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 (∀ 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 ¾" 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) 6x6/10xl0 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 ravels, 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:

Maximum Aggregate Size	Average Total Air Content	Total Air Content Range
3/8”	7.5%	6.5% - 9.5%
½”	7.0%	6.0% - 9.0%
¾”	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 ravels, 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
Steelox 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[1]	Mech. fasted membrane thickness (mils)	60
D412[2]	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
[3]	Seaming overlap (contact cement)	3"

[1]60 mil reinforced membrane for mechanical fastened roofs.
[2]For unreinforced membrane only. Breaking strength for reinforced membrane per ASTM D751 to be 140x150 lbf (minimum).
[3]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 & 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 daylights 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^{o}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 breech 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 combinating of the cores with the Owner. At that time it will be determined whether the Owner or the contractor will be responsible for the combinating.

11. If Owner is to do the combinating, 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 combinating, contractor is required to use the Best Locking Systems of St. Louis to do all combinating 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 that 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, combinated 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. Pipeand 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 tappings 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 55ºF, the preheat valve modulates to maintain preheat discharge air temperature set point.
   (2) With the outside air below 35ºF, the two (2) position preheat valve opens. The valve is sized for 10 ºF rise at full air flow.
   (3) With the outside air above 55ºF, 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>55ºF), the controller will maintain cooling coil discharge air temperature set point by modulating the cooling coil valve.
   (2) In the dehumidification mode (OA>55ºF & Zone RH >60%), the controller will maintain the dehumidification set point by modulating the cooling coil valve.
   (3) In the heating mode (OA<55ºF), the controller will shut the cooling coil valve.
   (4) When OA<35ºF, the antifreeze pump will be energized.

h. Heating coil control
   (1) In the dehumidification mode (OA>55ºF & Zone RH >60%), the controller will maintain the discharge air

temperature set point.

(2) In the heating mode (OA<55ºF), 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>55ºF), 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<55ºF), 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 50ºF or above 80ºF.

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<55ºF), the controller will maintain heating coil discharge air temperature set point by modulating the heating coil valve.
   (2) In the cooling mode (OA>55ºF), 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>55ºF), the controller will maintain cooling coil discharge air temperature set point by modulating the cooling coil valve.
   (2) In the heating mode (OA<55ºF), the controller will shut the cooling coil valve.
   (3) When OA<35ºF, 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<65ºF, modulate outside air, return and exhaust air dampers to maintain discharge air temperature set point.
   (2) When OA>65ºF, 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 5ºF 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.