual inspection. These repairs/corrections will include replacing any and all wet insulation. All repairs will be approved by, and made to the satisfaction of, the Owner's representative.
  - e. Owner will notify roofing contractor and manufacturer, if repairs covered by the warranty are required, within twenty (20) days of discovery of defects in the roofing system. Upon written notice from the Owner of any breach of warranty during applicable warranty period due to defective material or workmanship, the affected part of parts thereof will be repaired or replaced at no cost to the Owner within thirty (30) days of receipt of notice. Contractor should notify Owners when they come on Campus for warranty repairs. Should the roofing contractor or roof manufacturer fail or refuse to make necessary repairs or replacements, when requested by the Owner, the Owner may perform, or cause the necessary work to be performed at the roofing contractor and manufacturer's expense.
  - f. The following are excluded from this warranty:
    - (1) Roof maintenance
    - (2) Damage to any part of the building (other than the roofing system) or to its contents.
    - (3) Damage resulting from any one of the following:
      - (a) Cracking, warping, deflection or movement of building foundation.
      - (b) Natural disasters such as earthquake, hail, or wind exceeding 38, 54, 63, or 72 mph (review with project manager).
      - (c) Accidents, vandalism, or other uncontrollable events.
      - (d) Chemical attacks on the membrane from sources not present at time of roofing system installation.
      - (e) Excessive movement or deterioration of metal components adjacent to the roof or engaged therein.

## 11. Roof Installation

Roofing contractor must have the following qualifications:

- a. A minimum of five years experience in installation of the specified roof system.
- b. Roof manufacturer certification as an installer for specified roofing systems.
- c. Roof foreman and 50% of installing crew are trained and certified in the installation of specified roofing system. In addition, foreman will be full time at project site through roof completion.

### 4.7.3 Roofing Accessories

1. Parapet wall coping will be constructed with metal selected from one of the following materials:
  - a. Sheet metal, 22 or 24 gage, galvanized, factory finished with Kynar 500
  - b. Copper, ASTM B370, 16-20 oz.
  - c. Aluminum, .032" or .040", factory finished with Kynar 500
  - d. Stainless steel, .018 soft buff
2. Gravel stop/fascias will be aluminum, .050", and factory finished with a Kynar coated finish.
3. Installation will be in accordance with SMACNA minimum standards. End laps and side laps will provide for thermal expansion. Joints will have cover and backup plates.
4. Sheet metal roof accessories will be constructed with metal selected from one of the following materials:
  - a. Sheet metal, 20 gauge, galvanized, factory finished with Kynar 500
  - b. Copper, ASTM B370, 16-20 oz.
  - c. Aluminum, ASTM B209, alloy 3003, AA-C22A41 clear anodized finish, minimum 20 gauge
  - d. Solder, 50/50 ASTM B32
5. Surfacing aggregate shall be clean water worn opaque gravel.

## 4.7.4 Joint Sealers

1. The following joint sealer schedule will be reviewed and edited by the consultant and incorporated into the specifications.

JOINT SEALER	DESCRIPTION OF JOINT CONSTRUCTION AND LOCATION WHERE JOINT SEALER IS TYPICALLY APPLIED
Multi-Part Pourable Urethane Sealant	Exterior and interior joints in horizontal surfaces of concrete; between metal and concrete, mortar, stone and masonry.
Multi-Part Nonsag Urethane Sealants	Exterior vertical and horizontal joints subject to 12-2% to 25% movement including expansion joints, control joints in masonry or concrete. Sealants around window and door frames.
One-Part Acid-Curing Silicone Sealant	Exposed joints within glazed curtain wall framing system, skylight framing system, and aluminum entrance framing system. In masonry where silicone sealant was previously used.
One-Part Mildew Resistant Silicone	Interior joints in vertical surfaces of ceramic tile in toilet rooms, showers, and kitchens.
Acrylic-Emulsion Sealant	Interior joints in field-painted vertical and overhead surfaces at perimeter of elevator door frames and hollow metal door frames; and gypsum drywall, plaster and concrete or concrete masonry; and all other interior joints not subject to movement.
Foamed-In-Place Fire Stopping Sealant	Through penetrations in fire-resistance-rated floor and wall assemblies involving multiple pipes, conduits, and other items.
One-Part Fire Stopping Sealant	Through penetrations in fire-resistance-rated floor and wall assemblies involving single pipes, conduits where joint widths are narrow and of uniform width.

END OF SECTION

## 4.8 DOORS, WINDOWS & GLASS

### 4.8.1 Doors

1. Exterior doors at public entries will be aluminum, monumental grade, with medium stiles and weatherstripping, and will be insulated. All doors will have a center-locking rail. It is preferred that exterior pairs of doors have a center mullion (need for a fixed or removable mullion should be evaluated on a case by case basis). If a center mullion is not used, a stop type threshold (similar to Pemko 2005) shall be used. Kawneer 350 should be used as a standard of quality.
2. Low-usage or non-public exterior doors (mechanical areas, etc.) will be steel doors with steel frames. All steel will be minimum 16 gauge and 1 3/4" thick, galvanized, shop-primed, and painted with an epoxy or comparable paint. All steel doors and frames will be of welded construction with reinforcement at hardware locations. Steel doors will have a top channel cap, secured in place and sealed. At MU, the backside of exterior frames shall be primed and painted with an epoxy or comparable paint.
3. Wood doors will be solid core and comply with applicable National Window & Door Association (NWDA) and Architectural Woodwork Institute (AWI) quality standards.
4. Aluminum entrances and storefronts will have thermal break construction and comply with American Architectural Metal Association (AAMA) standards. Framing will also be thermally broken from any interior construction.

### 4.8.2 Windows

1. Aluminum windows will have thermal break construction and will comply with American Architectural Metal Association (AAMA) standards. Framing will be thermally broken from any interior construction.
2. All operable windows will be capable of being cleaned from the interior of the building and will be supplied with a positive locking device. Screens will not be supplied with the windows. All operating mechanisms will be heavy-duty, institutional grade construction.
3. In specifying windows, consideration will be given to replacement of broken glazing. It is preferred that replacement be possible from interior of the building. Other types of replacement require PM approval.
4. At MU, window units will comply with ASTM E283, E331, and E547. The Owner will retain the services of a testing company to perform these tests on

installed window units chosen at random by the Owner. Contractor will be responsible for retesting units that fail test.

#### 4.8.3 Glass and Glazing

1. Exterior windows and exterior glazed doors will have double glazing certified by the Insulating Glass Certification Council (IGCC).
2. All glazing in new windows, doors, storefronts, etc. will carry a ten year warranty on replacement of defective material.

#### 4.8.4 Finish Hardware

1. All door hardware will be heavy duty or institutional grade.
2. All public areas will be served by lever-handle locksets, similar in construction and design quality to Best 93K series- 14D lever.
3. All non-public areas (mechanical, custodian, serving, etc.) will be served by knurled handle locksets, similar in construction and design quality to Best 83K series.
4. At MU, mortise locksets will be used only in those areas requiring special security or functions. In all other areas cylindrical style locksets are preferred.
5. All locksets will accept Best Universal Lock Company 7 pin cores or cylinders. Other type locksets (electric, card access, combination, and panic devices) must have a key override function. Locksets shall be specified around Best Universal Lock Company. At MU, Arrow and Yale may also be specified. Do not specify Falcon, Sergeant or Lockwood. Other brands require PM approval.
6. All panic devices will be touch-bar type and will have a dogging function where allowed by code. If dogging function is not allowed by code, the non-egress side of the door should be equipped with a lever handle. Rim latch type devices are preferred. If a center mullion is not allowed by code, concealed vertical rod devices are preferred. In multiple door entries, only one doorway should be keyed from the exterior. Panic devices shall be specified around Von Duprin. At MU, Jackson may also be specified. Do not specify Sergeant or Dor-A-Matic. Other brands require PM approval.
7. Surface mounted parallel arm closers, mounted on the interior side of the opening, are preferred. All doors and frames will be reinforced at mounting locations. All screw and boltholes will be drilled and tapped. Wood doors should use thru-bolts. Floor mounted closers should not be used. Closers shall be specified

around LCN 4041. At MU, Rixon may also be specified. Do not specify Sergeant, Jackson or Yale. Other brands require PM approval.

8. Hager model #1191BB, ball-bearing type should be used as a standard of quality.
9. At MU, all door hardware in new construction will have either US 10 or US 26D finish. In existing construction, hardware color should match existing hardware color.
10. Early in the construction document phase, the architect should discuss the combining of the cores with the Owner. At that time it will be determined whether the Owner or the contractor will be responsible for the combining.
11. If Owner is to do the combining, specifications will require the contractor to supply Best 7-pin cores with two key blanks (no substitutions allowed), as required, for each lock.

Cylinder cores and key blanks will be shipped to the Owner for installation. The contractor will provide temporary construction cores until the Owner installs permanent cores.

12. If contractor is responsible for combining, contractor is required to use the Best Locking Systems of St. Louis to do all combining work per the key schedule supplied by the Owner.

The contractor will supply Best 7-pin cores and two key blanks (no substitutions allowed) to fit each core, as required for each lock. Owner will install the cores.

13. Door pulls with an offset design will not be used.

#### 4.8.5 Power Door Operators

1. Power door operators type of operation and equipment should be as follows:
  - a. Door should be operated only on demand by activation of a touch pad device. In manual mode, operators will require no more than 15 lbs. force to set in motion and 10 lbs. force to continue motion and shall provide no power assist.
  - b. MU Only: The preferred activating device for exterior installations is a touchless switch mounted at 30" AFF. Switch shall be specified around P.D.E. TLS 100 Touchless Infra-Red switch with 3"-14" range adjustment and 1-10 second time delay. The preferred activating device for interior installations is a press plate switch mounted at 30" AFF. Switch shall be specified around SEDCO #59H 42 square blue anodized plate engraved to read "Press to Operate Door". Use of other devices requires PM approval.

- c. Door type should be a swinging door and must have a positive locking device for exterior and fire rated doors. Panic devices like other entry doors (supplemented with an electric strike) are preferred.
- d. Inner and outer doors of vestibules should operate independently.
- e. Only a single leaf of pairs of doors should have a power operator.
- f. Door controls should accept electric and card access locking devices for after hour access.
- g. Doors should be equipped with a keyed deactivation switch for power opener that is accessible from floor level (panic bar allows after hours egress).
- h. Doors will be equipped with manufacturer ' s standard signs as required by code. At MU, the campus will provide signs.
- i. Door operating equipment will be rated for heavy-duty service and must be electrical actuated (no pneumatics). All control wiring must be low voltage and compatible with building security system. At MU, specifications should be based upon Dor-A-Matic, Besam, Horton, Stanley or Able.
- j. Door operating equipment will have a two-year warranty.
- k. All exceptions to these criteria (fully automatic operation, sliding doors, combined vestibule operation, etc.) must be reviewed and approved by the project manager.

END OF SECTION

## 4.9 FINISHES

### 4.9.1 Gypsum Drywall Systems

1. Use 5/8" Type X firecode drywall type construction and follow the USG gypsum board construction manual guidelines.
2. Twenty gauge (0.0329") minimum studs will be used. Specify both gauge and thickness. Wood studs will not be used.
3. Three coats of drywall finishing material (embedding, fill and finish) will be used in exposed applications. Finish coat and sanding may be omitted in concealed applications.
4. Demountable panel systems should not be used without PM approval.
5. Textured finishes will not be used on drywall ceilings.

### 4.9.2 Acoustical Ceilings

1. Consideration should be given to the use of ceiling tiles with non-sag warranties in high humidity or unconditioned spaces.
2. Ceiling grid will be an intermediate duty exposed grid system conforming to ASTM C635 (1" wide grid). Chicago Metallic 200 Snap Grid should be listed in the acceptable products.

Suspend the ceiling grid directly from the building structure. Do not hang other objects from the ceiling support system. All light fixtures will be supported independently of the ceiling support system. Light fixtures, grid and other ceiling accessories will have seismic bracing.

3. At MU, specify ceiling tiles around Armstrong Minaboard fissured tile in 2'x 4' and/or 2'x2' size, or equal. Appearance shall be listed as criteria for equal products to allow for maintenance stock.
4. Specialty ceiling tiles/systems require PM approval.

### 4.9.3 Paint Finishes

1. Wall finish shall be two coats plus primer of latex eggshell or satin paint. Flat paint will not be used. Paint should be the manufacturer 's premium product. In public areas, consider semi-gloss paint on veneer plaster or concrete masonry units.

2. Ceiling finish shall be two coats plus primer of latex flat paint. Paint should be the manufacturer's premium product.
3. Painted finish for door, window, and miscellaneous trim shall be two coats plus primer of latex or alkyd enamel semi-gloss paint. Paint should be the manufacturer's premium product.
4. Stain finish for door, window, and miscellaneous wood trim shall be oil based stain with a urethane topcoat. A medium to high sheen/gloss should be used.
5. Epoxy paints should be two-part systems.

#### 4.9.4 Floor Finishes

1. All vinyl composition tile will be a minimum of 1/8" thick.
2. Tile installed on slopes or inclines will be slip resistant.
3. Epoxy resin floors will be trowel applied, with a minimum thickness of 1/8" and integral curbs. Color will be integral to flooring material, not a surface coating.
4. Particular attention will be given to specification of preparation of the subfloor.
5. Ceramic tile grout should be pigmented or natural gray. White or near white grout shall not be used. Joints should be sealed with a silicone based product.
6. When specifying vinyl sheet goods, only premium products should be specified with particular attention to given surface preparation and seaming.

#### 4.9.5. Carpet and Base

1. The preferred quality criteria is direct glue down commercial grade carpet intended for use in commercial and public spaces with construction, fire ratings, static control and appearance appropriate for this use.
2. List fire performance criteria as a submittal item.
3. Identify the manufacturer, style, and construction criteria.
  - a. List manufacturer's name and address
  - b. Carpet pattern: Select a pattern that has good soil hiding characteristics and the right scale for the facility. Multi-color patterns are preferred. Solid colors should be used for borders and accents only.

- c. Carpet Color: Select a color that is appropriate for the facility and that has good soil hiding characteristics. Typically medium to dark colors are preferred.
  - d. Carpet Fiber: Specify branded nylon, type 6 or 6.6.
  - e. Carpet Construction: Tufted loop pile is preferred. Cut/uncut, cut and woven will be considered for specialty areas.
  - f. Minimum Pile Weight will be 26-oz/square yard (tufted loop) with maximum pile height of 0.20 inch.
  - g. Average Pile Density not less than 6000 (public areas).
4. List seaming diagram as a required submittal item.
5. Installation specification shall require the following:
- a. Extend carpet under open bottomed obstructions, under removable flanges and furnishings, and into alcoves and closets of each space.
  - b. Provide cutouts where required; blind cut edges properly where not concealed by protective edge guards or overlapping flanges.
  - d. Install carpet edge guard where carpet edge is exposed; anchor guards to substrate. Exposed carpet edges that abut an adjacent floor surface at a different finish or level shall be trimmed with vinyl edging approved by the Owner.
  - e. Hot melt seam adhesive or similar product recommended by the carpet manufacturer, for taping seams and butting cut edges at backing to form secure seams and preventing pile loss at seams.
6. MU only:
- a. Resilient base is preferred to be 1/8-inch thick vinyl. Joints to occur at inside corners where possible, and in no case closer than 24 inches to an external corner. Preformed corners shall not be allowed. Field fabricate corners using manufacturer recommended procedures.
  - b. Wood base, from hardwood species, is acceptable with approval of Owner's Representative. Medium Density Fiberboard (MDF) is not acceptable.

END OF SECTION

## 4.10 SPECIALTIES

### 4.10.1 Visual Display & Bulletin Boards

1. Bulletin boards in public areas will be enclosed.
2. At MU, all centrally scheduled classrooms will have chalkboards in lieu of marker boards.

### 4.10.2 Toilet Partitions

1. Toilet partitions will be either floor supported-overhead braced or floor and ceiling supported. Overhead braces will have anti-grip design. Wall Hung Urinal Screens will have integral wall mounting flange or continuous wall mounting bracket specified as a "Government Screen"; mounted to solid blocking in the wall.

### 4.10.3 Signs

1. At MU, all new signs are typically provided by the campus. Signs specified on MU projects will be coffee bean color background. The PM will coordinate review with the ADA Coordinator.

### 4.10.4 Toilet & Bath Accessories

1. Restroom toilet tissue dispenser at UMSL, MUS&T and UMKC will be a double row locked standard toilet tissue holder 5" in diameter that holds 2-1500 sheet rolls of tissue. An extra roll will automatically drop in place after bottom roll is used up. At least one tissue dispenser will be installed in each stall depending upon expected use of the area.

At MU, preferred toilet paper dispenser is a lockable dispenser constructed of stainless steel. The standard of quality is the Royce Rolls Ringer TP-4. The four roll dispenser is preferred but the designer will determine expected usage and may specify a two (2) or three (3) roll dispenser. MU Building Services will provide the padlock for these dispensers.

2. Restroom liquid soap dispenser will have a minimal capacity of 24 ounces and have precision mode gravity feed valve that delivers a measured amount of soap at each stroke of plunger. For MU: the preferred soap dispenser and standard of quality will be the Bobrick B-8226 pump style.
4. There will be an adequate number of paper towel dispensers for each restroom according to expected traffic flow. Towel dispensers will be of a size to

accommodate 10-3/4" by 9-2" single fold paper towels. For MU: the preferred roll towel dispenser and standard of quality will be the Howard Command 563-50.

4. Waste paper receptacles will have a minimum opening of 8" into the wall.
5. At MU, electric hand dryers and hands free operating mechanisms for water closets, urinals, and lavatories will be used.

END OF SECTION

#### 4.11 EQUIPMENT

##### 4.11.1 Projection Screens

To be added later.

##### 4.11.2 Laboratory Fume Hoods

To be added later.

END OF SECTION

#### 4.12 FURNISHINGS

##### 4.12.1 Window Treatments

1. Levelor Riviera horizontal mini-blinds will be used as a standard of quality.

##### 4.12.2 Auditorium Seating

To be added later.

##### 4.12.3 Entry Mats and Frames (MU Only)

1. Floor mats and frames will be recessed aluminum frame with carpet type insert.
2. Carpet and backing insert will be Class 1 fire rating with a minimal pile weight of 32 ounces per square yard. Color will be from manufacturer's available standards.

END OF SECTION

#### 4.13 SPECIAL CONSTRUCTION

To be added later.

END OF SECTION

#### 4.14 CONVEYING SYSTEMS

##### 4.14.1 General

1. Installing vendor will be responsible for all maintenance and service during the warranty period. Response to non-emergency service calls will be within four hours of the call. Response to emergency service calls will be within one-half hour of the call. Vendor will be financially responsible for these calls except those caused by power outages, acts of God, vandalism, and false reports.
2. All hydraulic elevators will be equipped with PVC containment piping encasing the cylinder ram and casing. Containment will be sealed at the bottom. Provide a means of testing the bottom seal and a means of evacuating any material that may enter the containment. Prevent any materials from entering the top of the containment.
3. Specification should state that the inspection and testing procedure outlined in ANSI A17.1 be conducted in the presence of the contractor, architect, Owner's representative, and elevator consultant retained by the Owner.
4. Provide a sump hole and pump in all elevator pits. Provide an electrical outlet by the sump hole. Sump pumps shall be connected to either the storm water or sanitary sewer lines. The Owner will make final determination based on ground water conditions. Sump pumps shall be equal to Stancor elevator Pit Oil-minder control system. Size of control and pump system to be determined based on ground water conditions.
5. Hydraulic piping shall not be installed underground.
6. Elevator Pit Subdrainage:
  - a. All buildings: Install waterproofing on sides and bottom of elevator pits. Waterstop all concrete joints.
  - b. Buildings without an underslab drainage system regardless whether footing drains are used: Install a groundwater collection sump pit in room close to elevator pit and with the bottom of the sump pit at least 2 feet below the bottom of the elevator sump pit.
  - c. Buildings with an underslab drainage system: Install the Subdrainage at an elevation below the elevator sump pit elevation.

##### 4.14.2 Controls

1. All elevator control systems will be such that any elevator repair company is able to troubleshoot, repair, maintain, or adjust the control system. No proprietary software or repair tools will be allowed. If an elevator control system has such software or repair tools; complete codes, tools, or other necessary means for

monitoring or repairing the control system will be supplied to the Owner at time of installation. If updates or changes are required, these will also be supplied to the University at no additional cost.

2. Passenger elevators will be equipped with a fireman's recall system in accordance with ANSI A17.1, 211.3 when required. Car and hall key switches will be operated by Chicago Lock SBEXA-112-3 pin tumbler locks, combined to the fireman service control master for the appropriate campus - Columbia: XX3835; Kansas City: XX3843; Rolla: XX3846; St. Louis: XX3852. Two (2) fireman recall system keys per elevator will be furnished.
3. Proximity type detectors will be used on elevator doors.
4. At MU, all elevator controls and indicators shall use a vandalism-resistant design. All hall and car buttons shall be raised California Style.

#### 4.14.3 Accessories

1. Telephone Cabinet: will be an "Elevator Phone" as manufactured by Electronic Micro Systems, Inc., 854 Chester Road, Winston-Salem, NC, 27104 (1-800-333-3671 or 1-919-765-8601), flush mount stainless steel finish (Model # PSL-V-D-Engraved). Features one-number autodialer, ringdown operation, automatic answering, intercom.

Connect to phone line in elevator machine room. All elevator telephone equipment provided by the contractor will be compatible with the Owner's telecommunications system.

#### 4.14.4 Finishes

1. Designer will evaluate expected use of the elevator when choosing floor covering. In areas with high student use, preferred covering is vinyl tile. If carpet is used, carpet tiles are preferred for ease of replacement.
2. All elevator lighting will be fluorescent.

END OF SECTION

## 4.15 MECHANICAL SYSTEMS

## 4.15.1 General

## A. Mechanical Systems; General; Piping General

1. All piping systems will be labeled, color coded with the type of service, (for refrigerant piping, indicate the type) and the direction of flow. Lettering will be placed at intervals of approximately 20' on straight runs of piping including risers and drops, adjacent to each valve and fitting, and at each side of penetrations of structure or enclosure. Lettering will be visible from the floor. For pipes 3/4" and smaller, permanent phenolic tags will be used. Insulated piping will be labeled as "non-asbestos." Schedule for banding and labeling of pipe and conduit will conform to ANSI A13.1.
2. All valves will be tagged with an engraved brass or plastic tag describing type of service and area controlled by the valve. Provide valve list for all valves located in the mechanical rooms.
3. Provide shut-off valves at all pipe branches and where required to facilitate partial system isolation.
4. All equipment, fixtures, or other appliances attached to any piping system will have a shut off valve located at the connection to the piping system.
5. All valves will be located with sufficient room for maintenance or replacement.
6. Manual type air vents will be installed in water systems at high points in the system.
7. Mechanical joint piping systems (Victaulic, etc.) will be used only for fire protection systems and in exposed areas for chilled water.
8. Armaflex type insulation will not be used on dual temperature piping.
9. All underground piping will have a minimum earth cover of 36" to the top of the pipe.
10. All underground piping systems will have a #12 AWG copper wire attached to the pipe for a tracing wire. Wire will be labeled and terminated in an accessible location. No splices in wire allowed. See standard detail in appendix.

11. All underground piping systems will have a non metallic warning tape, with appropriate wording, buried 24" above the top of the pipe.
12. All insulated exterior, exposed piping will have an aluminum jacket installed to protect the insulation. Jacket will be weather-resistant, water-proof, smooth surfaced aluminum with a minimum thickness of 0.016".
13. All insulated interior piping, that is exposed in occupied areas, and is within 6' of the finished floor, will have a PVC jacket installed. This jacket will be painted to match surrounding background.
14. All insulated interior piping that is exposed in mechanical rooms, and is within 6' of the finished floor, will have an aluminum jacket installed.
15. Hanger design, application, and installation will comply to MSS SP-58 and SP-69.
16. Where initial pressure is 100 psig or greater, and when required reduced pressure requirement is 20% less of initial pressure, two stage pressure reducing stations will be used.
17. Water piping systems will be cleaned according to AWWA M23.
18. All solder will be lead free.

B. Piping Penetrations

1. All penetrations of foundation walls will be leak proofed.
2. All penetrations, except steam tunnels, will be individual pipes or conduits. Groups of pipes or conduits in a common penetration will not be allowed.
3. Minimum strength of pipe penetrating foundation walls will be equal to Schedule 40.
4. All penetrations, except steam, steam condensate, or other high temperature piping, will be waterproofed in the following manner:
  - a. For new construction, the foundation wall will have a steel sleeve installed that is 2" larger in diameter than the conduit to be installed. For existing construction, the hole will be core drilled. In multiple duct situations, sufficient space will remain between the penetrations to maintain the structural integrity of the foundation wall.

- b. A rubber seal, equal to Link-Seal, will be installed in the space between the conduit and the sleeve or drilled hole, near the interior surface of the foundation wall. The same space will have waterproofing installed on the exterior side of the rubber seal.
5. The point of attachment for steam tunnels will have a concrete, cast-in-place transition, with waterstopping material cast into the concrete. The waterstopping will be embedded into the foundation wall according to the manufacturer's recommendations. Waterstopping material will be equal to Volclay RX-102.
6. Individual penetrations of steam and condensate lines will be installed as follows: The foundation penetration will be an anchor point and shall be reviewed by a structural engineer. The penetration will be sleeved with a steel sleeve at least 6 inches beyond the penetration. A flange will be welded to the sleeve and to the pipe on the interior side of the foundation wall with a continuous, waterproof weld. The exterior side of the penetration will have waterproofing material applied.

#### 4.15.5 REFRIGERANT COOLING SYSTEMS

##### A. Material

1. All piping and fittings will be copper except in an evaporative condenser, where steel piping is acceptable. Use Long radius fittings.
2. All solder will be 15% silver solder except on connections to expansion valves, sight glasses, and driers where Starbrite solder is acceptable.

##### B. Equipment

1. Compressors
  - a. All compressors will be supplied with a five (5) year warranty.
  - b. Multiple units are preferred over larger single units.
  - c. All compressors will be single speed.
  - d. All three (3) phase units will have adjustable voltage monitors for each phase, with manual reset.
  - e. Provide recycle timers and crankcase heaters with all compressors.
  - f. Provide high and low pressure switches.
2. All solenoid valves will have a manual lift stem.
3. Provide driers on all liquid lines with isolation valves on each side of the

drier.

4. Condensing units, if designed to operate at less than 55°F, will be provided with hot gas bypass and with condenser fan cycle control operated from the head pressure.
5. All coils will have copper tubes and aluminum fins.

#### 4.15.6 WATER COOLING SYSTEMS

##### A. Interior Chilled Water Systems

1. Piping
  - a. PVC will not be used for chilled water systems above ground.
  - b. Welded steel systems will use black steel piping and fittings, ASTM A53, Schedule 40. Minimum pipe size will be 3/4".
  - c. Copper systems will use a minimum of Type L copper.
  - d. Any threaded black steel pipe shall be schedule 80.
2. Valves
  - a. Control valves, for pipe sizes 3" and smaller, will be globe valves. For pipe sizes larger than 3", control valves will be butterfly valves.
  - b. Isolation valves, for pipe sizes 2" and smaller, will be ball valves. For pipe sizes larger than 2", isolation valves will be butterfly valves.
  - c. Balancing valves 2-1/2" and smaller will be plug valves. For pipe sizes larger than 2-1/2", butterfly valves will be used.
  - d. Butterfly valves will be resilient seated with bronze or stainless steel discs and will be bubble-tight. All butterfly valves will be lug-type and gear operated.
3. Insulation
  - a. All insulation will be either fiberglass, flexible unicellular foam, or cellular glass.
4. Stand alone chilled water systems will have a fill and make-up connection installed. A backflow preventer will be installed at each location. The connection will be sized to allow the filling of the system in approximately four hours.
5. Stand alone chilled water systems will have an air separator installed.

##### B Condenser Water Systems

1. Material: Schedule 80 PVC or high temperature (180°F). Fiberglass piping will be used at MU Only. Steel piping may be used upon approval at UMSL, UMKC, and MUS&T. Steel fittings or stainless steel (Schedule 10) fittings will be used at absorption chillers and pumps.

### C. Equipment

1. Cooling Towers
  - a. If year around operation is desired, a dry-basin type tower is preferred over sump heaters.
  - b. Gravity flow distribution systems are preferred.
  - c. All hot water basins will have easily removable covers.
  - d. A five-year warranty will be provided with each cooling tower.
  - e. All cooling towers must have CTI certified performance.
  - f. All fans will be gear/shaft driven with the motor located outside the air stream. No belt driven fans will be allowed. Designer will evaluate the use of 2-speed or variable speed fans. All variable frequency drives will be installed with a bypass switch. MUS&T Only: Variable frequency drives are desired on all cooling towers.
  - g. All cooling towers will have extended lubrication lines.
  - h. All cooling towers will have vortex breakers installed on cold water sumps.
  - i. Roof mounted cooling towers that are elevated above the surrounding grade will have deck installed around the perimeter of the tower.
  - j. Provisions will be made for complete tower drain down, ladders and walkways will be installed to allow access to tower fans, motors, gear boxes, etc.
  - k. Aesthetic qualities of any tower being located in public view will be evaluated. In most cases, screens will be required around cooling towers.
  - l. Galvanized towers nor galvanized metal within the tower will be allowed.
  - m. Support systems will be coated steel.
  - n. Designer will consider efficiency losses over time when sizing the cooling tower for a chiller.
2. Chillers
  - a. A hand-off-auto switch will be provided to allow local control or Energy Management Control System (EMCS) control. All control panels will be provided with interface capabilities for connection to the EMCS for demand control and chilled water reset. MU Only: Chiller controls will be digital type controls. For systems larger than 100 tons, controls will be integrated with the building EMCS.

- b. Provide thermometers and pressure gauges for entering and leaving condenser and chilled water and bypass lines. Thermometers will be 6" dial type. Mercury thermometers are not allowed in this application.
  - c. Provide hour meters on electric chillers.
  - d. MU Only: Owner will provide specifications for flow meters required for chilled water and condenser water.
  - e. Consideration will be given to sound attenuation when designing the location and installation of a chiller.
  - f. Condensate coolers will be used on absorption chillers.
  - g. All pipe connections to chillers will be flanged.
  - h. All cold sections and lines will be insulated.
3. Pumps
- a. All pumps will have mechanical seals. Pumps 7 1/2 horsepower and greater will have mechanical split seals. A standard of quality for mechanical split seals is Chesterton.
4. Expansion tanks
- a. All expansion tanks will be located on the suction side of pumps and will be diaphragm type.
5. All condensing water systems will have stainless steel strainers installed.
6. Controls
- a. All equipment will have a hand/off/auto switch installed to allow manual override of the normal controls.
  - b. Chiller controls will be digital and will include the capability to interface with the EMCS for chilled water reset, demand limiting, and remote start/stop.

#### 4.15.7 STEAM & HOT WATER HVAC SYSTEMS

- A. Medium and Low Pressure Steam (Above grade)
- 1. Pressure Reducing Valves (PRV)
    - a. Spence is the preferred brand of valve and will be used as a standard of quality. Other acceptable brands are Dunham/Bush and Spirax/Sarco.
  - 2. Pipe and fittings
    - a. All piping will be black steel. For supply, piping will be Schedule 40. For condensate, piping will be Schedule 80.

- b. Fittings 2" and smaller will be threaded cast iron or malleable iron. Fittings 2 1/2" and larger will be welded, with flanged connections to valves and equipment.
3. Valves 2" and smaller will be 150 lb. rising stem gate valves with a union on one side. Valves 2 1/2" and larger will be OS&Y gate valves. Globe valves will be used only for throttling purposes. Globe valves will be a minimum of 150 lb., and will be rated for steam.
4. All traps will be protected by a strainer upstream. Isolation valves will be installed on each side of each trap with blowdown. No integral check valves will be used.
5. Strainers will be Y-pattern, rated for steam, with stainless steel baskets. All strainers will be installed with a blow down valve.
6. Safety relief valves will have piping equal to or larger than tapings of the valve. Discharge will be piped to a safe point. It is preferred the discharge be piped to exterior of the building. Do not connect vent lines from pressure powered pumps or condensate pumps to a relief vent pipe.
7. Closed cell foam insulation will not be used.
8. All piping exposed in occupied areas, and is within 6' of the finished floor, will have an aluminum jacket installed. PVC will not be used for this jacket.
9. Heat exchangers will be ASME approved and will be installed with relief valves, rated for the service, on both steam and hot water systems. Locate heat exchangers to allow removal of the bundle. Install gauges and thermometers to indicate the following: pressure of entering steam, pressure and temperature of entering water, and pressure and temperature of leaving water. Install expansion tanks on the water side of all heat exchangers with a sight glass and provisions for draining and venting.
10. All coils will be tube-in-tube, non-freezing type with a minimum 1" O.D. tubing. Designer will consider the use of integral face and bypass coils, especially in situations using steam to pre-heat outside air. Provide two steam traps with bypass for all pre-heat coils.
11. Steam humidifiers will be equipped with normally closed controls to automatically shut off the steam supply during the cooling season.
12. Air vent/vacuum breakers will be installed on steam equipment as required.

13. Pressure powered pump (MU Only)
  - a. Pump shall be a pressure powered design, using 60 psig steam to pump low pressure steam condensate.
  - b. Pump shall be constructed with a cast iron body, designed for maximum operating pressure of 125 psig at 450°F. Pump shall include bronze or stainless steel check valves on the inlet and outlet, and connections for high pressure steam and vent. All connections shall be threaded or flanged. The pump shall contain a float operated snap acting mechanism to actuate fill and discharge cycles. All internal components shall be stainless steel.
  - c. Pump shall be equipped with a gage glass with brass cocks and manufacturer furnished insulating jacket.
14. Pressure powered pump/receiver: provide a condensate receiver inlet reservoir of welded steel construction, mounted above the pump and sized in accordance with the manufacturer's recommendations for the pump capacity. Condensate receiving tank shall have a drain installed.

B. Hot Water

1. Pipe and fittings may be either black steel or copper. Steel should be as described herein. Copper will be Type L and will be 3" or smaller.
2. All hot water piping will be insulated.
3. Pumps
  - a. Bell and Gosset will be used as the standard of quality.
  - b. Horizontal in-line pumps will have a maximum of one horsepower. Vertical in-line pumps will have a maximum of five horsepower, be mounted within 4' of the floor, and will be protected by a strainer. It is preferred all in-line pumps be close-coupled.

#### 4.15.8 AIR HANDLING SYSTEMS

A. Air handling units

1. All units will have a magnahelic type filter pressure differential indicator installed with a manifold and valves to isolate lines to each side of the filter.
2. Thermometers will be installed to show temperatures of the mixed, discharge, outside, and return air. Thermometers will be bi-metal type with a minimum dial face of 4".

3. All oil and grease lines will be extended to the exterior of the case.
4. All drain pans will be stainless steel, externally insulated and bottom drained. Provisions for cleaning will include either a removable pan or ease of access for cleaning in place. Traps for drain systems will be sized for the system served. Ensure adequate room for the size of trap required. Adjust the height of the housekeeping pad as required. A 6" minimum height housekeeping pad is preferred.

B. Coils

1. All coils will have a minimum of .025" tube wall thickness and 5/8" O.D. minimum diameter.
2. It is preferred hot water only coils have a maximum of 8 fins/inch. Dual temperature coils are preferred to have a maximum of 10 fins/inch.
3. All coils will have copper coils, aluminum fins, and non-ferrous headers.
4. Coils will be drainable.
5. All water coils will be piped for counter flow.
6. Balancing valves will be installed at the coil.

C. Dampers

1. All dampers that will be used in a fully closed position will be low-leakage type. A standard of quality is Ruskin CD60.

D. Fume Hoods and Laboratory Systems

1. Ductwork
  - a. All fume hood and laboratory exhaust system ductwork will be constructed with 304 stainless steel and will be of welded construction unless other materials are required by uses of a particular system.
2. Fume Hoods
  - a. The standard of quality for fume hoods is Kewaunee Air Flow Supreme.

#### 4.15.9 CONTROL SYSTEMS

A. Equipment

1. Install gauges on all input and output control signal lines at the controller.
  2. Sensors
    - a. All electronic temperature sensors will be 1,000 ohm platinum, resistance temperature detectors (RTDs) with two (2) wire connections. Install using thermo-conductive material in thermo wells.
    - b. If application requires a humidity sensor, a high quality unit should be specified. Hy-cal can be used as a standard of quality.
    - c. Differential pressure switches, if used for fan status on VAV applications, will not be Barber-Coleman PC301. All units used will be repeatable, reliable, and adjustable.
    - d. Air flow stations will be used to measure outside air on all systems. These stations will be averaging grid type with 90% accuracy that comply with ASHRAE standards for duct traversing.
    - e. Freeze-stats will be sized and configured to provide accurate averaging for the coil and will have a manual reset.
- B. Control tubing and wiring
1. UMKC, MUS&T, and UMSL: Control tubing will be seamless copper tubing, Type K or L, ASTM B88, or polyethylene non-metallic tubing, ASTM D2737. Polyethylene non-metallic tubing will be run within adequately supported rigid enclosure, such as metallic raceways, EMT, or PVC pipe. All tubing will be supported directly from the building structure with supports at a maximum of 6' on center. Control tubing will be routed through conditioned spaces. If such routing is not possible, the system will be supplied with air dryers and drip legs.
  2. MU Only: all tubing will be hard drawn copper except within 2' of a device, where poly tubing may be used. All tubing will be supported directly from the building structure with supports at a maximum of 6' on center. Control tubing will be routed through conditioned spaces. If such routing is not possible, the system will be supplied with air dryers and drip legs.
  3. All control wiring for binary inputs and outputs in control panels will be #12 or #14 stranded wire.
- C. Sequence of Operation (for MU Only):
1. The following sequences of operation are to show our preferred controls for a typical system. Where the designer determines these are not

appropriate for a specific design, these may be changed. However, every effort will be made to comply with the intent of these arrangements.

2. 100% outdoor air systems
  - a. Typical equipment list, in order from outside air intake to exhaust.
    - (1) Supply air duct
      - Outside air sensor
      - Outside air damper, NC, 2 position
      - Filter rack
      - Air flow monitor
      - Heat recovery coil
      - Heat recovery discharge air temperature sensor
      - Steam pre-heat coil w/ NO 2 position valve and NO modulating valve
      - Supply fan
      - Pre-heat coil discharge temperature sensor
      - Freeze-stat, manual reset
      - Chilled water coil, NC modulating valve, antifreeze pump
      - Cooling coil discharge temperature sensor
      - Heating coil, NO modulating valve
      - Humidifier, steam NC modulating valve, NC 2 position valve
      - Heating coil discharge temperature sensor
      - Smoke detector
    - (2) Occupant zone
      - Occupant override
      - Humidity sensor
      - Temperature sensor
    - (3) Exhaust air duct
      - Smoke detector
      - Air flow monitor
      - Heat recovery coil
      - Exhaust fan
  - b. Typical point list
    - (1) Analog inputs
      - Outside air temperature
      - Heat recovery discharge temperature
      - Pre-heat discharge temperature
      - Cooling coil discharge temperature
      - Heating coil discharge temperature
      - Zone temperature
      - Zone humidity
      - Supply fan air flow
      - Exhaust fan air flow
      - 3 heat recovery loop temperatures

- (2) Binary inputs
    - Supply fan status
    - Exhaust fan status
    - Heat recovery pump status
    - Occupant override
  - (3) Analog outputs
    - Supply fan speed
    - Exhaust fan speed
    - Pre-heat modulating valve
    - Chilled water valve
    - Hot water valve
    - Humidifier valve
    - Heat recovery loop valve
  - (4) Binary outputs
    - Supply fan start/stop command
    - Exhaust fan start/stop command
    - Heat recovery pump start/stop command
    - Pre-heat 2 position valve
    - Humidifier 2 position valve
    - Anti-freeze pump
    - Outside air damper
  - (5) Direct connected safeties
    - Freeze-stat
    - Supply fan smoke detector
    - Exhaust fan smoke detector
    - Outside air damper
    - Pre-heat 2 position valve
    - Outside air damper limit switch
    - Supply fan
    - Exhaust fan
- c. Safety and shutdown features
- (1) All safety shut downs will be hardwired into the system.
  - (2) In the event of a smoke alarm signal from either smoke detector (exhaust air duct or supply air duct), the supply and exhaust air fans will shut down and the outside air dampers will close.
  - (3) A manual reset freeze-stat on the upstream face of the cooling coil will stop supply and exhaust air fans, close outside air dampers and open the modulating preheat valve.
  - (4) An outside air damper limit switch will stop supply and exhaust fans when dampers are not open.
  - (5) The two (2) position humidifier valve will be closed upon shut down of supply air fan.
  - (6) For VAV systems, a manual reset high limit static pressure

- sensor will be located in the discharge ductwork near the fan discharge. It will shut down the supply air fan whenever static pressure is greater than the set point.
- d. Occupied/Unoccupied cycle
    - (1) Occupied/unoccupied cycle for the AHU will be determined by the controller scheduling program.
    - (2) During occupied cycle, the fans runs continuously. During the unoccupied cycle, the fans are off, outside air damper is closed and preheat coil remains in control.
    - (3) During the unoccupied cycle, a zone temperature sensor will enable the AHU system if the zone setback set point is reached.
    - (4) All systems will have an occupant override button located in the occupied zone.
  - e. Preheat control
    - (1) With the outside air below 55°F, the preheat valve modulates to maintain preheat discharge air temperature set point.
    - (2) With the outside air below 35°F, the two (2) position preheat valve opens. The valve is sized for 10 °F rise at full air flow.
    - (3) With the outside air above 55°F, preheat valves will be closed.
  - f. Static pressure control for VAV systems
    - (1) The controller will maintain the static pressure set point in the supply air ductwork by varying the speed of the fans.
    - (2) Ramp functions will be accomplished in the variable frequency drive controls, not in the EMCS controller software.
    - (3) Building pressure will be maintained by matching supply air and exhaust air flows, as measured by flow monitoring stations.
  - g. Chilled water coil control
    - (1) In the cooling mode (OA>55°F), the controller will maintain cooling coil discharge air temperature set point by modulating the cooling coil valve.
    - (2) In the dehumidification mode (OA>55°F & Zone RH >60%), the controller will maintain the dehumidification set point by modulating the cooling coil valve.
    - (3) In the heating mode (OA<55°F), the controller will shut the cooling coil valve.
    - (4) When OA<35°F, the antifreeze pump will be energized.
  - h. Heating coil control
    - (1) In the dehumidification mode (OA>55°F & Zone RH >60%), the controller will maintain the discharge air

- temperature set point.
      - (2) In the heating mode (OA<55°F), the controller will maintain the heating coil discharge air temperature set point by modulating the heating coil valve.
    - i. Humidifier control
      - (1) In the cooling mode (OA>55°F), the controller will shut the modulating humidifier valve and the 2 position valve. The 2 position valve will be used to stop the flow of steam to the steam jacket and humidifier.
      - (2) In the heating mode (OA<55°F), the controller will maintain the humidification set point by modulating the humidifier valve. The 2 position valve will open.
    - j. Heat recovery control
      - (1) Energize the heat recovery system when the outdoor air temperature is below 50°F or above 80°F.
- 3. Mixed air systems
  - a. Typical equipment list, in order from outside air intake to exhaust.
    - (1) Supply air duct
      - Outside air sensor
      - Outside air damper
      - Air flow monitor
      - Return air inlet w/ damper in cross connection
      - Filter rack
      - Supply fan
      - Mixed air temperature sensor
      - Heating coil, NO modulating valve
      - Heating coil discharge temperature sensor
      - Freeze-stat, manual reset
      - Chilled water coil, NC modulating valve, antifreeze pump
      - Cooling coil discharge temperature sensor
      - Smoke detector
    - (2) Occupant zone
      - Occupant override
      - Temperature sensor
    - (3) Return air duct
      - Return air temperature sensor
      - Smoke detector
      - Return air fan
      - Cross connection to supply air duct
      - Exhaust air damper
  - b. Typical point list
    - (1) Analog inputs
      - Outside air temperature
      - Mixed air temperature

- Cooling coil discharge temperature
- Heating coil discharge temperature
- Zone temperature
- Outside air flow
- Return air temperature
- Supply air static
- (2) Binary inputs
  - Supply fan status
  - Return fan status
  - Occupant override
- (3) Analog outputs
  - Supply fan speed
  - Return fan speed
  - Chilled water valve
  - Hot water valve
  - Outside air damper
  - Return air damper
  - Exhaust air damper
- (4) Binary outputs
  - Supply fan start/stop command
  - Return fan start/stop command
  - Anti-freeze pump
- (5) Direct connected safeties
  - Freeze-stat
  - Supply fan smoke detector
  - Return fan smoke detector
  - Outside air damper
  - High fan static
  - Supply fan
  - Return fan
  - Hot water valve
- c. Safety and shutdown features
  - (1) All safety shutdowns will be hardwired into the system.
  - (2) In the event of a smoke alarm signal from either smoke detector (return air duct or supply air duct), the supply and return and exhaust air fans will shut down and outside air dampers will close.
  - (3) A manual reset freeze-stat on the upstream face of the hot water heating coil will stop the supply, return and exhaust air fans, close outside air dampers and open the modulating heating valve.
  - (4) For VAV systems, a manual reset high limit static pressure sensor will be located in the discharge ductwork near the fan discharge and shut down the supply air fan whenever static pressure is greater than the set point.

- d. Occupied/Unoccupied cycle
  - (1) Occupied/unoccupied cycle for the AHU unit will be determined by the controller scheduling program.
  - (2) During occupied cycle the fans runs continuously. During the unoccupied cycle, fans are off, outside air damper is closed and heating coil remains in control.
  - (3) During the unoccupied cycle, a zone temperature sensor will enable the AHU system if the zone setback set point is reached.
  - (4) All systems will have an occupant override button located in the occupied zone.
- e. Heating coil control
  - (1) In the heating mode ( $OA < 55^{\circ}F$ ), the controller will maintain heating coil discharge air temperature set point by modulating the heating coil valve.
  - (2) In the cooling mode ( $OA > 55^{\circ}F$ ), the controller will shut the heating coil valve.
  - (3) For single zone systems, zone temperature will be used to control discharge temperature.
  - (4) For systems supplying more than one zone, discharge air temperature will be reset based on outdoor air temperature.
- f. Chilled water coil control
  - (1) In the cooling mode ( $OA > 55^{\circ}F$ ), the controller will maintain cooling coil discharge air temperature set point by modulating the cooling coil valve.
  - (2) In the heating mode ( $OA < 55^{\circ}F$ ), the controller will shut the cooling coil valve.
  - (3) When  $OA < 35^{\circ}F$ , the antifreeze pump will be energized.
  - (4) For single zone systems, zone temperature will be used to control the discharge temperature.
  - (5) For systems supplying more than one zone, the discharge air temperature will be reset based on outdoor air temperature.
- g. Outside air control
  - (1) When  $OA < 65^{\circ}F$ , modulate outside air, return and exhaust air dampers to maintain discharge air temperature set point.
  - (2) When  $OA > 65^{\circ}F$ , maintain minimum outside air position.
  - (3) Air flow monitor will be used to control minimum outdoor air position.
  - (4) When no chilled water is available and when outside air is  $5^{\circ}F$  less than return air, open outside air and exhaust air dampers to cool and ventilate occupied zones.
  - (5) When a CO2 monitor is used, maintain the return air set point through a point interface device loop by modulating outside air, return air, and exhaust air dampers.

- h. Static pressure control for VAV systems
  - (1) The controller will maintain the static pressure set point in the supply air ductwork by varying the speed of the fans.
  - (2) Ramp functions will be accomplished in the variable frequency drive controls, not in the EMCS controller software.

**GENERAL:**

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1. All fire protection systems shall be installed in accordance with the International Fire Code and applicable NFPA standards. This guideline provides additional requirements for the design and installation of Fire Protection and Fire Safety systems which will assure a functional and maintainable system over the life of the facility.
2. **Fire Safety** systems such as smoke detectors and fire alarms are intended to increase the level of life safety.
3. **Fire Protection** systems are intended to control fires and limit building damage.
4. Where a fire sprinkler is required as part of a fire safety system, as in an assembly or residence hall occupancy, it shall be designated as a **Fire Safety** system.
5. No fire protection system shall be removed or modified without permission of the AHJ.
6. The University is responsible for the operation and maintenance of the building fire protection systems.

**DESIGN GUIDELINES:**

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1. Fire Protection systems design includes all of the following components and systems:
  - 1.1. Automatic Sprinkler Systems
  - 1.2. Alternate Extinguishing systems
  - 1.3. Standpipes, combination and standard
  - 1.4. Fire pumps when required
  - 1.5. Fire extinguishers
  - 1.6. Supervision by the building Fire alarm
  - 1.7. Adequate provisions for testing and inspection
2. All new facilities and major renovations shall have an automatic fire sprinkler system, fire protection standpipe, fire extinguishers and fire alarm system throughout the facility, unless directed otherwise by the Project Manager.
3. Building occupancies shall be determined based on International Building Code. Hazard Class occupancy shall be based on NFPA 13 and 14
4. Automatic wet pipe fire sprinklers
  - 4.1. All sprinkler systems will have a double check type backflow preventer installed at the point of building entry
  - 4.2. Automatic wet pipe fire sprinkler systems are preferred.
  - 4.3. Fire department connection shall be located to provide unobstructed access as approved by the Project Manager.
  - 4.4. Automatic wet pipe sprinkler systems shall utilize flow switches as the waterflow detecting device. Flow switches shall be connected to the building fire alarm

system. Buildings should be zoned by floor or by area limitations. Each zone shall have a control valve, flow switch, pressure gauge and test drain connection. All zone water flow devices, valve tamper switches and air pressure for dry pipe systems shall be supervised by the building fire alarm system.

- 4.5. Pressure reducing valves on automatic systems are not required. Pressures are not expected to exceed pipe pressure ratings.
- 4.6. High temperature areas
  - 4.6.1. High or intermediate temperature sprinklers heads shall be provided in all mechanical rooms, elevator equipment rooms, and emergency generator rooms, attics and elsewhere when elevated ambient temperatures might be expected.
- 4.7. Dry pipe, Pre-action and combination systems
  - 4.7.1. Where space function, contents or process raises concerns about accidental water discharge a dry pipe, pre-action or combination systems shall be provided.
  - 4.7.2. Pre-action, interlocked systems should use smoke or heat detectors for one of the initiating signals.
- 4.8. Areas subject to freezing
  - 4.8.1. Where sprinklers may be subject to freezing temperatures, limited areas may be served by dry pipe heads.
  - 4.8.2. Larger areas should be served by a dry-pipe system
  - 4.8.3. Glycol systems shall not be installed, unless approved by the Project Manager.
- 4.9. Drainage
  - 4.9.1. All portions of the sprinkler system shall be provided with drain points. Any section of the systems that is trapped, shall be provided with a drain.
  - 4.9.2. Main drain shall be 2" dia. minimum.
  - 4.9.3. Drains shall be directed to a floor sink capable of handling the flow.
- 4.10. Alarm test connections
  - 4.10.1. Alarm test connections shall be provided for each zone. Test connection piping shall be routed to a single location, preferably a mechanical room. The location shall be provided with a floor sink capable of handling flow from the system. If a mechanical room is not practical, an exterior location, away from sidewalks and drives is acceptable.

## 5. Alternate Extinguishing Systems

- 5.1. Alternate extinguishing Systems (non-water based) may be required for certain areas where the function of the room or value of the contents, requires alternate methods. Examples include:
  - 5.1.1. Chemical storage areas
  - 5.1.2. Archive storage
  - 5.1.3. Data centers
  - 5.1.4. Kitchen Hoods and grease ducts
- 5.2. Alternate systems will be designed and installed per IFC Chapter 9 and applicable NFPA standards.

## 6. Fire Standpipe Systems

- 6.1. Fire standpipes will be designed in accordance with NFPA 14.
- 6.2. Systems type shall be Class 1.

- 6.3. Fire hoses will NOT be provided.
  - 6.4. Where practical, the standpipes may be combined with the automatic fire sprinkler riser.
  - 6.5. Where a fire pump is not required for the automatic sprinkler systems, a manual standpipe is acceptable.
7. Fire pumps
    - 7.1. Fire Pumps shall be provided when water supplies are shown to be inadequate.
    - 7.2. Fire pump systems shall be designed in accordance with NFPA 20.
    - 7.3. Fire pumps shall be located in a 2 hour fire room.
    - 7.4. Base mounted pumps are preferred over vertical inline pumps. Vertical inline pumps require approval of the project manager.
    - 7.5. Main fire pump and Jockey pump shall be accessible from all sides and shall not obstruct access to each other.
    - 7.6. Piping shall not obstruct access to the pumps.
    - 7.7. Room shall be provided with a 12 x 12 x 9" deep floor drain with a 4" waste connection.
    - 7.8. Pumps shall be installed with PVC drain lines.
    - 7.9. Pumps shall be installed with a common pressure gauge, with small ball valves to isolate suction and discharge pressures.
    - 7.10. Pump drain shall be provided with a ball valve shutoff and a 1" balance valve.
    - 7.11. See detail ABC
    - 7.12. Pressure reducing valves on automatic systems are not required. Pressures are not expected to exceed pipe pressure ratings.
  8. Fire Extinguishers
    - 8.1. Fire extinguisher types, quantity and locations shall conform to NFPA 10 and as follows.
    - 8.2. All fire extinguishers provided in public locations shall be provided with a recessed cabinet.
    - 8.3. A 5 lb. ABC Fire extinguishers shall be provided in all laboratories, with an exposed hanger, preferably near the door.
  9. Contract drawings
    - 9.1. Consultants will prepare contract drawings which describe in general terms the scope of work and specify the requirements for fire protection system actual design and installation. All fire protection and fire safety drawings shall be packaged together under the FP heading.
    - 9.2. These drawings, as a minimum, will provide the following information:
      - 9.2.1. Service entrance and back flow preventer location
      - 9.2.2. Fire department connection
      - 9.2.3. Building zones and classification of occupancy hazards
      - 9.2.4. Areas of special situations requiring alternate extinguishing systems
      - 9.2.5. Main pipe routing, standpipe and zone valve, tamper and flow switch locations.
      - 9.2.6. Drain valves and test locations
      - 9.2.7. Areas of possible obstructions from architectural, structural or mechanical objects.

- 9.2.8. Riser diagrams for all systems shall be included
- 9.2.9. Fire Extinguisher locations
- 9.2.10. Fire damper locations

#### 10. Design Coordination

- 10.1. Coordination of design is critical to a successful building project. During the design phase of a project, promptly notify architect, structural, civil and electrical engineers of changes which affect their work. Coordination should include but, is not limited to the following:
  - 10.2 Architect shall:
    - 10.2.1. Indicate the ceiling heights in all areas.
    - 10.2.2. Indicate fire walls and firestop requirements.
    - 10.2.3. Indicate soffits and other ceiling features that may be an obstruction to water distribution.
  - 10.3. Civil/Structural shall:
    - 10.3.1. Indicate any large structural members which might be an obstruction to water spray.
  - 10.4. Mechanical engineer shall:
    - 10.4.1. Indicate any large duct or other similar obstruction to fire protection piping and water spray pattern.
  - 10.5. Fire Protection engineer shall:
    - 10.5.1. Provide locations of fire extinguisher cabinets to the Architect.
    - 10.5.2. Provide information to the electrical engineer of locations of flow switches and tamper switches.
    - 10.5.3. Be aware of other areas and functions which might require special treatment such as archival space, kitchen areas, kitchen hoods, refrigerated areas, data centers, or chemical storage areas.
    - 10.5.4. Consultant shall request a recent water flow test from a fire hydrant near the project location. Project manager will coordinate the request with the local water purveyor.

#### **SPECIFICATIONS:**

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1. The following specifications apply to
  - 1.1. Automatic Wet Pipe Sprinkler Systems
  - 1.2. Standpipes
  - 1.3. Fire pumps
2. Design and install a new [or modify existing] automatic wet pipe fire extinguishing sprinkler systems for complete fire protection coverage.
3. Automatic wet pipe fire extinguishing sprinkler systems shall be designed in accordance with the required and advisory provisions of **NFPA 13** by hydraulic calculations for uniform distribution of water over the design area.
4. Discharge from individual heads in the hydraulically most remote area shall be between 100 percent and 120 percent of the specified density.

5. Each system shall include materials, accessories, and equipment inside and outside the building to provide each system complete and ready for use. Design and install each system to give full consideration to blind spaces, piping, electrical equipment, ducts, and other construction and equipment in accordance with detailed working drawings to be submitted for approval.
6. Locate sprinkler heads in a consistent pattern with ceiling grid, lights, and air supply diffusers. Heads in relation to the ceiling and the spacing of sprinkler heads shall not exceed that permitted by NFPA 13 for the indicated hazard occupancy.
7. Devices and equipment for fire protection service shall be UL Fire Prot Dir listed or FM P7825 approved for use in wet pipe sprinkler systems.
  - 7.1. Design Water Density \_\_\_\_\_ per SF
  - 7.2. Design Area \_\_\_\_\_ sq ft
  - 7.3. Hose Allowance \_\_\_\_\_ GPM
8. Calculate losses in piping in accordance with the Hazen-Williams formula with 'C' value of 120 for steel piping.
9. Base hydraulic calculations on a static pressure of [\_\_\_\_\_] psig with [\_\_\_\_\_]gpm available at a residual pressure of [\_\_\_\_\_] psig at the base of the sprinkler piping riser.
10. Computer calculations and or computer aided designs may be used to provide hydraulic calculations.
11. Prepare Minimum 24 by 36 inch detail working drawings of sprinkler heads and piping system layout in accordance with NFPA 13, "Working Drawings (Plans)." Show data essential for proper installation of each system. Show details, plan view, elevations, and sections of the systems supply and piping. Show piping schematic of systems supply, devices, valves, pipe, and fittings. Show point to point electrical wiring diagrams. Submit drawings including the hydraulic calculations signed and stamped by a registered fire protection engineer.
12. Fire Sprinkler shop drawings shall be submitted for review and approval PRIOR to installation. The plans will be reviewed by
  - 12.1. Authority Having Jurisdiction
  - 12.2. Maintenance Engineer /Fire Protection shop
  - 12.3. Design engineer
13. All sprinkler heads in a building shall be of the same manufacturer.
14. Only new equipment and pipe shall be used. All equipment shall be UL listed and FM approved.
15. Pipe material shall be ASTM A53, schedule 40 seamless steel pipe.
  - 15.1. Exception : Chlorinated Poly Vinyl Chloride is acceptable for areas of light hazard in residential classification in accordance with all applicable codes. Use of this product requires prior written authorization from the AHJ.

16. Pipe fittings shall be cast iron, malleable iron or steel.
17. Pipe joints may be seamless, welded, threaded or mechanically coupled.
  - 17.1. Welder and weld procedure qualifications shall be submitted with the sprinkler shop drawings. All welders and welding procedures shall meet or exceed AWS standard D10.9, level AR-3
  - 17.2. Grooved joint fittings are acceptable, except tee fittings serving small branches or single sprinkler heads shall be secured with a 2 bolt, cast iron strap. Branch fittings secured with wire straps are not permitted.
18. Fire department connections shall be as follows:
  - 18.1. Columbia: 4 inch STORZ type.
  - 18.2. Rolla:
  - 18.3. Kansas City:
  - 18.4. St Louis:
19. All fire protection piping shall be supported independently of all other building systems.
20. Zone control valves shall be butterfly with Aluminum bronze or neoprene coated ductile iron discs.
21. Hydraulic design information shall be posted per NFPA 13 near the water service entrance.

**GENERAL:**

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1. The objective of this guideline is to provide minimum standards for design and installation of exterior and interior plumbing systems to provide a durable, functional maintainable system which reduces failures over the life of the facility.
2. Design simplicity is emphasized with consideration to maintenance and expansion.
3. Maximum consideration shall be given to water and energy conservation within the limits of life cycle cost effectiveness
4. The health and safety of building occupants shall be the highest priority

**DESIGN GUIDELINES:**

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1. This design guideline establishes the basic requirements for the design of plumbing systems including functions, capacities, plumbing codes, industry standards and system and material limitations.
2. Plumbing system design includes all of the following components and systems:
 

2.1. Backflow prevention	2.7. Sanitary drainage
2.2. Pressure boosting equipment	2.8. Lab waste drainage
2.3. Water softeners	2.9. Storm water drainage
2.4. Water heating equipment	2.10. Under slab drainage
2.5. Domestic hot/cold water distribution	2.11. Sewage ejection equipment
2.6. Non-potable hot/cold water distribution	
3. All design calculations shall be based on the following references
 

3.1. Potable and non-potable water distribution	IPC 2006
3.2. Sanitary waste and vent	IPC 2006
3.3. Lab waste and vent	IPC 2006
3.4. Service Water Heating	ASHRAE Applications
3.5. Compressed Air	
3.6. Vacuum	
3.7. Natural Gas	IFGC 2006
4. Riser diagrams for all systems shall include a fixture unit schedule or summary of design basis for review.
5. Coordination
  - 5.1. Coordination of design is critical to a successful building project. During the design phase of a project, promptly notify architect, structural, civil and electrical engineers of changes which

affect their work. Coordination should include but, is not limited to the following:

5.2. Architect shall

5.2.1. Provide the layout of roof drainage points, restrooms, kitchens locker-room, electric water coolers, janitors' closets etc. to the engineer.

5.2.2. Indicate the ceiling heights where piping must be concealed.

5.2.3. Comply with ADAAG requirements.

5.3. Civil/Structural shall:

5.3.1. Provide the site plan with locations of sanitary, storm and water distribution systems and connection points including piping inverts on sanitary and storm.

5.4. Plumbing engineer shall

5.4.1. Provide information to the electrical engineer of electrical requirements of pumps, water heaters, and electric water coolers.

5.4.2. Shall select all plumbing fixtures and coordinate aesthetics with architect.

5.4.3. Shall relate to the architect and structural engineer chase locations and access door requirements.

6. Backflow Prevention

6.1. All building service shall be provided with back flow preventers at the point of building entry. No metering devices, taps, or other fittings will be located upstream of the backflow preventer. However, if a common supply serves both the domestic water system and the fire protection system, it is preferred the two systems split immediately upon entering the building. Install the backflow preventer for each system at this point.

6.2. As directed by the Project Manager, install two (2) backflow preventers each at 60% capacity.

6.3. Additional backflow preventers are required by IPC code on the following systems:

6.3.1. Non Potable water distribution for use in laboratories

6.3.2. Animal watering systems

6.3.3. Hydronic hot water or chilled water systems

6.3.4. Etc. where needed

6.4. The presence of a backflow preventer will prevent hot water from expanding into the water supply. Provide a properly designed expansion tank to address thermal expansion in hot water plumbing systems.

6.5. All backflow preventers shall be located and configured to allow ready accessibility for maintenance and testing. Minimum clearance is 24" in all directions.

6.6. No backflow preventers will be located more than 4' above the floor level.

6.7. Vertical backflow preventers will not be allowed unless approved by the project manager.

6.8. Pit installations of backflow preventers will not be allowed.

6.9. Drainage from backflow preventers shall be gravity drained to a floor sink of sufficient size to handle flow.

7. Pressure Boosting Equipment

7.1. Designer shall calculate the residual pressure available after the building backflow preventer and the required pressure at the top floor of the facility and evaluate the need for a pressure boosting system.

- 7.2. The minimum residual pressure at the top floor of a building shall be 30 PSI.
- 7.3. Pressure boosting systems shall consist of a minimum duplex pump system complete with adjustable speed drives and a programmable control system.
- 7.4. Designer shall evaluate the need for a storage tank in the system.
- 7.5. If a Booster pump is required for any part of the building system, then it shall be used for the entire building system.

## 8. Water softeners

- 8.1. A water softener is required for all domestic or non-potable water heaters
- 8.2. Other systems such as water service for Autoclaves may also benefit from using soft water
- 8.3. Size water softener capacity based on local water chemistry analysis provided by the utility or the Project Manager.
- 8.4. Water softeners shall be located in a room easily accessible by a pallet jack with a pallet of salt. Space shall be provided for at least one pallet of salt next to the brine tank. Large systems may require additional space. Under NO circumstances shall salt delivery and handling require the use of stairs.

## 9. Water Heating Equipment

- 9.1. Water heater shall be a steam fired, semi-instantaneous, vertical storage heater or steam fired instantaneous as directed by the Project Manager.
- 9.2. Where campus steam is not available, consultant may use natural gas fired heaters. Gas water heaters shall be a high efficiency, powered vent design with both PVC combustion and vent piping. Electric water heaters will only be allowed if approved by Project Manager.
- 9.3. Water heater shall be capable of entering a mechanical room through a standard 3'-0" x 6'-8" door. Maximum capacity of this size tank will be about 200 gallons.
- 9.4. After the engineer calculates the initial storage capacity and recovery, the engineer shall provide an equivalent overall system based on a smaller storage tank and larger recovery coil.
- 9.5. Multiple tanks are acceptable and may be required to meet demand.
- 9.6. Design temperature rise shall be 40F -140F.

## 10. All Piping Systems

- 10.1. No plumbing piping shall run through electrical rooms or elevator equipment rooms. This includes hot, cold, waste, vent, storm, piping systems.
- 10.2. There will be no floor drains in electrical rooms.
- 10.3. Relate to the structural engineer specific requirements for pipe routing and equipment supports.
- 10.4. Structural members shall not be modified to accommodate piping.

## 11. Domestic hot/cold water distribution

- 11.1. Follow generally accepted practices found in IPC, ASHRAE, ASPE resources.
- 11.2. Provide adequate shutoff zoning valves for maintenance. Typically at each floor, each branch or each restroom. DO NOT locate them in front of the restroom door.
- 11.3. Provide an accessible shutoff valve for each exterior wall hydrant

- 11.4. Provide a minimum of one exterior wall hydrant on each exterior wall and at least one wall hydrant every 100 lineal feet of exterior wall.

## 12. Non-potable hot/cold water distribution

- 12.1. Follow generally accepted practices found in IPC, ASHRAE, ASPE resources.
- 12.2. Provide adequate shutoff zoning valves for maintenance, typically at each floor and/or each branch.
- 12.3. Provide shutoff valves for each laboratory, but not in front of the lab door.
- 12.4. Label non-potable water at each outlet and at each sink.

## 13. Hot Water Recirculation

- 13.1. Hot water piping systems layout shall minimize the amount of recirculation piping required. A majority of heat loss in a hot water system comes from the re-circulation piping.
- 13.2. Use ASHRAE Applications, Chapter 49, Figure 2, as guidelines for system layout.
- 13.3. Each return branch shall have a calibrated balance valve.
- 13.4. Flow from each branch shall be as follows:
  - 13.4.1. .5 gpm for a ¾" or 1" riser
  - 13.4.2. 1 gpm for 1 ¼" and 1 ½" risers
  - 13.4.3. 2 gpm for risers 2" and larger.
- 13.5. Pipe flow velocity in return lines shall not exceed 2 fps.
- 13.6. Hot water recirculation pumps shall be close coupled, with a non-metal impeller. A main circuit setter shall be located on the discharge side of the pump.
- 13.7. Pump start-stop shall be connected to building automation system (i.e. Metasys for MU, Honeywell for UMKC, etc.) for scheduling.
- 13.8. Storage temperature shall be 130F. Delivery temperature shall be 120F
- 13.9. Department equipment requiring higher temperatures, a separate booster heater shall be provided with the equipment.

## 14. Sanitary drainage

- 14.1. Follow generally accepted practices found in IPC, ASPE resources.
- 14.2. In accordance with the IPC, all drainage systems located above the exterior sanitary sewer flowline elevations shall be GRAVITY flow.
- 14.3. Where a portion of the building drainage system is below the exterior sanitary sewer flowline elevations, the flow from that portion shall flow to a tightly covered and vented sump. A sump pump shall lift and discharge the effluent into the building gravity drainage system.
- 14.4. The connection point for pumped flow SHALL BE into the nearest manhole. Pumped flow shall not be connected into the building gravity flow unless approved by the Project Manager.
- 14.5. All sump pump stations shall be duplex.
  - 14.5.1. Exception: A simplex pump is acceptable for non- critical, clean water locations such as a condensate pump pit.
- 14.6. If the Project Manager approves tying the pumped flow into the gravity drain, the building drain shall be sized to accept full pump flow to avoid backing up into the gravity system.

One (1) gpm of sump pump flow will count as 2 Fixture Units for drainage calculation purposes.

14.6.1. While the basement fixture determines the sump pump sizing, the actual pump flow and head will determine the Fixture Units used for the final building drain sizing calculation.

#### 15. Lab waste drainage

15.1. Follow generally accepted practices found in IPC, ASPE resources.

15.2. Provide serviceable (easily removable) P-traps at all lab sinks.

#### 16. Storm water drainage

16.1. Follow generally accepted practices found in IPC, ASPE resources.

##### 16.2. Roof Drainage

16.2.1. Architectural considerations typically dictate roof design and thus the roof drainage system. In as much as it is possible, the intent of these guidelines should be used in the design of the roof drainage system.

16.2.2. Interior storm drainage piping is required unless another method is approved by the Project Manager. Exterior downspouts are not acceptable.

16.2.3. Where secondary (emergency) drains are required, preference shall be given to scuppers first and a secondary piping system second.

16.2.4. Secondary (emergency) roof drains shall not be located in the same sump as the primary roof drain.

16.2.5. Secondary (emergency) drains, both scuppers and interior piped systems shall discharge their drainage in a visible location THAT DOES NOT CAUSE ADDITIONAL PROBLEMS such as on water on a sidewalk that freezes in the winter.

16.2.6. Roof drainage system shall NOT connect to the foundation or underslab drainage system.

16.2.7. The base of the roof drain and all horizontal roof drain lines to the main vertical stack shall be insulated.

#### 17. Foundation drainage

17.1. All below grade buildings shall have an exterior footing drainage system.

17.2. Drainage system shall be gravity where possible.

17.3. Where the footing drains are above the storm water flowline, bring the footing drainage into the basement of the building to a clean water sump pump system. This system shall discharge to the storm water sewer through a dedicated piping system.

#### 18. Under slab drainage

18.1. Where soil testing indicates the presence of underground water and the need for an under slab drainage system, the systems shall drain by gravity to the storm sewer where possible.

18.2. Where the under slab drains are above the storm water flowline, bring the drainage to a clean water sump pump system. This system shall discharge to the storm water sewer

18.3. The under floor system and the foundation drain may be brought to a common sump pump but, collection piping shall not be combined. Each system should have a separate inlet to the sump.

#### 19. Elevator pit interior drainage

19.1. Where required by code, elevator pits shall have a sump and an oil minder pump.

19.2. Pump discharge shall be routed to a floor drain connected to the sanitary waste system in the nearest mechanical room.

#### 20. Elevator pit exterior drainage.

20.1. Where soil testing indicates the presence of underground water, and the need for under slab drainage, the bottom of the elevator pit will typically be 6 to 8 ft lower than the adjacent under slab drainage and therefore require a separate drainage system.

20.2. Gravity drainage is preferred where possible. Where the elevator drains are above the storm water flowline, bring the elevator drainage to a separate sump pump to a clean water sump pump system. This system shall discharge to the storm water sewer through a dedicated piping system.

20.3. DO NOT combine the higher underslab drainage system with the lower elevator pit drainage system. See Drawing P-??

#### 21. Sump Pumps

21.1. All pumps shall be submersible type

21.2. Elevator sump pumps shall be oil minder type pumps

21.3. Sump Pumps for clean water waste (e.g. mechanical room floor drains, underslab drainage) shall be submersible effluent sump pumps

21.4. Sump pumps for sanitary waste shall be grinder type pumps.

#### 22. Sump Pump Controls

22.1. MU will provide a control panel for contractor installation. See detail X.X.

22.2. Each pump system requires the following electrical service to the control panel:

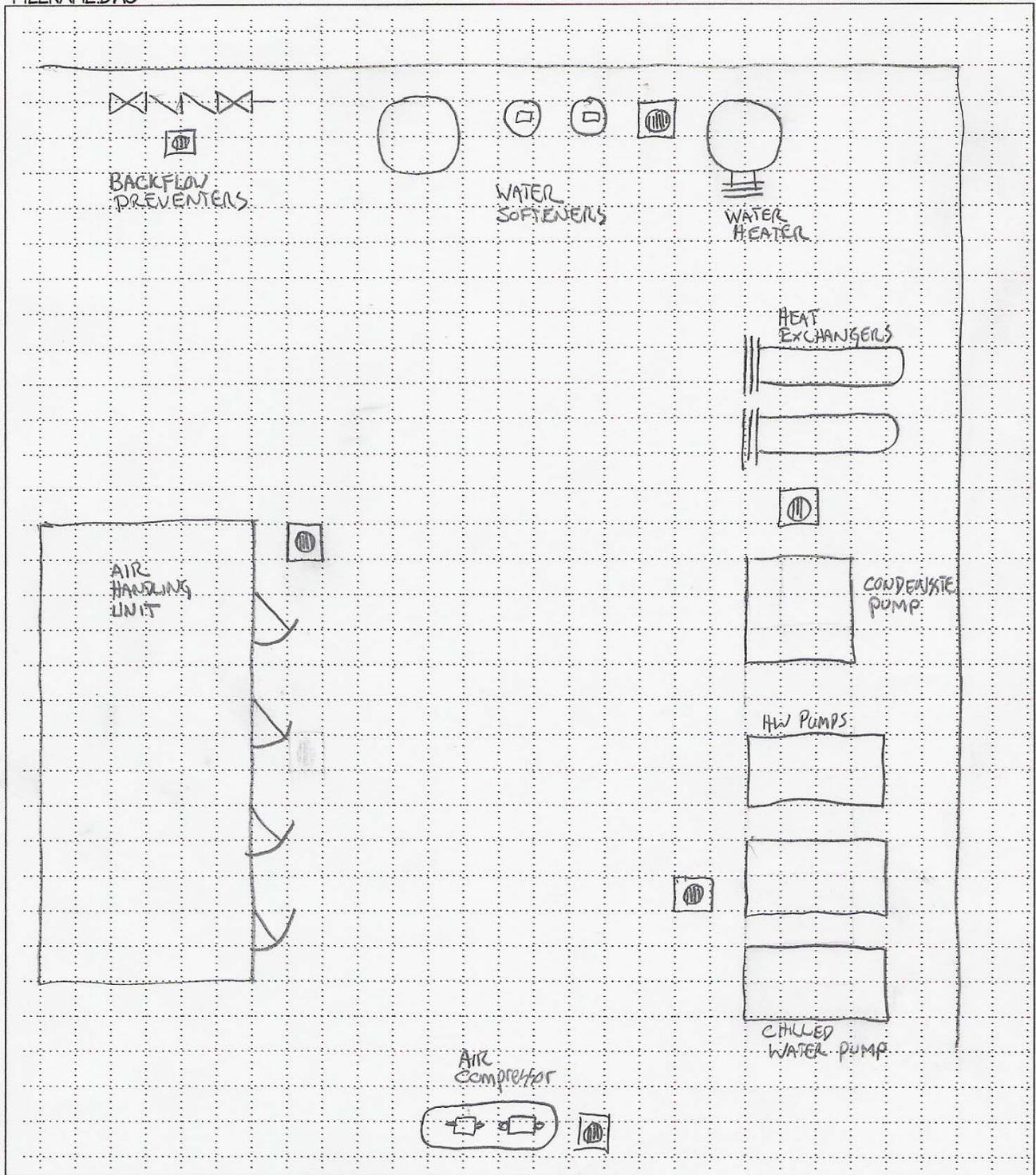
22.2.1. Separate power for each sump pump. Electrical service to be determined.

22.2.2. 120 volt control power circuit

22.2.3. Alarm System

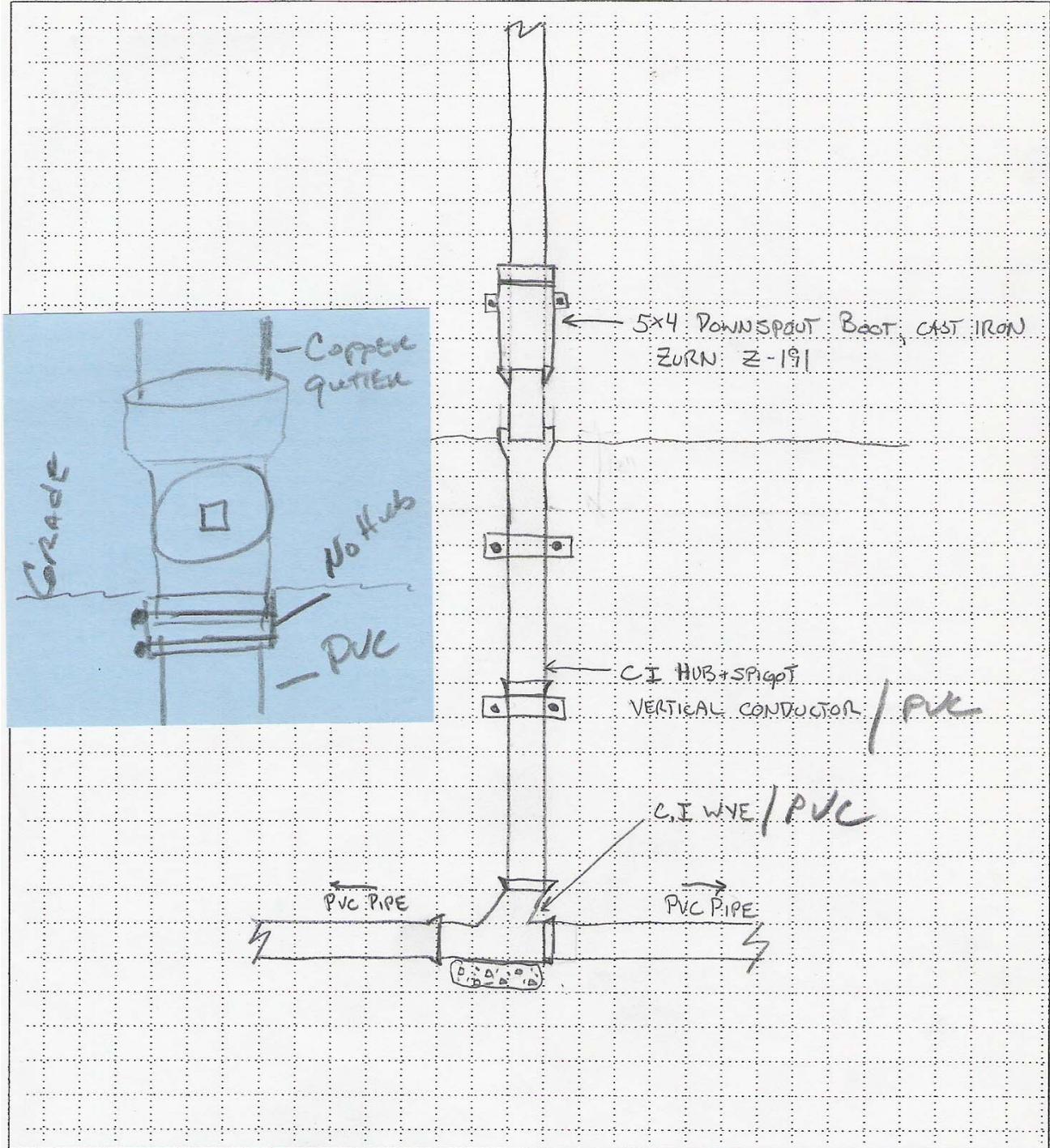
22.3. All float switches shall be mounted above the sump.

22.4. Floats shall be stainless steel.



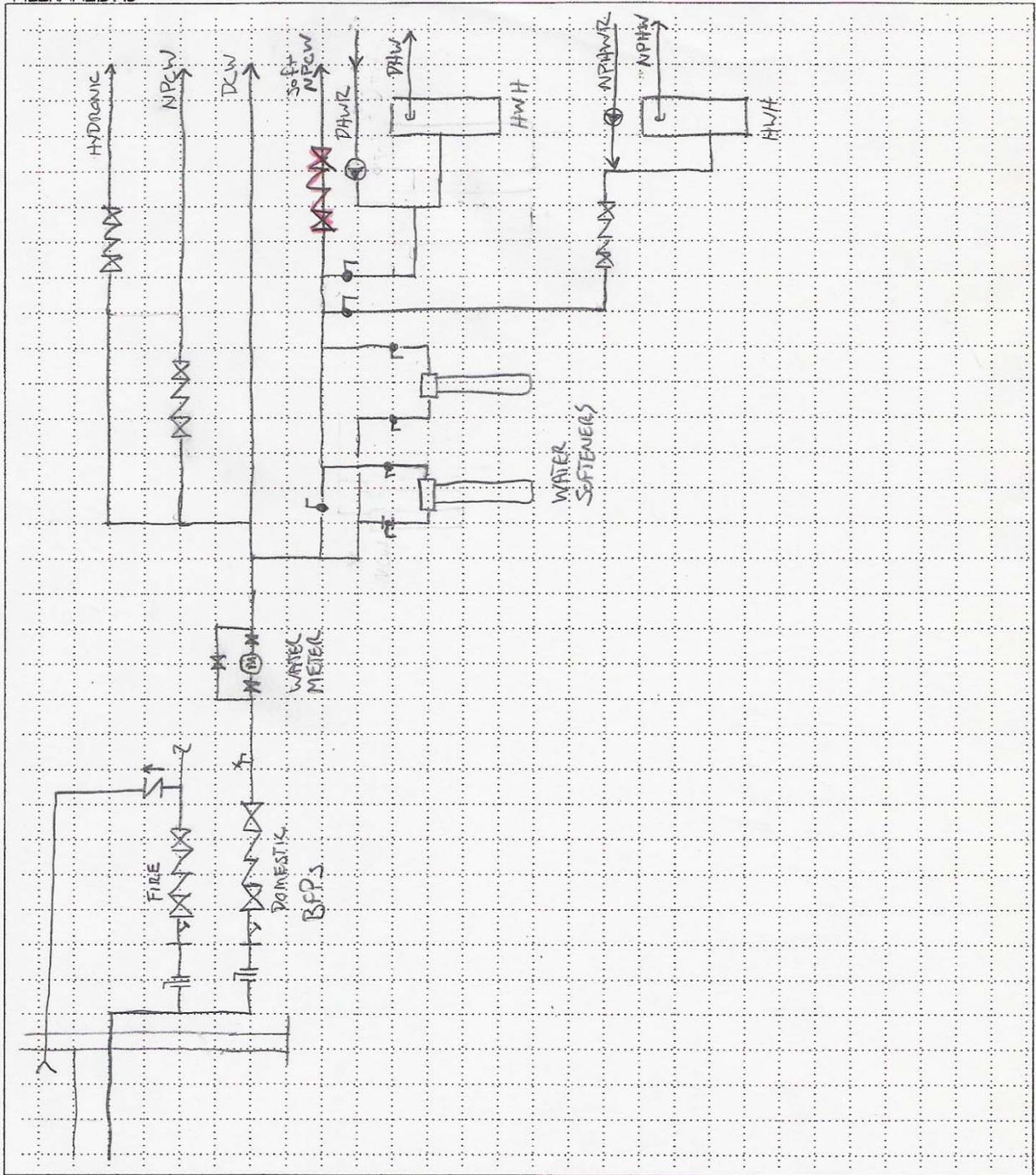
DATE: 1/5/2008	MECHANICAL ROOM FLOOR DRAIN TYPICAL LOCATIONS maintenance details	PROJECT NUMBER
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DWN BY: LS CKD BY: ls	 MAINTENANCE CAMPUS FACILITIES UNIVERSITY OF MISSOURI-COLUMBIA	

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<p>DATE: 1/5/2008</p> <p>▲</p> <p>▲</p> <p>▲</p>	<p>RAIN LEADER DETAIL</p> <p>maintenance details</p>	<p>PROJECT NUMBER</p>
<p>DWN BY: LS</p> <p>CKD BY: ls</p>	 <p>MAINTENANCE CAMPUS FACILITIES UNIVERSITY OF MISSOURI-COLUMBIA</p>	<p>SHEET</p> <p style="text-align: right; font-size: 2em;"><b>1</b> of 50</p>

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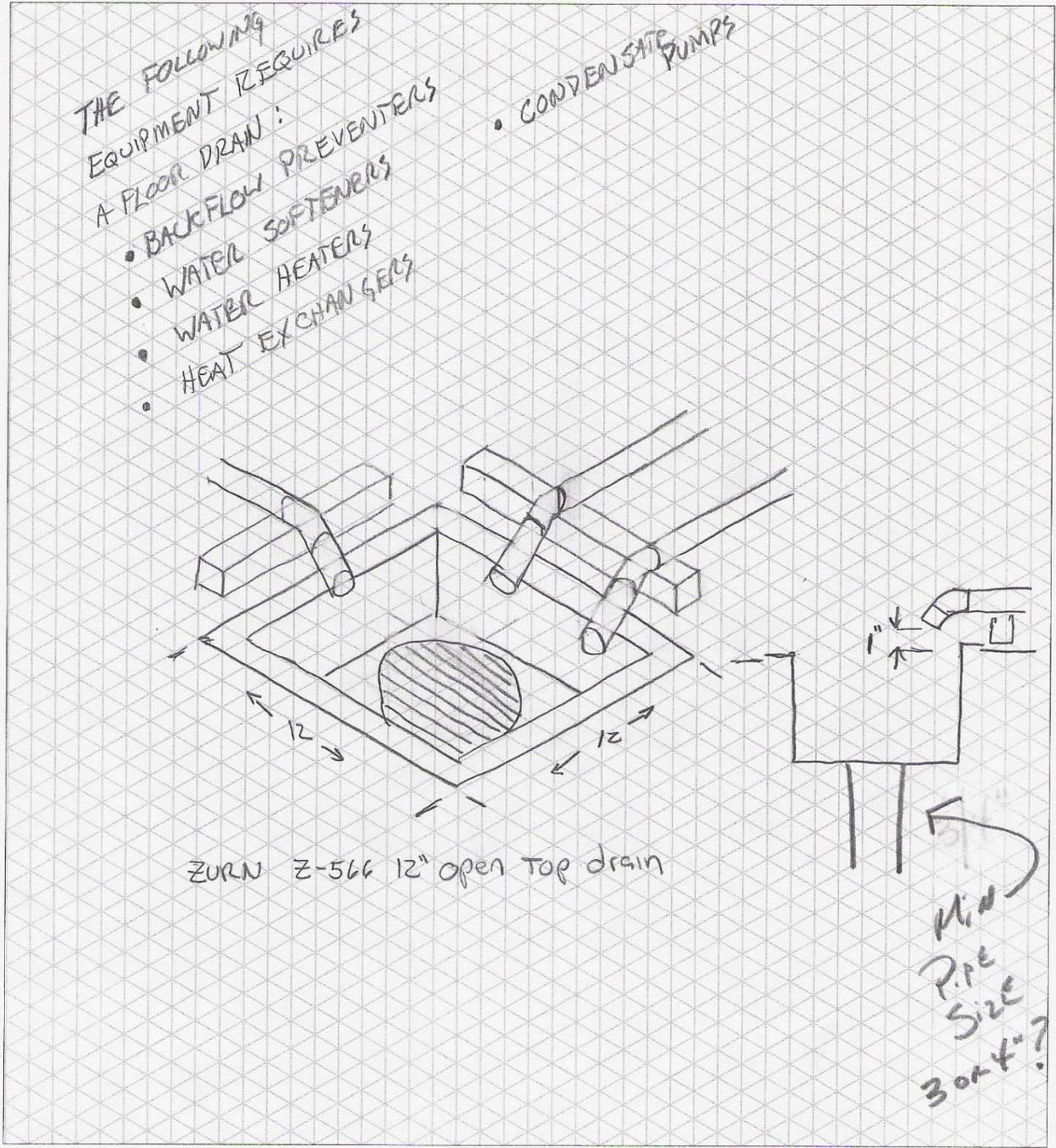
PLUMBING WATER Supply DIAGRAM  
 maintenance details



MAINTENANCE  
 CAMPUS FACILITIES  
 UNIVERSITY OF MISSOURI-COLUMBIA

PROJECT NUMBER  
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## **GENERAL:**

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The objective of this guideline is to provide minimum standards for design and installation plumbing systems. This section covers requirements for common work.

## **DESIGN GUIDELINES:**

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1. Section 22.05.13 Common Motor Requirements.
  - 1.1. All motors shall meet minimum ASHRAE energy efficiency requirements.
2. Section 22.05.16 Expansion Fittings, loops for plumbing piping
  - 2.1. System design shall provide adequate pipe offsets or loops and shall not use any manufactured expansion joint products.
  - 2.2. Provisions shall be made on vertical pipe risers to accommodate pipe growth when selecting pipe hangers and supports.
3. Section 22.05.19 Meters and gauges for plumbing
  - 3.1 Water meters will be provided as specified in section 331233.
  - 3.2 Thermometers shall be provided on water heaters on both CW and HW piping.
  - 3.3 Pressure gauges shall be provided on the following pieces of equipment:
    - 3.3.1 After the building backflow preventer
    - 3.3.2 After the building water meter.
    - 3.3.3 After the water softeners
    - 3.3.4 After the water heater on HW piping
    - 3.3.5 After the branch or isolation valve on each floor for both HW and CW piping.
4. Section 22.05.48 Vibration, seismic Controls for Plumbing Piping and Equipment
  - 4.1 Follow requirements of IPC
5. Section 22.05.53 Identification for Plumbing Piping and Equipment
  - 5.1 The following abbreviations shall be used in design documents and as actual labels on piping in the finished building:
    - 5.1.1 DCW Domestic Cold Water
    - 5.1.2 DHW Domestic Hot Water
    - 5.1.3 DHWR Domestic Hot Water Return
    - 5.1.4 NPCW Non-potable Cold Water
    - 5.1.5 NPCW Non-potable Hot Water
    - 5.1.6 NPHWR Non-potable Hot Water Return
    - 5.1.7 SW Sanitary Waste
    - 5.1.8 SV Sanitary Waste
    - 5.1.9 LW Laboratory Waste
    - 5.1.10 LV Laboratory Vent

- 5.1.11 SPD Sump Pump Discharge
- 5.1.12 ST Storm Water

**GENERAL:**

1. To provide minimum standards for design and installation of mechanical insulation products for piping that will be durable, functional and reduce failures the life of the facility.

**DESIGN GUIDELINES:**

1. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.
  - a. Exception: Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150.
2. Insulation thickness shall comply with ASHRAE 90.1 or the table below whichever is greater.

**PLUMBING SYSTEM INSULATION REQUIREMENTS**

System Type	Insulation Material	Jacket*	Run-outs	Branches, Mains, and Loops				
				Pipe Diameter (inches)				
				<1	1-1¼	1½-3	4-6	8>
				Insulation Thickness (inches)				
Domestic Hot and Cold Water, Mains and branches	¾" Flexible Elastomeric	Not required	¾"	¾"	¾"	¾"	¾"	¾"
Lavatory traps and drains	¾" Flexible Elastomeric	Not required	¾"	¾"	¾"	¾"	¾"	¾"
Floor drains near HVAC equipment	¾" Flexible Elastomeric	Not required	¾"	¾"	¾"	¾"	¾"	¾"
Roof Drains	¾" Flexible Elastomeric	Not required	¾"	¾"	¾"	¾"	¾"	¾"

\*Jackets are required in some locations. See notes #4 and #5 below.

**PIPING INSULATION SYSTEM NOTES TO BE INCLUDED IN THE SPECIFICATION**

1. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
2. For elastomeric insulation systems, use inserts by the same manufacturer of the

- insulating system being installed (i.e. for Armaflex, use Amafix.)
3. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.
  4. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
  5. All new interior piping that is exposed in mechanical rooms, and is within 6'-0" of the finished floor, shall have a PVC jacket installed.
  6. Any exposed piping within 6'-0" of the finished floor in an occupied space shall have a PVC jacket installed.
  7. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
  8. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
  9. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.
  10. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
  11. Where piping passes through fire walls indicated on the contract drawings, contractor shall install firestopping per firestop manufacturers instructions.
  12. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
  13. Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.
  14. Repair damaged sections of existing mechanical insulation, damaged during this construction period. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.
  15. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
  16. Wood blocking shall not be used.

## **GENERAL:**

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1. The objective of this guideline is to provide minimum standards for the design and installation of plumbing piping and specialties including:
  - 1.1. Water Supply and Distribution
  - 1.2. Sanitary Drainage
  - 1.3. Vents
  - 1.4. Traps
  - 1.5. Special Piping
  - 1.6. Roof Drains
  - 1.7. Floor Drains
  - 1.8. Hose Bibs
  - 1.9. Wall Hydrants

## **DESIGN GUIDELINES:**

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1. Refer section 220000
2. Water supply and distribution shall be one of the following:
  - a. Copper pipe and fittings, hard drawn, type L
  - b. Galvanized steel pipe and galvanized cast iron fittings
  - c. Ball valves, 2 piece, full port bronze
  - d. Butterfly valves, lug-type, ductile iron, aluminum bronze or neoprene coated ductile iron disc
3. Sanitary waste and venting, above grade, shall be one of the following:
  - a. No-Hub cast iron pipe and fittings
4. Sanitary waste, below grade shall be one of the following:
  - a. Hub and spigot cast iron pipe and fittings
5. Laboratory Waste and vent, above grade shall be one of the following:
  - a. Fuse seal Polypropylene pipe and fittings
  - b. Lab waste piping shall be used only on the piping from the sink to the nearest main riser.
6. Traps
  - a. See section 224000 for information on fixture traps for standard fixtures.
  - b. Laboratory sink traps shall have 2 slip joints and/or two piece trap for ease of trap maintenance
7. Storm drainage, above grade, shall be one of the following:

- a. No-Hub cast iron pipe and fittings
- 8. Storm drainage, below grade, shall be one of the following:
  - a. Hub and spigot cast iron pipe and fittings
  - b. Piping shall be a minimum of 4" diameter
- 9. Special piping
  - a. Distilled water – polypropylene piping shall be used
  - b. RO water - polypropylene piping shall be used
  - c. DI water - polypropylene piping shall be used
- 10. Roof drains
  - a. Minimum roof drain shall be 4" diameter
  - b. Piping shall be supported at each drain
- 11. Floor drains
  - a. Minimum floor drain shall be 3" diameter
- 12. Hose bibs
  - a. Vacuum breaker shall be built into hose bib
- 13. Wall Hydrants
  - a. Keyed type with recessed door
- 14. Water Hammer Arresters
  - a. Diaphragm type only. Shall be accessible

## References

**GENERAL:**

1. The purpose of this design guide is to:
  - 1.1. Standardize the types and quality of compressed air provided that is considered part of the facility systems.
  - 1.2. Standardize both the type of air compressor used and the installation details to facilitate the operation and maintenance of air compressors.
  - 1.3. And is applicable to all air compressors serving building HVAC, fire protection or central laboratory systems.

**DESIGN GUIDELINES:**

1. Types of air. University facilities may typically have 3 types of air. These are:
  - 1.1. Control air. Utilized for HVAC control systems
  - 1.2. Lab Air. Utilized for general laboratory work.
  - 1.3. Medical air. Utilized in hospitals and vet facilities.
2. Compressed Air Provided. The facility air compressor or the campus wide compressed air loop will provide lab air and control air. If medical air is required, it is the responsibility of the department to provide and maintain this compressor. All medical air systems shall be separate and independent of the facility system.
3. The facility air compressor or compressed air loop will provide Lab air and control air of the following minimum quality in accordance with ISO 8573.1 "Air Quality Classes",

	<i>ISO QUALITY CLASSES</i>	<i>MEASUREMENT</i>
<i>SOLIDS (IN MICRONS)</i>	1	0.1 Micron
<i>WATER (DEWPOINT)</i>	4	37.4 °F
<i>OIL (PPM)</i>	3	0.8 ppm

The contaminant levels in this table are the maximum allowed per ISO class.

4. Filters.
  - 4.1. Lab air and Control air systems shall be provided with the following:
  - 4.2. A pre-filter located between the air compressor and the refrigerated air dryer with a minimum filtration of 3 micron particulates and 5 ppm oil.
  - 4.3. A final filter located between the air dryer and the pressure regulators with a minimum filtration of .01 micron particulates and .01 ppm oil.
5. Dryers. Lab air and control air shall be provided with an air dryer capable of 37.4°F dewpoint. Control air that will be routed to an exterior location shall be provided with a small desiccant air dryer capable of -4°F dewpoint. Route condensate/drip line to nearest

6. Sizing. Compressed air sizing shall be based on generally accepted methods, using 1 scfm per lab outlet and applying a diversity factor based on the number of probable outlets in use.
7. Run time. The compressor shall be selected to provide a 30% run time based on a single compressor running. Duplex compressors shall be selected such that the combined run time shall not exceed 30%.
8. Air compressors shall be located in accessible locations for maintenance. A minimum 3 ft access space in front of serviceable belts, machine guards, oil reservoirs and electrical components shall be provided. Location shall not expose staff to other hazards such as hot piping, or heights. Route condensate/drip line to nearest floor drain.
9. All compressors shall be provided with a house keeping pad.
10. Vibration isolators shall be provided. Slab on grade may utilize rubber cork pads.
11. Installations on upper level floors should be analyzed for vibration and spring isolators/inertia pads provided if necessary.
12. Provide piping vibration isolators between compressor and fixed piping.
13. Compressors should be simplex / Duplex, alternating design, as directed by the project manager.
14. Power and Controls. On duplex compressors, provide a power circuit for each compressor motor and a separate power circuit for the controls.
15. Submittals should include catalog data, certified sound power ratings, Motor ratings and electrical characteristics plus motor and fan accessories. Shop drawings from the manufacturer detailing dimensions, weights, required clearances, components, and location and size of each field connection for each product specified
16. Close out manuals should include both Installation and Operations and Maintenance Manuals

**SPECIFICATION REQUIREMENTS:**

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1. Typical codes, standards and warranties shall apply and as indicated below:
  - 1.1. Provide a simplex/(duplex) tank mounted, two stage, reciprocating air compressor complete with tank, motors, drives and controls as specified herein.
    - 1.1.1. Capacity SCFM @ 125 psig
    - 1.1.2. Tank size Gallons
    - 1.1.3. Motor HP HP
    - 1.1.4. Compressor RPM RPM (maximum)
    - 1.1.5. Electrical Service \_\_\_\_\_ Volts/3 PH/60Hz

## 1.2. Compressor

- 1.2.1. Crankcase shall be one piece cast iron construction. A crankcase with separate, removable oil pan will not be acceptable.
- 1.2.2. Valve assemblies shall be disc and spring type which do not require the removal of the head for replacement. Reed type valves are not acceptable.
- 1.2.3. Crankshaft bearings shall be tapered roller type and shall be serviceable without disassembly of the unit. Bearing rated  $L_{10}$  life shall be a minimum 20,000 hours. Journal type bearings are not acceptable.
- 1.2.4. Compressor shall have a large crankcase oil reservoir with an oil sight glass for visual verification of oil level.
- 1.2.5. Cylinders shall be finned for heat dissipation.
- 1.2.6. Cylinder heads and cylinder shall be 1-piece design.
- 1.2.7. First stage piston shall be aluminum. Second stage piston shall be cast iron.
- 1.2.8. Each cylinder shall contain 4 rings, three compression rings and one oil ring
- 1.2.9. Piston rods shall be die-cast aluminum alloy.
- 1.2.10. Pressure relief valve shall be located at interstage and discharge
- 1.2.11. Fin tube intercoolers shall be provided between stages.
- 1.2.12. Fin tube aftercooler shall be provided between the pump and receiver, integral to the flywheel assembly.
- 1.2.13. Flywheel shall have fan wheels for additional compressor cooling.
- 1.2.14. Crankshaft shall be ductile iron crankshaft.
- 1.2.15. Maximum compressor RPM is 800.

## 1.3. Tank

- 1.3.1. Receiver tank shall be a horizontal steel tank, ASME rated with ASME relief valve.
- 1.3.2. Provide tapping for drain test cock.
- 1.3.3. A base shall be welded to the tank to secure the compressor and motor. The base shall slots to adjust alignment between motor and flywheel.

## 1.4. Motors. Alternating current, Squirrel Cage Induction Motor, Design B conforming to NEMA MG-1 Motors shall be selected for the capacity indicated. Motors shall not operate in the service factor. and as follows:

- 1.4.1. High Efficiency, Greater than 94%
- 1.4.2. Constant speed, 1750 RPM, Intermittent Duty
- 1.4.3. Insulation System: Class F
- 1.4.4. Enclosure and Method of Cooling: Open Drip Proof (ODP).
- 1.4.5. Service Factor 1.10 for 3 phase motors
- 1.4.6. Integral Thermal Overloads.
- 1.4.7. Bearings shall be ball bearings or cylindrical roller bearings and grease lubricated.
- 1.4.8. Bearing Life: L-10 of 30,000 hrs.
- 1.4.9. Terminal Box must meet or exceed NEMA standards.
- 1.4.10. Provide drain holes at low point in motor.
- 1.4.11. All hardware shall be Corrosion resistant.

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- 1.4.12. Provide lifting bolts on frame sizes over 180T.
- 1.4.13. Motor nameplate shall be stamped, 304 stainless steel and securely fastened to motor.
- 1.4.14. Motor shall be dynamically balanced.

## 1.5. Electrical and Controls.

- 1.5.1. Compressor shall be purchased without the factory control panel. MU Maintenance department shall furnish a control panel for each compressor on the project for the contractor to install.
- 1.5.2. Separate electrical service shall be provided to each compressor along with a separate 120 volt control circuit

## 1.6. Accessories

- 1.6.1. Low-resistance intake air filter; central station air filter rated of 97% efficiency rated air flow.
- 1.6.2. Provide an OSHA approved belt guard on unit.
- 1.6.3. Pressure Switch. Provide a 120 volt pressure switch to control on/off cycling.
- 1.6.4. Pressure Gauge. Provide a minimum 0 - 200 psig pressure gauge on the discharge piping.

**GENERAL:**

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1. The purpose of this design guide is to:
  - 1.1. Standardize the types and quality of vacuum air provided that is considered part of the facility systems.
  - 1.2. Standardize both the type of Vacuum Pump used and the installation details to facilitate the operation and maintenance of air compressors.

**DESIGN GUIDELINES:**

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1. Types of Vacuum.
  - 1.1. University facilities may have 2 types of vacuum systems. These are:
    - 1.1.1. Laboratory Vacuum. For general lab use.
    - 1.1.2. Medical Vacuum. Utilized in hospitals and vet facilities
2. The facility Vacuum system will provide lab vacuum. If medical vacuum is required, it is the responsibility of the department to provide and maintain this system. All medical vacuum systems shall be separate and independent of the facility system.
3. Sizing.
  - 3.1. Vacuum air sizing shall be based on generally accepted methods, using 1 scfm per lab outlet and applying a diversity factor based on the number of probable outlets in use.
  - 3.2. Run time. The compressor shall be selected to provide a 30% run time based on a single compressor running. Duplex compressors shall be selected such that the combined run time shall not exceed 30%.
4. Vacuum Pumps shall be located in accessible locations for maintenance. A minimum 3 ft access space in front of serviceable belts, machine guards, oil reservoirs and electrical components shall be provided. Location shall not expose staff to other hazards such as hot piping, or heights.
5. All compressors shall be provided with a house keeping pad.
6. Vibration isolators shall be provided. Slab on grade may utilize rubber cork pads.
7. Installations on upper level floors should be analyzed for vibration and spring isolators/inertia pads provided if necessary.
8. Provide piping vibration isolators between compressor and fixed piping.
9. Compressors should be Simplex/Duplex, alternating design, as directed by the project manager.
10. Power and Controls. On duplex compressors, provide a power circuit for each compressor motor and a separate power circuit for the controls.

11. Submittals should include catalog data, certified sound power ratings, Motor ratings and electrical characteristics plus motor and fan accessories. Shop drawings from the manufacturer detailing dimensions, weights, required clearances, components, and location and size of each field connection for each product specified
12. Close out manuals should include both Installation and Operations and Maintenance Manuals
13. Specification Requirements
  - 13.1. Typical codes, standards and warranties shall apply and as indicated below
  - 13.2. Provide a simplex/(duplex) tank mounted, two stage, reciprocating air compressor complete with tank, motors, drives and controls as specified herein.

Capacity	SCFM @ 125 psig
Tank size	Gallons
Motor HP	HP
Compressor RPM	RPM (maximum)
Electrical Service	_____Volts/3 PH/60Hz

**GENERAL:**

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1. To provide guidance in the selection of plumbing equipment. Guidance is classified as
  - 1.1. Acceptable manufacturers
  - 1.2. Preferred manufacturers
  - 1.3. Sole Source, no substitutes
2. These standards ensure the plumbing systems function properly, are easy to maintain and provide reliable operation over the life of the facility.

**DESIGN GUIDELINES:**

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1. Backflow Preventers.
  - 1.1. All backflow preventers must comply with Missouri DNR rules and regulations.
  - 1.2. Acceptable manufacturers include the following vendors:
    - 1.2.1. Watts
    - 1.2.2. Zurn
    - 1.2.3. Wilkins
2. Water booster pumps.
  - 2.1. Packaged units are preferred, with pumps, disconnects, controllers all assembled on a common base.
  - 2.2. Preferred manufacturers:
    - 2.2.1. Bell and Gossett
3. Water Softeners.
  - 3.1. Provide a single or duplex media and brine tank(s) and electronic water meter controller as follows:
    - 3.1.1. Control valve shall be a single body, 5 cycle, piston operated valve manufactured by Fleck. Individual diaphragm valves are NOT acceptable.
    - 3.1.2. Provide a electronic water meter to control regeneration schedule.
  - 3.2. Media tank shall be constructed of non-corrosive fiberglass
  - 3.3. Resin shall be a high capacity sulfonated polystyrene media capable of handling common hard water conditions.
  - 3.4. The brine tank shall be made of high density polyethylene to resist corrosion and puncture. Larger tanks are available on all commercial systems. Safety floats standard on all tanks. Salt grids are optional.
4. Water heaters
  - 4.1. The hot water heater package shall be steam fired, vertical pre-insulated tank and internal circulating pump with all necessary controls and piping accessories for a complete and useable hot water generator.
  - 4.2. The storage tank shall be glass lined, constructed and stamped according to ASME specifications for 125 psi working pressure. Water heater shall be capable of entering a mechanical room through a standard 3'-0" x 6'-8" door. Storage tank capacity shall be as scheduled. Tank shall be insulated with 3" fiberglass

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## Plumbing Equipment

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- insulation, with an R-value > 12.5. Tank shall be jacketed with heavy gauge steel with a baked enamel finish.
- 4.3. The unit shall be designed to recover the quantity of water in gallons per hour specified in the schedule, a 100°F temperature rise (40°F to 140°F) when supplied with 5 psi steam to the temperature regulator.
- 4.4. The heating coil shall be constructed and stamped according to section VIII of ASME code. The tube bundles shall be constructed of 3/4" O.D. 20 GA. deoxidized drawn copper tubing.
- 4.5. Unit shall have an ASME temperature & pressure relief valve.
- 4.6. The packaged unit shall also include the following:
- 4.6.1. A temperature regulator to be self actuated, direct acting Spence type E Valve and T124/134 temperature and pressure pilot. No substitutions are permitted.
  - 4.6.2. Main F&T trap, main "Y" strainer and associated black steel pipe.
  - 4.6.3. A bronze integral circulator pump with copper soldered recirculation line and (2) bronze ball valves.
  - 4.6.4. A drain valve and assembly. Jacket mounted temperature and pressure gauge.
  - 4.6.5. A temperature & pressure gauge.
  - 4.6.6. Full length channel base and lifting lugs.
  - 4.6.7. Air vent and vacuum breaker.
  - 4.6.8. A 4"x6" handhole, and 11"x15" manhole.
- 4.7. Preferred Manufacturers:
- 4.7.1. AO Smith Corporation
5. Electric Water Coolers
- 5.1. Units shall be a 1 or 2 (high/low) unit design, ADAAG approved with INTEGRAL refrigeration system. REMOTE refrigeration designs are NOT PERMITTED.
  - 5.2. Unit electric service shall be 110 volt.
  - 5.3. Elkay units are preferred.
  - 5.4. Bottle Fill stations included.
6. Sump pumps
- 6.1. Sewage, effluent pumps shall be a cast iron, oil-filled, non-clogging bronze impeller and U.L. Listed. Pump shall be capable of passing a 2" sphere.
  - 6.2. Grinder pumps shall be cast iron, bronze impeller with a stainless steel cutter and disc.
  - 6.3. For MU Only, pumps shall be purchased WITHOUT controls.
  - 6.4. For MU Only, Control panels will be provided by MU.
  - 6.5. Approved manufacturers
    - 6.5.1. Zoeller
    - 6.5.2. Gould

**REFERENCES**

**GENERAL:**

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1. The objective of this guideline is to provide minimum standards for PLUMBING FIXTURES that will a durable, functional maintainable system which reduces failures over the life of the facility.
2. Maximum consideration shall be given to water and energy conservation but, should also consider life cycle cost.
3. The health and safety of building occupants shall be the highest priority

**DESIGN GUIDELINES:**

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1. All fixtures, flush valves, faucets shall be water conserving types.
2. Water free urinals are NOT permitted.
3. Fixtures shall be standard commercially available units. Replacement parts and/or fixtures shall be supported by a local vendor. Delany is not an acceptable manufacturer.

1. Water Closets

- 1.1. Vitreous china, wall mounted, (action), 1.6 gallon flush, white with white seats.

- 1.1.1. Kohler or American Standard

- 1.2. Sensor operated, battery powered flush valves, 1" connections

- 1.2.1. Zurn or Sloan

2. Urinals

- 2.1. Vitreous china, wall mounted, (action), 0.25 gallon flush, white.

- 2.1.1. Kohler or American Standard

- 2.2. Sensor operated, battery powered flush valves, ¾" connections

- 2.2.1. Zurn or Sloan

3. Lavatories

- 3.1. AS selected by the architect and engineer.

- 3.2. Sensor operated, battery powered faucets connections, serviceable above the sink.

- 3.2.1. Zurn or Sloan

- 3.3. Polypropylene faucets are not allowed for lab pure water, DI or RO faucets.

4. Service sinks

- 4.1. Custodial service sinks shall be a floor sink style with a maximum 12" lift.

- 4.2. Trap size shall be a minimum of 3" diameter.

- 4.3. Provide stainless steel protective band on 2 sides.

**REFERENCES**

**GENERAL:**

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1. The purpose of this design guide is to:
  - 1.1. Standardize the types and quality of vacuum air provided that is considered part of the facility systems.
  - 1.2. Standardize both the type of Vacuum Pump used and the installation details to facilitate the operation and maintenance of air compressors.

**DESIGN GUIDELINES:**

---

1. Types of Vacuum.
  - 1.1. University facilities may have 2 types of vacuum systems. These are:
    - 1.1.1. Laboratory Vacuum. For general lab use.
    - 1.1.2. Medical Vacuum. Utilized in hospitals and vet facilities
2. The facility vacuum system will provide lab vacuum. If medical vacuum is required, it is the responsibility of the department to provide and maintain this system. All medical vacuum systems shall be separate and independent of the facility system.
3. Sizing.
  - 3.1. Vacuum air sizing shall be based on generally accepted methods, using 1 scfm at 15 IN. Hg, per lab outlet and applying a diversity factor based on the number of probable outlets in use.
  - 3.2. If there are any specific equipment requirements, the requesting department shall provide this information.
4. Locate the vacuum pump at the lowest level in the building.
5. Piping design shall include the following:
  - 5.1. Piping shall be designed similar to a plumbing waste system.
  - 5.2. Avoid "service drops" from the ceiling. Service at lab benches shall feed up from below.
  - 5.3. Slope piping in the direction of flow toward the compressor.
  - 5.4. Avoid places where liquid could be "trapped"
  - 5.5. Provide threaded cleanouts at changes in direction.
  - 5.6. Use long radius ell and wye fittings.
  - 5.7. Use ball valves for branch isolation
  - 5.8. Piping shall have a main line filter BEFORE the line connects to the vacuum pump. Filter shall have isolation valves on either side and a bottom drain.
  - 5.9. Vacuum piping shall connect to the vacuum tank inlet. There shall be a separate connection between the tank and the vacuum pump. V
  - 5.10. Vacuum piping discharge shall be located at the roof level or 20 feet from operable windows, air intakes, sidewalks etc.
6. Operating Pressure. Operating pressure at the vacuum pump shall be 20" Hg.

7. Run time. The vacuum pump shall be selected to provide a 30% run time based on a single compressor running. Duplex compressors shall be selected such that the combined run time shall not exceed 30%.
8. Vacuum Pumps shall be located in accessible locations for maintenance. A minimum 3 ft access space in front of serviceable belts, machine guards, oil reservoirs and electrical components shall be provided. Location shall not expose staff to other hazards such as hot piping, or heights.
9. All equipment shall be provided with a house keeping pad.
10. Vibration isolators shall be provided. Slab on grade may utilize rubber cork pads.
11. Installations on upper level floors should be analyzed for vibration and spring isolators/inertia pads provided if necessary.
12. Provide piping vibration isolators between vacuum pump and fixed piping.
13. Vacuum pumps should be simplex / Duplex, alternating design, as directed by the project manager.
14. Pump design.
  - 14.1. Rotary vane and water liquid ring pumps are not permitted.
  - 14.2. Other than that, we're pretty open to suggestions.
15. Power and Controls. On duplex systems, provide a power circuit for each compressor motor and a separate power circuit for the controls.
16. Submittals should include catalog data, certified sound power ratings, Motor ratings and electrical characteristics plus motor and fan accessories. Shop drawings from the manufacturer detailing dimensions, weights, required clearances, components, and location and size of each field connection for each product specified
17. Close out manuals should include both Installation and Operations and Maintenance Manuals

#### **SPECIFICATION REQUIREMENTS:**

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**GENERAL:**

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The scope of this document is to provide general requirements for electrical work.

**DESIGN GUIDELINES:**

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1. All electrical systems to buildings will be oversized for future requirements. A minimum of 20% spare capacity should be provided within each breaker panel board. Spare capacity is defined as 20% space feeder capacity and 20% spare poles within the panel.
2. Only UL or equivalent approved appliances and equipment shall be specified.
3. Electrical kilowatt-hour meters will be provided in new buildings.
4. Electrical panels, switchgear, transformers and distribution equipment shall be located in dedicated lockable rooms.
5. Electrical loads shall be fed from distribution panels located on the same floor as the load itself. Feeding power loads from floors above or below the connected load will not be permitted unless approved by the Project Manager.
6. Provide all electrical equipment with a local disconnecting means.
7. Power and control wiring systems including low voltage shall be provided using raceways as outlined in these guidelines. Bus Duct is not permitted unless approved by the Project Manager.
8. Exterior handicapped ramps will be electrically heated with self-regulating heat trace cable for snow/ice melting and monitored and controlled by the BAS.
9. Provide expansion fittings at expansion joints. Treat expansion joints as seismic joints for seismic movement and bracing purposes.
10. Distribution of power, lights, fire alarm, telephone, and miscellaneous signals will be in conduit. Conduit systems shall consist of rigid metal, EMT, or a combination of the two as required by applicable codes and standards. (Threaded IMC shall not be used.)
11. Service Entrance:
  - 11.1. In new installations, only one disconnect per voltage will be installed per service entrance or a double ended w/tie breaker setup may be installed, unless approved by the Project Manager.
  - 11.2. Where more than one section is required, a switchboard shall be used. If only one section is required, then a panelboard is acceptable.

- 11.3. All 480-volt service entrance main breakers or fused switches that are rated 1,000 amps or higher are required to have Ground Fault Protection (GFP). This equates to 665 KVA with a single main breaker of standard design.
- 11.4. Where the service entrance disconnect is equipped with GFP, the consultant shall provide time and current setting for the GFP. The service entrance GFP will coordinate with feeder circuits that have GFP and small feeder breakers (such as 20 or 30 amps) in insure the feeder circuit will open before the GFP can trip the main breaker. Where the service entrance disconnect has GFP, feeder breakers that supply motor loads without isolation transformers shall have GFP.
- 11.5. The service entrance disconnect will include sensing for a single-phase condition on the power system. A single-phase detection relay will have an adjustable time delay of 1 to 10 seconds before opening the main breaker and shall not operate for loss of voltage on all three phases. The relay shall only open the service entrance disconnect after loss of voltage to one phase has been detected for 10 seconds.

**GENERAL:**

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The scope of this document is to provide requirements for low voltage (600 volts and below) electrical power conductors and cables.

**DESIGN GUIDELINES:**

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1. All conductors shall be copper.
2. Dedicated neutral conductors shall be used for all single phase loads unless approved in writing by the project manager.
3. All neutral conductors will be a minimum of full size. Designer will evaluate the need for oversized neutral conductors.
4. Circuits that are dedicated to power pre-wired equipment such as office furniture partitions that require multiple branch circuits may use shared neutrals if the following conditions are met.
  - 4.1. Line to neutral voltage is 120 volts (nominal).
  - 4.2. The neutral conductor is oversized (#10 AWG minimum for a 20 amp circuit).
  - 4.3. The pre-wired equipments have oversized neutral conductors (#10 AWG minimum for a 20 amp circuit).
5. Minimum Conductor size is #12 AWG.
6. Minimum Insulation rating is 90°C.
7. Conductor Rating:
  - 7.1. For 100 amps and below: Conductor shall be rated per the 60°C table.
  - 7.2. For over 100 amps: Conductor shall be rated per the 75°C table.

**NOT PERMITTED:**

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1. No aluminum conductors shall be used.
2. Pre-wired systems such as type AC (armored cable), type MC (metal-clad) and type NM (nonmetallic-sheathed cable) shall not be used unless approved in writing by the project manager prior to start of construction. (Exception: MC may be used for lighting fixture whips up to 6'-0" long. They must be dedicated, not daisy chained together.)

**GENERAL:**

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The scope of this document is to provide requirements for Grounding and Bonding for electrical systems.

**DESIGN GUIDELINES:**

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1. Grounding systems should be designed and installed to provide a resistance of five (5) ohms or less. The preferred grounding electrode is a ground ring or (in new construction) a concrete-encased electrode.
2. Grounding electrode conductors shall be insulated stranded copper conductors. Concealed terminations (such as below grade and within concrete) and terminations to the grounding electrode shall be made using exothermic welds.
3. Grounding conductors shall be insulated copper conductors. Grounding conductors larger than # 8 AWG should be stranded, and conductors small than # 8 AWG should be non-stranded (solid).
4. Where isolated grounding conductors are required, the grounding conductor shall be identified by the use of a spirally applied set of two (2) orange stripes over the green conductor insulation. Each orange stripe shall be 1/16 inch minimum width.
5. Building columns, roof steel, and footer steel reinforcing shall be electrically continuous for grounding purposes.
6. All grounding and bonding shall meet or exceed the requirements of the National Electrical Code.

**NOT PERMITTED:**

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1. Metal underground water pipes shall NOT be used as the grounding electrode, but shall be bonded to the grounding system.
2. Building steel shall not be used as a grounding path unless the steel and connections are designed for this use, or grounding capability has been reviewed by a qualified registered professional engineer and a report provided with the engineers seal affixed.

**GENERAL:**

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The scope of this document is to provide requirements for providing requirements for low voltage (600 volts and below) electrical power raceway and boxes.

**DESIGN GUIDELINES:**

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1. All conductors shall be installed in a raceway system.
2. Indoor raceway shall be EMT, Rigid Metal Conduit, or approved surface raceway.
3. Schedule 80 PVC conduit will be utilized anywhere underground conduit emerges from concrete.
4. Rigid metal conduit or Schedule 80 PVC conduit shall be used for exterior locations. Expansion shall be considered for all exterior conduit.
5. Elbows for rigid metal conduit, 3 inches and larger, shall be either plastic coated or tape coated (for corrosion control) rigid metal conduit to prevent damage from pulling ropes. Rigid metal conduit shall be used for at least the first 5 feet of horizontal run out from the building to allow for building settling over time.
6. EMT will not be used outdoors, in wet/damp locations, or in floor crawl spaces. Exposed EMT will also not be allowed below 7 feet AFF in areas where raceway may receive physical abuse (such as hallways, mechanical rooms, storage rooms, and janitor closets), unless the conduit is 2" or larger in diameter.
7. Garages and similar areas shall be considered a wet location. Electrical rooms in a garage shall be considered a wet location. All panels and electrical devices shall be installed on unistruct in electrical rooms in garages.
8. Conduit will be supported from the building structure. Attachment to other pipes, conduits, ductwork, etc. will not be allowed.
9. No conduit will be allowed to be embedded in a concrete slab. All conduits below a slab shall be a minimum of 12" below the concrete slab.
10. All empty conduits shall contain a pull string.
11. Non-metallic conduit or boxes will not be used unless approved in writing by the Project Manager prior to construction. In cases where they are used, conduit 2" and smaller will be a minimum of Schedule 80.
12. PVC Conduit will be used for underground electric circuits less than 600 volts that are:
  - 12.1. Under paved areas and areas scheduled to be paved.

- 12.2. Next to permanent buildings, under formal planting beds and in extremely high traffic (vehicular and pedestrian) areas that would be difficult to excavate due to regular heavy use.
- 12.3. All other applications 277 volt or less may be direct buried if approved by the project manager.
  - 12.3.1. If direct buried, 24 inches of cover is required unless approved by the Project Manager.
- 12.4. A red plastic tracer tape is to be buried 12" above the cable or conduit in all installations.
13. PVC conduit shall be a Schedule 40 minimum weight unless otherwise indicated, and shall be designed for the electric application with all connections solvent welded.
14. All metallic fittings will be compression type rated for ground connection.
15. All exposed conduit installed in a finished space will be painted to match the background.
16. Conductors carrying more than 150V to ground will not be installed in conduits with conductors carrying less than 150V to ground
17. Feeders:
  - 17.1. All feeders will have a separate copper grounding conductor installed. In no case will the conduit or raceway be used as the grounding conductor, however all metallic raceway shall be electrical continuous and bonded to the grounding conductor.
  - 17.2. All conduit sizes and conductor numbers and sizes will be shown on the drawings.
  - 17.3. Conduit shall be sized at least one size above the NEC requirement of wire being installed or anticipated to be installed, with the minimum size to be 1"
18. Branch Circuits:
  - 18.1. A separate grounding conductor will be installed. Use of the conduit or raceway is not an acceptable grounding method, however all metallic raceway shall be electrical continuous and bonded to the grounding conductor.
  - 18.2. For Branch circuits, the minimum conduit size will be ¾" except for switch legs, lighting whips (supplying a single fixture circuit), and control wiring which may be ½".

**GENERAL:**

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The scope of this document is to provide requirements for Identification For Electrical Systems.

**DESIGN GUIDELINES:**

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1. Electrical equipment shall be identified with permanent engraved nameplates.
2. All switchboards, panelboards, motor control centers, motor starters, and equipment local disconnects shall be identified with an engraved nameplate.
3. All overcurrent protective devices installed in electrical service entrance panels, switchboards, and power panel shall have individual engraved nameplate indicating the load they feed. Lighting panels shall also have an engraved nameplate indicating which panel it is served from.
4. Lighting panels shall have index cards neatly typed with "as built" branch circuit information. The index card holder should be metal construction permanently attached to the panel door.
5. Nameplates
  - 5.1. Nameplates shall be engraved three-layer laminated plastic. Nameplates used for identification shall be white background with black lettering. Nameplates used for warnings shall be red background with white lettering.
  - 5.2. Lettering should be ¼ inch high for identifying grouped equipment and loads. Lettering should be 1/8 inch high for identifying individual equipment and loads.
6. Color code secondary service, feeder, and branch circuit conductors with factory applied heat shrink (no cold applied) color as follows:

208/120 Volts	Phase	480/277 Volts
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	White or Gray
Green	Ground	Green

**GENERAL:**

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The scope of this document is to provide requirements for a low voltage (600 volts and below) overcurrent protective device coordination studies and documentation.

**DESIGN GUIDELINES:**

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1. A low voltage coordination study shall be provided for projects installing electrical overcurrent protective devices. The study shall include maximum short circuit calculations, coordination analysis, and settings for all protective devices with adjustable set points. The protective device settings must address the need to minimize arc flash hazards while maintaining proper coordination. The coordination study shall be based on the specific devices installed and include (but not be limited to) the following:
  - 1.1. Service Entrance Equipment.
    - 1.1.1. All overcurrent protective devices installed in service entrance panels.
  - 1.2. Feeder Circuits.
    - 1.2.1. All three (3) phase Feeder circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
  - 1.3. Branch Circuits.
    - 1.3.1. All three (3) phase Branch circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
    - 1.3.2. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.
  - 1.4. Motor Control Centers
    - 1.4.1 All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.
2. Format
  - 2.1. The preliminary coordination study should be submitted to the Owner's Representative no later than six (6) weeks after overcurrent protective device shop drawings have been approved.
  - 2.2. The coordination study shall be reviewed and updated to reflect any changes within one week of the final electrical walk through for punchlist. The low voltage coordination study shall include the stamp or seal and signature of the preparing engineer, and shall be reviewed and approved by the Engineer of Record.
  - 2.3. A complete set of manufacturers' descriptive literature and detailed instructions for adjusting overcurrent protective devices shall be provided to the Owner's Representative within six (6) weeks after overcurrent protective device shop drawings have been approved.

- 2.4. The low voltage coordination study shall be provided using the SKM Systems Analysis, Inc SKM Power Tools Electrical Engineering Software (PTW 32).
- 2.5. Prior to project completion, the low voltage coordination study shall be provided in both hard copy and on computer disk. The hard copy shall include time current curves (for phase and ground fault settings) for each panel and the corresponding TCC report clearly showing each device set point (see attached example TCC and TCC report). The computer disk shall include the complete coordination file including all device curves (use the SKM "Project - Backup" command).

**GENERAL:**

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The scope of this document is to provide requirements for providing a low voltage (600 volts and below) Arc Flash Hazard Analysis and documentation.

**DESIGN GUIDELINES:**

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1. A low voltage Arc Flash Hazard Analysis shall be provided for projects installing electrical overcurrent protective devices. The analysis shall be based on the specific equipment installed, and shall be updated to include project “as built” documentation. Where the arc flash hazard/risk category is equal to or greater than level 3, the overcurrent protective device coordination study should be reviewed to reduce the hazard/risk level. The analysis shall be based on the specific devices installed and include (but not be limited to) the following:
  - 1.1. Service Entrance Equipment.
    - 1.1.1. All overcurrent protective devices installed in service entrance panels.
  - 1.2. Feeder Circuits.
    - 1.2.1. All three (3) phase Feeder circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
  - 1.3. Branch Circuits.
    - 1.3.1. All three (3) phase Branch circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
    - 1.3.2. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.
  - 1.4. Motor Control Centers.
    - 1.4.1. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horse power.
2. The project shall include printed waterproof labels for equipment that lists the specific arc flash hazard/risk category at each location.
3. Format
  - 3.1. A preliminary Arc Flash Hazard Analysis should be submitted to the Owner’s Representative no later than six (6) weeks after the overcurrent protective device shop drawings have been approved.
  - 3.2. The Arc Flash Hazard Analysis shall be reviewed and updated to reflect any changes and corrections to conductor length within one week of the final electrical walk through for punchlist. The low voltage arc flash hazard analysis shall include the stamp or seal and signature of the preparing engineer, and shall be reviewed and approved by the Engineer of Record.

- 3.3. Owner approved Arc Flash Hazard warning labels shall be furnished and installed prior to project completion.
- 3.4. The low voltage arc flash hazard analysis shall be provided using the SKM Systems Analysis, Inc SKM Power Tools Electrical Engineering Software (PTW 32).
- 3.5. Prior to project completion, the low voltage arc flash hazard analysis shall be provided in both hard copy and on computer disk. The hard copy shall clearly show each device set point. The computer disk shall include the complete coordination file including all device curves (use the SKM "Project - Backup" command).

**GENERAL:**

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The scope of this document is to provide requirements for Low Voltage Transformers including (but not limited to) transformers for general applications, transformers rated for non-linear loads, shielded transformers, and drive isolation transformers.

**DESIGN GUIDELINES:**

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1. Low voltage transformers shall be UL listed and meet applicable NEMA standards. Transformers should be two winding dry type design with 115 degree centigrade temperature rise and 220 centigrade class core and coil insulation. Transformer kVA ratings shall be based on self cooled (AA) capacity without the use of any fans.
2. Low voltage transformers with receptacle loads or loads with harmonic content shall be K rated with a minimum rating of K-4.
3. Load calculations shall be provided and be based on the following:
  - 3.1. Receptacles located in offices, classrooms, laboratories, or research facilities shall be considered to have 80 percent of their load be harmonic producing devices (such as computers, laser printers, and copy machines).
4. Low voltage transformers for isolation of adjustable speed drives (variable frequency or other designs) shall be specifically designed for that use.
5. Three phase low voltage transformers should have delta connected primary and wye connected secondary windings. Three phase transformers should have six (6) full capacity taps in 2-1/2 percent increments.
6. All conductor connections shall be oxide inhibited.

**NOT PERMITTED:**

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Transformers with fan cooling with integral shunt trip high temperature protection shall not be used, and should be specifically excluded in project specifications.

**GENERAL:**

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1. The scope of this document is to provide requirements for switchboards, panelboards, and motor control centers.
2. Load Centers are not allowed. Minimum level of quality is a panelboard or switchboard.

**DESIGN GUIDELINES:**

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## 1. Switchboards

- 1.1. Switchboards shall be a metal-clad assembly design, which provides ease of maintenance and testing without service interruption. It shall be a vertical free standing rigid metal enclosure with “compartments” used for additions and removal of circuit breakers and other equipment devices.
- 1.2. Circuit breakers 200 amps and larger shall have adjustable trip settings.
- 1.3. The switchboard assembly and location shall allow for future additions and changes to the switchboard.
- 1.4. Switchboard shall provide both front and rear access with hinged doors. Front access only shall be approved by the Project Manager.
- 1.5. All power and ground lugs to the switchboard shall be compression-type, long-barrel double –hole, copper type lugs.
- 1.6. Switchboard shall consist of self-supporting feeder cubicles bolted together to form rigid metal enclosure. Each device shall be capable of being operated without opening the switchboard door.
- 1.7. Switchboard shall be provided with local instrumentation and control system for automatic and manual operation of the switchboard and for monitoring and control during operation.
- 1.8. Switchboard shall be equipped with appropriate devices for local testing and monitoring.
- 1.9. Switchboards shall have 20% spare capacity for future loads. Spare Capacity is defined as 20% feeder capacity and 20% spare poles within the panel.
- 1.10. When switchboards are equipped with ground fault protection, all overcurrent protective devices installed in the switchboard shall have ground fault protection. Ground fault sensing (when installed) shall use individual phase sensing and a neutral current sensor (such as a current transformer). Single unit (zero sequence) sensors shall NOT be used.
- 1.11. Service entrance switchboards should have three phase voltage monitoring relay to trip the main in the event of sustained loss of one phase or phase unbalance in excess of 8 percent (with time delay of 10 seconds +/-). The voltage monitoring relay shall be General Electric Company model SPVRB or approved equal, and include a stored energy device such as a trip capacitor. The voltage monitoring relay shall NOT operate when power is lost to all three phases within the 10 second delay.

## 2. Panelboards

## 26 2400 Switchboards, Panelboards and Motor Control Centers 2010.01

- 2.1. Panelboards shall be a dead front, safety type with a door-in-door hinge and consisting of a fully rated, isolated neutral bus, an equipment ground bus and main copper bus with two bolt compression lugs used to terminate feeders.
  - 2.2. Feed through lugs are not acceptable.
  - 2.3. Circuit breakers shall have bolted bus connections. Plug-in circuit breakers are not acceptable.
  - 2.4. All wire connections, with the exception of screw terminals shall be wire nut type and shall be suitable for copper wire.
  - 2.5. Balance the loads supplied by the panelboard in accordance with NECA 407.
  - 2.6. Panel board shall have a typewritten directory describing the service of each circuit.
  - 2.7. Provide each panelboard with a permanently attached nameplate displaying, at a minimum, the panelboard name, voltage, phase and feeder origin. Label each circuit breaker sequentially from left to right and top to bottom with permanent tags.
  - 2.8. Panelboard shall be sized to provide spare capacity for future loads. Do not provide spare breakers. Spare Capacity is defined as 20% feeder capacity and 30% spare poles within the panel.
  - 2.9. All panelboards shall be located in a dedicated, lockable electrical room or closet.
  - 2.10. Branch circuit panelboards shall be located on the same floors as the loads they serve except emergency panelboards may be located as is practical.
  - 2.11. When panelboards are equipped with ground fault protection, all overcurrent protective devices installed in the switchboard shall have ground fault protection. Ground fault sensing (when installed) shall use individual phase sensing and a neutral current sensor (such as a current transformer). Single unit (zero sequence) sensors shall NOT be used.
3. Motor Control Centers
    - 3.1. Motor Control Centers shall have a main circuit breaker, control devices, motor thermal overload protection devices, circuit overcurrent protective devices, etc. for all HVAC motors greater than ½ HP.
    - 3.2. Provide vertical hinged door wiring compartments with access to each starter unit for power and control wiring. Provide accessible pullbox compartments at top and bottom of each cubicle, for horizontal wiring between cubicles. Provide conduit entrance space in top and bottom of each cubicle. Provide hinged doors same size as starter enclosure for access to starter. Provide interlocked access to starter, so that the door cannot be opened without opening starter overcurrent device. Use matching blank panel doors for unused space and future starter provisions. Enclosure shall be NEMA Type 1A gasketed-general purpose – Indoor NEMA ICS-6.
    - 3.3. All Bussing shall be 98% conductivity, electroplated copper with fully overlapped joints. Run main bussing horizontally through cubicles connected to vertical riser busses for connection of starter units. Vertical riser bussing shall be rated 300 or 600 amperes based on size and rating of the starters connected, and shall be rated to carry full load current. Provide special bussing required for loads, which exceed standard vertical bus ratings. Arrange bussing for extension to future sections. Provide 100% rated copper neutral bus isolated from the enclosure.
    - 3.4. Provide spare capacity for future HVAC loads. Spare Capacity is defined as 20% feeder capacity and 20% spare poles within the panel.

**GENERAL:**

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The scope of this document is to provide requirements for wiring devices.

**DESIGN GUIDELINES:**

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1. All receptacles and switches will have a minimum rating of 20 amps and will be commercial specification grade. A standard of quality for switches is Leviton #??? and for receptacles is Hubbell #???? or Leviton #????.
2. Preferred color for receptacles and switches is ivory. Other colors may be used to match existing devices or for special uses.
3. In areas required to have ground fault interrupting capability, GFI receptacles shall be used in lieu of GFI breakers, unless approved by the Project Manager.
4. Designer will evaluate the need for steel, nylon or other special types of covers, depending on the usage of the area.
5. The preferred mounting heights, above finished floor, are 48" for switches, and 18" for receptacles.
6. Each restroom shall have a minimum of one receptacle and it shall be a GFI receptacle.

**GENERAL:**

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The scope of this document is to provide requirements for fuses, enclosed switches and circuit breakers.

**DESIGN GUIDELINES:**

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1. Fuses
  - 1.1. Renewable fuses will not be used.
  - 1.2. As much as possible, equipment should be specified with fuse holders that will accept fuses dimensionally the same as Class H fuses.
  - 1.3. A box to store fuses will be required for fuses over 400 amps. The box shall be a metal box, designed to store fuses, mounted in a highly visible location, and labeled appropriately.
2. Enclosed Switches
  - 2.1. All Enclosed Switches shall be NEMA Type HD (Heavy Duty) quick-make, quick-break disconnect switches with dual cover interlock to prevent door opening when switch is closed. An operator override will be provided to allow the door to be opened without having to open the switch. Switch shall be padlockable in 'closed' and 'open' position and the disconnect switch shall be provided with an external indication of 'on' and 'off'.
  - 2.2. Motors and other equipment not within sight of their feeder over current protection devices will be fed from disconnect switches located at the motor or equipment.
  - 2.3. All enclosed switches shall have a durable label permanently attached to the inside of the cover describing the fuse size, type, current limiting ability and devices controlled.
  - 2.4. All enclosed switches intended for use on circuits where current limiting fuses are required will be specified with rejection clips designed to permit installation of Class R fuses only.
  - 2.5. All enclosed switches shall have a grounding bar.
  - 2.6. Enclosed switches in mechanical rooms and potential wet locations (i.e. animal rooms, greenhouses, etc.) will have NEMA 3R enclosures unless the environment or usage requires a more restrictive enclosure.
  - 2.7. Enclosed switch is required between the motor and a variable speed drive.
3. Circuit Breaker
  - 3.1. Bolt-in breakers shall be used. Plug-in breakers are not allowed. Square D I-Line and GE Spectra Series are acceptable.
  - 3.2. Two and Three pole circuit breakers shall have an internal common trip and all circuit breakers frame sizes rated 200-amp and larger shall have interchangeable trips.
  - 3.3. Only one conductor shall be connected to each circuit breaker, unless the circuit breaker is designed and Listed for multiple conductors.
  - 3.4. No piggy back breakers will be allowed.
  - 3.5. All general purpose power circuits will be a minimum of 20 amps.

**GENERAL:**

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The scope of this document is to provide requirements for interior lighting.

**DESIGN GUIDELINES:**

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1. Illumination design shall comply with the latest editions of the Illuminating Engineering Society (IES) Lighting Handbook and ASHRAE 90.1.
2. Lighting Calculation shall be submitted at Design Development. These calculations shall show iso-photo (contours) diagrams of each space, average foot candle levels and min/max ratios. These calculations shall be submitted concurrent with the ASHRAE 90.1 compliance submittal.
3. Accessibility of light fixtures for changing lamps and ballast shall be considered when selecting and placing fixtures.
  - 3.1. Fixtures shall not be placed over stairs. In stairwells, lights shall be located on landings.
  - 3.2. All fixtures shall be installed or mounted within 11'-0" AFF.
  - 3.3. In Auditoriums, lighting shall be designed to minimize the use of scaffolding to change lamps and ballast.
  - 3.4. In no case shall the changing of a lamp or ballast require the fixtures to be removed or require the demolition of the ceiling.
  - 3.5. Provide a 6'-0" electrical whip on all cove lighting so that it may be lifted out of the cove for maintenance.
  - 3.6. For Fixtures in Atriums along walkways, the fixture shall be placed a minimum of 4'-0" from the atrium opened wall and shall be positioned such that the fixture can be maintained with the ladder facing the atrium. See drawing 265100.1.
4. Use the same type of lamps to the greatest extent possible throughout the facility. This reduces the storage of mass quantities of different types of lamps and eases the maintenance of the lighting system.
5. Use energy efficient lamp technology. T-8, 31-watt, lamps (4 ft. in length) are the standard lamps to be used on a project. Compact fluorescents shall use four pin lamps in lieu of 2 pin. All lamps shall be low mercury type.
6. The minimum color rendering index (CRI) for fluorescent lamps shall be 80.
7. All ballast for fluorescent fixtures shall be electronic, high frequency type with plug in type disconnect, and end of life sensor. Ballast shall be Class 'P', and CSA certified and shall comply with FCC and NEMA limits governing electromagnetic and radio frequency interference and shall not interfere with operation of other electrical equipment. Ballast shall meet the following requirements:
  - 7.1. Power Factor = 0.95 (minimum)
  - 7.2. Average Lamp Crest Factor = 1.7 (maximum)

- 7.3. Total Harmonic Distortion (THD) = 10% (maximum)
- 7.4. Sound Rating = Class A
- 8. Lighting Control
  - 8.1. Provide local switching for all lighting. Offices, corridors, equipment rooms, etc. will be provided with separate switches except for night lights.
  - 8.2. Open Office spaces shall have the lighting switched in office groups. Light control shall provide for a two hour override for lighting in these areas afterhours.
  - 8.3. One switch to provide minimal lighting is required at the back of lecture halls and auditoriums close to a door.
  - 8.4. Occupancy Sensors with dual contacts (Watt Stopper Dual Technology type) shall be used for lighting control in most building spaces. Wall light switches are still required in all locations where occupancy sensors are used.
  - 8.5. Timers shall be used for lighting control in mechanical, electrical, telecommunication, etc. rooms.
- 9. All damp/wet locations (animal rooms, greenhouses, mechanical rooms, etc.) shall be provided with lighting fixtures rated for wet locations.
- 10. Step lighting along egress path is required in all sloped or stepped auditoriums and lecture halls.
- 11. All exit lights shall be LED type.
- 12. Emergency lighting needs to meet minimum required by code, but should not be excessive.
- 13. Specialty lighting for specific occupancies is acceptable if approved by the Project Manager.

**GENERAL:**

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1. The objective of this guideline is to provide minimum standards for design and installation of fire alarm systems for the University of Missouri.
2. All new buildings and major renovations at the University of Missouri will include central, zoned, addressable, microprocessor based fire alarm system with manual or automatic alarm initiation as required by code.
3. Fire alarm systems are Life Safety Systems and the utmost of care must be taken when designing these systems.
4. All designs must be in full compliance with the UM adopted version of NFPA 72 *National Fire Alarm Code* that is in effect for the project as well as all other applicable codes and standards adopted by the University of Missouri.
5. Design is to be done by an engineer who is licensed by the State of Missouri or a NICET Level IV technician certified in Fire Protection Engineering Technology – Fire Alarm Systems. Fire alarm plans and specifications must be sealed by a Missouri Professional Engineer who has training and experience in the design of fire alarm systems of the type and scope included in the project. Further, the registrant who seals the documents must be able to answer questions posed by code reviewers on the project.

**DESIGN GUIDELINES:**

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1. This design guideline establishes the basic requirements for the design of fire alarm systems including functions, layout, industry standards, permissible systems, and materials.
2. Fire alarm system design includes but is not limited to all of the following components and systems:
  - 2.1. Fire alarm panel
  - 2.2. Initiating devices
  - 2.3. Notification devices
  - 2.4. Mass notification systems (if desired or required)
  - 2.5. Other code required element
3. Design calculations shall be done in accordance with NFPA 72 and the following requirements:
  - 3.1. Current draw on each notification circuit with allowance for 20% expansion.
  - 3.2. Voltage drop on each notification circuit.
  - 3.3. Stand-by battery capacity for entire system including any power expanders.
  - 3.4. Table showing specified device capacity for each addressable loop and the corresponding number of devices assigned.

#### 4. Coordination

- 4.1. Coordination of design is critical to a successful building project. During the design phase of a project, promptly notify architect, structural, civil and electrical engineers of changes which affect their work. Coordination should include but, is not limited to the following:
  - 4.1.1. Confirm location of main fire alarm panel with PM. The local fire department must confirm the panel location or an annunciator with full capabilities must be provided at the designated fire department entrance.
  - 4.1.2. Provide a connection which will
  - 4.1.3. Coordinate with fire protection engineer for locations of flow switches, tamper switches, fire pumps as well as any other code required devices.
  - 4.1.4. Coordinate architectural features with Architect including door hold open devices, door locking devices that must be released by the fire alarm system, or other building related features.
  - 4.1.5. Coordinate with the electrical engineer for power needs as well as any other electrical devices requiring interconnection with the fire alarm system.
  - 4.1.6. Coordinate with the HVAC engineer for connections to air handlers including smoke devices and any code required smoke evacuation systems.
  - 4.1.7. If a new fire alarm system is being installed in an existing building, the existing fire alarm system shall be maintained fully operational until the new equipment has been tested and accepted.
  - 4.1.8. If a security system is available in the building where a new fire alarm panel is being installed, trouble and alarm outputs from the fire alarm panel will be connected to the security system to allow reporting of a fire alarm to Campus Police through the security system. All fire alarm panels will be capable of reporting through the security system or other external system.
    - 4.1.8.1. MU ONLY: If an Energy Management Controls System (EMCS) is available in the building where a new fire alarm panel is being installed, trouble and alarm outputs from the fire alarm panel will be connected to the EMCS

#### 5. System Requirements

- 5.1. All new fire alarm panels shall be microprocessor based non-coded, addressable systems.
- 5.2. All new fire alarm panels are to be expandable. Future ability to provide fire alarm service for entire building or planned building expansion is required. Each notification circuit shall contain a minimum of 20% excess capacity. The 20% capacity should be in addition to the capacity for any planned expansion of the fire alarm or voltage drop.
- 5.3. Where voice systems are used, they must be designed to meet the code requirements for that occupancy. Installing a voice system where it is not required by code does not create the requirement for a Fire Command Center. However, where the voice system is to be used for any type notification other than fire (such as weather) then mass notification requirements in the code may be required. For information on mass notification see NFPA 72 3.3.102 for definition and Annex E or. UM will use NFPA 72 including Annex E to determine code

compliance.

- 5.4. All device locations shall comply with ADAAG requirements. Special care will be taken on systems for residential occupancies.
- 5.5. Wiring systems for both notification and addressable loops shall be Class B unless directed otherwise by the PM or required by other codes.

#### 5.6. Notification zones

- 5.6.1. These requirements shall include all notification devices such as strobes, horns, or speakers. Multiple circuits may be needed as in the case of speakers and strobes.
- 5.6.2. At a minimum, each occupied floor shall be on a separate circuit.
- 5.6.3. Where a floor is divided into separate fire areas, each fire area shall be on a separate circuit unless modified by code.

#### 5.7. Initiation zones

- 5.7.1. Addressable loops shall be designed for reliability. For that reason, the fire alarm system will require a minimum of two loops for smaller buildings and additional loops for larger buildings.
- 5.7.2. Each building shall have one addressable loop per floor to parallel the notification circuits.
- 5.7.3. Where floors are divided into multiple fire areas, each fire area is to be on a separate loop.

### 6. Information Shown on Drawings

- 6.1. Plans shall show all devices required by code including:

#### 6.1.1. Alarm Sequence Matrix & Coordination

- 6.1.1.1. Provide a matrix showing alarm and initiation devices by category on one axis and device action on the second axis. An example would be elevator lobby smoke detector. Actions would be such as general alarm, elevator recall, shut down air handlers, etc.
- 6.1.1.2. Show and specify sequence on air handler shut down. Air handlers shall be controlled by the FA panel through an addressable relay and not a contact on the smoke detector.
- 6.1.1.3. Smoke detectors, heat detectors, flow switches, and pull stations activate the general alarm mode unless directed otherwise by the PM and supported by code. For example, duct smoke detectors should, but are not required to, initiate a general alarm.

#### 6.1.2. Alarm Initiation Devices

- 6.1.2.1. Pull stations are required on all occupancies and must be located within 5' of each exit from a floor. Mounting height is to be noted on drawings. The preferred mounting height is 48" to the center of the device.

- 6.1.2.2. Smoke and heat detectors are to be shown where required by applicable codes.
  - 6.1.2.3. Plans shall clearly show where more than one duct detector is required because of duct size.
  - 6.1.2.4. Flow switches are to be shown on the fire alarm plan as well as the riser. These devices are to be coordinated with the sprinkler design.
- 6.1.3. Notification Devices
- 6.1.3.1. Notification devices shall be limited to strobes, horns and speakers unless approved otherwise by the Project Manager.
  - 6.1.3.2. All strobes, horns, speakers, etc. are to be shown on the plans
  - 6.1.3.3. The mounting height, candela rating, sound level settings are to be shown on the drawings. Sound level, candela, or other information that must be set by device shall be shown next to the device. Mounting height for strobes, horns, and speakers shall be 80” to the bottom of the device. Where a low ceiling does not permit this mounting height, consult NFPA 72 for mounting height and adjustments for coverage. For residence hall sleeping rooms, consult “Sleeping Area” tables in Chapter 7 of NFPA 72.
  - 6.1.3.4. Spacing of devices is outlined in NFPA 72. Designer must be diligent in showing spacing for strobes that meet code requirements as well as the sound levels required for horns and speakers. A note shall be put on the plans to instruct the contractor to get the approval of the engineer prior to moving any device more than 12”. The placement of devices on the plans shall take this movement into account when allowing for clearances and code required locations.
- 6.1.4. Supervisory Devices
- 6.1.4.1. Show required supervisory devices including tamper switches, fire pump, engine generator, or other required supervisory signals. Coordinate the location of tamper switches and other supervisory devices with the appropriate discipline.
- 6.1.5. Emergency Control Functions
- 6.1.5.1. All emergency control functions and their locations shall be shown on the drawings.
  - 6.1.5.2. Door hold opens are to be coordinated with the Architect for location and function. Provide required smoke detectors where applicable. Hold opens may be released by circuit or controlled by addressable relays and may, in some cases, be controlled by other systems in concert with fire alarm. Designer shall be fully aware of and design control for the functions desired and required by code.
  - 6.1.5.3. Door unlocking where desired or required shall be coordinated with other disciplines and assure that all applicable egress codes are being followed. Door security (locking) and unlocking functions must be reviewed and approved by

the AHJ.

6.1.5.4. Elevator recall shall be done in accordance with the UM adopted version NFPA 72 and the latest ASME A17.1 elevator code. All work shall be coordinated with other disciplines. Typical recall is as follows and each requires a separate output device on the system.

6.1.5.4.1. Elevator recall to designated level

6.1.5.4.2. Elevator recall to alternate level

6.1.5.4.3. Visual warning for elevator(s) activated by equipment room or hoistway devices.

6.1.5.4.4. Elevator shutdown initiated by equipment room heat detectors. Elevator shutdown on sprinkler activation shall not be permitted.

#### 6.1.6. Expander Panels

6.1.6.1. Expander panels should only be used on renovation projects. New buildings should use panels and sub-panels that are capable of full coordination and communication.

6.1.6.2. Where used, expander panels will not be placed above ceilings, in closets or other hard-to-find places. The designer will show the location of all expander panels clearly on plans.

#### 6.1.7. Sub Panels and Annunciators

6.1.7.1. Sub panels and annunciators shall be clearly shown on the plans.

#### 6.1.8. Riser diagrams are required for the entire system including:

6.1.8.1. Notification devices for each and every floor indicating circuiting which will correspond with calculations done under paragraph 3 above.

6.1.8.2. Expander panels including notification devices connected to expander panel and sufficient information to verify calculations required in paragraph 3 above.

6.1.8.3. Addressable loops showing all initiating devices, supervisory devices and output devices on each loop that will correspond to paragraph 3 above. This includes all relays and monitoring devices for air handlers, elevators, fire alarm systems, kitchen suppression systems, etc.

6.1.8.4. Sub panels and annunciator panels.

#### 6.1.9. Power

6.1.9.1. Alarm power supply disconnect, where not in a panelboard, shall be painted red and labeled "FIRE ALARM." Where in a panelboard provide with lockable handle or cover and red laminated plate next to breaker with white lettering "FIRE ALARM". Location for power shall not be located in corridors or other public areas. Power disconnect shall be in a secure space accessible only by authorized personnel.

## 7. Specifications

- 7.1. All items in this section **must** be included in the fire alarm specifications.
- 7.2. All devices, equipment and installation are to be provided by a single source who assumes responsibility for the entire system per NFPA 72. Non addressable devices do not have to be of the same brand as the main system, but must meet the manufacture's requirements and UL ratings for the system installed.
- 7.3. Fire alarm cabinet shall be lockable dead-front, steel enclosure arranged so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control panel, provide exactly matching modular unit enclosures. Provide cabinets large enough to accommodate all components and to allow ample gutter space for interconnection of panels as well as field wiring. Identify each enclosure by an engraved red laminated phenolic resin nameplate. Lettering on the enclosure nameplate shall not be less than 1 inch high. Identify individual components and modules within the cabinets by machine lettered signs or labels.
- 7.4. System submittals must include:
  - 7.4.1. Power Calculations:
    - 7.4.1.1. Battery Capacity Calculations: Battery size shall be a minimum of 125% of the calculated requirement. Batteries must be capable of operating the panel in normal mode for 24 hours with sufficient capacity to operate the panel in alarm mode for 15 minutes at the end of that 24 hour period.
    - 7.4.1.2. Supervisory power requirements for all equipment.
    - 7.4.1.3. Alarm power requirements for all equipment.
    - 7.4.1.4. Power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst case condition.
  - 7.4.2. Complete manufacturer's catalog data on all devices, modules, bases, etc.
  - 7.4.3. Submit panel and annunciator panel configuration showing layout including the following as applicable:
    - 7.4.3.1. Master system CPU including all fire detection, evacuation alarm control modules, and supervised power amplifiers with the required back up modules.
    - 7.4.3.2. Circuit interface panels including all modules.
    - 7.4.3.3. Power supplies, batteries and battery chargers.
    - 7.4.3.4. Pre-amplifiers, amplifiers, and tone generators.
    - 7.4.3.5. Equipment enclosures.
    - 7.4.3.6. Alarm monitoring modules, and supervised control modules.
    - 7.4.3.7. Initiation loop must be capable of supporting at least 60 devices of any type. If the loop supports different numbers of different type devices, it must be capable of supporting at least 60 devices of each type.
    - 7.4.3.8. Alarm notification circuits must be capable of 1.5 amps per circuit at 24vdc.

Panels capable of allowing varying current draws per circuit, but allowing an average of 1.5 amps average may be allowed if the engineer designs the circuits appropriately. In that case each circuit must still have .3 amp minimum allowed for future in addition to the designed load.

- 7.4.3.9. Wireless systems are not permitted.
- 7.4.4. A complete proposed system database including a description of all logic strings, control by event programming and point identification labels on a computer CD or 3.5" high density floppy disk and in a formatted printed form, as required for offsite editing, uploading and downloading shall be submitted for evaluation by the owner. A programming manual shall accompany the submitted program and shall be adequate to allow understanding, operation and editing by the system.
- 7.4.5. The latest version of software for programming the fire alarm system. A programming manual shall accompany the submitted program and shall be adequate to allow understanding, operation and editing by the system.
- 7.5. Specification submittal requirements are to state that proposed vendors must be able to show the ability to respond to requests for service within 24 hours and the ability to supply replacement parts for the system within 48 hours relative to the site where the system is to be installed.
- 7.6. All fire alarm panels will be equipped with a "walk test" feature. This allows each activating device to be tested without the need to reset the panel after each device is activated.
- 7.7. All fire alarm panels will be equipped with a "building evacuate" switch.
- 7.8. System shall be capable of silencing horns while leaving strobes in alarm. System reset shall reset both horns and strobes. Acknowledge shall silence horns. These functions shall only be accessible to authorized personnel. This provision may be in conflict with NFPA 72, but is accepted as a variance by UM.
- 7.9. Each circuit, initiating and notification, will have a disconnect switch in the Fire Alarm Control Panel (FACP) to disable the circuit during maintenance. This may be a physical switch or a "soft" switch that disables the circuit and causes a trouble on the panel until the circuit is re-set. The circuit must be disabled and reset by one action of a qualified person who has access to these switches. These switches are not to be accessible from the operator portion of the panel but must require the panel to be fully opened to gain access.
- 7.10. If door hold-opens are used, they will be wall-mounted, magnetic type with proper mounting blocking in the wall. Combination door closer/hold-opens will not be used.
- 7.11. All pull stations will be key operated, keyed the same as the building fire alarm panel. Engineer shall verify key type used by the campus and specify that key type where the campus has a standard.
- 7.12. Smoke Detectors
  - 7.12.1. Infrared detector light source with matching silicon cell receiver. Ionization type smoke detectors will not be allowed unless directed by the Project Manager.

**GENERAL:**

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The scope of this document is to provide instruction for the installation and testing of underground domestic water lines.

**DESIGN GUIDELINES:**

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## 1. Materials, Pipe and Pipe Fittings

## 1.1. All underground water piping shall be PVC.

- 1.1.1. EXCEPTION: Lines passing directly over steam tunnels or direct buried steam/condensate lines must be ductile iron with 2" R-5 extruded polystyrene insulation board between the pipe and steam lines.

1.2. PVC Pipe (Open Trench Construction)

- 1.2.1. 2 Inches to 12 Inches: AWWA C900; Pressure Class 150 (DR 18); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.
- 1.2.2. 4 Inches to 24 Inches: AWWA C905; Pressure Rating 165 (DR 25); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.
- 1.2.3. Gaskets: ASTM F 477, elastomeric seal.

## 1.3. Ductile-Iron Pipe

- 1.3.1. 2 Inches to 24 Inches: AWWA C151; Mechanical Joint Pipe; 150 psi working pressure; Minimum Thickness Class 50; with integrally cast flanged bell, cast iron gland, and rubber gasket.
- 1.3.2. Lining: Standard cement lining with asphalt coating.
- 1.3.3. Encasement: AWWA C105, polyethylene film.

## 1.4. Pipe Fittings

- 1.4.1. 2 Inches to 24 Inches: AWWA C153; 350-psi pressure rating.
- 1.4.2. Lining: Standard cement lining with asphalt coating.
- 1.4.3. All pipe fittings shall be cast-iron construction, installed wrapped with AWWA C105 polyethylene film.

## 1.5. Restraints

- 1.5.1. Mechanical joint: AWWA C111. Provide retainer type packing glands with rubber gasket, for use with PVC pipe and conforming to Uni-B-13-92. Pipe sizes 4" to 12" must also be FM approved. Mechanical joint restraints shall be Megalug 2000 PV, as manufactured by EBAA Iron Inc., Eastland TX, or approved equal.
- 1.5.2. Joint Retainers: Provide ductile iron split serrated ring harnesses and rod type joint retainers for PVC bell and spigot joints. Clamps shall be designed for use with PVC pipe and shall meet Uni-B-13-92 Standards and be FM approved on sizes 4" to 12". Restraint harnesses shall be Series 1500 for pipe 4 inches to 12 inches, and Series 2800 for pipe 14

inches and larger, all as manufactured by EBAA Iron Inc., Eastland TX or approved equal.

- 1.5.3. Rods, nuts and washers: ¾" SS304 all thread rods, nuts and washers.
- 1.5.4. All pipe restraints shall be installed wrapped with AWWA C105 polyethylene film.
- 1.5.5. Link Assembly: Seal annular space for piping passing through walls with interlocking synthetic rubber link assembly, Link-Seal® as manufactured by PSI-Thunderline Corporation, Houston TX, or approved equal.

## 1.6. Pipe cleaning pigs

- 1.6.1. Pigs shall be constructed from open cell polyurethane foam with, medium density ranging from 5 lbs/cu. ft. to 8 lbs/cu ft.
- 1.6.2. All pigs used shall be made for hand launching and specifically for the type and size of pipe being installed.
- 1.6.3. Pigs shall be Product Code B-3 as manufactured by Pipeline Pigging Products Inc., Houston TX, or approved equal.

## 2. Installation

### 2.1. Preparation of Trench

- 2.1.1. Trench bottom shall be graded to provide a smooth, firm, stable, and rock-free foundation throughout the length of the piping.
- 2.1.2. All rock greater than one inch in diameter found in the trench shall be removed for a depth of six inches below the bottom of the pipe and replaced by suitable bedding material.
- 2.1.3. Unstable, soft, and unsuitable materials shall be removed at the surface upon which pipes are to be laid and backfill with crushed stone as indicated on the drawings.
- 2.1.4. Layers of crushed stone shall be installed in the bottom of trench as indicated on the drawings. Shape stone layer to fit bottom of piping. Dig bell holes at each pipe joint to relieve the bells of all loads and to ensure continuous bearing of the pipe barrel on the foundation.

### 2.2. Pipe Separation

- 2.2.1. Finished pipe installation shall have minimum 12" separation to all other utilities.
- 2.2.2. Maintain at least a ten foot (10') horizontal separation of water mains from any existing or proposed sanitary sewer. The distance must be measured edge to edge. Installation of the water main closer to a sanitary sewer is acceptable where the water main is laid in a separate trench or on an undisturbed earth shelf located on one (1) side of the sanitary sewer at an elevation so the bottom of the water main is at least eighteen inches (18") above the top of the sanitary sewer.
- 2.2.3. Provide a minimum vertical distance of eighteen inches (18") between the outside of the water main and the outside of the sanitary sewer where water mains cross the sanitary sewer mains. This shall be the case where the water main is either above or below the sanitary sewer. At crossings, one (1) full length of water pipe must be located so both joints will be as

far from the sanitary sewer line as possible. Special structural support for the water and sanitary sewer pipes may be required.

- 2.2.4. Provide at least a ten-foot (10') horizontal separation between water mains and sanitary sewer force mains. There shall be an eighteen-inch (18") vertical separation at crossings
- 2.2.5. Locate water mains so that they do not pass through or come in contact with any sanitary sewer manhole
- 2.2.6. Consult the system owner where above conditions cannot be met.

### 2.3. Installation of Pipe and Pipe Fittings

- 2.3.1. PVC (Polyvinyl Chloride) Pipe: Install in accordance with AWWA C605.
- 2.3.2. All joints shall be restrained with joint retainers. All fittings shall be restrained with retainer type packing glands.
- 2.3.3. Install stainless steel rods between fittings on all offsets and between fittings, valves, and blind flanges, in addition to the Megalugs. On isolated fittings, valves, etc., attach restraint rings to PVC pipe and install stainless steel rods between fitting and restraint rings. Rods shall be positioned through the bolt holes in fitting and Megalug. Each rod will require four nuts and washers. Duct lugs are acceptable. The number of stainless steel rods required per fitting flange shall be as follows:

<u>Pipe Diameter</u>	<u>No. of Rods</u>
10" and Less	2
12"	3
14"	4
16"	5
18"	6

- 2.3.4. All ductile iron pipe, fittings, valves, etc. shall be wrapped with a polyethylene cover conforming to AWWA C105, and installed per AWWA C600.
- 2.3.5. All dead end mains shall have a dry barrel fire hydrant at the end to facilitate flushing of the main.
- 2.3.6. Pipe shall be installed in clean condition, and shall never be laid in trenches with standing water. The trench shall be dewatered during installation of the water line. Open pipe ends shall be protected with a hard cap or inflatable plug at the end of the work day. **NO PLYWOOD OR DUCTTAPE COVERINGS WILL BE ALLOWED**

### 2.4 Backfill

- 2.4.1 Under Pipe: All backfill under the barrel of the pipe shall be free from debris, organic matter, and stones larger than one inch, and shall be tamped into place. Sand or crushed stone aggregate (95% passing a 1/2" screen but not more than 10% passing a #200 sieve) are acceptable substitutes for soil.
- 2.4.2 Adjacent To and Top of Pipe: The first one foot of backfill over the top of pipe shall be "3/4 inch minus waste rock with fines" uncleaned crushed stone aggregate. The balance of the trench shall be mechanically filled to

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## Water Distribution Piping

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six inches below the proposed finished grade of the surrounding terrain. Backfill shall be free of debris, brush, roots and stones or rubble more than one inch.

2.4.3 Rough final grading of subgrade and the placement of final topsoil shall be detailed on the drawings.

2.4.4 All sidewalks, paving, etc. which are removed or damaged during construction shall be replaced and shall match existing.

## 2.5 Identification

2.5.1 Install continuous plastic underground warning tape during back-filling of trench for underground water piping. Tape shall be located twenty-four (24) inches above pipe, directly over each water line.

2.5.2 Tape trace wire to the top of each water line with duct tape every five (5) feet. Wire splices shall be minimized. Terminate trace wires inside building and inside valve boxes. Drill ¼" hole in PVC valve box one inch below cast iron cover. Route wire up outside of valve box, through ¼" hole and knot. Upon completion of installation and final grading, a continuity test on the wire shall be performed and all breaks shall be repaired.

## 3. Testing

## 3.1. Field Quality Control

3.1.1. See section 331300 Disinfecting for cleaning and disinfection requirements.

3.1.2. Piping Tests: Leak and pressure tests shall follow procedures outlined in AWWA M23. Conduct piping tests before joints are covered. Use only potable water.

3.1.3. Simultaneous Tests: Conduct leak and pressure testing at the same time. All tests shall be conducted in the presence of the Owner's Representative. Test at not less than 100 psig for 1 hour.

3.1.4. Test Report: Submit Test Reports to the Owner's Representative.

## 4. Commissioning

4.1. System shall be placed in operation only after testing shows the absence of bacteriological contamination and approved by Owner's Representative.

4.2. At MU: Only Campus Facilities - Energy Management Steam and Water personnel will be allowed to operate valves on new water systems.

**REFERENCES**

Section 331300 Disinfecting

Section 331114 Potable Water Horizontal Directional Drilling

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## Water Distribution Piping

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**REFERENCES**

Section 331300 Disinfecting

Section 331114 Potable Water Horizontal Directional Drilling

**GENERAL:**

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The scope of this document is to provide instruction for the installation of underground domestic water lines installed for the University of Missouri using horizontal directional drilling.

**DESIGN GUIDELINES:**

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**1. Materials, Pipe and Pipe Fittings, General**

- 1.1. All underground water piping shall be PVC. **EXCEPTION:** Lines passing directly over steam tunnels or direct buried steam/condensate lines must be ductile iron with 2" R-5 extruded polystyrene insulation board between the pipe and steam lines.
- 1.2. **PVC Pipe (Trenchless Construction)**
  - 1.2.1. 2 Inches to 12 inches: AWWA C900; Class 150 (DR 18); cast iron O.D. equivalent; with grooved ends suitable for restrained joint coupling.
  - 1.2.2. Couplings: Non-metallic restrained joint coupling with PVC precision machined housing, nylon joint retaining splines, elastomeric O-ring seals, beveled leading edges, with pressure rating equal to or greater than pipe.
  - 1.2.3. Gaskets: ASTM F477, elastomeric seal.
  - 1.2.4. Coupling Lubricant: Coupling manufacturer's standard for permanent joints.
  - 1.2.5. Compliance: Complete restrained joint pipe and coupling system shall be Factory Mutual approved, Underwriter's Laboratory Listed, and shall comply with National Sanitation Foundation Standard No. 61 and UNI-BELL UNI-B-13.
  - 1.2.6. Restrained joint piping system shall be Certa-Lok C900/RJ system, as manufactured by CertainTeed, Valley Forge PA, or approved equal.
  - 1.2.7. Link Assembly: Seal annular space for piping passing through walls with interlocking synthetic rubber link assembly, Link-Seal® as manufactured by PSI-Thunderline Corporation, Houston TX, or approved equal.

**2. Trenchless Piping Installation**

- 2.1. It is the desire of the system owner to assure that trenchless piping installation be completed in a timely, quality and accurate manner utilizing good, well-maintained equipment and trained competent personnel. Trenchless piping must be installed on a route as close to the drawings as possible to prevent interference with buried utilities and other obstructions, and to prevent future accidental excavation damage.
- 2.2. Trenchless piping installation shall only be allowed if previously approved by system owner.
- 2.3. Directional drilling and pipe installation shall be done only by an experienced operator specializing in directional drilling and whose key personnel have at least five (5) year experience in this work.
- 2.4. Pipe installed by the directional drilled method must be located in plan as shown on the Drawings, and must be no shallower than shown on the Drawings unless otherwise approved. The actual horizontal and vertical alignment of the pilot bore

shall be plotted at intervals not exceeding twenty (20) feet. This "as built" plan and profile shall be updated as the pilot bore is advanced. Instrumentation shall be utilized at all times that will accurately locate the pilot hole and measure drilling fluid flow and pressure.

- 2.5. Pilot hole shall be drilled on bore path with no deviations greater than 5 feet left/right/depth over a length of 100 feet. In the event that pilot does deviate from bore path more than this amount, the Engineer shall be notified and Engineer may require the pilot drill to be pulled back and redrilled from the location along bore path before the deviation. The final exit point of pilot hole shall be within five (5) feet of the location shown on the drawings.
  - 2.6. Trenchless piping installed using directional drilling equipment shall be installed in full compliance with restrained joint piping system manufacturer's instructions.
  - 2.7. Field grooving tools, pulling heads, spline insertion tools, etc. shall be piping system manufacturer's standard.
  - 2.8. Comply with piping system manufacturer's requirements on maximum pulling force, minimum bend radius, maximum deflection, etc. During pull-back operations, no more than the maximum safe pipe pull pressure shall be applied at any time. Maximum allowable tensile force imposed on the pull section shall be equal to, or less than 80% of the pipe manufacturer's safe pull (tensile) strength.
  - 2.9. Provide pressure relief holes at close enough intervals to prevent buckling of pavement/sidewalks. If damage does occur, the pavement shall be repaired in accordance with pavement details provided.
  - 2.10. Trace wire shall be pulled with pipe, without splices. Upon completion of installation, a continuity test on the wire shall be performed and all breaks shall be repaired.
3. Pipe Separation
- 3.1. Finished pipe installation shall have minimum 12" separation to all other utilities.
  - 3.2. Maintain at least a ten foot (10') horizontal separation of water mains from any existing or proposed sanitary sewer. The distance must be measured edge to edge. Installation of the water main closer to a sanitary sewer is acceptable where the water main is laid in a separate trench or on an undisturbed earth shelf located on one (1) side of the sanitary sewer at an elevation so the bottom of the water main is at least eighteen inches (18") above the top of the sanitary sewer.
  - 3.3. Provide a minimum vertical distance of eighteen inches (18") between the outside of the water main and the outside of the sanitary sewer where water mains cross the sanitary sewer mains. This shall be the case where the water main is either above or below the sanitary sewer. At crossings, one (1) full length of water pipe must be located so both joints will be as far from the sanitary sewer line as possible. Special structural support for the water and sanitary sewer pipes may be required.
  - 3.4. Provide at least a ten-foot (10') horizontal separation between water mains and sanitary sewer force mains. There shall be an eighteen-inch (18") vertical separation at crossings
  - 3.5. Locate water mains so that they do not pass through or come in contact with any sanitary sewer manhole
  - 3.6. Consult the system owner where above conditions cannot be met.

4. Backfill

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- 4.1. Rough final grading of subgrade and the placement of final topsoil shall be detailed on the drawings.
  - 4.2. All sidewalks, paving, etc. which are removed or damaged during construction shall be replaced and shall match existing.
5. Testing
- 5.1. See section 331300 Disinfecting for cleaning and disinfection requirements.
  - 5.2. Piping Tests: Leak and pressure tests shall follow procedures outlined in AWWA M23. Conduct piping tests before joints are covered. Use only potable water.
  - 5.3. Simultaneous Tests: Conduct leak and pressure testing at the same time. All tests shall be conducted in the presence of the Owner's Representative. Test at not less than 100 psig for 1 hour.
  - 5.4. Test Report: Submit Test Reports to the Owner's Representative.
6. Cleaning
- 6.1. See section 331300 Disinfecting for cleaning and disinfection requirements.
7. Commissioning
- 7.1. System shall be placed in operation only after testing shows the absence of bacteriological contamination and approved by system owner.
  - 7.2. MU: Only Campus Facilities - Energy Management Steam and Water personnel will be allowed to operate valves on new water systems.

## REFERENCES

Section 331300 Disinfecting

**GENERAL:**

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The scope of this document is to provide instruction for the installation and testing of domestic water valves.

**DESIGN GUIDELINES:**

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## 1. Materials

## 1.1. Valves and Valves Boxes

- 1.1.1. Non-rising Stem Gate Valves: ANSI/AWWA C509, resilient seated, bronze stem, cast-iron or ductile-iron body and bonnet, epoxy coated disc, stem nut, 250 psig working pressure, mechanical joint ends. Valves shall be Model A-2360 as manufactured by Mueller Company, Decatur IL, or approved equal. Valves shall turn clockwise to close.
- 1.1.2. Ball Valves: Threaded bronze, 125 lb., 2-piece design, full port. Valves shall be Model T-580 as manufactured by NIBCO, Elkhart IL, or approved equal.
- 1.1.3. Valve Boxes: Valve box shall be 6" PVC C900 pipe with cast iron cover No. 2195 as manufactured by Clay and Bailey Manufacturing Company, Kansas City MO, or approved equal. Lid shall be marked "WATER". Provide below grade concrete collar in planted and asphalt areas.

## 2. Installation

## 2.1. Valve Storage:

- 2.1.1. Use the following precautions for valves during storage:
  - 2.1.1.1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
  - 2.1.1.2. Protect valves from weather - valves shall be stored indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

## 2.2 Handling:

- 2.2.1 Use a sling to handle valves whose size requires handling by crane or lift. Valves shall be rigged to avoid damage to exposed valve parts. Do not use hand wheels or stems as lifting or rigging points.
- 2.2.2 Domestic Water Service: AWWA-Type Gate Valves: Comply with AWWA C600. Install buried valves with stem pointing up and with valve box.
- 2.2.3 Valve boxes shall be installed vertically with top of box even with final grade.

## 3. Testing

- 3.1. All valves shall be pressure tested in accordance with standards set forth in the Water Piping Construction Standard.

3.2. All valves shall be disinfected in accordance with standards set forth in the Water Piping Construction Standard.

4. **Commissioning**

4.1. MU only: All valves under pressure in the MU water distribution mains will be operated only by Campus Facilities - Steam & Water Distribution personnel, except in cases of extreme emergency. All valves installed as part of new construction shall remain fully closed during construction.

**REFERENCES**

**MU CAMPUS ONLY****GENERAL:**

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The scope of this document is to provide instruction for the installation and testing of a fire hydrant installed at the University of Missouri - Columbia.

**DESIGN GUIDELINES:**

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**1. Materials**

- 1.1. University fire hydrants shall be Super Centurion Fire Hydrants, Model 250, Number A-423, as manufactured by Mueller Water Products, Decatur IL. No substitutions will be allowed.
- 1.2. Fire hydrants shall be painted in the following manner using Sign Painters' 1 Shot Lettering Enamel or approved equal:
- 1.3. University water: Barrel - Metallic Gold, Caps - Black, Bonnet - Red.
- 1.4. City water, University maintained fire system: Barrel - Metallic Gold, Caps - Red, Bonnet - Red.

**2. Installation**

- 2.1. The location of new fire hydrants shall be determined by a collaboration of system owner, City of Columbia Fire Department and the design engineers.
- 2.2. Installation of fire hydrants maintained by the University shall be installed per "Fire Hydrant Detail" and in strict accordance with manufacturer's written instructions.
- 2.3. Installation of fire hydrants maintained by the City of Columbia shall be in strict accordance with Columbia Water and Light Specifications as last revised.
- 2.4. The pumper nozzle shall be installed pointing to the street and/or away from the building.

**3. Testing**

- 3.1. Newly installed fire hydrants shall be cleaned and pressure tested in accordance with standards set forth in section 331300 - Disinfecting of Water Utility Distribution, and will be flow tested by system owner.

**4. COMMISSIONING**

- 4.1. Water will be turned on to the hydrant by Campus Facilities - Energy Management Utility Distribution personnel.

**REFERENCES**

Section 331300 - Disinfecting of Water Utility Distribution.

**GENERAL:**

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1. The scope of this document is to provide instructions for water revenue metering installed at the University of Missouri.
2. As these meters will be used to measure building water usage for utility billing purposes, the meter shall be carefully sized considering the projected building utilization, number of fixtures and fixture flow quantities, process equipment, usage diversification and meter pressure loss. All capacities and selections must be approved by system owner before completing final selection.
3. Nutating disc meters are to be installed on applications requiring water flows equal to, or less than one-hundred (100) gallons per minute. Turbine meters are to be installed on applications requiring water flows more than one-hundred (100) gallons per minute. Compound meter are to be installed on applications that will see large peak flows over typical normal flows.

**DESIGN GUIDELINES:**

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1. Materials
  - 1.1. The University of Missouri has standardized on bronze disc and turbine utility meters as manufactured by BadgerMeter, Milwaukee, WI. Substitutes will not be accepted.
  - 1.2. Nutating Disc Meter
    - 1.2.1. Construction shall comply with ANSI and AWWA C700 standards as required for domestic water metering applications.
    - 1.2.2. Meter housing and housing top plate shall be cast bronze construction. The measuring chamber, disc, strainer, and generator housing shall be thermoplastic construction. Register lid and box shall be thermoplastic and bronze and trim shall be stainless steel or bronze.
    - 1.2.3. Register shall be a straight-reading odometer-type totalization display (gallons), 360 degree test circle with center sweep hand and flow finder to detect leaks. Register shall be installed using TORX tamper resistant seal screws. Meters shall be provided with an integral strainer. A tamper resistant calibration plug seal shall also be provided to protect from unauthorized personnel.
    - 1.2.4. Meters shall be Recordall disc models 35, 70, 120 and 170.
  - 1.3. Turbine Meter
    - 1.3.1. Construction shall comply with ANSI and AWWA C701 standards as required for domestic water metering applications.
    - 1.3.2. Meter housing shall be cast bronze construction. Nose cone, straightening vanes and rotor shall be thermoplastic construction. Register lid and shroud shall be thermoplastic and bronze and trim shall be stainless steel.

1.3.3. Register shall be a straight-reading odometer-type totalization display (gallons), 360 degree test circle with center sweep hand and flow finder to detect leaks. Register shall be installed using TORX tamper resistant seal screws. A tamper resistant calibration plug seal shall also be provided to protect from unauthorized personnel.

1.3.4. Meters shall be provided with an integral 316 stainless steel strainer manufactured and installed into its inlet end complete with a removable cover plate which will permit easy access to the strainer for routine cleaning.

1.3.5. Meters shall be Recordall Turbo Series 160, 200 450, 1000 and 2000.

#### 1.4. Compound Meter

1.4.1. Construction shall comply with ANSI and AWWA C702 standards as required for domestic water compound metering applications.

1.4.2. Meter housing shall be cast bronze construction. Nose cone, straightening vanes, rotor, rotor and valve casing, measuring chamber and disc and high flow valve shall be thermoplastic construction. Register lid and shroud shall be thermoplastic and bronze and trim shall be stainless steel.

1.4.3. Register shall be a straight-reading odometer-type totalization display (gallons), 360 degree test circle with dual center sweep hands. Register shall be installed using TORX tamper resistant seal screws. A tamper resistant calibration plug seal shall also be provided to protect from unauthorized personnel.

1.4.4. Meters shall be Recordall Compound Series.

#### 1.5. Plate Strainers

1.5.1. Plate strainers shall exceed AWWA standards. Double-flanged housing and cover shall be constructed of cast bronze. Strainer screen and housing bolts shall be stainless steel. Housing cover seal and flange gaskets shall be neoprene rubber. Screen shall have 3/16" perforations with a minimum straining area that is double the meter inlet size. Flange connections shall be elliptical (2" meters) or round. Plate strainers shall be as manufactured by BadgerMeter or approved equal.

## 2. Installation

2.1. Installation of water meter, valving, bypass loop and water sampler/test outlet shall be in strict accordance with manufacturer's printed instructions and recommendations, applicable ANSI and AWWA requirements, and as detailed on "Bronze Disc Water Meter Installation Detail" and "Bronze Turbo Water Meter Installation Detail."

2.2. The preferred location for water revenue meter installation is within a building mechanical room. In some cases, water meter may need to be installed in an exterior below-grade meter pit. These pit installations shall be installed in strict accordance with manufacturer's printed instructions and University of Missouri "Meter Box Pit Detail" drawing.

2.3. Water meters shall be installed with a three-valve bypass design using ball valves (2" or less) or OS&Y rising stem gate valves (larger than 2"). The bypass valve shall be full-flow and capable of being locked. All other valves associated with the meter installation shall be ball valves. Turbine water meters shall be installed in a

straight run with no obstructions a minimum of ten diameters upstream and five diameters downstream.

- 2.4. Water meter shall be installed after the backflow prevention device but prior to any booster pumps or pressure reducing valves.
  - 2.5. Water meter shall be installed no greater than 4' from the floor. Variations from this requirement need prior approval from system owner. If this requirement is impossible or the meter is located in an inaccessible location, the meter shall be equipped with a Read-O-Matic remote read, and the register shall be mounted no greater than 4' from the floor.
3. Commissioning
    - 3.1. Water service will not be turned on until the water meter is fully installed and operating satisfactorily, the downstream water piping is successfully leak tested and secure (including freeze protection), and the necessary backflow preventer device is installed and successfully tested with the delivery of the test report to the Owner's Representative.
    - 3.2. MU Only: Only Energy Management Steam and Water Distribution personnel will be authorized to turn water service on or off.

## REFERENCES

**GENERAL:**

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The scope of this document is to provide instruction for the cleaning and disinfecting of underground domestic water lines.

**DESIGN GUIDELINES:**

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## 1. Cleaning

- 1.1. All domestic potable water systems shall be clean and free of foreign matter and shall be disinfected and tested for bacteriological contamination before the system is put into operation, as required by the State Division of Health and in accordance with AWWA C651 or C652 or the following provisions.
- 1.2. Disinfection shall be performed AFTER leak and pressure tests are completed.
- 1.3. All new water lines shall be cleaned and flushed with a polyfoam pig prior to chlorination and sanitation. Flush the potable water system with clean, potable water until no dirty water appears at the points of outlet.
- 1.4. Pipe cleaning pigs
  - 1.4.1. Pigs shall be constructed from open cell polyurethane foam with, medium density ranging from 5 lbs/cu. ft. to 8 lbs/cu ft.
  - 1.4.2. All pigs used shall be made for hand launching and specifically for the type and size of pipe being installed.
  - 1.4.3. Pigs shall be Product Code B-3 as manufactured by Pipeline Pigging Products Inc., Houston TX, or approved equal.
- 1.5. Fill the system with a water-chlorine solution containing at least 50 parts per million of chlorine, valve off, and allow to stand for at least twenty-four (24) hours; or fill system with a water-chlorine solution containing at least 200 parts per million of chlorine, valve off, and let stand for three (3) hours.
- 1.6. After allowed standing time, flush the system with clean potable water until no chlorine (in excess of public water supply) remains at any point of outlet.
- 1.7. The system shall be thoroughly and completely flushed at maximum water pressure, and if it is shown by a bacteriological examination made by the authority having jurisdiction that contamination still persists in the system, the above procedure shall be repeated.
- 1.8. MU Only: Campus Facilities - Energy Management Steam and Water personnel will draw water samples for bacteriological testing and send sample off for testing. At all other campuses, contractor shall be responsible for taking and sending the sample for testing.
- 1.9. The system owner will be financially responsible for first bacteriological test on a section of line to be tested. The cleaning procedure shall be repeated if biological examination shows evidence of contamination. Costs incurred due to subsequent testing from an initial positive sample shall be paid for by the installers.
- 1.10. Allow forty-eight (48) hours for return of testing before making tie-ins to existing system.

**2. Commissioning**

- 2.1. System shall be placed in operation only after testing shows the absence of bacteriological contamination and approved by system owner.
- 2.2. MU Only: Only Campus Facilities - Energy Management Steam and Water personnel will be allowed to operate valves on new water systems.

**REFERENCES**

**GENERAL:**

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The scope of this document is to provide instruction for the installation and testing of chilled water piping installed for the University of Missouri.

**DESIGN GUIDELINES:**

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## 1. Materials

## 1.1. Pipe and Pipe Fittings – General

1.1.1. PVC (Polyvinyl Chloride) Pipe (for open trench construction):

1.1.1.1. 4 Inches to 12 Inches: AWWA C900; Pressure Class 150 (DR 18); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.

1.1.1.2. 14 Inches to 24 Inches: AWWA C905; Pressure Rating 165 (DR 25); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.

1.1.1.3. Gaskets: ASTM F 477, elastomeric seal.

1.2.1 PVC (Polyvinyl Chloride) Pipe (for trenchless construction):

1.2.1.1 4 inches to 12 inches: AWWA C900; Class 150 (DR 18); cast iron O.D. equivalent; with grooved ends suitable for restrained joint coupling.

1.2.1.2 Couplings: Non-metallic restrained joint coupling with PVC precision machined housing, nylon joint retaining splines, elastomeric O-ring seals, beveled leading edges, with pressure rating equal to or greater than pipe.

1.2.1.3 Gaskets: ASTM F477, elastomeric seal.

1.2.1.4 Coupling Lubricant: Coupling manufacturer's standard for permanent joints.

1.2.1.5 Compliance: Complete restrained joint pipe and coupling system shall be Factory Mutual approved, Underwriter's Laboratory Listed, and shall comply with National Sanitation Foundation Standard No. 61 and UNI-BELL UNI-B-13.

1.2.1.6 Restrained joint piping system shall be Certain Teed Certa-Lok C900/RJ system, or approved equal.

## 1.1.2. Ductile-Iron Pipe:

1.1.2.1. 4 Inches to 24 Inches: AWWA C151; Mechanical Joint Pipe; 150 psi working pressure; Minimum Thickness Class 50; with integrally cast flanged bell, cast iron gland, and rubber gasket.

1.1.2.2. Lining: Standard cement lining with asphalt coating.

1.1.2.3. Encasement: AWWA C105, polyethylene film.

## 1.1.3. Ductile-Iron Pipe Fittings:

1.1.3.1. 4 Inches to 24 Inches: AWWA C153; 350-psi pressure rating.

1.1.3.2. Lining: Standard cement lining with asphalt coating.

1.1.3.3. Encasement: AWWA C105, polyethylene film.

1.1.3.4. Fitting Restraint:

- 1.1.3.4.1. Mechanical joint: AWWA C111. Provide retainer type packing glands with rubber gasket, for use with PVC pipe and conforming to Uni-B-13-92. Pipe sizes 4" to 12" must also be FM approved. EBAA Megalug 2000 PV or approved equal.
- 1.1.3.4.2. Rods, nuts and washers: 3/4" SS304 all thread rods, nuts and washers.
- 1.1.3.4.3. Joint Retainers: Provide ductile iron clamp and rod type joint retainers for PVC bell and spigot joints. Clamps shall be designed for use with PVC pipe and shall meet Uni-B-13-92 Standards and be FM approved on sizes 4" to 12".
- 1.1.3.4.4. EBAA Series 1600 for pipe 4 inches to 12 inches, or approved equal.
- 1.1.3.4.5. EBAA Series 2800 for pipe 14 inches and larger, or approved equal.
- 1.1.3.4.6. Link Assembly: Seal annular space for piping passing through walls with interlocking synthetic rubber link assembly, Link-Seal by Thunderline Corporation or equal.

## 2. Installation

### 2.1. Preparation of Trench

- 2.1.1. Grade trench bottom to provide a smooth, firm, stable, and rock-free foundation throughout the length of the piping. All rock greater than one inch in diameter found in the trench shall be removed for a depth of six inches below the bottom of the pipe and replaced by suitable bedding material.
- 2.1.2. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with crushed stone as indicated on the drawings.
- 2.1.3. Provide layers of crushed stone in the bottom of trench as indicated on the drawings. Shape stone layer to fit bottom of piping. Dig bell holes at each pipe joint to relieve the bells of all loads and to ensure continuous bearing of the pipe barrel on the foundation.
- 2.1.4. Finished pipe installation shall have minimum 12" separation to all other utilities.

### 2.2. Installation of Pipe and Pipe Fittings

- 2.2.1. PVC (Polyvinyl Chloride) Pipe: Install in accordance with AWWA C605.
- 2.2.2. All underground water / chilled water piping shall be PVC.
- 2.2.3. EXCEPTION: Lines passing directly over steam tunnels or direct buried steam/condensate lines must be ductile iron with 2" R-5 extruded polystyrene insulation board between the pipe and steam lines.
- 2.2.4. All joints shall be restrained with joint retainers. All fittings shall be

- 2.2.5. Install stainless steel rods between fittings on all offsets and between fittings, valves, and blind flanges, in addition to the Megalugs. On isolated fittings, valves, etc., attach restraint rings to PVC pipe and install stainless steel rods between fitting and restraint rings. Position rods through the bolt holes in fitting and Megalug. Requires four nuts and washers on each rod. Duct lugs are acceptable. The number of stainless steel rods required per fitting flange are as follows:

<u>Pipe Diameter</u>	<u>No. of Rods</u>
to 10"	2
12"	3
14"	4
16"	5
18"	6

- 2.2.6. Ductile iron pipe, fittings and valves shall be wrapped with a polyethylene cover conforming to AWWA C105. Install per AWWA C600.
- 2.2.7. Installation of Trenchless Piping System: Trenchless piping installed using directional drilling equipment shall be installed in full compliance with restrained joint piping system manufacturer's instructions.
- 2.2.8. Field grooving tools, pulling heads, spline insertion tools, etc. shall be piping system manufacturer's standard.
- 2.2.9. Comply with piping system manufacturer's requirements on maximum pulling force, minimum bend radius, maximum deflection, etc.
- 2.2.10. Provide pressure relief holes at close enough intervals to prevent buckling of pavement/sidewalks. If damage does occur, the contractor shall repair in accordance with pavement details provided.
- 2.2.11. Trace wire shall be pulled with pipe, without splices. Trace wire shall be tested for continuity in presence of Owner's Representative, after pulling is completed.
- 2.2.12. Pipe shall be installed in clean condition, and shall never be laid in trenches with standing water. Contractor shall make provisions to keep the trench dewatered during installation of the water line. Protect open pipe ends with a hard cap or inflatable plug at the end of the work day. **NO PLYWOOD OR DUCTTAPE COVERINGS WILL BE ALLOWED.**

### 3. Identification

- 3.1. Install continuous plastic underground warning tape during back-filling of trench for underground water / chilled water and compressed air piping. Locate 24 inches above pipe, directly over each water line.
- 3.2. Tape trace wire to the top of each water / chilled water line with duct tape every 5 feet. Contractor shall minimize wire splices. Terminate trace wires inside building and inside valve boxes. Drill 1/4" hole in PVC valve box 1" below cast iron cover. Route wire up outside of valve box, through 1/4" hole and knot.

#### 4. Trenchless Piping Installation

- 4.1. It is the desire of system owners to assure that trenchless piping installation be completed in a timely, quality and accurate manner utilizing good, well-maintained equipment and trained competent personnel. Trenchless piping must be installed on a route as close to the drawings as possible to prevent interference with buried utilities and other obstructions, and to prevent future accidental excavation damage.
- 4.2. Trenchless piping installation shall only be allowed if previously approved by system owner.
- 4.3. Directional drilling and pipe installation shall be done only by an experienced operator specializing in directional drilling and whose key personnel have at least five (5) year experience in this work.
- 4.4. Pipe installed by the directional drilled method must be located in plan as shown on the Drawings, and must be no shallower than shown on the Drawings unless otherwise approved. The actual horizontal and vertical alignment of the pilot bore shall be plotted at intervals not exceeding twenty (20) feet. This "as built" plan and profile shall be updated as the pilot bore is advanced. Instrumentation shall be utilized at all times that will accurately locate the pilot hole and measure drilling fluid flow and pressure.
- 4.5. Pilot hole shall be drilled on bore path with no deviations greater than 5 feet left/right/depth over a length of 100 feet. In the event that pilot does deviate from bore path more than this amount, the Engineer shall be notified and Engineer may require the pilot drill to be pulled back and redrilled from the location along bore path before the deviation. The final exit point of pilot hole shall be within five (5) feet of the location shown on the drawings.
- 4.6. Trenchless piping installed using directional drilling equipment shall be installed in full compliance with restrained joint piping system manufacturer's instructions.
- 4.7. Field grooving tools, pulling heads, spline insertion tools, etc. shall be piping system manufacturer's standard.
- 4.8. Comply with piping system manufacturer's requirements on maximum pulling force, minimum bend radius, maximum deflection, etc. During pull-back operations, no more than the maximum safe pipe pull pressure shall be applied at any time. Maximum allowable tensile force imposed on the pull section shall be equal to, or less than 80% of the pipe manufacturer's safe pull (tensile) strength.
- 4.9. Provide pressure relief holes at close enough intervals to prevent buckling of pavement/sidewalks. If damage does occur, the pavement shall be repaired in accordance with pavement details provided.
- 4.10. Trace wire shall be pulled with pipe, without splices. Upon completion of installation, a continuity test on the wire shall be performed and all breaks shall be repaired.

#### 5. Testing

##### 5.1. Field Quality Control

- 5.1.1. Piping Tests: Leak and pressure tests shall follow procedures outlined in

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AWWA M23. Conduct piping tests before joints are covered. Use only potable water.

5.1.2. Simultaneous Tests: Conduct leak and pressure testing at the same time.

All tests shall be conducted in the presence of the Energy Management – Steam and Water personnel or their designee. Test at not less than 100 psig for 1 hour.

5.1.3. Test Report: Submit Test Reports to the system owner personnel.

## 5.2 Cleaning

5.2.1 Cleaning of all piping shall be performed as detailed in section 331300 Disinfecting of Water Utility Distribution. Chilled water distribution piping does not require disinfection.

## 6. Commissioning

6.1. System shall be placed in operation only after piping has been leak tested, flushed clean and approved by system owner personnel.

## REFERENCES

**GENERAL:**

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The scope of this document is to provide instruction for the installation of junction boxes, control conduit and pull rope to be run along with chilled water piping.

**DESIGN GUIDELINES:**

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**1. Materials****1.1. Junction Boxes**

- 1.1.1. Junction Boxes: Minimum dimensions shall be 24" x 18" x 18" (L x W x D).
- 1.1.2. Roadway, Parking Lots and Service Drives: Heavy duty, cast iron box with hot-dip galvanized finish. Removable cover shall be checkered ductile iron with stainless steel cover screws. Junction box shall have an H-20 load rating and be suitable for installation in roadway. Junction box shall be ER series, as manufactured by Spring City Electrical Mfg. Co. or approved equal.
- 1.1.3. Grass and Sidewalks: High strength, light duty, composite box and cover with 8,000# design rating. Removable cover shall be skid resistant and labeled AFiber Optics A with stainless steel cover screws. Junction box shall be suitable for sidewalks or grass areas. Junction box shall be PG style, as manufactured by Quazite, or approved equal.

**1.2 Controls Conduit and Pull Rope**

- 1.2.1 Buried Conduit: PVC, Schedule 40, rated for 90 degrees C. cable and shall comply with NEMA Standards for electrical non-metallic conduit. PVC conduit shall be as manufactured by Carlon Electrical Sciences, Inc. Cleveland, Ohio or approved equal.
- 1.2.2 Exposed Conduit: Exposed conduit shall consist of all metal raceway, long radius fittings and hardware, EMT type. Conduit shall be hot dipped galvanized.
  - 1.2.2.1 Fittings shall consist of die cast, metal alloy bodies, device boxes, insulated bushings, seal fittings, cord fittings etc. as manufactured by Appleton Electric Co. Or approved equal.
  - 1.2.2.2 Hardware shall consist of all malleable iron conduit clamps, beam clamps and hangers required to install the raceway system. Raceway support spacing shall not exceed 10 feet.
- 1.2.3 Pull Rope: Low stretch polyester braided rope rated for 800 lbs. Greenlee model 78-3310-34122 or approved equal.

**2. Installation****2.1. Control Conduit and Pull Rope**

- 2.1.1. All direct buried PVC conduit shall be straight, level runs to prevent conduit damage during cable installation.
- 2.1.2. Install PVC bell end fittings at each PVC termination. Bell fittings shall be grouted flush with the inside of the wall.

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- 2.1.3. All offsets and turns shall be constructed with LONG RADIUS (36" minimum) conduit fittings.
  
- 2.1.4. All joints shall be sealed with approved joint solvent cement to prevent conduit joints from separating during construction.
- 2.1.5. After installation, contractor shall swab out conduit to remove any rocks and debris. Swabbing shall be conducted with the Owner's Representative present. Owner Representative shall be notified 24 hours prior to swabbing.
- 2.1.6. Install pull rope in conduit. Terminate in junction boxes and in buildings.

**GENERAL:**

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The scope of this document is to provide instruction for the installation and testing of chilled water valves.

**DESIGN GUIDELINES:**

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**1. Material****1.1. Valves**

- 1.1.1. Butterfly Valves: AWWA C504, Class 150B service, with cast iron body, cast iron disc with stainless steel seating edge, BUNA-N seal, 304 stainless steel valve shaft, self-lubricating valve bearings, fully grease packed actuator with stops in the open/close position. The actuator shall have a traveling nut which shall engage alignment grooves in the housing and shall have a built-in packing leak bypass to eliminate possible packing leakage into the actuator. Valve interior and exterior surfaces except for seating shall be coated with two coats of asphalt varnish. Valves shall have mechanical joint ends. Valves shall be Pratt Groundhog or approved equal.
- 1.1.2. Ball Valves: Threaded bronze, 125 lb., 2-piece design, full port. Valves shall be Nibco T-580 or approved equal.

- 1.2 Valve Boxes: Valve box shall be 6" PVC pipe, ASTM D3034, SDR 35, with cast iron cover. Clay and Bailey No. 2194 or approved equal. Lid shall be marked "WATER". Provide below grade concrete collar in planted areas.

**1.3 Chilled Water Vent Boxes**

- 1.3.1 Roadway, Parking Lots and Service Drives: Heavy duty, street rated cast iron with hot-dip galvanized finish. Removable cover shall be checkered steel with stainless steel cover screws. Removable cover shall be checkered steel with stainless steel cover screws. Junction box shall have an H-20 load rating and be suitable for installation in roadway. Minimum dimensions shall be 12" x 12" x 24" (L x W x D). Junction box shall be ER Series, as manufactured by Spring City Electrical Manufacturing Co., or approved equal.
- 1.3.2 Grass and Sidewalks: Vent box shall be 18" PVC pipe, ASTM F679, SDR 35, with cast iron water well cover. Clay and Bailey No. 2361 or approved equal. Lid shall be marked "WATER."

**2. Installation**

- 2.1. Valve Storage: Use the following precautions for valves during storage:
  - 2.1.1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
  - 2.1.2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor

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storage is necessary, support valves off the ground or pavement in watertight enclosures.

2.1.3. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use hand wheels or stems as lifting or rigging points.

2.2. Valve Installation

2.2.1. Chilled Water Service 6" and Larger: AWWA-Type Butterfly Valves: Comply with AWWA C600. Install buried valves with stem pointing up and with valve box.

2.2.2. Chilled Water Vents: Bronze Ball Valves.

2.2.3. Valve boxes shall be installed vertically with top of box even with final grade.

3. Testing

3.1. All valves shall be pressure tested in accordance with standards set forth in the Chilled Water Piping.

## REFERENCES

**GENERAL:**

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This standard covers the general description and requirements for the design and installation of medium voltage systems on the University of Missouri – Columbia campus. Refer to construction standards for individual parts of the system which shall be followed.

**DESIGN GUIDELINES:**

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All medium voltage circuit extensions and upgrades shall be of underground design with red concrete encased duct banks and concrete manholes large enough for personnel entry to construct and repair cable systems. Other than cables, no medium voltage equipment shall be installed in manholes.

**REFERENCES**

**GENERAL:**

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The scope of this document is to provide instruction for installation and testing of electric power duct banks.

**DESIGN GUIDELINES:**

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## 1. Materials

## 1.1. Conduit

- 1.1.1. Underground concrete encased electric conduit duct banks shall consist of Type DB-60 polyvinyl chloride (PVC) conduit rated for 90°C cable and meeting NEMA Standard TC-6 and ASTM F-512 for underground applications.
- 1.1.2. The standard conduit sizes shall be 2", 3", 4", and 5" for all conduits.
- 1.1.3. Conduits shall have long rigid steel metallic sweep elbows, 48" minimum radius for horizontal bends and 36" radius for vertical bends. Conduit elbows shall be PVC coated with taped ends.
- 1.1.4. All joints shall have watertight seals.
- 1.1.5. Conduit End Bells
  - 1.1.5.1. Conduit end bells for PVC conduit shall be polyvinyl chloride (PVC).
  - 1.1.5.2. Conduit end bells for rigid galvanized steel conduit shall be hot-dipped galvanized malleable iron or steel, threaded to the end of the rigid galvanized steel conduit.

## 1.2 Concrete

## 1.2.1 Color Additive

- 1.2.1.1 The concrete for all concrete encased conduit duct banks shall have the color additive "Colorcron-Tile Red" as manufactured by Masterbuilders, Solomon Grind Chemical Services #140 Red, or approved equal. The color additive shall have a minimum concentration per manufacturer's recommendation per yard of concrete and shall be mixed throughout the entire duct bank concrete.

## 1.2.2 Admixtures

- 1.2.2.1 Air-entraining mixture shall be used for all exterior concrete and shall conform to ASTM C260. The total calculated air content by volume as determined by ASTM C231 shall be as follows:

Maximum	Total Air
Coarse	Content, %
<u>Aggregate</u>	<u>Includes</u>
<u>Size</u>	<u>Trapped Air</u>
3/4"	3-8
1"	4-6

1.2.2.2 Water reducing admixture shall be used to reduce the total water requirements. Water reducing admixture shall meet the requirements of ASTM C494, Type A.

1.2.2.3 Calcium chloride or accelerating admixtures containing calcium chloride shall not be used.

### 1.2.3 Proportioning

1.2.3.1 Concrete slump at the time of placement as determined by ASTM C13 shall be 3" to 4". Tolerance up to 1" above maximum will be allowed providing average of batches tested does not exceed maximum.

1.2.3.2 The minimum 28 day concrete compressive strength for concrete shall be 4,000 psi (6 sacks/cu. yd. minimum).

### 1.2.4 Reinforcement

1.2.4.1 All concrete encased electric conduit duct banks shall contain steel reinforcing throughout the entire length as indicated on Typical Duct Bank Detail.dwg. The minimum size of reinforcing steel shall be size No. 4.

### 1.2.5 Backfill

1.2.5.1 Backfill material shall be clean fill. No concrete or large rocks are to be used.

## 1.3 Accessories

1.3.1 The pull string installed in spare conduits shall have a minimum of 240 lbs. tensile strength and shall be rot and mildew resistant. Pull string shall have permanently printed sequential measurements at one foot increments.

1.3.2 Use plastic plugs with wick for drainage to seal spare conduits in manholes.

## 1.4 Underground Warning Tape

1.4.1 Warning tape shall be fabricated from polyethylene film, and shall be 6 inches wide and not less than 3.5 mils thick.

1.4.2 Warning tape shall be high visibility red in color and imprinted at frequent intervals with black letters having the following wording: CAUTION BURIED ELECTRICAL LINE BELOW

## 2. Installation

### 2.1. Conduit and Duct Banks

2.1.1. Conduit shall be adequately and properly supported on solid earth, or other indicated means, throughout the entire length of the run. All conduits shall be laid straight and true.

2.1.2. Verify routing locations of conduit prior to rough-in.

2.1.3. Couplings for conduits in a group shall be staggered at least six (6) inches.

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- 2.1.4. Underground conduit duct banks shall be installed a minimum of 36" below finished grade to the top surface of the duct bank.
- 2.1.5. Underground conduit duct banks shall be at least 12 inches away from all other underground utilities; gas, water, electric, telephone, communications, etc., and at least 36 inches away from steam pipe lines and steam tunnels, trenches, or manholes.
- 2.1.6. Conduits shall be installed with a minimum slope of ½% toward manholes or other drainage points.
- 2.1.7. Intermediate and base spacers shall be used to obtain uniform separation and alignment during the installation of the concrete for concrete encased duct banks. Maximum intervals between spacers shall be 8 feet.
- 2.1.8. Concrete encased conduit duct bank penetrations into manholes shall continue completely through the wall of the manhole and shall use one large hole rather than several smaller holes. If this method is not practical, the concrete may stop outside the manhole but must be pinned to the manhole with steel pins to prevent any differential settlement.
- 2.1.9. Conduit end bells shall be installed at all conduit terminations in each manhole.
  - 2.1.9.1. Conduit end bells for PVC conduit shall be cast in place in the concrete wall of the manhole and glued to each end of each Type DB PVC conduit.
  - 2.1.9.2. Conduit end bells for rigid galvanized steel conduit shall be cast in place in the concrete wall of the manhole.

## 2.2. Concrete

- 2.2.1. All duct banks used for 13.8Kv system shall be encased in red concrete.
- 2.2.2. Placing, Curing, and Backfill
  - 2.2.2.1. Precautions shall be used to prevent ducts from floating.
  - 2.2.2.2. Concrete shall be placed with the aid of a mechanical vibrator.
  - 2.2.2.3. Curing shall be continued for at least 7 days in the case of all concrete except high-early-strength concrete for which the period shall be at least 3 days. Excavations should not be backfilled until concrete has cured.
  - 2.2.2.4. In no cases shall duct bank sidewall thickness exceed 12" from side of duct.
- 2.2.3. Reinforcement
  - 2.2.3.1. The reinforcing steel shall be installed longitudinally, at each corner of the duct bank (in cross section) and along the top and bottom and sides at a maximum of 12 inches on center. All reinforcing steel (including bottom) shall have a minimum concrete cover of 1-1/2 inches. Reinforcing shall be installed latitudinal, as needed, to hold the longitudinal steel in place during the placement of the concrete but no more than 48" apart. Refer to Typical Duct Bank Detail.dwg.

## 2.3. Accessories

- 2.3.1. All empty or "spare" conduits shall have a nylon or polypropylene pull string installed for future use. Leave not less than 2 feet of slack at each end of pull string.



**GENERAL:**

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The scope of this document is to provide instruction for the installation of concrete electric manholes.

**DESIGN GUIDELINES:**

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## 1. Materials for Manhole

- 1.1. Cast-in-Place or Pre-Cast concrete may be used.
- 1.2. The minimum 28 day concrete compressive strength for concrete shall be 4,000 psi.
- 1.3. The minimum inside dimensions for a manhole is 12' x 6' wide, and 6'6" high.
- 1.4. Only ready mixed concrete shall be used. Ready mixed concrete shall be mixed and transported to the job site in accordance with ASTM C94 "Specifications for Ready Mixed Concrete".
- 1.5. Manholes shall be designed in compliance with ASTM C857-87, "Standard Practice for Minimum Structural Design Loading for Underground Pre-cast Concrete Utility Structures". Wheel loading shall be HS-20.
- 1.6. Manholes shall be manufactured in accordance with ASTM C858-83, "Standard Specifications for Underground Pre-cast Concrete Utility Structures".
- 1.7. Shall be designed per ACI 318-02 "Building code Requirements for Structural Concrete."
- 1.8. Design loads shall consist of dead load, live load, impact, surcharge load, and any other loads which may be imposed upon the structure
- 1.9. Sump
  - 1.9.1. The sump shall have a concrete bottom and shall be 18 inches as shown on Manhole Detail Drawing.
  - 1.9.2. The manhole floor is to be sloped to the sump pit.
  - 1.9.3. Sump pit is to be located in the middle of the floor below the entry hole.
  - 1.9.4. There is to be no grating over the sump pit.
- 1.10 Reinforcement
  - 1.10.1 All concrete used in the construction of the manholes shall contain steel reinforcing bars to conform to all applicable building codes. All reinforcing steel shall conform to ASTM 432 and ASTM A305 Specifications.
- 1.11 Accessories
  - 1.11.1 Cable pulling-in irons shall be Cooper Power Systems Catalog No. DU1T1; Joslyn Manufacturing and Supply Company Catalog No. J8120; Hubbell/Chance Catalog No. 8120; or approved equal.
  - 1.11.2 Manhole Covers and Frames
    - 1.11.2.1 Manhole access is to be in the middle of the manhole ceiling, with the sump pit located directly underneath (see Manhole Detail.dwg for reference).

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1.11.2.2 Manhole covers shall consist of a solid circular gravity lid and frame. The lid and frame shall be heavy duty type, fabricated from gray cast iron.

1.11.2.3 Manhole lids shall have a checkered design with the word ELECTRIC cast into the top surface.

1.11.2.4 Manhole frames shall provide a 36-inch diameter opening. The opening through the concrete roof of each manhole shall be 40.5 inches in diameter.

1.11.2.5 Manhole frames and covers shall be Neenah Foundry Company Catalog No. R-1640-D, or approved equal. The cover shall have two (2) pick holes located 180° apart.

1.11.2.6 Vent cover and frame shall 8-1/2" clear opening, cast iron, heavy duty, Neenah R-5901-A with open grate lid.

1.11.3 Conduit End Bells

1.11.3.1 Conduit end bells for PVC conduit shall be polyvinyl chloride (PVC) type glued to the end of each PVC conduit. Conduit end bells shall be Carlon Electrical Products Catalog No. E297\_, or approved equal by Condux International, Inc., Certainteed Products Corp. or Can-Tex Industries.

1.11.3.2 Conduit end bells for rigid galvanized steel conduit shall be hot-dipped galvanized malleable iron or steel, threaded to the end of the rigid galvanized steel conduit and cast in place in the concrete wall of the manhole and shall be O-Z/Gedney Company Type TNS or approved equal by Appleton Electric or Crouse-Hinds.

1.11.4 Cable Racks

1.11.4.1 Cable racks shall be heavy duty type fabricated from 50% glass-reinforced nylon or a non-metallic material having equal mechanical strength, thermal resistance, chemical resistance, dielectric strength and physical properties.

1.11.4.2 Stanchions

1.11.4.2.1 Size of stanchions shall be coordinated with Energy Management Electric Distribution Engineer.

1.11.4.2.2 Stanchions shall incorporate multiple arm mounting holes that are 4 inches apart and recessed attachment bolt mounting holes.

1.11.4.2.3 Stanchions shall be Model CR\_\_-B as manufactured by Underground Devices, Inc. or approved equal.

1.11.4.3 Cable Support Arms

1.11.4.3.1 Cable support arms shall be heavy duty type fabricated from 50% glass-reinforced nylon or a non-metallic material having equal mechanical strength, thermal resistance, chemical resistance, dielectric strength and physical properties. Cable support arms shall be 14 inches in length, with 5 slots for cable wire ties.

1.11.4.3.2 Provide a positive locking clip for each and every cable support arm supplied to prevent disengagement of the cable support arm from the cable rack due to upward force on the support arm.

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1.11.4.3.3 Cable support arms shall be Model RA14 with Model HDL lock as manufactured by Underground Devices, Inc. or approved equal.

1.11.5 Cable Support Insulators

1.11.5.1 Cable support insulators shall be fabricated from high-grade electrical porcelain and shall have rounded corners and edges to prevent cable sheath damage.

1.11.5.2 Cable support insulators shall be Model DE11U1 as manufactured by Cooper Power Systems, or approved equal.

1.11.6 Cable Ties

1.11.6.1 Cable ties shall be weather resistant self-locking high strength UV-resistant black nylon, having a minimum length of 15 inches and a minimum loop tensile strength of 120 lbs, meeting Military Specifications MS 3367-3-0. Cable ties shall be Ty-Rap Catalog No. TY5275MX; 3M Catalog No. 06277; W.H. Brady Company Series CTUN-400HBK; or approved equal.

1.11.7 Grounding

1.11.7.1 Grounding rods shall be 3/4-inch diameter, 10 feet long, high strength solid steel rod with a bonded copper jacket, and UL listed.

1.11.7.2 Grounding rods shall be manufactured by Copperweld Steel Company, ITT Weaver; Thomas & Betts; Blackburn; Joslyn Mfg. and Supply Co.; or approved equal.

1.12 Waterproofing

1.12.1 All manholes shall be waterproofed.

1.12.2 Sheet membrane waterproofing system shall be Bituthene 3000/Low Temperature Membrane by Grace Construction Products, or Carlisle CCW MiraDRI 860/861. Membrane shall be a self-adhesive, cold-applied composite sheet consisting of a thickness of 1.4 mm (0.056 in.) of rubberized asphalt and 0.1 mm (0.004 in.) of cross-laminated, high density polyethylene film. Provide rubberized asphalt membrane covered with a release sheet which is removed during installation. No special adhesive or heat shall be required to form laps.

1.12.3 Protection board shall be expanded polystyrene board 1" thick for vertical application with the following characteristics. Adhere to waterproofing membrane with Bituthene Protection Board Adhesive.

1.12.4 Asphaltic hardboard shall be Bituthene Asphaltic Hardboard by Grace Construction Products; a pre-molded semi-rigid protection board consisting of bitumen, mineral core and reinforcement. Provide two (2) layers of 3 mm (0.125 in.) thick hardboard on horizontal surfaces.

1.12.5 Waterstops for use in manholes shall be sodium bentonite clay type 3/4" by 3/8" thick, Volcay Waterstop RX-102.

2. Installation for Manholes

2.1. Cast-in-Place Concrete Manholes

2.1.1. Concrete work excavations shall not be backfilled until the concrete has cured, or a minimum of seven (7) days after concrete placement.

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- 2.1.2. The subgrade walls, roof, and risers of all new manholes shall be waterproofed.
- 2.1.3. All concrete work for the manholes shall be formed, using proper concrete forms.
- 2.1.4. The inside surfaces of manhole walls and ceilings shall have a smooth finish. Manhole floors shall have a non-slip broom finish.
- 2.1.5. Furnish and install all required appurtenances for each manhole, such as cast iron cable pulling-in irons, cast iron frame and cover, conduit end bells, cable racks, grounding rods, etc. Set them into position in forms before pouring concrete.
- 2.1.6. Cable rack stanchions shall be installed on each wall of every manhole. Maximum spacing of stanchions shall be 3'0" on center. Stanchions shall be bolted to manhole walls using stainless steel expansion anchors in accordance with the cable rack manufacturer's recommendations.
- 2.1.7. Provide a minimum of three (3) cable support arms for every stanchion supplied.
- 2.1.8. Cable Support Insulators
  - 2.1.8.1. Each insulator with cables shall be tied to the cable support arm when installing the cables by wrapping two cable ties, in opposite directions, completely around the cables, the insulator, and the cable support arm. Cable ties shall be long enough to accomplish this.
- 2.1.9. Pulling-in Irons
  - 2.1.9.1. Furnish and install the pulling-irons opposite each duct-bank entry.
- 2.2. Pre-cast Concrete Manholes
  - 2.2.1. The sub-grade walls, roof, and risers of all new manholes shall be waterproofed.
  - 2.2.2. Pre-cast concrete manholes shall be installed in accordance with the manhole manufacturer's instructions.
- 2.3. Waterproofing
  - 2.3.1. Cleaning and Protection: Remove any masking materials after installation. Clean any stains on materials which would be exposed in the completed work.
- 2.4. Grounding
  - 2.4.1. Manhole shall have two grounding rods in each electric manhole. Grounding rods shall be driven into the soil beneath the manhole and cast in place with the installation of the concrete floor of the manhole. Grounding rods shall be located in diagonally opposite corners of the manhole, located 5 inches out from each wall, and projecting 6 inches above the finished floor level.
  - 2.4.2. Manhole shall have a size 4/0 bare stranded copper conductor around the inside perimeter of each electric manhole. The conductor shall be fastened to the manhole concrete wall every 4 linear feet at a height of 6 inches above the finished floor using two-hole copper tubing straps.
  - 2.4.3. The copper grounding conductor shall be connected to each grounding rod by means of exothermic welding.

2.5. Sump

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- 2.5.1. Provide a concrete sump in the center of the floor of each manhole for the collection of any water which might enter the manhole. The manhole floor shall slope towards the sump with a minimum slope of 1/8 inch per foot. A sump pump is not required.
- 
3. Commissioning
    - 3.1. All soil and debris shall be removed from manholes.
    - 3.2. Verify all pull strings and caps are installed.
    - 3.3. All soil and debris shall be removed from manholes and equipment pads where duct banks terminate.
    - 3.4. Verify all pull strings and caps are installed.

**REFERENCES**

**GENERAL:**

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The scope of this document is to provide instruction for the installation and testing of underground medium voltage cable systems.

**DESIGN GUIDELINES:**

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## 1. Materials

## 1.1. 15 kV Cable

- 1.1.1. Conductor: Annealed, uncoated copper compact stranded ASTM B-496.
- 1.1.2. Strand Screen: Extruded semiconducting EPR. Must meet or electrical and physical requirements of ICEA S-93-639/NEMA WC74 S-97-682, AIEC CS8 and UL 1072.
- 1.1.3. Insulation: 15 kV insulated with 100% Ethylene Propylene Rubber (EPR) for 133 percent insulation level, 220 mils average thickness (198 mils minimum) The insulation shall not contain any polyethylene
- 1.1.4. Insulation Screen: Extruded semiconducting EPR. Must meet or exceed electrical and physical requirements of ICEA S-93-639/NEMA WC74 & S-97-682, AIEC CS8 and UL 1072. The screen shall not contain any polyethylene.
- 1.1.5. Shield: Shield shall be overlapped 5 mil bare copper tape, helically applied.
- 1.1.6. Jacket: Jacket thickness shall not be less than 80 mils of black polyvinyl chloride.
- 1.1.7. Temperature Ratings
  - 1.1.7.1. Wet or dry normal rating - 105 deg C
  - 1.1.7.2. Emergency rating - 140 deg C
  - 1.1.7.3. Short circuit rating - 250 deg C
- 1.1.8. Standard sizes used on University of Missouri – Columbia campus; System owner must approve the conductor sizes prior to installation.
  - 1.1.8.1. #2
  - 1.1.8.2. #4/0
  - 1.1.8.3. 350kcmil
  - 1.1.8.4. 500kcmil
- 1.1.9. The cable must be flat line corona tested with less than 5 picocoulombs by manufacturer. Cable shall meet the requirements of AIEC CS6, ICEA S 68-516, and UL1072.
- 1.1.10. Manufacturers: Okonite or Kerite - No substitutions to are allowed.

1.2. Terminations: Terminations shall be outdoor type cold shrink silicone rubber skirted termination kit as manufactured by 3M

1.3. Splices: Splices shall be in-line cold shrink type QS-III as manufactured by 3M.

1.4. Fire Tape: Fire tape shall be 3 inch wide Scotch® 77 Fire-Retardant Electric Arc Proofing Tape manufactured by 3M.

## 2. Installation

- 2.1. All cables shall be installed in concrete encased duct banks, manholes or cable trays.
- 2.2. Care shall be taken not to damage the cable during installation. The cable ends shall be kept sealed when not being worked on to prevent water entry. Energy Management – Electric Distribution shall be notified of any damage to evaluate repair or replacement requirements.
- 2.3. Pulling tensions and side wall pressures shall not exceed manufacturers maximum recommended values.
- 2.4. Cables shall be neatly trained around the walls of manholes utilizing cable support racks. Cables running across the middle of manholes will not be accepted.
- 2.5. Terminations and splices shall only be performed by personnel trained and experienced in the installation of this type of materials. Each termination or splice shall be inspected by Energy Management Electric Distribution personnel prior to the installation of the outer covering.
- 2.6. Fire tape all exposed cable in manholes using a minimum overlap of 50%. Fire tape into duct where practical.
- 2.7. Ground cables shall be installed in each section. A #2 stranded, 600V cable shall be used when a #2 or 4/0 primary cable is being installed and a 4/0 stranded, 600V cable shall be used when a 350kcmil or 500kcmil primary cable is being installed
- 2.8. Ground all terminations and splices in manholes or at equipment.

## 3. Testing

- 3.1. The cable shall have DC High Potential Test after it has been pulled into the duct and the splice or termination has been prepared but before the shrink tubing has been installed. Cable shall have 60kV DC applied for 15 minutes with data taken at 1 minute intervals. Written report shall be delivered to system owner including all data and results or conclusions. Cable is to be grounded for 30 minutes after test.
- 3.2. Insulation ground wall test (Megger) at 5kV DC to be performed after all splices and terminations have been completed. Written report of result of test with resistance values shall be delivered to system owner.

## 4. Commissioning

- 4.1. MU Only: All in service switchgear shall be operated by Energy Management Electric Distribution personnel only.
- 4.2. MU Only: All splices, terminations, testing, grounding, and fire taping shall be completed prior to Energy Management Electric Distribution personnel energizing the cable

## REFERENCES

**GENERAL:**

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The scope of this document is to provide instruction for the installation and testing of revenue class electric energy meters installed at the University of Missouri.

**DESIGN GUIDELINES:**

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## 1. Materials

## 1.1. Meter

- 1.1.1. The kWh meter for all the new installations shall be Landis & Gyr AXS4e Solid-State Polyphase Meter.
- 1.1.2. 3-Wire Delta Application
  - 1.1.2.1. Type: Cat. #4E010000-0000, class 20, service 3D, wires 3, test amp 2.5, form 5S, standard nameplate
- 1.1.3. 4-Wire Wye Application
  - 1.1.3.1. Type: Cat #4E000000-0000, class 20, service W, wires 4, test amp 2.5, form 9S, standard nameplate

## 1.2. Current Transformers

- 1.2.1. The Current Transformers (Instrument Transformers) shall meet the applicable provisions of ANSI C57.13-1978 (R1986) and ANSI C12.11-1987
- 1.2.2. Current transformers (CT's) shall be of a design for indoor use suitable for electricity metering grade. The CT's shall be suitable for padmount distribution transformer installation. The current transformer body construction shall be of molded insulation. The preferred outside body shape or configuration shall be Grecian Urn style. The CT's shall be window-type with voltage application range of 1.2 to 15kV.
- 1.2.3. The ratio factor (RF) of selected CT's shall be enough to pick up a small load. At full load, meter current must not exceed the CT's maximum rating. CT ratio and RF rating shall be coordinated with Energy Management Electric Distribution.
- 1.2.4. Other CT specifications shall be as follows
  - 1.2.4.1. ANSI Accuracy Class, 60Hz
  - 1.2.4.2. B0.2 Burdens per ANSI
  - 1.2.4.3. Polarity permanently molded primary H1/H2 and secondary X1/X2
  - 1.2.4.4. Stainless steel Name Plate shall carry all information prescribed by the ANSI standard and installed at easy to read location

## 1.3. Wiring

- 1.3.1. All secondary current circuit wiring shall be of pvc insulated, flexible, *multi-stranded* and colored (red, yellow, blue, white) wire with appropriate gauge as shown in the table, in section 3.2 below.
- 1.3.2. All potential wiring shall be #12 AWG pvc insulated, *solid* stranded and colored (red, yellow, blue, white) wires.

1.4. Meter Base (Socket)

1.4.1. The Meter Sockets shall conform to ANSI Standard C12.7-1993. The meter base shall have CT's short-circuiting arrangement and disconnect switches for potential circuits.

1.4.2. The acceptable meter sockets are:

1.4.2.1. Landis & Gyr 13 terminal, pre-wired Cat. #9837-0354

1.5. Fuse Blocks

1.5.1. Cooper Industries, Bussman Fuse Block #BM6033B, 30A, 600V

1.6. Fuse

1.6.1. Cooper/Bussmann KTK-2

2. Installation

2.1. The installation of energy meter shall be according to NEC, ANSI and IEEE C12 Electricity Metering standards, where applicable

2.2. The Contractor shall supply and install current transformers, fuse block and fuses, meter socket, meter, conduits, prescribed wires and other material and gadgets required to complete the job.

2.3. Meter Wiring

2.3.1. The maximum distance in feet between CT and meter shall meet ANSI accuracy classification at B0.2 accuracy class

AWG Copper Wire Size	NO. 12 multi-stranded	NO. 10 multi-stranded	NO. 8 multi-stranded	NO. 6 multi-stranded
Max. Distance (in feet)	31	49	79	126

2.3.2. Energy Management Electric Distribution Crew shall terminate all wires at the current transformers, fuse block, and the meter.

2.3.3. The wiring detail is shown in sketch Metering Detail.dwg.

2.4. Meter Location

2.4.1. The location of the meter shall be coordinated with system owner. Consideration shall be given to the monthly meter read in determining the accessibility of the location. The preferred location is on an exterior wall near the transformer.

3. Testing

3.1. Warranty and Other Requirements

3.1.1. A Certified Factory Test Report of the meter to be installed shall be given to Energy Management Electric Distribution prior to the installation. After the new installation is energized for the first time, the system owner shall program an “in service” test and calibrate the kWh meter in the presence of the contractor or his representative. If the “in service” testing results indicate a faulty meter, a replacement meter shall be provided.

4. Commissioning

4.1. MU Only: The meter shall be programmed and inserted into socket by system owner personnel.

**REFERENCES**

**GENERAL:**

The scope of this document is to provide instruction for the installation and testing of Medium Voltage, 3 Phase, Pad Mounted Transformers installed at the University of Missouri. Preferred transformers are of pad mounted construction. Special consideration can be made with approval from project manager for installation of dry type transformers.

**DESIGN GUIDELINES:****Materials**

## 1. General

## 1.1. General Specifications

- 1.1.1. The transformer shall be outdoor rated
- 1.1.2. Less-flammable liquid filled
- 1.1.3. Pad mounted
- 1.1.4. Live-front or Dead-front (*as coordinated with system owner*)
- 1.1.5. Switching options for radial or loop (*as coordinated with system owner*)
- 1.1.6. Standard sizes in table below
- 1.1.7. All exterior surfaces shall be designed to prevent holding or pooling of water or liquids.

## 1.2. Ratings

- 1.2.1. KVA Rating (*as coordinated with system owner*).
- 1.2.2. Nominal Primary voltage shall be 13,800 volts line-to-line, three-phase, delta connected.
- 1.2.3. Nominal secondary voltage 277/480Y Volts or 120/208Y Volts (4-wire wye secondary).

## 1.3. Impedance &amp; Losses

- 1.3.1. Percent impedance and losses shall comply with values listed in Table below.

Size (kVA)	Secondary Voltage	Losses Not To Exceed (Watts)			Impedance (in the range of)
		No Load	Full Load	Total	
75	120/208	225	400	625	2.5% to 4.0%
112.5	120/208	325	575	900	2.5% to 4.0%
150	120/208	450	750	1200	2.5% to 4.0%
225	120/208	550	1100	1650	2.5% to 4.0%
300	120/208	700	1650	2350	2.5% to 4.0%
500	120/208	1000	3000	4000	5% to 6%
750	120/208	1200	5000	6200	5% to 6%
1000	120/208	1700	6500	8200	5% to 6%
1500	120/208	2200	10000	12200	5% to 6%
2000	120/208	2800	13500	16300	5% to 6%

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225	277/480	600	1200	1800	2.5% to 4.0%
300	277/480	750	1500	2250	2.5% to 4.0%
500	277/480	1000	2800	3800	5% to 6%
750	277/480	1200	4000	5200	5% to 6%
1000	277/480	1500	6500	8000	5% to 6%
1500	277/480	2200	9000	11200	5% to 6%
2000	277/480	2800	12000	14800	5% to 6%

1.4. Required Standards

1.4.1. All equipment shall conform to the latest revision of all applicable standards.

A listing of these standards includes, but is not limited to:

- 1.4.1.1. NEMA
- 1.4.1.2. NESC
- 1.4.1.3. NEC
- 1.4.1.4. ANSI
- 1.4.1.5. IEEE
- 1.4.1.6. Federal Occupational Safety and Health Standards

1.5. Construction Features

1.5.1. Pad Mount (ANSI Standard C57.12, latest revision).

1.5.2. Compartment type

- 1.5.2.1. The transformer shall have high and low voltage compartments assembled side by side as an integral unit with no live parts accessible without opening the compartment doors.
- 1.5.2.2. The high voltage compartment shall be located on the left.
- 1.5.2.3. High voltage compartment shall be separated from the low voltage compartment by a metal barrier.
- 1.5.2.4. No bolts, screws or other fastening devices shall be externally removable.
- 1.5.2.5. There shall be no openings where sticks, rods or other devices could be inserted and contact live parts.
- 1.5.2.6. Compartments shall limit water entry.
- 1.5.2.7. A non-conductive, removable barrier shall be installed in the high voltage compartment in a manner which will restrict access to the live front area without lifting and removing the barrier. Barrier shall be clearly marked "Danger High Voltage" (*Live Front Only*).
- 1.5.2.8. Low voltage bushings shall be supported to the top of transformer to prevent oil leaking from the bushing due to the weight of the cables attached to them.

1.5.3. Liquid immersed

1.5.4. Self cooled

1.5.5. Bolt-on covers

1.5.6. Equipment must be new; re-manufactured equipment will not be accepted.

1.6. Noise level Requirement

1.6.1. IEEE/ANSI/NEMA standards

1.6.2. Not to exceed the levels given by NEMA TR1-1980

## 1.7. Transformer enclosure

- 1.7.1. Supplied with jacking provisions and lugs for lifting.
- 1.7.2. Enclosure and base constructed for sliding and rolling.
- 1.7.3. Enclosure shall be tamper proof.
- 1.7.4. Have self-starting penta-head bolts
- 1.7.5. Shall prevent accumulation and pooling of water

## 1.8. Doors

- 1.8.1. The secondary door shall include provisions for a lock, which must be removed to remove the penta-head bolt.
- 1.8.2. The primary door shall be separate and interlock with the secondary door in a manner, which the secondary door must be opened first before the primary door can be opened.
- 1.8.3. The primary door shall also be secured by penta-head bolts other than the bolts securing the secondary door.

## 1.9. Paint

- 1.9.1. Munsell green #7.0GY3.29/1.5
- 1.9.2. Minimum Thickness of 2.5 MIL
- 1.9.3. A small container of touch up paint shall be supplied with the transformer and given to system owner.

1.10. Fault Indicator (*Loop Feed Installations only*)

- 1.10.1. Bottom sill of primary compartment shall have a hole capable of mounting a Fisher Pierce model 1515WB-12A3-10SL-B fault indicator.
- 1.10.2. The hole shall have a permanent cover installed prior to shipping which can be removed only from the inside of the compartment.

## 2. Electrical Specifications

## 2.1. 3 Phase

## 2.2. 60 Hertz

## 2.3. Primary Windings

- 2.3.1. Copper conductors.
- 2.3.2. Primary windings should be transposed for reduced losses at fundamental (60Hz) and harmonic frequencies, if advisable per manufacturer.
- 2.3.3. Primary windings shall be designed to withstand high 3rd, 9th, and 15th harmonic circulating currents.

## 2.4. Secondary Windings

- 2.4.1. Copper Conductors
- 2.4.2. Secondary Windings should be transposed for reduced losses, at fundamental (60Hz) and harmonic frequencies, if advisable per manufacturer.
- 2.4.3. Use smaller paralleled conductors instead of one larger cross-section single conductor or a single thin tape type of conductor.
- 2.4.4. Individual conductors shall be insulated.

## 2.5. Transformer Core

- 2.5.1. Steel core stock
- 2.5.2. Core shall be designed and constructed to reduce eddy current losses at fundamental and harmonic frequencies.
- 2.6. Neutral Conductor
  - 2.6.1. Sized to handle up to 2 times the rated phase current continuously.
- 2.7. Wiring Connections
  - 2.7.1. Suitable for Copper or Aluminum termination lugs.
  - 2.7.2. High voltage terminals shall be a two-hole lug type connection with ½” holes on 1 ¾” centers capable of connection either copper or aluminum (**Live Front Only**).
  - 2.7.3. Low voltage terminals shall be tinned spade having eight (8) – 9/16” holes on 1 ¾” centers for conductor connections.
- 2.8. Arrestors
  - 2.8.1. Three (3) – 10kV rated, 8.4kV MCOV
  - 2.8.2. Transformer must have mountings provided for lightning arrestors.
- 2.9. Primary Bushings
  - 2.9.1. Shall have a 95kV BIL rating
  - 2.9.2. Live Front
    - 2.9.2.1. Three (3) 15kV Live Front porcelain primary bushings, for a delta connection of 13,800V.
  - 2.9.3. Dead Front
    - 2.9.3.1. Six (6) - 15kV, 200A primary bushing wells, in accordance with ANSI standard C119.2, for a delta connection of 13,800V.
    - 2.9.3.2. Bushings for 200 Amp load break elbows shall be supplied for each well.
    - 2.9.3.3. Use other 3 bushings for arrestors if not a loop fed unit.
    - 2.9.3.4. Bushing wells shall have covers in place for shipping and storage
- 2.10. Secondary bushings
  - 2.10.1. Four secondary bushings shall be supplied for wye connections
  - 2.10.2. Shall have a 30kV BIL rating with a tinned spade having eight (8) - 9/16@ holes on 1 ¾” centers for conductor connections
  - 2.10.3. Shall be supported to the top of transformer to prevent oil leaking from the bushing due to the weight of the cables attached to them.
- 2.11. Primary Voltage Taps shall be supplied to provide five (5) - 2.5% no load tap changes, two above and two below rated voltage.
- 2.12. Fusing
  - 2.12.1. Oil immersed bayonet expulsion fuses and in-tank, current limiting fuses.
  - 2.12.2. Bayonet fuses shall be removable with a hot stick.
  - 2.12.3. Current limiting fuses shall have an interrupting capacity greater than 40,000A
  - 2.12.4. Fusing combination shall provide full range protection for low and high current faults

2.12.5. Three spare bayonet fuses shall be supplied with the transformer. (*This totals six bayonet fuses.*)

2.12.6. The let-through current of the in-tank current limiting fuse cannot exceed the interrupting rating of the switch specified

3. Insulating Media and Ratings

3.1. Maximum average winding temperature rise of 65 degrees C

3.2. Winding insulation shall have a rating of 120 degrees C

3.3. Transformer shall have ambient temperature rating of 40 degrees C

3.4. Transformer shall be filled with a nonflammable fluid (mineral oil is not acceptable).

3.4.1. Liquid level indicator shall be supplied and located inside the low voltage compartment.

3.4.2. Drain valve and sampling device shall be installed in the primary compartment.

3.4.3. Pressure relief valve

3.4.3.1. A pressure relief valve shall be supplied.

3.4.3.2. Qualitrol series 201 pressure relief valve or approved equal for NEC code 450-23 application

3.4.3.3. Volume of valve must meet all applicable codes

3.4.4. Temperature indicator shall be supplied.

4. Switching

4.1. Switching needs for radial fed configuration

4.1.1. One 300A in-tank two position load break radial switch

4.1.2. One switch on primary to turn the transformer on/off

4.2. Switching needs for loop fed configuration (***Dead Front Only***)

4.2.1. Three 300A load break switches

4.2.2. This allows for transformer on/off and two line terminals each with on/off

4.3. Switch must be rated to interrupt the current for the transformer

4.4. Switch must be capable of being operated with a hot stick

5. Grounding

5.1. Three grounding connections, each with two (2) 1/2@-13 UNC tapped holes

5.1.1. Primary compartment

5.1.2. Secondary compartment

5.1.3. Outside of the tank

5.2. A copper connection strap from the neutral to ground shall be supplied.

6. Nameplate

6.1. The nameplate shall be engraved.

- 6.2. An addition to normal information, the following items shall be included on the nameplate of each unit:
  - 6.2.1. kVA ratings
  - 6.2.2. Primary voltage
  - 6.2.3. Secondary voltage
  - 6.2.4. BIL ratings
  - 6.2.5. Temperature ratings
  - 6.2.6. Primary and Secondary voltages for each tap setting
  - 6.2.7. Date of Manufacture.
  - 6.2.8. Name of Manufacturer.
  - 6.2.9. Transformer K factor (if rated)
  - 6.2.10. Type of conductor in windings.
  - 6.2.11. Impedance expressed in percentage.
  - 6.2.12. Detail circuit diagrams of primary switch configuration and switch ratings.
  - 6.2.13. Delta - wye or delta -delta diagram detailing the relationship of primary to secondary bushings.
  - 6.2.14. Statement "Transformer filled with less-flammable fluid".
  - 6.2.15. Statement "Transformer filled with fluid containing no detectable PCB's at time of manufacture."
  - 6.2.16. Total weight of unit expressed in pounds.
  - 6.2.17. Weight of unit without oil.
7. Labeling
  - 7.1. Standard labeling for pad-mounted equipment
  - 7.2. Transformer shall have a blue "CONTAINS NO PCBs" label placed inside of the secondary compartment door and another same label placed on the outside of the tank
  - 7.3. Transformer shall have a "Danger-High Voltage" label on the outside of the primary compartment door meeting all applicable standards
8. Submittals
  - 8.1. MU Only: Campus Facilities - Energy Management Electric Distribution must approve the construction drawings prior to construction of each type of transformer supplied.
  - 8.2. A completed "Transformer Losses in Watts" data sheet (see attached) must be completed and included in submittal for each type of transformer
    - 8.2.1. Losses cannot exceed the values listed in the table above
    - 8.2.2. A duly authorized officer of the transformer supplier company must sign the data sheet

## **Installation**

1. Refer to Transformer Pad Detail.dwg for foundation and mounting requirements
  - 1.1. Care shall be taken during lifting/moving not to damage or bump the transformer.
  - 1.2. Must have 8' clear area in front of doors and 3' clear area on the sides
  - 1.3. Locate unit in accessible location for maintenance, operation, and replacement

- 1.4. Bollards may be needed
  - 1.5. Number and location of transformers coordinated with Energy Management Electric Distribution
2. Grounding
    - 2.1. Must have one ground rod in opening

**Testing**

1. Tested impedance of the supplied transformer shall be in the range as specified in the table above prior to delivery
2. System owner unit will perform TTR, Megger, and Ground testing prior energizing the transformer

**Commissioning**

1. MU Only: System owner will set the proper tap on the transformer, energize the transformer and check for proper voltage.

**REFERENCES**

**GENERAL:**

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The scope of this document is to provide instruction for the installation and testing of medium voltage switchgear.

**DESIGN GUIDELINES:**

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## 1. Materials

1.1. Switchgear shall be Vista as manufactured by S&C Electric configured for 3-, 4-, 5-, or 6-ways as required. No Substitutions will be accepted.

1.1.1. 3-Way, 1-Fault Interrupter /Catalog #: 853212-P4-O-L2

1.1.2. 4-Way, 2-Fault Interrupter /Catalog #: 854222-P4-O-L2

1.1.3. 5-Way, 3-Fault Interrupter /Catalog#: 855232-P6-O-L2

1.1.4. 6-Way, 4-Fault Interrupter /Catalog#: 856242-P6-O-L2

## 1.2. Voltage Ratings

1.2.1. 13.8 kV Nominal

1.2.2. 15.5 kV Max Design

1.2.3. 95 kV BIL

## 1.3. Current Ratings

1.3.1. 600 Amp Continuous Bus

1.3.2. 600 Amp Continuous Load Dropping

1.3.3. 600 Amp Continuous Load Interrupter Ways

1.3.4. 600 Amp Continuous Fault Interrupter Ways

## 1.4. Fault Duty Ratings

1.4.1. 25,000 Amp RMS Symmetrical, three-time fault closing duty-cycle

1.4.2. 65,000 Amp Peak, three-time fault closing duty-cycle

1.4.3. 12,000 Amp RMS Symmetrical, ten-time fault closing duty-cycle

1.4.4. 32,500 Amp Peak, ten-time fault closing duty-cycle

## 1.5. Fault Interrupter Ways

1.5.1. 25,000 Amp RMS Symmetrical, three-time fault interrupting duty-cycle

1.5.2. 12,500 Amp RMS Symmetrical, ten-time fault interrupting duty-cycle

## 1.6. Required Optional Features

1.6.1. P4, P6 – Mild-steel, Olive Green

1.6.2. O – Two-hole ground pad per way

1.6.3. L2 – Low Voltage Phasing Option

## 2. Fault Interrupter

2.1. Programmable overcurrent control

2.2. Vacuum fault interrupters to provide 3-pole fault interruption

3. Drawings
  - 3.1. Record drawings shall be sent to system owner at the time of order.
4. Installation
  - 4.1. Refer to Switchgear Pad Detail.dwg for foundation requirements.
  - 4.2. Care shall be taken not to damage the switchgear during moving and installation.
  - 4.3. There shall be an 8 foot long, level, clear area in front of doors and a 3 foot level clear area by switch operating handle locations to allow for safe operation and maintenance.
  - 4.4. Route cable beneath switchgear to avoid excessive slack.
  - 4.5. The switchgear shall be bolted down to the pad per manufacturer's recommendations.
  - 4.6. The edges of the switchgear at the concrete shall be sealed with clear silicone caulk.
  - 4.7. Cable connections shall be torqued to manufacturer's recommendations.
  - 4.8. The switchgear shall be grounded to the ground ring detailed in the Switchgear Pad Detail.dwg. All cable shield drain lines shall be connected to the grounding conductor.
5. Testing
  - 5.1. Insulation ground wall test (Megger) at 5kV DC must be performed after all splices and terminations have been completed. Written report of result of test with resistance values shall be delivered to system owner.
  - 5.2. If Megger test is passed, a Hipot test shall be performed on the switchgear at 35 kVDC for 15 minutes.
6. Commissioning
  - 6.1. MU Only: All medium voltage switchgear shall be operated by Campus Facilities - Energy Management Electric Distribution personnel only.
  - 6.2. MU Only: All terminations, testing, fire taping, and grounding shall be completed prior to placing the equipment in service by system owner personnel. Campus Facilities - Energy Management Electric Distribution personnel shall perform energizing of the switchgear.

## REFERENCES