

# UC Berkeley

## Campus Design Standards



**Purpose:** The University of California, Berkeley created the Campus Design Standards to guide design and construction professionals to complete lasting, high-quality additions to the campus built environment. These Standards, along with applicable codes, ensure that new construction and renovation projects at UC Berkeley integrate industry best practices and experience with existing campus buildings, infrastructure, grounds, and maintenance issues.

**Administration:** The Campus Design Standards are administered by the Campus Building Department and were developed in concert with the Capital Strategies, Capital Projects, Planning and Environmental Policy, Facilities Services, the Office of Environment, Health & Safety, UCPD and other campus units. They apply to all UC-sponsored construction projects. These standards use the Construction Standards Institute’s 2016 MasterFormat. Where a division is not listed in this document, there are no current campus standards and current applicable code shall prevail.

**Changes and Revisions:** The Campus Design Standards are formally revised triennially in sync with the adoption cycle of the California Building Code. Due to the ever-evolving construction environment, revisions between code cycles may be necessary. As part of the plan review process, the Campus Building Department will consider project specific needs when evaluating requests for alternates to or variances from these standards. In addition, we welcome input on these standards at any time, from anyone. Questions and comments regarding, as well as proposed changes and revisions to the Campus Design Standards may be directed to:

[building@berkeley.edu](mailto:building@berkeley.edu) or:

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## 02 00 00 Existing Conditions

### 02 20 00 Assessment

### 02 21 00 Surveys

#### 02 21 13 Site Surveys

1. See Appendix D: *Room Numbering Guidelines* for room and roof numbering. Projects shall ensure that new room numbering comports with policy and existing, nearby room numbers and that roofs, mechanical penthouses and similar structures comport with policy and existing roof numbers.

### 02 40 00 Demolition and Structure Moving

1. Clearly identify on drawings the extent and scope of demolition work.

### 02 42 00 Removal and Salvage of Construction Materials

1. See Section 01 74 16 *Construction Waste Management and Disposal* for more information
2. Clearly identify on drawings the items to be turned over to the Owner. Specify a procedure for delivery to Owner. Identify those items which:
  - a. go to Excess & Salvage
  - b. go to Facilities Services
  - c. go to Building or Department Representative (i.e. Building Coordinator or Department's Management Services Officer)
  - d. other
3. Clearly identify on drawings items to be:
  - a. relocated and where items are to be relocated
  - b. saved and protected
  - c. removed and disposed (and identify such on Construction Waste Management plan)
  - d. salvaged, maintained and relocated (e.g. specimen trees)
4. Utility disconnection and re-establishment of services: Coordinate with Facilities Services, EBMUD and PG&E via the University of California University's Representative.
5. Protect building exterior and landscape areas and repair any damage caused by the Project to new condition (see Division 32: Exterior Improvements).
6. Path of travel for ingress to and egress from campus shall include requirements for site protection, clean up and repairs.
7. The Contractor shall be responsible for disposal of all construction debris.

#### 02 41 19 Selective Demolition

Selective Demolition: All requirements in 02 42 00 (Removal and Salvage of Construction Materials) apply to this Section. In addition the following shall be considered in selective demolition:

1. Utility Disconnection: Coordinate with Facilities Services via the University of California University's Representative.
2. Path of travel for debris removal - include requirements in specifications for:
  - a. Dust protection.
  - b. Cleanliness.
  - c. Clean-up.

- d. Protection of ventilation systems.
  - e. Vibration and Noise control.
3. Temporary Partitions and Barriers: Ensure assemblies are rated if in an exit corridor.
  4. Protect from dust intrusion all smoke alarm and sprinkler heads. Where sprinkler heads are protected from dust and paint overspray, remove protection daily at the close of the construction day, re-enabling the system to function. Coordinate with the University's Representative for disarming fire alarm devices where there is a risk of dust. Bagging of smoke detectors is prohibited without prior approval of the Designated Campus Fire Marshal (DCFM).
  5. Protect special architectural features, plaques and ornamentation.
  6. Protect elevators.
  7. The Contractor shall confirm structural capacity for debris removal and equipment along the path of travel.
  8. Coordinate with the University Police Crime Prevention Unit for disarming or protecting intrusion alarm systems/components and video systems/components.
  9. Coordinate with the University Police Crime Prevention Unit for disabling or modifications to campus emergency phones.

## 02 70 00 Water Remediation

1. Storm Water Discharge:
  - a. See Division 01 57 00: Temporary Controls for construction-related specifications.
  - b. See Division 22 14 00: Facility Storm Drainage for permanent installation requirements.
  - c. The University's Representative will coordinate with Physical and Environmental Planning (PEP) and Environment, Health & Safety (EH&S) for project-appropriate specification language.
  - d. Sprinkler and/or stand pipe water discharge shall be directed to sanitary drains or sewers.
  - e. Designers shall consider the discharge from main drains, inspector's test valves, auxiliary drains, testing discharge from pumps, standpipes, pressure-reducing valves, backflow prevention devices and similar appurtenances and comply with requirements outlined in these specifications.

## 03 00 00 Concrete

### 03 05 00 Common Work Results for Concrete

1. All Work to minimally conform to ACI 318 (latest edition), “Building Code Requirements for Structural Concrete and Commentary” and all other American Concrete Institute Standards.
2. Exterior exposed concrete surfaces not to receive other finishes shall be treated with a fluid-applied penetrating water repellent. See Division 07 00 00: Thermal and Moisture Protection.

### 03 30 00 Cast-In-Place Concrete

1. Under-slab Vapor Retarder Barrier: Provide beneath all slabs on grade.
  - a. Minimum Type: 10-mil thick polyethylene sheeting complying with ASTM D4397-10, “Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.”
  - b. Provide Class A retarder conforming to ASTM E1745-11, “Specification for Plastic Water Vapor Retarders used in Contact with Soil or Granular fill Under Concrete Slabs,” where slabs are to receive resilient, wood, and carpet flooring and where recommended by the Project’s Geotechnical Engineer for existing and anticipated below grade hydrostatic water conditions at the Project site.
  - c. Install over prepared aggregate base material.
  - d. Joints in the barrier shall be lapped and taped.
2. Curing materials, surface texture, flatness and levelness for concrete flatwork shall be selected for compatibility with finish floor materials. Where surface is to remain unfinished, an appropriate curing agent shall be applied.
3. Floor and slab construction shall conform to the following:
  - a. Flatwork tolerances shall be determined using flatness and levelness F-numbers measured in accordance with ASTM E1155-14, “Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers”.
  - b. Use “Alpha” Class designations where the scope of work is limited or less than 3,000 square feet.
4. Completed, exposed, exterior concrete flatwork shall have a medium broom finish and maintain a surface coefficient of friction of more than 0.5 for slip resistance. Where field or lab tests indicating compliance are required, they shall be in accordance with the following, as appropriate:
  - a. ASTM D2047, "Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine"
    - i. Where sealers are to be used, tests shall be taken after application of the sealer.
  - b. ASTM E303, “Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester”
    - i. Minimum British Pendulum Number (BPN) of 36 is required for flat work, and 55 for outdoor sloped conditions.

### 03 33 00 Architectural Concrete

For architecturally-exposed concrete where appearance is important, the University’s Representative shall:

1. Require submission of formwork design for review of form types, location of joints and ties, details of reveals, chamfers, textured surfaces, and other visual aspects of concrete.
2. Require a full-size mock-up of a typical section of work at the Project site (in-place mock-up preferable).
3. Stress proper storage and repair of forms with restrictions on reuse of worn forms.
4. Review slump, aggregate size, and steel placement to ensure proper placing and aggregation of concrete for desired appearance.

5. Consider use of super-plasticizers and integral color.
6. Require small samples prior to fabrication of full-size mock-up (in-place mock-up preferable). Set clear tolerances for finish surfaces.
7. Clearly limit deviation from level and plumb.
8. Set amount of rock pockets, sand streaks and similar surface defects that are allowable.
9. Set maximum amount and types of patching that are acceptable.
10. Require conformance to appropriate formwork class.

*03 35 43 Polished Concrete*

1. Polisher Qualifications

- a. Experience: Select a company that has successfully completed five projects similar in design, products, and extent to scope of this Project; with a record of successful in-service performance; and with sufficient production capability, facilities and personnel to produce specified work.
- b. Supervision: Company shall maintain a competent supervisor who is on site at Project during times specified work is in progress, and is currently certified as Craftsman-Level 1 or higher by CPAA, CBC Craftsman, or equivalent.
- c. Manufacture Qualifications: Approved by manufacture to apply fluid- or liquid- applied products

2. Field Mock-up

- a. Before performing work in this Section, provide following field mock-up to verify selections made under submittals and to demonstrate aesthetic effects of polishing. Approval does not constitute deviations from Contract Documents, unless the Owner's Representative specifically approves deviations in writing.
  - i. Form, reinforce and cast concrete slab for ten (10) square foot field mock-up.
  - ii. Concrete shall be same mix design as scheduled for Project
  - iii. Placement and finishing work shall be performed by the same personnel as will place and finish concrete for the Project
  - iv. Mockup shall be representative of work to be expected
  - v. Perform grinding, honing and polishing work as scheduled for the Project using same personnel as will perform work for the Project.
  - vi. Approval is for following aesthetic qualities:
    1. Compliance with approved submittals
    2. Compliance with specified aggregate exposure class
    3. Compliance with specified appearance level.
    4. Compliance with specified color
  - vii. Obtain Owner's Representative approval before starting work on the Project.
  - viii. Protect and maintain approved field mock-ups during construction in an undisturbed condition as a standard for judging completed work.

3. Specify flatness tolerances for concrete that will be polished:

- a. Use the F-number system as measured by ASTM E 115 with tolerances as follows:
  - i. Flatness Minimum F(F) 50 overall, and 35 local
  - ii. Levelness: Minimum F(L) 35 overall, and 25 local.

4. Specify final polished concrete floor finish:

- a. Select aggregate exposure using following terminology:
  - i. Select Aggregate Exposure Class A – Cement Fines: Surface exposure of 85 to 95% cement fines and 5 to 15% fine aggregate based on visual observation of the overall area of the polished floor.



- ii. Select Aggregate Exposure Class B – Fine Aggregate: Surface exposure of 85 to 95% fine aggregate and 5 to 15% cement fines and coarse aggregate based on visual observation of the overall area of the polished floor.
  - iii. Select Aggregate Exposure Class C – Coarse Aggregate: Surface exposure of 80 to 90% coarse aggregate and 10 to 20% cement fines and fine aggregate based on visual observation of the overall area of the polished floor.
- b. Select Appearance Level using following terminology:
- i. Appearance Level 1 – Flat (Ground)
    - 1. Procedure: Recommended not less than 4 step process with full refinement of each diamond tool with one application of densifier
    - 2. Measurement: Determine the Image Clarity Value, %, and the Haze Index:
      - a. Image Clarity Value, %: An average value of 9 or less measured in accordance with ASTM D5767 prior to the application of sealers
      - b. Haze Index: An average value less than 10 measured in accordance with ASTM D4039 prior to the application of sealers
      - c. The minimum number of testes distributed across the polished surface should be three, for areas up to one-thousand (1000) square feet and one additional test for each thousand square feet or fraction thereof. This applies to both the Image Clarity Value and Haze Index
  - ii. Appearance Level 2 – Satin (Honed)
    - 1. Procedure: Recommended not less than 4 step process with full refinement of each diamond tool with one application of densifier
    - 2. Measurement: Determine the Image Clarity Value, %, and the Haze Index:
      - a. Image Clarity Value, %: An average value of 10 to 39 measured in accordance with ASTM D5767 prior to the application of sealers
      - b. Haze Index: An average value less than 10 measured in accordance with ASTM D4039 prior to the application of sealers
      - c. The minimum number of tests distributed across the polished surface should be three, for areas up to one-thousand (1000) square feet and one additional test for each thousand square feet or fraction thereof. This applies to both the Image Clarity Value and Haze Index
  - iii. Appearance Level 3 – Polished
    - 1. Procedure: Recommended not less than 4 step process with full refinement of each diamond tool with one application of densifier
    - 2. Measurement: Determine the Image Clarity Value, %, and the Haze Index:
      - a. Image Clarity Value, %: An average value of 40 to 69 measured in accordance with ASTM D5767 prior to the application of sealers
      - b. Haze Index: An average value less than 10 measured in accordance with ASTM D4039 prior to the application of sealers
      - c. The minimum number of tests distributed across the polished surface should be three, for areas up to one-thousand (1000) square feet and one additional test for each thousand square feet or fraction thereof. This applies to both the Image Clarity Value and Haze Index
  - iv. Appearance Level 4 – Highly Polished
    - 1. Procedure: Recommended not less than 4 step process with full refinement of each diamond tool with one application of densifier
    - 2. Measurement: Determine the Image Clarity Value, %, and the Haze Index:
      - a. Image Clarity Value, %: An average value of 70 to 100 measured in accordance with ASTM D5767 prior to the application of sealers

- b. Haze Index: An average value less than 10 measured in accordance with ASTM D4039 prior to the application of sealers
- c. The minimum number of tests distributed across the polished surface should be three, for areas up to one-thousand (1000) square feet and one additional test for each thousand square feet or fraction thereof. This applies to both the Image Clarity Value and Haze Index

5. Accessories:

- a. Grout Material: A thin mortar used for filling spaces. Acceptable products shall be:
  - i. Epoxy, urethane, polyurea, or polyaspartic resins.
  - ii. Latex or acrylic binders mixed with cement dust from previous grinding steps.
  - iii. Silicate binders mixed with cement dust from previous grinding steps.
- b. Joint filler: Two component, semi-rigid epoxy for filling control and construction joints in concrete floors. Custom color to match existing flooring. Custom color to match concrete flooring. Euclid Chemical Company “EUCO 700” or equal. Default color is clear.

6. Slip Resistance

- a. Refer to Section 03 30 00, Subsection 4.

**03 45 00      Precast Architectural Concrete**

- 1. For pre-cast architectural concrete, the same requirements as Section 03 33 00 (above) shall apply.

## 04 00 00 Masonry

### 1. General

- a. Reinforcing steel shall be inspected to verify proper placement, tying and clearances prior to grouting.
- b. If not painted, the exposed exterior face of concrete masonry units (CMU) and brickwork shall be treated with a fluid-applied penetrating water repellent. Division 07: Thermal and Moisture Protection.

### 2. Products

- a. Hollow and solid CMU shall conform to ASTM C90, "Specification for Loadbearing Concrete Masonry Units," Grade N.
- b. Solid clay brick shall conform to ASTM C216, "Specification for Facing Brick (Solid Masonry Units Made From Clay or Shale)," Grade MW.
- c. Hollow facing and building clay brick shall conform to ASTM C652, "Specification for Hollow Brick (Hollow Masonry Units Made From Clay or Shale)," Grade MW.
- d. An integral water-repellent admixture shall be used in the manufacturer of block and in mortar mix at the jobsite for concrete masonry construction at exterior walls not to be covered by other exterior finish materials.

### 3. Execution

- a. Material and workmanship for installation of CMU shall conform to requirements of the National Concrete Masonry Association (NCMA), the Concrete Masonry Association of California and Nevada (CMACN) and the California Building Code (CBC).
- b. Cold and hot-weather construction procedures shall be used, demonstrating compliance with requirements included in ACI 530.1, "Specification for Masonry Structures."
- c. Control joints shall be caulked on both interior and exterior faces before interior wall finish materials are applied.
- d. Mortar profile at exposed exterior horizontal joints shall be selected to discourage collection of water in joints.
- e. "Cap" concrete masonry unit walls by filling the top row of the blocks with cement to eliminate rodent access to the interior of the wall.

## 05 00 00 Metals

### 05 05 00 Common Work Results for Metals

1. Shop drawings are required for fabrication of structural steel and custom fabricated assemblies.
  - a. The Contractor shall be required to verify field conditions and dimensions.
  - b. Drawings shall be reviewed for constructability.
2. Steel base plates shall be provided for items bearing on concrete. Anchor bolts shall be used for leveling. Space below plates shall be filled solid with appropriate non-shrink grout.
3. Exposed welds shall be ground smooth. Templates shall be used for setting anchor bolts.
4. The Contractor shall supervise installation of anchor bolts and related items to assure proper setting in concrete.
5. Metal exposed to atmosphere, moisture or embedded directly in concrete shall be hot dipped galvanized minimum four inches (4") above surface of concrete.
6. Metal exposed to atmosphere or moisture shall be lead-free coated, hot-dip galvanized.
7. The Contractor shall be required to submit completed "Procedure Qualification Record" (PQR), "Welding Procedures Specification" (WPS) and Welder Performance Qualification Records. Certified manufacturers' test reports are required for all steel brought on site. Any pre-welded steel shall be accompanied by appropriate material and workmanship qualifications.
8. Mock-ups: Full-size, partial mock-ups may be considered for ornamental metal items to verify conformance to design intent, review quality of workmanship, and evaluate applied coatings and colors (in-place mock-ups preferred).

#### 05 05 13 Shop-Applied Coatings for Metal

1. General:
  - a. Comply with National Assoc. of Architectural Metal Manufacturers' [AMP 500-06: Metal Finishes Manual](#) recommendations for applying and designating finishes.
  - b. Shop-primed ornamental metal shall be finished in the shop to the greatest extent possible
2. Products:
  - a. Galvanizing-Repair Paint: Minimum 82 percent zinc-dust-content paint for re-galvanizing welds in galvanized steel, complying with FS DOD-P-21035a. Where repaired galvanizing is to be left exposed, use repair paint that will closely match appearance of hot-dip galvanizing.
  - b. Primer for Galvanized Steel: Inorganic, zinc-rich: "Tneme-Zinc 90-97," Glidden, or equal, 2.0 to 3.5 mil dry-film thickness (DFT).
  - c. Finish Coatings:
    - i. Select coatings for durability, fade resistance, and abrasion resistance where subjected to any contact
    - ii. Field applied coatings shall be VOC compliant and selected for long-term durability and ease of maintenance and repair.
3. Galvanizing:
  - a. Comply with ASTM A153-09, "Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware", for galvanizing of iron and steel hardware.
  - b. Comply with ASTM A123-13, "Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products", for galvanizing of rolled, pressed, and forged-steel shapes, plates, bars, and strips 1/8 inch thick and heavier.
  - c. Comply with ASTM A123-13 for galvanizing of assembled steel products.
4. Surface Preparation of AESS and Ornamental Metal: Comply with SSPC: The Society for Protective Coatings (SSPC) surface preparation specification No. 6 or No. 10. If steel is to be galvanized, prepare surface to this standard prior to galvanizing.

- a. Galvanized Steel Prior to Priming: SSPC SP No. 1 exercising care not to damage galvanizing.
- 5. Zinc coating damaged after fabrication shall be repaired with paint in accordance with ASTM A780-09, "Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings," American Hot-Dip Galvanizers Association publication, "Recommended Practice for Touch-up of Damaged Galvanized Coatings," and recommendations of repair paint manufacturer.
- 6. Zinc-coated surfaces to be painted shall be chemically treated prior to painting in accordance with SSPC standard SP-1, "Solvent Cleaning," exercising care not to damage galvanizing.
- 7. After erection, abraded areas of shop primer, field bolts, and welds shall be spot painted and touched-up with the same coating used for shop priming.
- 8. Clearly indicate whether protective coatings are to be shop and/or field applied including intermediate and finish coats.

*05 05 19 Post-Installed Concrete Anchors*

Owner's Representative to select appropriate requirement for the given project:

1. General:

- a. Submit manufacturer's literature and calculations for anchoring and fastening devices to Owner's Representative for approval.
- b. For concrete, use two-piece cinch anchors, epoxied anchors and/or wedge anchors, as appropriate for conditions and function.
- c. The use of pneumatic-driven anchors or fasteners and power-driven or powder-driven anchors or fasteners is prohibited.

--- OR ---

1. General:

- a. Submit manufacturer's literature and calculations for anchoring and fastening devices to Owner's Representative for approval.
- b. For concrete, except as listed below, use two-piece cinch anchors, epoxied anchors and/or wedge anchors, as appropriate for conditions and function. Concrete nails are not permitted.
- c. The use of low velocity powder-activated tools is permitted only for the conditions described below. The use of medium and high velocity powder-activated fasteners as defined by ANSI A10.3 is prohibited.
  - i. Permitted Uses of Low Velocity Powder-Actuated Fasteners:
    - 1. Anchoring metal track for interior non-load bearing walls. Note: Door frames shall be fastened with two-piece expansion anchors.
    - 2. Fastening of furring strips to concrete walls.
    - 3. Temporary fastening and concrete forming.
    - 4. Installation of incidental straps and wires used to suspend the following:
      - a. Metal duct work of 25 pounds per linear foot or less;
      - b. Piping of 1" diameter or less;
      - c. Electrical conduit of 2" diameter or less.
    - 5. Fastening of plaster accessories, flashing and similar items with negligible loading.
  - ii. Requirements for Low Velocity Powder Actuated Fasteners.
    - 1. Minimum shank: .143 inch diameter; minimum penetration: 1.25 inches for 3000 psi concrete; minimum rated tensile strength: 310 lbs; minimum rated shear strength: 420 lbs. Contractor shall submit calculations to substantiate selection.
    - 2. Weight suspended from each connection shall not exceed 200 lbs.

3. Where designated by Owner's Representative, anchors, fasteners and ties installed utilizing low velocity powder-actuated tools will be tested by an independent testing laboratory to resist two times the design load. Any such anchor, fastener or tie which fails such a test shall be replaced by Contractor at no cost to Owner.
- iii. Procedures for use of low velocity powder actuated tools:
  1. The use of low velocity powder actuated tools shall comply with Federal OSHA safety requirements and California Code of Regulations Title 24, including the requirement that the operator of the tool be trained and certified. Submit certification to Owner's Representative.
  2. Submittal of manufacturer's literature and calculations for anchoring and fastening devices shall include load calculations and minimum spacing for fasteners for each specific use. Design for a factor of safety of two times allowable load. Calculations shall be signed by Contractor's structural engineer. Structural engineer shall be registered in California.
  3. Conform to Sheet Metal and Air Conditioning Contractors' National Association (SMACN) low velocity shotpin installation requirements.

05 10 00 Structural Metal Framing

05 12 00 Structural Steel Framing

05 12 13 *Architecturally-Exposed Structural Steel Framing*

1. Members intended to be left exposed in completed construction shall be designated as "Architecturally Exposed Structural Steel" (AESS) or "Architecturally Exposed Steel" (AES) shall meet, at a minimum, the special requirements of [AISC 303-10: Code of Standard Practice for Steel Buildings and Bridges](#), Section 10. An upgrade to these minimum requirements shall be considered for structural steel based on project conditions. Consult with University's Representative for specific requirements.
2. In addition to AISC 303-10, Section 10, ornamental metal work shall conform to recommended practices of the National Association of Architectural Metal Manufacturers (NAAMM). Consult with University's Representative for specific requirements.

05 40 00 Cold-Formed Metal Framing

1. Cold-Formed Metal Framing shall comply with the most recent version of the American Iron and Steel Institute' AISI S100-2007, *North American Specification for the Design of Cold-Formed Steel Structural Members*.
2. Refer to 05 05 19 *Post-Installed Concrete Anchors* for requirements of anchors in concrete walls, floors and ceilings.

05 51 00 Metal Stairs

1. Specify class of stairs using NAAMM terminology as follows:
  - a. Industrial Class
  - b. Service Class
  - c. Commercial Class
  - d. Architectural Class
2. Delegated design and engineering of all but Architectural Class stairs is acceptable. See 01 13 00 for acceptable contract types for delegated design.
  - a. Stairs shall be designed and engineered by a structural engineer licensed in the State of California.

- b. Show in detail the construction, thickness of metals, jointing, methods of installation, fastening and supports, including tread and landing supports, location and sizes of welds, anchoring, hangers, additional reinforcing of braced structural steel, and other pertinent information. Show reactions and eccentricities of metal stairs where imposed on the building structure. Submit plans, sections and details drawn to scale. Shop drawings shall contain the design, type of steel and load assumptions, and shall bear the seal of a structural engineer licensed in the State of California. Where conditions in three or more consecutive stories are exactly alike, the drawings may be broken and noted to include the duplicate runs
3. Structural Engineer of Record (SEOR) shall provide engineering criteria, including but not limited to the following:
- a. Live Loads:
    - i. Stair Treads:
    - ii. Stringers:
  - b. Deflection Criteria: Deflection of support members including stringer shall not exceed the following under full design loading:
    - i. Total Load:
    - ii. Live Load:
    - iii. Railing and Handrail Deflection:
    - iv. More stringent requirements will apply, as appropriate, to protect finishes and other attached elements.
  - c. Lateral Loads: Design and construct metal stairs, suspended platforms and platform landing to withstand seismic lateral forces in accordance with the following:
    - i. Seismic weight shall be a percentage of live load plus dead load of stair as specified by the SEOR. Maximum lateral deflections of any portion of stairs shall not exceed a horizontal displacement of one-eighth inch (1/8").
  - d. Interstory Drift: Design sliding connections at each level to accommodate a maximum inelastic response displacement equal to a seismic drift.
  - e. Overall Design Requirements
    - i. All Structural steel framing supporting stairs shall be considered as having neither torsional capacity nor lateral capacity for loads applied transversely to unbraced flanges or beams. Any beam flange that is not attached to a concrete slab or concrete fill on metal deck through welded studs shall be considered unbraced. Complete secondary framing specifically required to resist torsional and lateral loads shall be designed, fabricated and installed as part of the metal stair design-built or designated design and engineering submittal.
    - ii. Where any connection or bracket imposes more than 1 ksi of total bending stress into the flanges or web of a structural steel beam or column, stiffeners and other plates shall be designed, fabricated and installed to reduce the local bending stress at or below the above limit
4. Select fabrication class from NAAMM terminology as follows:
- a. Type 1 – Ornamental quality, where appearance is a critical factor
  - b. Type 2 – Weld of good appearance used in public areas where high ornamental quality is not required
  - c. Type 3 – Where not subject to view, such as at service stairs
  - d. Type 4 – When appearance is not a factor, used in industrial and non-public areas.

05 70 00      **Decorative Metal**

- 1. Walkway canopies, railings, and guardrails shall be designed to reflect their exposure to student use.
- 2. Shop drawings are required for fabrication of canopies, railings, guardrails, and similar work.

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## 07 00 00 Thermal and Moisture Protection

### 07 05 00 Common Work Results for Thermal and Moisture Protection

#### 1. General:

- a. Ease and efficiency of future re-roofing operations shall be considered when selecting a roofing system.
  - i. Minimize the number of roof penetrations and equipment pads. Use one larger pad and not several smaller pads to greatest extent possible.
  - ii. Protect existing adjacent building roofs from construction activity. Clearly specify and document access requirements, staging areas, protection of building and surrounding areas, and scaffolding.
- b. Any project that involves alteration of an existing roof (including but not limited to mechanical equipment replacement, construction of new curbs, platforms or sleepers, or penetration of existing roofs for any reason) the University's Representative shall perform due diligence to ascertain the warranty status of the roof in questions, its composition and any other special considerations. If under warranty, the following requirements shall apply:
  - i. If under installer's warranty, original installer shall be contracted to perform modifications, in order to maintain installer's warranty
  - ii. If under manufacturer's warranty only, selected roofing contractor shall be certified to perform modifications by the roof's manufacturer and shall secure a letter of acceptance from the manufacturer in order to maintain manufacturer's warranty.

#### 2. References:

- a. The latest editions of the following documents and publications shall apply to roofing work:
  - i. American Society for Testing and Materials (ASTM): Standards as listed.
  - ii. FM Global (FM): Loss prevention data books and materials approval publications.
  - iii. ITS ETL Semco: "Building Materials Directory," Warnock Hersey Mark.
  - iv. National Roofing Contractors Association (NRCA): "Roofing and Waterproofing Manual."
  - v. Sheet Metal and Air Conditioning Contractors National Association (SMACNA): "Architectural Sheet Metal Manual."
  - vi. Underwriters Laboratories Inc. (UL): "Roofing Systems and Materials Directory," "Building Materials Directory," and "Fire Resistance Directory."

## 07 10 00 Dampproofing and Waterproofing

#### 1. Introduction:

- a. Below grade foundation walls, retaining walls, above-grade concrete and masonry planters, and other structures subject to hydrostatic pressure shall receive appropriate dampproofing or waterproofing.
- b. The Contractor shall give the manufacturer and the University's Representative seventy-two (72) hours' notice prior to beginning work.

#### 2. Warranty:

- a. The Manufacturer shall supply a minimum twenty (20) year written warranty against water penetration through the treated areas.

#### 3. Installation of Systems:

- a. A written clarification from the Manufacturer's Representative shall be required when a particular condition warrants special design or substitution of materials.

## 07 14 00 Fluid-Applied Waterproofing

1. Introduction:
  - a. Exterior exposed masonry and concrete surfaces that will not receive other finishes shall be treated with a fluid-applied penetrating water repellent.
  - b. The Manufacturer's Representative shall be present and approve surface preparation, application methods, and completed work.
2. Warranty:
  - a. The Manufacturer shall supply a five (5) year written warranty that surfaces treated with water repellent shall be free of defects in materials and workmanship, and that surfaces shall remain water repellent.
  - b. Where terms of the manufacturer's guarantee require, provide a full-time jobsite inspector to supervise application.
3. Products:
  - a. Water repellent material formulation and concentration shall be selected based on porosity and composition of material to receive treatment, and level of water-repellency required.
  - b. Products shall be VOC compliant.
4. Preparation:
  - a. Power-wash surfaces prior to application.
  - b. Wash water shall not be discharged to or allowed to enter the storm drain system. Wash water shall be contained and properly disposed in accordance with UC Berkeley's [Water Protection Policy](#).
  - c. Repoint joints and/or route cracks as required. Repointing and/or filler materials shall be compatible with the water repellent.
  - d. Cleaning and repointing/filling shall be completed and areas allowed to dry prior to application of water repellent.
  - e. Prior to application, manufacturer shall certify in writing if moisture content is acceptable.
5. Adjacent surfaces and landscaping shall be protected from overspray. Application: Apply material as recommended by the manufacturer.

## 07 20 00 Thermal Protection

### 07 21 00 Thermal Insulation

1. General
  - a. Asbestos containing materials shall not be used and project specifications shall specifically prohibit their use.
2. Criteria
  - a. Insulating values shall be based on conformance with requirements of the latest version of California Code of Regulations Title 24 but shall be not less than the following:
    - i. Walls: R-19 for assemblies above grade, R-13 for interior below grade and R-5 for exterior below grade.
    - ii. Roofs/Ceilings: R-30 for total assembly.
    - iii. Raised Floor (non-concrete): R-19 for total assembly.

07 30 00 Steep Slope Roofing

07 31 00 Shingles and Shakes

07 31 13 Asphalt Shingles

1. Materials

- a. Utilize only "Premium" quality, heavy-duty, dimensional shingles unless otherwise approved by the University's Representative complying with ASTM D3018, Type I, ASTM D3462, and with the following characteristics:
- b. Weight: Not less than 240 pounds per square, nominal.
- c. Fire Rating: UL Class A.
- d. Wind Rating: Passes UL 997 and FM Global Property Loss guidelines.

2. Execution:

- a. Use an eighteen-inch (18") wide self-adhesive strip at rakes, eaves and roof to wall intersections. The self-adhesive strip shall turn up vertical surfaces a minimum of three inches (3") and shall be installed prior to underlayment. The Manufacturer of underlayment and pre-strips shall be approved by the University.
- b. Use corrosion resistant fasteners. Staples are not permitted.
- c. Use six (6) nails and two (2) dabs of mastic per shingle when slope exceeds sixty degrees (60°).
- d. Provide for step flashing at inside and outside corners and intersections with vertical surfaces.
- e. Provide reglet-type detachable 2-piece metal counterflashing.
- f. Provide metal flashing at rake-to-rake intersections.
- g. Utilize two layers of ridge shingles with mastic sealant between butt ends at ridges. Provide ridge venting where required.
- h. Use metal eave nosing and strap gutters to fascia or rafter ends. Do not use wing-type gutters. Fascia shall be installed after underlayment; double seal.
- i. Double-seal valley pans to underlayment.
- j. Use shingle vent whenever possible. Do not use staples as fasteners.

3. Guarantees/Warranties

- a. Manufacturer: Provide standard Cedar Shake and Shingle Bureau 25-year material warranty and 30-year warranty for fire retardant pressure treatment.
- b. Contractor: As required for asphalt shingles.

07 31 29 Wood Shingles and Shakes

1. General: Comply with applicable standards of the Cedar Shake & Shingle Bureau, Sumas, WA.

2. Materials:

- a. Shingles: "Number 1 Red Cedar Shingle" with "Certi-Guard" blue label fire retardant treatment and UL Class C label for exterior fire exposure.
- b. Fasteners: Corrosion-resistant "box" nails of size as recommended by manufacturer.

3. Guarantees/Warranties:

- a. Manufacturer's Warranty: Not less than thirty (30) years.
- b. Contractor: Five (5) year workmanship and installation guarantee against leakage and other workmanship and installation failures. Terms of warranty shall include:
  - i. Defects include water leakage from the roof and flashing, curling or cupping of shingles, shingles which have blown off, loosening or dislodgement of metal flashing
  - ii. Making emergency, temporary repairs within twenty-four (24) hours of notification
  - iii. Completion of permanent repairs within thirty (30) days.

## 07 32 00 Roof Tiles

### 07 32 13/16 Clay/Concrete Roof Tiles

1. Existing Tile Roofs:
  - a. Verify historic significance and ascertain requirements for replacement or patching with the University's Representative.
  - b. Issues to be reviewed include extent of impact on roofing by the Project, condition of existing tiles, weatherproofness of existing system, condition of existing flashing, and availability of matching replacement tiles.
  - c. When feasible, reuse tiles.
2. Materials:
  - a. Sheet underlayment shall be 1 or 2-plys of self-adhering (SA) membrane or a 2-ply built-up, inorganic underlayment (only on wood substrate).
  - b. Fasteners: Minimum penetration, tile tie systems are preferred. Use utility double flashings at pipe penetrations.
3. Provide reglet-type detachable 2-piece metal counterflashing. Do not use surface-mounted reglets.

## 07 50 00 Membrane Roofing

1. General
  - a. Use of catalytic converter fume eliminator shall be required on all hot applications.
2. Single-ply membrane systems shall not be used except where specific project requirements necessitate their use or a single-ply system is the most appropriate solution.
  - a. Where singly-ply membrane systems are selected, components and accessories shall be from a single manufacturer, guaranteed for compatibility by the manufacturer, and applied by roofing contractors who carry current manufacturer's applicator certifications for the system specified.
  - b. Single-ply membrane systems shall include manufacturer-approved walk-pads and adequate, compatible protection for roof-mounted equipment.
3. Guarantees/Warranties:
  - a. Built-up Bitumen Membrane and Rubber Systems:
    - i. Contractor: Five (5) year workmanship and installation guaranty against leakage and other workmanship and installation failures.
    - ii. Manufacturer: Minimum twenty (20) year "Membrane System Warranty."

## 07 60 00 Flashing and Sheet Metal

1. General:
  - a. Designers shall design and provide details including isometric views for all flashing of complicated joints or where dissimilar materials interact.
  - b. Equipment pad flashing or caps shall be stainless steel unless otherwise directed by the Owner's Representative or where such flashing or caps should be made of copper for historical or aesthetic purposes.
  - c. Low slope metal roofing, less than 4:12, is not allowed.
  - d. Sheet underlayment shall be inorganic.
  - e. Use utility double flashings at pipe penetrations.
2. Guarantees
  - a. Metal Flashing Systems:
    - i. Contractor: Five (5) year workmanship and installation guaranty against leakage and other workmanship and installation failures.

### 3. Quality Assurance

- a. Work shall be in accordance with applicable provisions of the following:
  - i. "Architectural Sheet Metal Manual" of the Sheet Metal and Air Conditioning Contractors' National Association Inc. (SMACNA Manual).
  - ii. FM Global (FM): Loss prevention data books and materials approval publications.
  - iii. NRCA "Roofing and Waterproofing Manual."

### 4. Installation

- a. Sheet metal joints shall be pop riveted and soldered.
- b. Exposed edges shall be hemmed 1/2 inch.
- c. Dissimilar metals shall be separated.
- d. At all perimeter edges, provide a continuous cleat to meet FM Global Property Loss guidelines.
- e. Protect all roof surfaces from damage due to sheet metal work.

## 07 70 00 Roof and Wall Specialties and Accessories

### 07 72 00 Roof Accessories

#### 1. Fall Protection System:

- a. The Contractor shall provide fall protection for personnel in accordance with The Cal/OSHA regulations related to Fall Protection in construction, Title 8 of the California Code of Regulations, Chapter 4. Division of Industrial Safety, Subchapter 4. *Construction Safety Orders* during all phases of construction. Where fall protection systems outlined by Cal/OSHA are impractical, the Contractor shall submit in writing to the University's Representative a Fall Protection Plan which comports to the requirements of Subchapter 4. Construction Safety Orders, Article 24. Fall Protection §1671.1. *Fall Protection Plan*.
- b. The installation of permanent fall protection systems shall be required for new roofs and ledge projections to protect personnel from the risk of falls when working at elevated heights.
- c. The System shall be designed in consultation with Facilities Services, appropriate trades, Environment, Health and Safety, and other affected University personnel.
- d. The University will develop an Operating Procedures Outline Sheet (OPOS) for projects that meet criteria for such requirements and that designers of the respective building components related to safety equipment are expected to coordinate such designs with the OPOS. Coordinate with University's Representative and Facilities Services.

## 07 90 00 Joint Protection

### 07 92 00 Joint Sealants

#### 1. General

- a. Designers shall specify sealants that meet the VOC and other requirements of CA Title 24 Pt. 11 *California Green Buildings Standards Code*
- b. Designers shall select the most appropriate type of sealant for the application with performance and longevity being primary criteria.
- c. Designers shall indicate the locations and profiles of sealants in submitted details.
- d. Designers shall specify color of sealants.

#### 2. Warranties

- a. General: Joint sealants shall be repaired or replaced that fail to achieve airtight and watertight seal or otherwise fail to perform as intended because of leaking, crumbling, hardening, shrinkage, bleeding, sagging, staining, loss of adhesion or cohesion, or do not cure within the specified warranty periods.
  - i. Contractor: Five (5) years.

- ii. Manufacturer: Twenty (20) years.
- 3. Quality Assurance
  - a. Work shall comply with ASTM C1193.
  - b. Preconstruction Field-Adhesion Testing: Before installing elastomeric sealants, field test their adhesion to Project joint substrates as follows:
    - i. Locate a mock-up test joint.
    - ii. Conduct field tests for each type of elastomeric sealant and joint substrate indicated.
    - iii. Notify Architect seven (7) days in advance of dates and times when test joints will be erected.
    - iv. Arrange for tests to take place with the Owner's Representative and joint-sealant manufacturer's technical representative, if available, present.
    - v. Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C1193 unless other method included in Appendix of ASTM C1193 is more appropriate.
      - 1. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
      - 2. For sealants that fail adhesively, retesting shall be done until satisfactory adhesion is obtained.
    - vi. Contractor shall submit written report whether sealant in joint connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Data on pull distance used to test each type of product and joint substrate shall be included in the report.
    - vii. Evaluation: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, shall be considered satisfactory.
    - viii. Sealants that fail to adhere to joint substrates during testing shall not be used.
    - ix. Joint profile shall shed water.
    - x. Use primer prior to application of sealant.
- 4. Through penetrations of fire-rated partitions, walls floors, etc. shall be fire-stopped with materials per approved listed fire-stopping assemblies and systems.
- 5. Joint systems at fire-rated walls and/or floors shall be assembled with materials per approved listed fire-rated joint systems.

## 08 00 00 Openings

### 08 10 00 Doors and Frames

1. Refer to *05 05 19 Post-Installed Concrete Anchors* for requirements of anchors in concrete walls, floors and ceilings.

### 08 11 00 Metal Doors and Frames

#### 1. Frames

- a. Designers shall indicate door types using Steel Door Institute (SDI) standard nomenclature letters and symbols as indicated in the most recent edition of SDI 108: *Recommended Selection and Usage Guide for Standard Steel Doors*.
- b. Type: Fully welded conforming to ANSI/SDI A250.8-2017. Knock-down frames shall be acceptable for inner office locations and on renovation projects.
- c. Grouted or poured in place frames shall have mortar boxes for hardware.
- d. Header Reinforcing: Building entrance and restroom frames to receive full closer 14-gauge steel channel reinforcement, all other frames to receive 14-gauge sleeve.
- e. Frames at exterior openings and interior openings four feet (4'-0") wide and wider shall be 14-gauge.
- f. Exterior frames shall be galvanized.
- g. Except as otherwise required for fire rating and by size of opening, frames at interior openings shall be 16-gauge.
- h. Provide three (3) silencers for each single door and two (2) at head of pairs of doors except at frames with weather-stripping, smoke, or sound seals.
- i. Fire-rated frames shall be labeled with required rating indicated.

#### 2. Doors

- a. Type: Flush, conforming to ANSI/SDI A250.8-2017 Level 2 and Physical Performance Level B, Model 2. No hollow-core doors shall be allowed.
- b. Face Sheets: 16-gauge for all exterior doors, and interior doors up to four feet (4'-0") wider. Exterior doors, restroom doors and animal lab doors shall be galvanized.
- c. Reinforce doors for finish hardware in accordance with ANSI/SDI A250.8-2017 Table 4, modified as follows:
  - i. Hinges: 1-1/2 inch steel plate six inches (6") longer than hinge and secured with not less than six (6) spot welds.
- d. Surface-Applied Closers: All metal doors shall be reinforced for closers. Required Clearances: In accordance with ANSI/SDI Standard except as follows.
- e. Non Fire-Rated Doors:
  - i. Jambs and Head: 3/32 inch.
  - ii. Meeting Edges at Pairs of Doors: 1/8 inch.
  - iii. Bottom: 3/8 inch there is no threshold or carpet, 1/8 inch at thresholds or carpet.
- f. Glazing Beads:
  - i. Type: Screw on, 1/2 inch by 1/2 inch by 14-gauge steel channels, factory installed and secured with countersunk, flat head, machine screws at six inches (6") on center.
  - ii. Corners shall be mitered.
  - iii. Fixed frame stops shall be securely welded to the door on the secure side.
- g. Louvers:
  - i. Locate factory-prepped louvers a minimum twelve inches (12") above finish floor.
  - ii. Design: Inset, welded, with mitered frame. Louvers shall not permit line-of-sight.
- h. Finishes, General:



- i. Comply with NAAM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for cleaning, treating, priming, and when specified, finishing,
- i. Steel Sheet Finishes:
  - i. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, “Solvent Cleaning”; remove dirt, oil, grease, or other contaminants that could impair paint bond. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP3, “Power Tool Cleaning,” or SSPC-SP6/NACE No. 3, “Commercial Blast Cleaning.”
  - ii. Factory Priming for Field-Painted Finish: Apply shop primer specified in Division 9 Sections “Painting” and “High-Performance Coating” for exterior doors and frames, immediately after surface preparation and pretreatment. Apply a smooth coat of even consistency to provide a uniform dry film thickness of not less than 0.7 mils.
- 3. Installation Of Steel Doors and Frames
  - a. Frames shall be installed in accordance with ANSI/SDI A250.11 *Recommended Erection Instructions for Steel Frames*.
  - b. Field cutting for hardware and other modifications is not permitted.
  - c. Coat inside of frames and anchors with asphaltic paint where frames are set in masonry walls and are to be grout filled.

## 08 14 00 Wood Doors

- 1. Flush Doors
  - a. Warranty: Interior solid-core doors; lifetime of the original installation.
  - b. Fabrication:
    - i. Door Grade: North American Architectural Woodwork Standards—Custom Grade.
    - ii. Hardwood Face Panel Grade at Transparent Finish Doors: HPVA “A.”
    - iii. Designer shall indicate species and cut in specifications
    - iv. Hardboard faces are not acceptable.
    - v. Wood faces shall be 5-ply construction. 7-ply is not acceptable.
    - vi. Doors shall be fabricated to conform to the North American Architectural Woodwork Standards
    - vii. Thickness: 1-3/4 inches.
    - viii. Use mineral core where required for fire rating.
    - ix. Vertical Exposed Edges of Stiles: Solid stock, fire-retardant treated where required, with no finger joints, knots, pitch pockets, or other defects. Provide matching hardwood, solid stock or minimum 1/4-inch thick veneer, same species as door faces with concealed cross banding at transparent-finished doors.
    - x. Provide lock blocks to suit hardware for mineral-core doors; two (2) four inch (4”) minimum (including stiles) width and twenty inch (20”) length.
    - xi. Provide 5-inch top and bottom rail for mineral-core doors.
    - xii. Pre-fit and pre-machine doors for hardware at place of manufacturer.
    - xiii. Wood doors shall be factory-prepared for installation of all hardware including raceways for electrified hardware.
    - xiv. Factory-cut openings for vision panels and louvers:
      - 1. Discuss security with Client regarding vision panel use.
- 2. Stile and Rail Doors
  - a. Doors shall be fabricated to conform to the the North American Architectural Woodwork Standards
  - b. Thickness: 1-3/4 inches.
  - c. Grade: Premium.
  - d. Custom veneers at transparent finish shall be minimum 1/16-inch thick over engineered core.



- e. Source Limitations: Obtain stile and rail wood doors through one (1) source from a single manufacturer.
- 3. Finishing
  - a. Transparent Finish: Provide factory finish only.
  - b. Opaque Finish: Factory primed and either shop or field-finish painted.
- 4. Delivery, Storage and Handling
  - a. If shop drawings exist, mark each door on top and bottom rail with opening number used on drawings.
- 5. Installation
  - a. Doors shall be installed in accordance with requirements to North American Architectural Woodwork Standards.

## 08 30 00 Specialty Doors

- 1. Access Doors
  - a. Provide in locations required to give access to plumbing, mechanical, electrical, or similar devices concealed in walls or ceilings.
  - b. Doors shall be sized to provide sufficient access for maintenance. Designer shall indicate size and dimensioned location in documents. Placement of door shall be for reasonable access to equipment.
  - c. Where located in a fire-rated assembly, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in UL "Classified Building Materials Index." Provide UL label on each access door.
  - d. Doors shall be fabricated of continuous welded-steel construction.
  - e. Designs:
    - i. Framed Partitions: Flanged type for flush mounting with concealed frames.
    - ii. Tile, Masonry and Concrete: Trim style with 3/4-inch wide, flush flange.
  - f. Locks:
    - i. Nonpublic Areas: Allen type screwdriver-operated latch.
    - ii. Public Areas: Key-operated cylinder lock with Medeco KeyMark x4 SFIC cylinder to match the building key system. No substitution.
  - g. Finishes:
    - i. Typical Locations: Factory-applied rust-resistant prime coat. Doors shall be finish painted at public locations.
    - ii. In Restrooms and other wet locations: Stainless steel with No. 4 satin finish.
- 2. Overhead Coiling Fire Doors
  - a. Comply with most recently adopted edition of NFPA 80.
  - b. Doors shall be motor-operated, automatic closing.
  - c. One (1) set of all tools and devices necessary to safely reset and service the door shall be provided to the University for each type of door.
  - d. Source Limitations: Obtain overhead coiling doors through one (1) source from a single manufacturer.
    - i. Obtain operators and controls from the overhead coiling door manufacturer.
  - e. Discontinued models of doors shall not be installed.
  - f. Power and Operator:
    - i. Motor shall lower and raise door.
    - ii. Each door shall be on its own dedicated, 120V AC circuit with circuit(s) clearly noted on respective electrical panel.
    - iii. Fire-release electrical circuits shall be dedicated circuits.
    - iv. Motor shall be connected to the building fire alarm system.

- g. Automatic Closing:
  - i. Doors shall be equipped with both audible and visible warning device when automatic release is activated.
  - ii. Backup battery shall allow for system operation for a minimum of seventy-two (72) hours during a power outage. If power outage is longer than seventy-two (72) hours, the door shall close automatically.
  - iii. An automatic reverse safety switch located within a resilient housing shall extend the full width of the bottom rail.
- h. Keys and Keying:
  - i. If overhead coiling door is required to be lockable, locksets shall be furnished with Medeco KeyMark x4
  - ii. SFIC cylinder to match building key system; no substitution.
- i. Installation:
  - i. Installation shall allow for sufficient and safe access to mechanisms for resetting, servicing and repair.
  - ii. Engage an experienced installer who is an authorized representative of the overhead coiling door manufacturer for both installation and maintenance of units.

08 40 00 Entrances, Storefronts and Curtain Walls

08 41 00 Entrances and Storefronts

08 41 13 Aluminum-Framed Entrances and Storefronts

1. Performance:
  - a. Designer shall specify door performance class, wind loads and other performance criteria.
  - b. Doors shall meet resistance to corner racking when tested by the Dual Moment Load test.
  - c. Doors shall meet performance criteria as specified by the designer and tested under AAMA 501.1-17, *the Standard Test Method for Water Penetration of Windows, Curtain walls and Doors Using Dynamic Pressure* or AAMA 501.2, *Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems*)
  - d. Doors shall be weatherstripped to meet the following air infiltration requirements when tested in accordance with AAMA/WDMA/CSA 101/I.S. 2/A440:
    - i. Pairs of Doors: Maximum of 2.3 cfm per linear foot of perimeter crack at a pressure differential of 1.56 psf.
    - ii. Single Doors: Maximum of 2.0 cfm per linear foot of perimeter crack at a pressure differential of 6.24 psf.
  - e. Exposed fasteners in frame or door are not acceptable.
2. Aluminum alloy tubular extrusions, 0.125-inch minimum wall thickness – 1 piece
3. Stile width:
  - a. Top: eight inches (8")
  - b. Center: six inches (6")
  - c. Bottom: eighteen inches (18")
4. Welding of doors or frames is not acceptable.
5. Warranty: Warrant doors and frames including excessive deflection, faulty operation and deterioration of finish or construction in excess of normal weathering.
6. Warranty Period: Ten (10) years.
7. Hardware:
  - a. Automatic Operators: See “Automatic Entrances” below.
  - b. See 08 70 00 for additional hardware requirements.

## 08 42 00 Entrances

### 08 42 29 Automatic Entrances

1. Automatic operation doors occurring in fire-rated construction shall comply with the most recent NFPA 80 6.1.3.4 and shall be coordinated with the building's fire alarm system.
2. Automatic entrance doors shall be installed at the main entries of new major buildings and at new main entries for renovation projects.
3. The design, style, functional characteristic, hardware, and other door features shall be selected and specified on a case-by-case basis. They shall be bar style unless:
  - a. They prove cost prohibitive due to conditions on site; or,
  - b. Required clearances prove infeasible.
4. Operation:
  - a. Operation is swinging.
  - b. Operator is electric.
5. Latching devices shall be concealed vertical rod.
6. Activators:
  - a. Radio Frequency actuators are preferred.
  - b. Push plates or vertical actuation bars shall comply with CBC Section 11B-404.2.9
  - c. Where push plates, vertical actuation bars or other similar operating devices are provided, they shall be placed in a conspicuous location. A level and clear floor or ground space for forward or parallel approach shall be provided, centered on the operating device. Doors shall not swing into the required clear floor or ground space for the operating device.
  - d. Only one (1) leaf is required to be activated by push pads at double doors.
7. Products:
  - a. Exterior doors: Horton Automatics Heavy Duty HD-Swing 4000 LE series, Detex 2000 Record or equal
  - b. Interior doors: Horton Automatics EasyAccess Series 7100 Low Energy or equal
8. Installer Qualifications:
  - a. Engage an experienced installer to assume engineering responsibility and perform work who has specialized in installing entrance systems and who is acceptable to the manufacturer.
9. Warranty Period:
  - a. Ten (10) years on all components of storefront door systems and replacement doors.
10. Designer shall coordinate the specification and operation of automatic entrances with security, electrical and fire alarm systems.

## 08 70 00 Hardware

1. General Requirements
  - a. One (1) each of any non-standard installation and maintenance tool.
  - b. On pairs of exterior doors provide exit only hardware on inactive leaf.
2. Warranties
  - a. Finish hardware shall have the following extended warranties against all defects in materials and workmanship, including without limitation against failure to perform as required as follows from date of acceptance:
    - i. Door Closers: Ten (10) years.
    - ii. Locksets: Five (5) years.

- iii. Exit Devices: Three (3) years.
- iv. All Other Hardware: Two (2) years.

### 3. Locks and Cores (UCPD Mandatory Locks and Cores Requirements – No Substitutions)

- a. Small 7-pin Format Interchangeable Cores (SFIC).
  - i. Medeco KeyMark x4 system on all interior doors.
  - ii. Medeco KeyMark x4 system on all exterior doors. Buildings with a card-key shall have the exterior doors keyed to a Medeco KeyMark x4 EMS system.
  - iii. Medeco KeyMark x4 system on interior card-keyed doors.
- b. At existing projects where Medeco is not already the existing keyway, if the scope of work affects less than twenty-five percent (25%) of door locks, retain existing keyway and match to existing product type and keyway.
- c. Locks in gender inclusive-restrooms shall be Bobrick Model 1002612 Occupancy Indicator Latch (UCPD Mandatory Requirements – No Substitutions)
- d. All permanent cores and keying shall be provided and installed by Facilities Services.
- e. For temporary/jobsite security, Contractor shall provide and install metal construction cores only. Composite construction cores are not acceptable.

### 4. Hinges

- a. Manufacturer: Stanley, McKinney, Hager and Ives Hinge Division.
  - i. Interior openings: Butt Hinges
  - ii. Exterior openings: Continuous Hinges
  - iii. Butt Hinge Type: Five-knuckle, button tips, except as otherwise required. Hinges for doors with closers shall be ball bearing.
  - iv. Continuous Hinge Type: Pin and barrel stainless steel.
  - v. Exterior cut swinging doors shall have non-removable pins and shall be non-ferrous.
  - vi. Labeled Doors: Steel or Stainless Steel.
  - vii. Bearings and raceways shall be stainless steel.
  - viii. Hinges shall be secured with stainless steel or silicone bronze screws. Riveted or welded hinges are not acceptable.
  - ix. The size and weight of butt hinges shall be determined by the following:
    - 1. Doors 1-3/4 Inches Thick and up to 41 Inches Wide: 4-1/2 Inches tall.
    - 2. Doors 1-3/4 Inches Thick and 41 Inches to 48 Inches Wide: 5 Inches tall.
    - 3. Widths: Sufficient to clear trim projection when door swings 180 degrees.
    - 4. Exterior and high traffic openings: Heavy Weight
    - 5. Interior low traffic openings: Standard Weight
  - x. Quantity: Two (2) hinges for doors up to five feet (5') high, and one (1) additional hinge for each 2-1/2 feet of height or fraction thereof over five feet (5').

### 5. Locksets and Latchsets

- a. Provide all locks, latches, and cylinders of the same Manufacturer to ensure compatibility and warranty.
- b. Designer to coordinate specification of electrified devices with card readers and/or other security systems; specifically, verify REX requirements.
- c. General:
  - i. Type: Mortised.
  - ii. Lever design
    - 1. At renovations, match existing.
    - 2. At new construction projects Schlage 06A or Sargent L Series.
  - iii. Backset: 2-3/4 Inches.

- iv. Mortise: Schlage L9000 Series, Sargent 8200 Series or Best 45H; no known equal.
- v. Provide mortise housing to accept either, based on the Project's key system 7-pin SFIC.
- vi. At existing sites currently using cylindrical locksets:
  - 1. Cylindrical: Schlage D Series, Sargent 10 Line or Best 9K; no known equal.
  - 2. Provide levers to accept SFIC 7 pin cylinders.
- vii. Strikes: Standard curved lip, or with extended curved lips where required to protect trim and jamb from being marred by latch bolt. Provide with dust pockets.
- viii. Dead bolts shall have a one inch (1") projection.

## 6. Exit Devices

- a. Models: Von Duprin 99 Series or Sargent 80 Series based on compliance of performance specifications as specified below.
- b. Designer to coordinate specification of electrified devices with card readers and/or other security systems; specifically, verify REX requirements.
- c. Selected devices shall have the following characteristics:
  - i. Materials: Aluminum, Brass, Bronze or Stainless Steel base metal, plated or finished to match required hardware finish. Moving parts of die-cast "pot" or "white" metals are not acceptable.
  - ii. Provide certification by independent testing laboratory that specified devices have completed over 1,000,000 cycles and still perform in accordance to ANSI/BMHMA A156.3 – 1994.
  - iii. All devices shall have the ability of conversion to electrified usage.
  - iv. Furnish glass bead kits for vision lites where required.
  - v. The unlatching force shall not exceed fifteen pounds (15#) applied in the direction of travel for fire-rated doors. This force shall not exceed five pounds (5#) for non-rated doors.
  - vi. Electrified devices shall use an electric power transfer unit to wire transfer between the frame and the door,
  - vii. Glass doors shall not possess panic hardware with manual dogging devices.
- d. Interior Doors:
  - i. Single Doors: Von Duprin L99 or Sargent 80 Series, no known equal.
  - ii. Double Doors with Vertical Rod Combinations: Von Duprin 9927L or Sargent 8600 Series, no known equal.
- e. Exterior Doors:
  - i. Single Doors: Von Duprin L99 or Sargent 80 Series, no substitution.
  - ii. Double Doors:: Von Duprin L99 or Sargent 80 Series with keyed removable mullions, no substitution.
- f. Operation:
  - i. Lock automatically when closed-key retracts latchbolt.
  - ii. When push pad is locked down by hex key dogging, latchbolt is retracted and doors operate push-pull.

## 7. Closers

- a. Manufacturers: LCN or Norton 7500XSN – Based on compliance with performance specification listed below.
  - i. Internal Closers: LCN 4040XP or Norton 7500XSN; no known equal.
  - ii. External Closers: LCN 4040XP or Norton 7500XSN; no known equal.
- b. All closers shall be by the same Manufacturer to facilitate maintenance and servicing. An authorized factory representative shall inspect closers after installation to ensure proper adjustment and operation.

- c. Closers shall be non-handed and shall be capable of mounting hinge side, top jamb, stop side or on a bracket.
- d. All closers shall utilize a temperature stable fluid capable of withstanding temperature ranges of 120 degrees F to -30 degrees F without requiring seasonal adjustment of closer speed to properly close the door.
- e. Use parallel-arm closers at reverse-bevel doors and where doors swing full 180 degrees.
- f. Closers shall have separate and independent screw valve adjustments for latch speed, general speed, and hydraulic back-check. Back-check shall be located to effectively slow the swing of door at minimum of 10 degrees in advance of the dead stop location.
- g. Parallel arm closers shall incorporate one-piece solid forged steel stud shoulder bolts and shall be incorporated in regular arms and hold-open arms. All other closers shall have forged steel main arms. Built-in stop arms or “cush” stop arms are not acceptable.
- h. Exterior or vestibule doors where conditions would be better suited for floor closers, use Rixson #27 or equal including an intermediate pivot.

#### 8. Electronic Hardware

- a. Card key control systems shall conform to U.C. Police control equipment and policy (see Division 28, *Electronic Safety and Security*). Architectural hardware shall conform to Division 8.
- b. Automatic swing entrance hardware shall be electronic; Horton 4100 or Horton 7100; no known equal.
- c. Electronic hardware shall be fail secure with provision for emergency exiting where required.
- d. Electrified door hardware is the campus standard. Electric strikes shall be considered on a case-by-case basis in retrofit construction only. Electric strikes shall be Von Duprin or HES.
- e. Electronic systems shall be of the same manufacturer (locking device, power supply, etc.).

#### 9. Fasteners and Anchors

- a. Hardware shall be furnished with required fasteners in accordance with the following guidelines:
  - i. Finish on exposed fasteners shall match finish on item being fastened.
  - ii. Fasteners shall be appropriate to substrate which hardware is being fastened.
  - iii. Closer at wood fire doors shall be attached using hex bolts.
  - iv. Exposed screws shall have Phillips style head.
  - v. Hardware fastened to concrete or masonry shall be installed with manufacturer-supplied fasteners.

#### 10. Miscellaneous Items

- a. Doorstops: Provide where required to prevent door or hardware from striking an adjacent wall or obstruction.
- b. Push and Pull Plates:
  - i. Manufacturers: Ives, Rockwood, DonJo.
  - ii. Size: Four inches (4”) by sixteen inches (16”).
  - iii. Plates shall be without screw holes when used with pulls. Pulls shall be through-bolted at grip only.
  - iv. Doors with push plates and pulls with the cylinder on the push side shall have recessed pulls used in conjunction with the push plates; Rockwood No. 95, or equal.
  - v. For double doors, remove the exterior handle or pull associated with the inoperative leaf.
- c. Vestibule Doors (including Aluminum Doors):
  - i. Door Pulls: Rockwood #146 or similar.
  - ii. Push Plates: 18 Gauge Stainless Steel.
- d. Kick Plates: Provide at doors with closers.
- e. Surface and Flush Bolts:

- i. Automatic Flush Bolts shall be of the low operating force design. Utilize the top bolt only model for interior door where applicable and as permitted by testing.
- ii. Manual Flush Bolts only permitted on storage or mechanical openings as scheduled.
- iii. Provide dust proof strikes at openings using bottom bolts.
- iv. Flush Bolts:
  - 1. Metal Doors: Glynn-Johnson Constant Latching FB50 Series.
  - 2. Wood Doors: Glynn-Johnson Constant Latching FB60 Series.
  - 3. Flush bolts shall have a lever arm that is connected to the bolt mechanism and is not friction-operated.
  - 4. Face plates shall be shaped to match the door edge.
  - 5. Operating mechanism for bottom flush bolts shall be not more than twelve inches (12") above the finish floor, and top flush bolt shall be not more than seventy-two inches (72") above the finish floor.
  - 6. Bottom flush bolts shall have dustproof strikes.
- v. Surface Bolts shall have a dustproof strike or easy-to-clean floor strike.
- vi. Lifting handles on surface bolts shall be mechanically fastened, not press fitted.
- f. Stops, Holders, and Bumpers:
  - i. Stops:
    - 1. Preferred: Wall type; Ives WS407, or equal.
    - 2. Where wall type is not suitable, use floor type; Ives FS436, FS437, or equal.
  - ii. Overhead Stops and Holders: Glynn-Johnson 90M.
  - iii. Holders and Bumpers: Glynn-Johnson F9, F10 or W2, or equal.
  - iv. Stops shall be solid or forged bronze; wrought is not acceptable.
  - v. Wall-mounted stops shall be secured with concealed fasteners.
  - vi. Rubber bumpers shall be fastened by a pin or screw that goes through the rubber and seats into the metal on the opposite side. A rubber bumper that is screwed into the metal holder is acceptable.
  - vii. Stops and holders shall be secured with anchors in concrete. Use screws to stud or backing at framed walls in high-traffic areas.
  - viii. Automatic holders at exterior doors are not allowed.
- g. Thresholds:
  - i. Manufacturers: NGP, Pemko.
  - ii. Design shall have a center reinforcing leg as designed by the manufacturer.
  - iii. The threshold shall extend the full width of the opening as a single piece with ends cut to jamb profile except where floor closers are installed. In this situation, the threshold shall be cut in half to facilitate changing closers without the need to pull a pair of doors to change a single closer.
- h. Silencers:
  - i. Provide at exterior and interior doorframes except at frames to receive sound seals or weatherstripping.
  - ii. Quantity:
    - 1. Single Doors: Three (3) each lock jamb frame.
    - 2. Double Doors: Two (2) for each leaf at head frame, plus three (3) each on astragal.
  - iii. Manufacturer and Product:
    - 1. Metal Frames: Glynn-Johnson 64 or equal.
    - 2. Wood Frames: Glynn-Johnson 65 or equal.
- i. Smoke Seals and Weatherstripping:
  - i. 20-Minute Rated Wood Doors: NGP 5050 Self-Adhesive Gasketing – Silicone.
  - ii. 60-90 Minute Rated Wood Doors: NGP 9440 Self-Adhesive Gasketing – Intumescent Batwig.

- j. Padlocks shall be provided with Small format IC core as required, keyed to building master keying system.
- k. Coordinators: Provide at double doors with closers to assure proper closing.
- l. Campus lock boxes for UCPD and/or Facilities Services access shall be installed on all buildings or adjacent locations by Facilities Services.

11. Keys and Keying

- a. New Buildings: Medeco keymark x4, 7-pin SFIC.
  - i. All housing, locking (rim, mortise or cylindrical) devices to accept the 7-pin SFIC.
  - ii. For construction purposes, use SFIC 7-pin temporary metal construction core.
  - iii. Facilities Services' Lock Shop shall provide and install final cores.
- b. Major Additions, Renovations to Existing Buildings: Cores to match existing building key system or 7-pin Small Format Interchangeable Core (as directed by Facilities Services' Lock Shop); no substitute:
  - i. All housing, locking (rim, mortise or cylindrical) devices to accept the 7-pin SFIC cylinder.
  - ii. For construction purposes, use SFIC temporary construction core.
  - iii. Facilities Services' Lock Shop shall provide and install final cores.
- c. Mechanical, Electrical, Utility, Data Rooms: 7-Pin Small Format Interchangeable Core; no substitute:
  - i. All housing, locking (rim, mortise or cylindrical) devices to accept the 7-pin SFIC cylinder.
  - ii. For construction purposes, use 7-pin SFIC temporary construction core.
  - iii. Facilities Services' Lock Shop shall provide and install final cores.
- d. Keyed Elevator Switches: 7-Pin Small Format Interchangeable Core; no substitute.
- e. Key-Operated Mailboxes: 7-Pin Small Format Interchangeable Core; no substitute.
- f. Fire Curtain Switches: 7-Pin Small Format Interchangeable Core, no substitute.
- g. Removable Mullions: 7-Pin Small Format Interchangeable Core, no substitute.
- h. Knox Boxes: 1300 or 4400 series. Indicate Designated Campus Fire Marshal approved locations on drawings. Coordinate installation with UCPD.

12. Finishes

- a. Campus standard is satin chromium plated, 626, 612, or oil-rubbed bronze, 613.
- b. Existing Facilities: Finishes shall be as listed or to match existing.

13. Installation

- a. Locksets and latchsets shall be installed after doors have received final finish coat. If installed prior to application of final coat, lockset or latchset shall be removed to permit painting.
- b. Locksets and latchsets in wood doors shall be installed in mortise or holes prepared by using a mortising or boring jig.

14. Recommended Hardware By Room Type

- a. General:
  - i. Lockset: Mortise. Cylindrical only at sites to match existing.
  - ii. Function: Listed functions for each space are general guidelines. Final function shall be determined based on usage of space.
  - iii. Additional hardware shall be provided as required in accordance with these guidelines, code, and specific Project conditions.

Room Type	Schlage	Sargent	Remarks
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Office	L9050	8205	Latchbolt retracted by lever from either side unless outside is made inoperative by key outside or by lever inside. Outside lever remains locked until door is unlatched from inside or by counter clockwise rotation of key. Auxiliary latch deadlocks latchbolt when door is closed.
Labs, Entrances	L9060	35H7G3H	Latchbolt retracted by lever from either side unless outside is locked by key from inside. When locked, latchbolt retracted by key outside or lever inside. Auxiliary latch deadlocks when door is closed.
Storage and Mechanical Rooms	L9080	35H7EW3H	Latchbolt retracted by key outside or by lever inside. Outside lever always inoperative.
Passage, non-locking	L9010	35H7N3H	Latchbolt retracted by lever from either side at all times.
Classroom, Public Toilets	L9070	35H7J3H	Latchbolt retracted by lever from either side unless outside is locked by key. Unlocked from outside by key. Inside lever always free for immediate exit.
Uncontrolled Library Exit	<p>All Exterior doors shall be equipped, in coordination with the exterior door hardware, with an emergency exit similar to Detex EA500 or Alarm lock PG21 or PG21e.</p> <p>The emergency exit alarm locks may be key operated from inside, outside or both as directed by the University's Representative and Library Architect.</p>		

Cylindrical Locksets: Schlage or Best; no known equal

Room Type	Schlage	Best	Remarks
Office	D53JD or BD	93K7AB15D	Pushing button locks outside lever until unlocked by key or by turning inside lever.
Labs, Entrances	D60JD or BD	93K7C15D	Unlocked by key from outside when outside lever is locked by key in inside lever. Inside lever is always unlocked.
Storage and Mechanical Rooms	D80JD or BD	93K7D15D	Outside lever fixed. Entrance by key only. Inside lever always unlocked.
Passage, non-locking	D10S	93K7N15D	Latchbolt retracted by lever from either side at all times.
Classroom, Public Toilets	D70JD or BD	93K7R15D	Latchbolt retracted by lever from either side unless outside is locked by key. Unlocked from outside by key. Inside lever always free for immediate exit.
Gender Inclusive Restroom stalls	Bobrick Model 1002612 Occupancy Indicator Latch (UCPD Mandatory Requirements – No Substitutions)		

08 50 00 Windows

08 56 00 Special Function Windows

08 56 56 Security Window Screens

1. Security Screens where required shall be 316 Marine Grade High-Tensile Stainless Steel Black Powder Coated Security Mesh by Vista Security Screens (formally Garda). Consult with UCPD Crime Prevention Unit for specific placement and installation requirements (police@berkeley.edu).

08 80 00 Glass and Glazing

08 81 00 Glass Glazing

1. Industry Standard

- a. Comply with Glass Association of America “GANA Glazing Manual.”

2. Glass Materials

- a. Annealed Float Glass: ASTM C1036, Type I, Class 1, Quality q3 or better.
  - i. Obtain annealed float glass units from one (1) manufacturer using the same type of glass and other components for each type of unit indicated.
- b. Heat-Strengthened and Tempered Float Glass: ASTM C1036, Type I float glass as specified above and conforming to requirements of ASTM C1048 and as specified.
  - i. Tempered glass shall meet ANSI Z97.1 test requirements.
  - ii. Glass shall be tempered using the roller hearth method.
  - iii. Heat-strengthened glass shall have surface compression levels between 3500 and 7000 psi.
  - iv. Obtain heat-strengthened and tempered float glass units from one (1) manufacturer using the same type of glass and other components for each type of unit indicated.
- c. Insulating Glass: Certified under IGMA-approved program and meeting CBA Grade requirement when tested in accordance with ASTM E773 and ASTM E774.
  - i. Units shall be fabricated from specified float glass.
  - ii. Provide tempered glass for both lights of glass where required by code.
  - iii. Obtain insulating glass units from one manufacturer using the same type of glass and other components for each type of unit indicated.
- d. Flat Wire Glass: ASTM C1036, Type II, Class 1, Form 1, Quality q8, 6.0 mm thick.
  - i. Flat wire glass is only acceptable where specified in CBC Chapter 24 and shall only be used when matching existing installations in close proximity within the same building.
  - ii. Mesh Design: Baroque or Georgian (square).
  - iii. Obtain flat wire glass units from one manufacturer using the same type of glass and other components for each type of unit indicated.
- e. Mirror Glass: ASTM C1036, Type I, Class 1, quality q2, 1/4 inch thick.
  - i. Provide silver coating, copper-protective coating, and 1-mil-thick mirror backing paint.
  - ii. Comply with CS 27.
- f. Spectrally Selective and Tinted Glass: These are acceptable glass Types and should be considered where required to control excessive heat gain and use is acceptable to University’s Representative.
  - i. Obtain spectrally selective and tinted glass units from one (1) manufacturer using the same type of glass and other components for each type of unit indicated.
- g. Spandrel Glass: Subject to approval by the Owner’s Representative.
- h. Reflective Glass shall not be allowed for exterior windows.

- i. Other glass Types such as obscure, laminated, decorative, and others as may be required based on usage, shall be considered on an individual basis.
- 3. Glazing Materials
  - a. Sealants for Glazing:
    - i. Interior Locations, If Not Dry Glazed:
      - 1. Typical: One-part, gun grade; Tremco "Mono," Pecora "60 Plus," or equal.
    - ii. Exterior Locations: One-part, gun-grade silicone; GE "Silicone Construction Sealant Series SCS- 1200," Dow-Corning "999 Building Sealant," or equal.
  - b. Glazing Blocks and Spacers: Closed-cell neoprene complying with ASTM C509, in black color.
  - c. Glazing Gaskets: Types and sizes as required, preformed, premolded corners; F.H. Maloney, D.S. Brown, or equal.
    - i. Full-Density EPDM: Conforming to NAAMM Standard SG-1.
    - ii. Closed-Cell Neoprene: Capable of 24 percent to 40 percent compression.
    - iii. PVC: Complying with ASTM D2287.
    - iv. Standard products provided by aluminum framing, window, or entrance manufacturer, if at variance with the above, are acceptable.
  - d. Glazing Tape:
    - i. Typical: Butyl rubber type, black color; Pecora "Extru-Seal Tape G-66," Tremco "440 Tape," or equal.
    - ii. Fire-Rated Glass: Closed-cell PVC or as otherwise approved by glass manufacturer for required fire rating.
  - e. Source Limitations for Glazing Accessories:
    - i. Obtain glazing accessories from one source for each product and installation method.

09 00 00 Finishes

09 05 61 Common Work Results for Flooring Preparation

1. Concrete surfaces shall be subject to moisture content testing to determine the subsurface moisture content of the concrete slab to receive resilient flooring.
  - a. Flooring shall not be installed over substrates that exceed maximum moisture content allowed by the manufacturer to effect required warranty.
  - b. Review alternative solutions and construction assemblies for concrete slab on grade to mitigate potential or tested moisture vapor problems including topical coatings, concrete additives, and below slab barriers.

09 20 00 Plaster and Gypsum Board

09 21 00 Plaster and Gypsum Board Assemblies

09 21 16 Gypsum Board Assemblies

1. Non-Load Bearing Metal Framing
  - a. Wall Systems: Select steel studs in accordance with the manufacturer's standard load tables and the following design pressures and deflections:
    - i. At Stairs, Elevator Hoistways, and Other Vertical Shafts: L/120 at 10 psf.
    - ii. At Ground Floor Lobbies: L/120 at 15 psf.
    - iii. At Partitions to Receive Stone Cladding: L/360 at 15 psf or 0.5 G (half the weight of stone cladding) applied laterally, as required by CBC Section 1632.
    - iv. At Partitions to Receive Lath and Plaster: L/360 at 15 psf.
    - v. At All Other Partitions: L/240 at 5 psf.
    - vi. At non-composite conditions where wallboard is partial height, require calculations be submitted by a structural engineer licensed in the State of California verifying compliance with required deflection.
  - b. Joisted ceiling deflection shall be designed to limit deflection to L/360.
  - c. Steel framing shall be isolated from the building structure so as to prevent transfer of loading imposed by structural movement.
  - d. The contractor shall be required to submit and conform to the ICC Report of framing system for stud gauge and spacing for all wall conditions.
  - e. Require submittals that utilized manufacturer's standard details for bracing, top and bottom plate, and framing all openings. Specify fasteners, top and bottom, both sides.
  - f. Materials:
    - i. General: Metal studs, track, and sheet metal furring channels shall comply with ASTM C645.
    - ii. Partitions:
      1. Minimum of 33 mils.
      2. Use minimum 54 mil studs at least 3-5/8 inches wide at wall-mounted fixtures, casework, equipment, shelving, handrails, and grab bars.
      3. Manufactured Shaft Enclosure System, Cavity Wall Type: "Cavity Shaft Wall System, C-H Stud Design," by U.S. Gypsum; "620 Shaftwall System" by Domtar Gypsum; or equal. Select system and UL Design based on required fire rating.
    - iii. Wire for tying and bracing shall be galvanized, soft annealed steel.
    - iv. Specify that installation of metal framing complies with requirements of ASTM C754.
  - g. Show and detail metal backing plates on Drawings, minimum of 54 mils.
  - h. If a fire rated assembly is required, indicate UL, CBC or other CSFM approved listing on Drawings. Assembly detail shall match the referenced assembly.

- i. Powder driven fasteners, if used, shall conform to the requirements specified in Division 1 and restrictions imposed by the Project's Structural Engineer at post-tensioned slabs.
- j. In gypsum board ceilings, locate and show required access panels as specified for HVAC, fire protection or other systems. Size access panels large enough to provide maintenance access.
- k. Where multi pipe/cable runs occur in corridors such as in Laboratory buildings, the use of suspended finished ceilings is discouraged.
- l. Use Manufacturer's span table to determine appropriate framing size. For example, see [http://www.ssma.com/filebin/pdf/SSMA\\_Product\\_Technical\\_Guide\\_11-13-17-1.3.pdf](http://www.ssma.com/filebin/pdf/SSMA_Product_Technical_Guide_11-13-17-1.3.pdf) or <http://www.clarkdietrich.com/support-tools/support-docs/load-tables>

## 2. Gypsum Board

- a. Industry Standards: Work shall comply with the applicable requirements of GA publication GA- 216 and GA-214.
- b. Materials:
  - i. Fire-Rated Board: ASTM C1396, Type X, unless more stringent type required by code.
    - 1. Thickness: 5/8 inch, unless otherwise noted.
    - 2. Edges: Tapered and rounded.
    - 3. Size: Four feet (4'-0") wide by lengths that will result in minimum footage of joints.
  - ii. Fire-Rated Water-Resistant Board: ASTM C1396, Type X.
    - 1. Thickness: 5/8 inch.
    - 2. Edges: Tapered.
    - 3. Size: Four feet (4'-0") wide by lengths that will result in minimum footage of joints.
  - iii. Glass-mat faced gypsum board in wet locations and as tile backing board per latest edition of TCNA Handbook for Ceramic, Glass, and Stone Tile Installation:
    - 1. USG Durock, Fiberock Aqua-Tough, or approved equal
  - iv. Shaft-Liner Board: ASTM C442, 1 inch thick, square edge, unless otherwise required for selected UL assembly.
  - v. Laminating Adhesive: VOC compliant and as recommended by gypsum board manufacturer for laminating gypsum board together in fire-rated construction.
  - vi. Screws: Phillips head with bugle shape, Type S, conforming to ASTM C1002. Use Type W for attachment to wood.
  - vii. Concealed Metal Reinforcements and Casing: Electrogalvanized, conforming to ASTM C1047.
  - viii. Taping and Finishing Products: Comply with ASTM C475 and with manufacturer's recommendations for specific project conditions.
- c. Installation:
  - i. General: Comply with ASTM C840 and GA-216 in addition to requirements of the CBC. Conform to UL designs for fire-rated partitions except where exceeded by other requirements.
  - ii. Provide concealed metal reinforcement at external corners and where gypsum board meets dissimilar material.
  - iii. Use glass-mat faced gypsum board as outlined above or cementitious backer board at partitions to receive ceramic tile, in damp areas, and where exposed to excessive moisture. Do not use on ceilings unless support framing is minimum twelve inches (12") on center. Use cementitious backer board or equivalent for partitions in wet areas.
  - iv. Glass-mat faced or moisture resistant gypsum board shall be used in areas in which the sheet material is the finished condition.
  - v. Seal perimeter and penetrations at sound-rated construction to meet specific project acoustical requirements.

- vi. Construction Tolerances:
  - 1. Gypsum board surfaces to be painted shall have no measurable variation in any two foot (2'-0") direction and a maximum variation of 1/8 inch in ten feet (10'-0") when a straightedge is laid on the surface in any direction.
  - 2. Coordinate with tolerances required for surfaces to receive tile.
  - 3. Do not exceed 1/16-inch offset between planes of abutting sheets at edges or ends.
- vii. Level of Finishes: In accordance with GA-214.
  - 1. At Locations Indicated to Receive "Fire-Taping" and at Unexposed Gypsum Board Applications: Level 1.
  - 2. Areas to Receive Ceramic Tile: Level 3.
  - 3. Designer shall clearly indicate areas that are critically lit and scheduled to receive Level 5 finishing.
  - 4. All Other Locations: Level 4.

09 30 00 Tiling

09 30 13/33 Ceramic/Stone Tiling

1. Part 1: General

a. General Requirements

- i. Designers shall specify installation method using current TCNA method standards and nomenclature.
- ii. Ceramic and Tile flooring installations shall achieve a minimum wet dynamic coefficient of friction or DCOF AcuTest value of 0.42, as verified by field test or manufacturer certificate.
- iii. In restrooms, bathrooms and shower/locker rooms, walls and floors shall have commercial grade ceramic tile not smaller than four inches by four inches (4" x 4") with dark colored grout.
- iv. Ceramic and Tile flooring shall not be used in laboratory spaces.
- v. Special patterns and layouts shall be shown on the Drawings.
- vi. Coordinate requirements for extra material quantities and delivery after completion with the Owner's Representative.

b. Submittals

- i. Master grade certificates for each shipment, type, and composition of tile, signed by the manufacturer and installer.

c. Green Building

- i. In projects required to achieve US Green Building Council LEED certification, ceramic and stone tile shall be evaluated and specified by the designer to achieve LEED credits wherever practical.

2. Part 2: Products

a. Materials

- i. General: Tile shall conform to ANSI A137.1 "Standard Grade" requirements.
- ii. Environmental Criteria:
  - 1. Preference shall be given to re-used or reclaimed ceramic or stone tiles that are in fair and usable condition.
  - 2. Ceramic, glass, ceramic/glass composite, and terrazzo-type tiles shall contain a minimum of 50% (combined) post-industrial/post-consumer recycled content.
  - 3. The specified percentage is based upon the weight of the component materials.
  - 4. Glazings used for the glazed tiles shall be lead-free.

iii. Adhesives and Sealants:

1. The VOC content of adhesives, sealants and sealant primers shall be less than the current VOC content limits of South Coast Air Quality Management District (SCAQMD) Rule 1168 and all sealants used as fillers shall meet or exceed the requirements of the Bay Area Air Quality Management District Regulation 8, Rule 51. (<http://www.aqmd.gov/rules/reg/reg11/r1168.pdf>; <http://www.baaqmd.gov/dst/regulations/rg0851.pdf>)
  2. Aerosol adhesives shall meet the VOC limits of the “Green Seal Environmental Standard for Certification of Commercial Adhesives” (GS-36) of Green Seal, Inc. (<http://www.greenseal.org/certification/standards/commercialadhesives.cfm>)
  3. All adhesives, sealants and sealant primers shall be free of the prohibited chemicals as defined in GS-36.
- iv. Mortars/Grouts:
    1. The VOC content of mortars or grouts for ceramic tile installations shall not be in excess of 150 grams/liter, less water and less exempted compounds.
  - v. Metal Edging or Stone Threshold: Provide where tile flooring terminates at dissimilar floor material.
  - vi. A waterproofing membrane shall be provided under tile at wet areas and Restrooms above grade.
  - vii. Epoxy grout shall be used on floors of Restrooms, Bathrooms and locker/changing facilities.
  - viii. Cementitious backer board at wet locations shall conform to ANSI A118.9. Use fire-rated backer board at rated partitions to maintain rating of partition.
  - ix. Sealers shall be used on unglazed floor tile only after review with the University’s Representative and impact on the Project budget.
  - x. Protective Paper: Non-staining laminated and reinforced Kraft paper with bituminous or latex binder.

### 3. Part 3: Execution

#### a. Installation

- i. Allowable Tolerances of Surfaces to Receive Tile:
  1. Maximum Variation in Vertical Surfaces: 1/8 inch in eight feet (8’-0”).
  2. Maximum Variation in Horizontal Surfaces: 1/8 inch in ten feet (10’-0”).
- ii. Surface preparation, setting of tile, grouting, and cleaning shall be in accordance with applicable requirements of ANSI standards for selected setting methods.
- iii. Recommended Installation Methods:
  1. TCNA Methods are referenced. Coordinate final system selection on wall or partition construction, location in building, and anticipated abuse.
    - a. Wall Tile at Dry Areas: TCNA Method W243.
    - b. Wall Tile at Showers: TCNA Method B415 and W244.
    - c. Floor Tile at Shower: TCNA Method B420.
    - d. Floor Tile at Restrooms: TCNA Method F122.
- iv. Protective paper shall be applied over floor tile for minimum of three (3) days after grouting is completed to prevent escape of moisture, cure grout, and provide protection until acceptance.

#### b. Site Environmental Procedures

- i. Waste Management: As specified in Section 01 74 19 – Construction Waste Management and Disposal and coordinate with the manufacturer(s) for recycling programs for collection of construction scrap, unused material, demolition scrap, and packaging material.

1. General Requirements

- a. Selection of acoustical ceiling systems shall be based on careful analysis of function, aesthetic, cost, sound absorption and noise reduction, and durability.
- b. For special assembly areas, retaining of an acoustical consultant shall be considered to provide assistance and advice in the design and acoustical treatment.
- c. Metal panel systems or acoustical ceiling components such as torsion spring clip removal panels or panels that contain devices and/or are fixed shall only be designed and specified in consultation with the University's Representative
- d. Extra stock shall be provided—consult with the University's Representative to determine extra stock amounts required of each project.

2. Quality Assurance

- a. Seismic Requirements: Ceilings shall comply with CCR T-24 and CBC code requirements for seismic bracing of ceiling suspension system.
- b. Surface Burning Characteristics: Provide products complying with ASTM E 1264 for Class A products and meeting the following when tested in accordance with ASTM E84.
  - i. Flame Spread: 25 or less
  - ii. Smoke Developed: 50 or less
- c. Fire-rated ceilings shall be rated in accordance with ASTM E119 and bear an Underwriters Laboratories Inc. (UL) Time Design number applicable to the proposed installation.
- d. Tolerances:
  - i. Deflection, ASTM C635: Maximum 1/360 of span. Applies to suspension system components, hangers, and fastening devices supporting light fixtures, ceiling grilles, and acoustical panels.
  - ii. Allowable Tolerance of Finished Acoustical Ceiling System: Level within 1/8 inch in twelve feet (12'-0").

3. Warranty

- a. Acoustical ceiling products shall be provided with the following extended product warranties by manufacturer:
  - i. Acoustical Panels: Ten (10) years.
  - ii. Suspension Grid: Ten (10) years.

4. Materials

- a. Suspension Systems: Exposed grid type. Do not use concealed spline systems.
  - i. Comply with ASTM C635.
  - ii. Structural Classification: Not less than Intermediate-duty.
  - iii. Main, Cross Members, Edge Moldings: Zinc coated; electrogalvanized or hot-dip galvanized cold-rolled steel. Use hot-dip galvanized system at damp locations.
  - iv. Rough Suspension: Galvanized, soft-annealed, mild steel wire.
  - v. Power-driven fasteners shall conform to Division 1 requirements.
- b. Acoustical Panels and Tiles:
  - i. Acoustical panels shall conform to FS SS-S-118B, Type III (mineral fiber), Class 25, unless otherwise accepted by University's Representative for Project aesthetic or acoustical requirements.
  - ii. Provide USDA/FSIS approved panels at food preparation areas. Minimum Performance Requirements:
  - iii. Color/Light Reflectance (LR): 0.75. Noise Reduction Coefficient (NRC): 0.75. Ceiling Attenuation Class (CAC): 35.



- c. Products shall be selected with consideration of IAQ requirements.
  - d. Consideration shall be given to products with recycled material content and that can be recycled.
  - e. In renovation products, match existing adjacent acoustical units where possible. Do not mix new and existing units in any given space.
  - f. Coordinate selection of acoustical units with existing building standard.
5. Adhesive for Tiles: VOC compliant, ASTM D1779 bearing UL label for Class 0-25 flame spread.
6. Leveling Splines for Tiles: Fiber, metal, or plastic, manufactured specifically for leveling adhesive- applied tile, as recommended by tile manufacturer.
7. Installation
- a. Suspension system, including necessary hangers, grillage, and other supporting hardware, shall conform to requirements of UBC Standard 25-2, "Metal Suspension Systems for Acoustical Tile and for Lay-in Panel Ceilings" and ASTM C636.
  - b. Acoustical panels shall be installed in grid system in accordance with Cisca publication "Acoustical Ceiling Use and Practice."
  - c. CBC Standard shall govern if in conflict or more restrictive than industry standards and publications.
  - d. Where tegular edge panels are used, panel edges shall be trimmed or routed to provide regular edge at perimeter moldings.
  - e. Suspension system shall not be secured to ductwork.
  - f. Exit signs, sprinkler cases, signage and other items shall not be attached to lay-in panels.

09 60 00      Flooring

09 65 00      Resilient Flooring

1. Part 1: General

a. General Requirements

- i. Completed work for all types of hard flooring installations shall be field tested to achieve a minimum wet dynamic coefficient of friction or DCOF AcuTest value of 0.42.
- ii. Existing Conditions:
  - 1. Coordinate requirements for mock-ups and submittals with the University's Representative.
  - 2. Removal or encapsulation of existing tile containing asbestos shall be coordinated with the University's Representative and conform to hazardous material procedures in Division 1.
- iii. Special patterns and layouts shall be shown on the Drawings.
- iv. Unless specifically requested, do not specify extra material.
- v. Specify moisture content testing to determine the subsurface moisture content of the concrete slab to receive resilient flooring

b. Green Building

- i. All new construction and major renovations must meet the current UC policy and procedure requirements included in the UC Sustainability Practices Policy: <http://ucop.edu/sustainability/policy-areas/index.html>. The UC Sustainability Practices Policy provides guidance on the required Environmentally Preferable Purchasing and on UC's USGBC LEED certification and credit requirements. UC Berkeley has material requirements that must be met as well and are provided in more detail in Part 2 below.

2. Part 2: Products

a. Materials

- i. Environmental Criteria:

1. Preference shall be given to rapidly renewable materials or products (materials or products made from plants that are typically harvested within a ten (10) year or shorter cycle).
  2. At the discretion of the Owner's Representative, linoleum tile or sheet flooring may consist primarily of renewable materials including linseed oil, cork flour, wood flour, pine rosin, and jute. Additional components may include inert fillers, pigments, or other secondary materials; however, the products shall not contain synthetic latex, vinyl, or other thermoplastics or thermosetting plastics as backing or prefinished coatings.
  3. Unless required by programmatic needs, all flooring shall be certified low-emitting, complying with both the indoor air quality and VOC requirements of the most recent edition of the California Green Building Standards Code and carrying a UL GREENGUARD certification. Substitutions must demonstrate certification.
- ii. Vinyl Composition Tile (VCT): Conform to ASTM F1066.
    1. Minimum Thickness: 1/8 inch.
    2. Color: Integral throughout with distinct pattern. Use of solid and light colored tile shall be avoided.
  - iii. Sheet Flooring:
    1. Vinyl shall conform to ASTM F1913 and as described in the environmental criteria above.
    2. Flooring at Laboratories, glass wash and other areas where liquids are used or stored shall be watertight and chemical resistant. Flooring shall be compatible with the chemicals to be used or stored.
    3. Flooring shall be suitable for installation as a seamless floor with welded seams at all locations.
    4. Self-coved base shall have cove filler strip backing.
  - iv. Resilient Base: Conform to ASTM F1861, Type TS, vulcanized rubber or Type TP, rubber.
    1. Avoid use of pre-molded pieces except at exposed ends.
    2. Lengths: Roll type to allow for minimum number of joints.
  - v. Adhesives and Sealants:
    1. The VOC content of adhesives, sealants and sealant primers shall be less than the current VOC content limits of South Coast Air Quality Management District (SCAQMD) Rule 1168 and all sealants used as fillers shall meet or exceed the requirements of the Bay Area Air Quality Management District Regulation 8, Rule 51. (<http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1168.pdf>; <https://www.baaqmd.gov/rules-and-compliance/current-rules>)
    2. Aerosol adhesives shall meet the VOC limits of the "Green Seal Environmental Standard for Certification of Commercial Adhesives" (GS-36) of Green Seal, Inc. (<http://www.greenseal.org/certification/standards/commercialadhesives.cfm>)
    3. All adhesives, sealants and sealant primers shall be free of the prohibited chemicals as defined in GS-36.
  - vi. Water-resistant, as recommended by manufacturer of resilient flooring material for conditions of installation. Adhesive shall meet VOC requirements.
    1. Waxes and Applied Finishes:
      - a. New Buildings: The Contractor shall use Facilities Services' current specified wax and no known equal. Special restrictions on maintenance coatings for installed products shall be provided to the Owner.
      - b. Renovations: Except for specialty coatings such as static control coatings, final waxing or finish will be provided and applied by the Owner. Special

restrictions on maintenance coatings for installed products shall be provided to the Owner.

2. Edge Strips: Provide where resilient flooring terminates, exposing edge of covering, unless included as part of abutting floor material installation.
3. Other resilient flooring materials, including rubber and solid vinyl, shall be reviewed with the University's Representative prior to selection for appropriateness and conformance with the Project budget.

### 3. Part 3: Execution

#### a. Installation

- i. Comply, at minimum, with the linoleum manufacturer recommendations for space ventilation during and after installation.
- ii. For larger areas, it is strongly encouraged that a supply of 100% outside air is provided during construction and for as long as possible following construction.
- iii. When installed over concrete slabs, verify compatibility of the linoleum and adhesives with curing compounds, leveling agents, or sealing agents used for slab preparation.
- iv. Comply with ASTM F710 and manufacturer's recommendations for surface preparation.
- v. Flooring shall fit tile neatly and tightly into breaks and recesses to fit within 1/64 inch of abutting surfaces.
- vi. Flooring shall extend under fixed base cabinets and floor-mounted cases.

#### b. Site Environmental Procedures

- i. Waste Management: As specified in Section 01 74 19: Construction Waste Management and Disposal. Coordinate with manufacturer(s) for recycling programs for collection of construction scrap, unused material, demolition scrap, and packaging material.

## 09 67 00 Fluid-Applied Flooring

### 1. General Requirements

- i. Completed work for all types of hard flooring installations shall achieve a minimum wet dynamic coefficient of friction or DCOF AcuTest value of 0.42.
2. Contractor or subcontractor performing the work shall demonstrate not less than five (5) years of application of specified product and carry manufacturer's applicator certifications where required for warranty purposes.
3. Wet Lab Floors shall be non-yellowing, water-borne, penetrating polymer resin applied to unpainted, smooth concrete after testing outlined in 09 05 61, *Common Work Results for Flooring Preparation*.

## 09 68 00 Carpeting

### 1. Part 1: General

#### a. General Requirements

- i. The selection of carpet shall consider use, user, durability, serviceability, replacement accessibility, sustainability, and appearance.
- ii. Use of carpet in high traffic areas requires approval of the Owner's Representative.
  1. Carpet shall not be used on walls or in elevators.
  2. Carpet shall not be used in laboratory spaces.
  3. Carpet tiles shall not be used except at raised access floors; they pull-up with extraction cleaning.
- iii. Specify that carpet edges be buttered and sealed to minimize unraveling.
- iv. Specify edge conditions; require thresholds.
- v. Carpet which is to be removed for disposal shall be placed in a recycling program.

- vi. All new carpet specified must be from a supplier that will take back the carpet at the end of its life and recycle the used product. [http://www.ucop.edu/purchserv/psa\\_db/search.php](http://www.ucop.edu/purchserv/psa_db/search.php)
- vii. Unless specifically requested, do not specify extra material.
- b. Submittals
  - i. Seaming diagrams for review by the University's Representative shall be required.
- c. Warranty
  - i. The Contractor shall provide a five (5) year extended written warranty, co-executed by the installing Subcontractor, agreeing to repair, replace, reset, or restretch carpeting that fails in installation materials or workmanship within the specified warranty period.
  - ii. In addition to others available for selected carpet, the following manufacturer product warranties are required:
    - 1. Against surface pile abrasive wear (fiber loss) in excess of ten percent (10%) for a period of ten (10) years from the date of installation.
    - 2. Ten (10) years' antistatic warranty.
- d. Green Building
 

All new construction and major renovations must meet the current UC policy and procedure requirements included in the UC Sustainability Practices Policy: <http://ucop.edu/sustainability/policy-areas/index.html>. The UC Sustainability Practices Policy provides guidance on the required Environmentally Preferable Purchasing and on UC's USGBC LEED certification and credit requirements. UC Berkeley has material requirements that must be met as well and are provided in more detail in Part 2 below.

## 2. Part 2: Products

### a. Materials

- i. Adhesives: Provide manufacturer's recommended water-based, mildew-resistant adhesive, produced expressly for use with type of carpet and substrates indicated.
  - 1. The VOC content of adhesives, sealants and sealant primers shall be less than the current VOC content limits of South Coast Air Quality Management District (SCAQMD) Rule 1168 <http://www.aqmd.gov>
  - 2. All sealants used as fillers must meet or exceed the requirements of the Bay Area Air Quality Management District Regulation 8, Rule 51. <http://www.baaqmd.gov>
  - 3. Aerosol adhesives shall meet the VOC limits of the "Green Seal Environmental Standard for Certification of Commercial Adhesives" (GS-36) of Green Seal, Inc. <http://www.greenseal.org/>
  - 4. All adhesives, sealants and sealant primers shall be free of the prohibited chemicals as defined in GS-36. On glue-down installations, latex adhesives shall not be used.
  - 5. Specify acrylic, rather than latex adhesives.
- ii. Carpet:
  - 1. General:
    - a. Designers shall specify carpet available from suppliers in the UC Office of the President (UCOP) systemwide designated construction agreement: <https://www.ucop.edu/procurement-services/for-suppliers/ucop-designated-construction-agreements.html#carpet>
    - b. Specify carpets manufactured with fusion-bonded backing, rather than latex-backed carpets.
  - 2. Environmental Criteria:
    - a. All carpet and rugs purchased or used shall comply with the California Gold Sustainable Carpet Standard. <http://www.documents.dgs.ca.gov/green/epp/standards.pdf>

3. The use of the higher environmental standard, California Platinum Sustainable Carpet Standard, shall be the discretion of the owner. Flammability: Conform to the following, unless otherwise acceptable to, or required by, the State of California.
  - a. DOC FF-1-70 or DOC FF-1-70 (Methanamine Tablet Test): Pass and meet the "Standards for the Surface Flammability of Carpets."
  - b. NFPA 258 or ASTM E662 (Smoke Density): Specific Optical Density (DM) of 450 or less (flaming).
  - c. ASTM E648 (Floor Radiant Panel Test): 0.22 or higher.
4. Product Specifications – Typical Locations:
  - a. Construction: Tufted, low nap or level loop. Pattern: Non geometric, non-directional.
  - b. Colors and Shades: Medium intensity; not so light as to easily show soiling, or so dark as to show dust and lint. Do not use solid colors.
  - c. Face Fiber: 100 percent solution dyed 6,6 nylon.
  - d. Face Weight:
    - i. Tufted: 28 ounces per square yard, minimum.
    - ii. Woven: 25 ounces per square yard, minimum.
  - e. Effective Gauge: 1/8-inch minimum.
  - f. Protective Anti-soiling Treatment: Standard of carpet manufacturer.
  - g. Static Control: AATCC 134 (Electrostatic Propensity of Carpet). Less than three kilovolts (3.0 kV) of static at seventy degrees Fahrenheit (70°F) and twenty percent (20%) humidity. Use carpet that develops less than two kilovolts (2.0 kV) of static at computer areas.
  - h. Lifetime antimicrobial warrantee.
5. Rapidly Renewable
  - a. Certain carpet systems made from rapidly renewable materials (e.g. wool carpet) shall be investigated as an environmentally friendly alternative.

### 3. Part 3: Execution

#### a. Installation

- i. Carpet and adhesive shall be applied in accordance with manufacturer's instructions and requirements of CRI 104.
- ii. Prior to carpet installation, the contractor shall verify that dirt and dust have been removed and that the surface to receive carpet is level to standard tolerances.

#### b. Site Environmental Procedures

- i. Waste Management: As specified in Section 01 74 19: Construction Waste Management and Disposal. Coordinate with manufacturer(s) for take-back programs for collection of construction scrap, unused material, demolition scrap, and packaging material.

09 90 00      [Painting and Coating](#)

09 91 00      [Painting](#)

### 1. Part 1: General

#### a. General Requirements

- i. Do not specify alkyd paints for interior applications without special authorization from the Owner's Representative and The Office of Environment, Health & Safety (EH&S).
- ii. To the maximum extent practicable, materials shall be by a single manufacturer with additional manufacturers providing systems not offered by the principal manufacturer.

09 00 00      Finishes

Adopted February 25, 2020

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- iii. Selection of paints and coatings shall be based on careful analysis of function, aesthetic, cost, sustainability and durability.
  - iv. Preparing painted surfaces for repainting may cause disturbance of lead containing coatings in a manner that could result in elevated blood lead levels for workers performing those activities. See Division 01 35 13.43: Special Project procedures for Contaminated Sites.
- b. Green Building
- i. All new construction and major renovations must meet the current UC policy and procedure requirements included in the UC Sustainability Practices Policy: <http://ucop.edu/sustainability/policy-areas/index.html>. The UC Sustainability Practices Policy provides guidance on the required Environmentally Preferable Purchasing and on UC's USGBC LEED certification and credit requirements. UC Berkeley has material requirements that must be met as well and are provided in more detail in Part 2 below. .
- c. Submittals
- i. The Contractor shall provide the Owner with a complete list of materials including those resulting from field changes. List to include manufacturer's code, name, lot number, and paint label analysis or formula. List shall be cross referenced to systems and numbers used in the Contract Documents.
  - ii. Unless specifically requested, do not specify extra paint stock.
  - iii. Verification of applicator's experience and qualifications shall be submitted by the Contractor.

## 2. Part 2: Products

### a. Materials

- i. General:
  - 1. Use the manufacturer's best quality paint in the manufacturer's professional product line. Products shall be free of mercury and lead.
  - 2. Materials selected for coating systems for each type surface shall be the product of a single manufacturer or shall be acceptable to the manufacturer of finish coating for system.
  - 3. Paints and stains shall be delivered ready-mixed to jobsite.
- ii. Environmental Criteria:
  - 1. All interior and exterior paints and coatings used shall be certified according to the latest "Green Seal Environmental Standard for Paints" (GS-11), Green Seal, Inc. <http://www.greenseal.org/index.cfm>
  - 2. All anti-corrosive paints shall satisfy the latest "Green Seal Environmental Standard for Anti-Corrosive Paints", (GS-03), Green Seal, Inc. <http://www.greenseal.org/index.cfm>
  - 3. All coatings, primers and undercoats shall satisfy the South Coast Air Quality Management District Rule 1113 for architectural coatings. [http://www.aqmd.gov/ceqa/notices/2007/noe/1113\\_NOE.pdf](http://www.aqmd.gov/ceqa/notices/2007/noe/1113_NOE.pdf)
  - 4. The Owner shall have the discretion to require more stringent Zero VOC paints and coatings or natural paints.
- iii. Indoor Air Quality:
  - 1. VOC limits for interior and exterior paints and coatings are defined by the latest GS-11 as follows:
    - a. Interior Paints and Primers: Non-flat: 150, Flat: 50
    - b. Exterior Paints and Primers: Non-flat: 200, Flat: 100
  - 2. VOC limits for anti-corrosive paint are defined by the latest GS-03 as follows:
    - a. Anti-Corrosive Paints: Gloss: 250, Semi-gloss: 250, Flat: 250

3. Restricted chemical compounds as defined by the latest GS-11 and GS-03 shall not be used as ingredients in the manufacture of the product.
- iv. Gloss:
  1. Levels: 60-degree meter gloss reading range:
    - a. Eggshell: 5 to 20.
    - b. Satin: 20 to 25.
    - c. Semi-gloss: 35 to 65.
  2. Locations of Use:
    - a. Satin or eggshell finish shall be used in offices and departmental work space.
    - b. Washable, semi-gloss finish shall be used in public areas, including entries, corridors, stairwells, classrooms, restrooms, and laboratories.
- b. Colors
  - i. Use standardized paint colors from the University's color palettes as follows for high-traffic and public areas.

Kelly Moore Color Code	Kelly Moore Color Name	Equivalent Acceptability*
23	Swiss Coffee	Yes
49	Antique White	Yes
14	Frost	Yes
41	Snip of Tannin	Yes
42	Wise Owl	Yes
36	Navajo White	Yes
27	Bone	Yes
46	Acoustic White	Yes
* Benjamin Moore, Fuller O'Brien, or pre-approved equal.		

- ii. Use Light Colors To:
  1. Reduce inventory to fewer colors.
  2. Reduce waste of non-used deep-tone colors.
  3. Save time matching colors.
  4. Enable faster turn-over rate on materials, reducing possibility of paint spoilage. Enable faster service, i.e., response, touch-ups.
- iii. Avoid use of deep-tone colors because they:
  1. Cost more.
  2. Do not reflect light as well as light colors.
  3. Are difficult, it not impossible, to match.
  4. Fade faster.
- iv. Where appropriate, specify paint mil thickness to ensure suitable coverage and durable finish.

### 3. Part 3: Execution

#### a. Installation

- i. Surface preparation as required by the paint manufacturer, including cleaning, patching, sealing at doors and windows, and leveling.
- ii. Initial coatings shall not be applied until moisture content of surface is within limitations recommended by the paint manufacturer.
- iii. Coordinate with the University's Representative for removing existing items on walls, storage and re-installation.



- iv. Do not paint over name plates and fire labels. Cross-reference and coordinate with Divisions 21: Fire Suppression and 26: Electrical. Note that the Contractor is responsible to coordinate with the University's Representative for the protection of smoke detectors and sprinkler heads during painting activities.
- v. Minimum Required Number of Coats:
  - 1. Existing Coating or Shop-Applied Primer: Two (2).
  - 2. New and Not Shop Primed: Primer and two (2) finish coats.
  - 3. Additional coats shall be applied at no additional cost as required to hide base material completely, produce uniform color, and provide required and satisfactory finish.
- b. Site Environmental Procedures
  - i. Waste Management: As specified in Section 01 74 19: Construction Waste Management and Disposal and as follows:
    - 1. Coordinate with manufacturer(s) for take-back program for collection of construction scrap, unused material, demolition scrap, and packaging material.
    - 2. Where feasible, separate demolition waste, construction waste, and recycling to further utilize waste reduction programs.

### *09 91 13 Exterior Painting*

- 1. Utilities and Poles
  - a. All above ground utilities, such as backflow devices, light poles, signposts, water valves, etc., shall be painted the standard campus color "Elephant's Breath" (or approved equal), direct to metal, with a water based paint with a satin enamel finish.



## 10 00 00 Specialties

### 10 05 00 Common Work Results for Specialties

#### 1. Custodial Maintenance

- i. Custodial Maintenance areas must conform to the University of California Office of the President (UCOP) [Custodial Ergonomic Design Guidelines for New Construction and Existing Buildings](#).
- ii. Additionally:
  1. Room to be for exclusive use of custodial staff. Do not place utilities or other functions in custodial maintenance areas. Key to preserve use by custodial staff.
  2. Door shall swing out, into hall or room.
  3. Adequate ventilation shall be provided.
  4. At least one (1) floor-mounted sanitary sewer sink per facility shall be provided for janitorial waste water to prevent illicit discharges into the storm drain system (WDR 2013-0001).
- b. All products, floor surfaces, tiles, wall finishes, etc., shall have specifications requiring cleaning and maintenance procedures and schedules and/or product manuals.

### 10 10 00 Information Specialties

#### 10 11 00 Visual Display Units

1. Review schedule and lead time with the University's Representative; equipment may be Owner-furnished and Contractor installed.
2. Displays mounted to structural elements of buildings (columns, shear walls, and other like elements) require stamped engineering drawings and calculations. Project shall provide mount and anchor details to Campus Building Department and project engineer. Concrete structural elements shall be scanned prior to drilling of anchor holes to avoid rebar, post-tensioned cables, or embedded building systems.
3. Thoroughly coordinate details for mechanical operations, electrical operations, access, size and location.
4. Coordinate framing for backing and reinforcement.
5. Coordinate via the University's Representative with the Office of Media Services (OMS) for product selection and specification.

### 10 14 00 Signage

1. For building evacuation signage, display the street address, building name, and UCPD cellular phone number of 510-642-3333 (aside 911).
2. Accessible Exit Signage.
  - a. A tactile sign stating EXIT and complying with ICC A117.1 shall be provided adjacent to each door, no more than four inches (4") from the door jam, to an egress stairway, an exit passageway, or the exit discharge.
    - i. Mount sixty inches (60") above floor to centerline.
    - ii. Braille must be grade two (2) or better.
3. "No Exit" Door Sign requirements:
  - a. Doors located close to egress doors that can be mistaken for an exit must be identified as "NO EXIT".
  - b. Code requires the "No" to be at least two inches (2") high and the "Exit" to be at least one inch (1") high so the occupants will focus on the "NO" and not the "EXIT." Furthermore, "NO" must be proportionally twice as high as the word "EXIT" on "NO EXIT" signs.

4. For specific requirements of all other interior signage, consult the Campus Architect and see Appendix C: *Campus Sign Standards*.
5. Exterior signage, including building number and name lettering, donor plaques, directional signage and department or unit signage must be approved by the Campus Architect: <https://capitalstrategies.berkeley.edu>

10 20 00 Interior Specialties

10 28 00 Toilet, Bath and Laundry Specialties

10 28 13.13 Commercial Toilet Accessories

1. Accessories

- a. Paper and soap dispensers shall be surface mounted. Recessed units are not permitted. All soap and paper dispensers to be provided by Facilities Services.
- b. Freestanding compost receptacles shall be Rubbermaid Slim Jim, 23 Gal, green in color, model FG354007GRN, unless otherwise specified. Recessed trash receptacles are not permitted.
- c. The use of pull down shelving in toilet stalls is recommended; otherwise, well-anchored stainless steel shelves shall be provided.
- d. Project shall coordinate with the University's Representative, who will coordinate with Facilities Services, before specifying toilet room accessories.

2. Stall Partitions

- a. Stall partitions may not be floor-mounted, except where required by code or elsewhere in these Design Standards. Ceiling-hung partitions shall have adequate backing or other structural support to withstand the force of the doors they serve closing with no deflection or sag. This may require structural engineering to determine appropriate support and attachment.
- b. Stainless steel and enameled steel partitions are not permitted.
- c. Plastic laminate, solid phenolic plastic and solid polymer partitions are acceptable. Solid polymer partitions are preferred for maintenance and graffiti resistance. Review partition selection with the University's Representative to assure selection is appropriate for specific conditions.
- d. In Gender Inclusive restrooms, partitions shall be floor-to-ceiling, with less than one-quarter inch (1/4") gap at top or bottom. Locks in gender inclusive-restrooms shall be Bobrick Model 1002612 Occupancy Indicator Latch (UCPD Mandatory Requirements – No Substitutions)

3. Mirrors

- a. Mirrors, if at all possible, shall be on separate wall from sink basins. Mirrors hung above sink shall be set at a maximum height of seven feet (7'-0") above floor. Soap dispensers shall not be mounted on mirrors. Provide ceramic tile or painted wallboard as mounting surface for soap dispensers.

4. Electrical Outlet and Hose Bib

- a. Provide 110v electrical outlet and standard hose bib in every restroom.

5. General Considerations

- a. In new construction and substantial remodels provide:
  - i. Custodial Break Room for custodial staff. Consider storage for personal items, facilities such as phone and data and furnishings suitable for a staff break room. Discuss specific requirements with the University's Representative.
  - ii. Lactation Room for building occupants and compliance with campus policy (Accommodation for Nursing Mothers). Rooms must:
    1. Provide private space
    2. Minimum of one (1) electrical outlet
    3. Provide a sink and counter
    4. Be keyed using Trilogy T-3 lock, in accordance with UCPD protocol for Lactation Rooms (programmed with 200 codes). Contact the Breastfeeding Support Program Manager to discuss other needs ([breastfeeding@lists.berkeley.edu](mailto:breastfeeding@lists.berkeley.edu)).

- iii. Gender-inclusive restroom facilities located on the main floor of the building, consistent with UCOP policies on gender-inclusive facilities. Campus practice is to incorporate multi-stall gender-inclusive facilities and discourages separate single-occupant gender-inclusive restrooms.
  - iv. Shower and changing room facilities when an indoor bicycle storage room is provided, consistent with LEED (one per first 100 occupants and one additional shower for every 150 occupants afterwards). Consider storage for personal items, such as lockers and furnishings suitable for such a facility targeted for bicycle commuters.
- b. Restrooms are high maintenance areas on campus. Therefore, it is important to use commercial grade products, designed for high usage. These products are cost effective in the long term.

10 40 00      *Safety Specialties*

10 43 00      *Emergency Aid Specialties*

*10 43 13      Defibrillator Cabinets*

1. Defibrillator Cabinets shall be provided in all new construction projects and for the floor(s) of a building impacted by renovation projects valued above \$1,000,000, where appropriate. Contact the AED Program at University Health Services (<https://uhs.berkeley.edu/aed>) for coordination.

*10 43 21      Emergency Evacuation Chairs*

1. Emergency Evacuation Chairs shall be provided in all new construction projects and for the floor(s) of a building impacted by renovation projects valued above \$1,000,000, where appropriate. Contact the Office of Emergency Management (<https://oem.berkeley.edu>) for coordination.

10 44 00      *Fire Protection Specialties*

*10 44 13.53      Security Fire Extinguisher Cabinets*

1. Indicate location on drawing.
2. Recessed cabinets installed in corridors and fire rated walls require approval by the Designated Campus Fire Marshal (DCFM).
3. Install standard 5lbs, 2A10BC fire extinguishers for low-level hazards. Wherever possible, match existing brand and type for consistency within the building. Fire extinguishers shall comply with California Code of Regulations, Title 19.

10 70 00      *Exterior Specialties*

10 73 00      *Protective Covers*

*10 73 43      Transportation Stop Shelters*

1. The Campus has entered into a master contract with Clear Channel Outdoor for the provisioning and maintenance of bus shelters. Projects installing bus shelters on University property or on City of Berkeley property for the benefit of the campus community shall abide by this master contract and use bus shelters as provided and maintained by Clear Channel Outdoor.

10 80 00 Other Specialties

10 81 00 Pest Control Devices

1. Special consideration shall be paid to pest control when designing, building and repairing campus environs. In addition to the items outlined below, pest control design guidelines and best practices may be found here: <http://www.sfenvironment.org/download/pest-prevention-by-design-guidelines>.
2. Exterior Light Fixtures: Exterior light fixtures shall be designed so that birds cannot roost or nest on or in them. Surfaces that would be available for roosting should have a 45 degree angle, or bird-proofing materials should be installed. This is especially important for light fixtures next to entrances to the building.
3. Exterior Doors: Gaps under and between exterior doors shall not exceed 3/16" to exclude rodents. This includes roll-down loading dock doors. Door sweeps to a door is not a long-lasting solution; the actual door shall have no more than 3/16" clearance. In areas of high rodent pressure, affix to all external doors a 26-gauge sheet metal kick plate at least twelve inches (12") tall.
4. Windows and Doors in Museum and Collection Storage: Windows opening to museums and collection storage areas such as libraries must be screened to exclude museum pests (beetles and moths). There shall be NO gap under and between exterior doors. Interior doors shall be tight-fitting, including sweeps, to prevent pests (beetles, moths, mice) from passing through.
5. Pipe Insulation and Furniture in Laboratories, Kitchens, and Animal Rooms: All pipe insulation must have smooth surfaces with no gaps. Do not install pegboard in kitchens, animal rooms or laboratories. All permanently installed furniture in kitchens, animal rooms and laboratories must be sealed at points of attachment, under countertops, and inside to prevent pests from harboring in the gaps. All built-in cabinets, closets, and similar casement/millwork must be sealed leaving no gaps in which pests may hide.
6. Exterior design: Decorative lattices shall not be placed over entrances, or shall be designed in such a way that birds will not roost on them. Avoid creating sheltered areas or cave-like openings under eaves, roof lines, etc. Use bird barrier netting or other devices to exclude pigeons from these areas. To prevent pigeons from roosting, ledges over 3 inches wide in protected areas shall have a 45 degree angle or pigeon-proofing materials shall be attached to them.
7. Exterior Pest Barriers and Seals: Seal all construction from foundation to roof to prevent access by pests such as bats, birds and rodents.
8. See Division 01 57 00: Temporary Controls for jobsite-related pest control requirements and Division 32 90 00: Planting for pest control-related planting requirements.

## 11 00 00 Equipment

### 11 50 00 Educational and Scientific Equipment

#### 11 53 00 Laboratory Equipment

##### *11 53 13 Laboratory Fume Hoods*

(See [ACGIH Ventilation Handbook](#), [8CCR5154.2](#), [ANSI Z9.5 2012](#) and [University of California Lab Safety Design Manual](#))

1. Each hood must have a quantitative airflow monitor so that operators can determine at all times if hood is functioning properly (e.g., digital airflow meter, or magnahelic gauge). The monitor should be connected to an alarm.
2. Fume hoods shall be located in areas of minimum air turbulence and away from doors and windows, and in a manner that will not impede egress.
3. Shutoff valves for services, including gas, air, vacuum and electricity, shall be outside of the hood enclosure in a location where they will be readily accessible in the event of fire in the hood. Each valve shall be individually labelled with the name of the utility that valve services.
4. Initial testing results for fume hood face velocities must be forwarded to Environment, Health and Safety (EH&S). The position of the sashes while measurements were taken shall be indicated both on the hood and in the testing results. This shall be done prior to use of the fume hood. For vertically rising sashes, the typical maximum height is eighteen inches (18”), and there shall be stops on the sash to indicate the maximum opening.
5. If a Cal/OSHA regulated carcinogen, as listed in Title 8 CCR, 5209, is to be used or stored in a hood, the satisfactory average airflow face velocity design for that hood shall be 150 FPM, at indicated sash positioning, with no measurement below 125 FPM. The typical satisfactory range for campus fume hoods is 100 -150 FPM.
6. To reduce energy use of hood systems, use variable air volume (VAV) hood controls with bypass baffles set only below the last six inches (6”) of face in buildings that have a variable volume air distribution HVAC systems. Perform a life cycle cost analysis of variable volume and constant volume systems and select optimal system. Contact the Facilities Services Energy Office for economic and financial assumptions. Any VAV control system shall have emergency switch that allows maximum flow. VAV systems are not to be used where carcinogens are regularly used.
7. See Division 23 00 00: Heating, Ventilating and Air Conditioning (HVAC) for fume hood ductwork requirements
8. The mechanical engineer shall specify fume hood (FH) types and controls (e.g. proximity sensors, sash closers, sash position or velocity sensors), snorkels, use of bypass air for exhaust, and specific TAB requirements such as room pressurization.
9. Rooftop exhaust stacks must be designed using a lab exhaust dispersion study. Alternate designs must be approved by EH&S and Energy Office. Each hood shall be labeled to indicate which hood fan it is connected to. Hood fans are typically located on roofs or outside the building envelope. Booster fans are not recommended for hazardous exhaust inside occupied buildings because they can positively pressurize the exhaust duct.
10. The fume hood exhaust system shall be designed with redundant hood fans so that exhaust is maintained in the event that one fan is not functioning.
11. Room air currents at the fume hood shall be minimized (not to exceed thirty percent [30%] of the face velocity).
12. Chemical storage areas under fume hoods shall be connected to the exhaust system. Flammable vapors shall be exhausted above the hood with metal piping. Corrosive vapors can be exhausted into the back plenum of

the fume hood, only where the connecting exhaust piping rises at least ten inches (10") above the work surface.

13. Exhaust hood fans shall be connected to emergency power that will provide at least half of normal airflow during a power failure. (Note: Not required in buildings without emergency power generation).
14. New fume hoods shall be from a manufacturer acceptable to the university and specifically approved by EH&S. All fume hood designs shall demonstrate containment of tracer gas less than 4.0AM0.01 and 4.0AI0.05 when tested according to ASHRAE Test Standard 110-1995.
15. Ductless fume hoods are not permitted without prior written approval of EH&S.
16. Green Building: All new construction and major renovations must meet the current UC policy and procedure requirements included in the UC Sustainability Practices Policy: <http://ucop.edu/sustainability/policy-areas/index.html>. The UC Sustainability Practices Policy provides guidance on the required Environmentally Preferable Purchasing, UC's USGBC LEED certification and credit requirements, and Labs21.

### *11 53 33 Emergency Safety Appliances*

1. Flammable Liquid Storage Cabinets
  - a. Flammable liquid storage cabinets shall be approved and labeled by Underwriter's Laboratory (UL) Factory Manual (FM) or the State Fire Marshal (SFM)
  - b. Provide capability to exhaust solvent storage cabinets. Vents shall be exhausted through the lower bung opening. Piping shall be resistant to high temperatures generated by fire. Stainless steel, hard-soldered copper and carbon steel are acceptable vent materials.
  - c. Doors to solvent storage cabinets shall be self-closing with a latch, but are not required to be self-latching in accordance with codes.
2. Refrigerant Leak Detection Systems
  - a. Refer to *23 60 00 Central Cooling Equipment* for requirements regarding refrigerant leak detection systems

### *11 53 53 Biological Safety Cabinets*

1. There are several classes of Biological Safety Cabinets (BSC), with the most common type on campus being the Class II. Consultation shall be required between the end user and EH&S when determining what type of cabinet is needed. For NIH guidelines, see: [http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/News\\_to\\_Use\\_June\\_2010.aspx](http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/News_to_Use_June_2010.aspx)
  - a. Placement
    - i. Biological safety cabinets shall be located out of the traffic pattern and away from doors, preferably at the dead-end of the laboratory. The cabinet should be placed so that there is a minimum clearance of three inches (3") on each side of the cabinet and at least one and one-half inches (1-1/2") in back. Sufficient clearance shall be maintained above the cabinet to allow testing, a minimum of twelve feet (12') above to any structure. The discharge from nearby supply air registers should be directed away from the cabinets. The electrical outlet for the cabinet shall be accessible for service and electrical safety testing without moving the cabinet.
  - b. Certification
    - i. Biological safety cabinets installed as part of a building or renovation project shall be tested and certified in place as meeting National Sanitation Foundation Standard 49 prior to completion of the Project. Records of certification shall be forwarded to Environment, Health and Safety (EH&S) by the Contractor or the testing and certification agency.



- c. Utility Services
  - i. Utility services needed within a BSC shall be planned for carefully. Protection of vacuum systems shall be addressed. Electrical outlets inside the cabinet shall be protected with ground-fault circuit interrupters and shall be supplied by an independent circuit. When propane or natural gas is present, a clearly marked emergency gas shut-off valve outside the cabinet shall be installed for fire safety. All non-electrical utility services shall have exposed, accessible shut-off valves. The use of compressed air within a BSC shall be carefully considered and controlled to prevent aerosol production and reduce the potential for vessel pressurization.
- d. Types of Biological Safety Cabinets. (refer to [8CCR5154.2](#) and [National Sanitation Foundation Standard 49](#))
  - i. Class II, Type A cabinets are designed to return air to the laboratory, and do not generally require external venting. If a cabinet is vented into a common exhaust system, a canopy connection is recommended (see Recommendations for Installation from NSF Manual.)
  - ii. Class II, Type B cabinets require an external exhaust blower and should be connected directly to an exhaust system that discharges to the outdoors. The venting system shall include a leak-tight duct, a damper in the duct near the cabinet to permit flow adjustment and decontamination, and an external exhaust blower as the final system component (see Recommendations for Installation from NSF Manual).
    - 1. The exhaust blower shall be sized to deliver the required exhaust airflow (as specified by the cabinet manufacturer), considering pressure losses in the duct, and allowing at least two inches of water gauge (2 iwg) for a dirty HEPA filter. If a charcoal filter is used downstream of the HEPA filter, an additional one inch water gauge (1 iwg) or the manufacturer's recommended resistance shall be provided.
    - 2. An audible and visible alarm must be provided at the cabinet to indicate loss of exhaust flow in accordance with 8CCR5154.2. This can be a differential pressure switch across the exhaust filter, air-proving sail switch at the blower discharge, or flow measuring station in the exhaust duct.
    - 3. It is recommended that each Type B cabinet have its own exhaust system and not be ganged with other Biological Safety Cabinets or chemical fume hoods. If a Type B cabinet contains an internal blower which provides or contributes to exhaust flow and feeds into a system with an external blower, the cabinet and external blowers must be interlocked.

11 60 00      [Entertainment and Recreation Equipment](#)

11 61 00      [Broadcast, Theater and Stage Equipment](#)

11 61 13      [Folding and Portable Stages](#)

- 1. Stages, risers and platforms erected for concerts or other similar events shall conform to Section 108, *Temporary Structures and Uses*, of the most recently adopted California Building Code. They must be:
  - a. Accessible, with means of ingress and egress for the disabled as required by applicable codes, regulations, and campus policies.
  - b. Erected according to the manufacturer's instructions
  - c. Inspected prior to use
- 2. Generators, cord and other ancillary equipment must conform to the applicable sections of the most recently adopted versions of the California Building Code and California Electrical Code.

11 80 00 Facility Maintenance and Operation Equipment.

11 81 00 Facility Maintenance Equipment

*11 81 29 Facility Fall Protection*

1. In all roofing replacement projects, the project shall investigate the potential for adding permanent fall protection systems in buildings that do not currently have one. Coordinate with Capital Projects and Facilities Services
2. Cal/OSHA Section 3296(b)(1) requires the University to fund inspection of fall protection anchor points and formally notify the contractor according to Cal/OSHA Section 3292(c)(3) if their employees would be using those points. The inspection must be done by an independent consultant who is a Cal/OSHA certified Scaffolding Inspection and Testing (SIT) person or company.

11 82 00 Facility Solid Waste Handling Equipment

1. Refer to Division 32 33 00: Site Furnishings for waste receptacle and enclosure requirements.
2. Compactor use shall be approved by the Owner prior to design phase.



12 00 00 Furnishings

12 20 00 Window Treatments

12 21 00 Window Blinds

12 21 13 *Horizontal Louver Blinds*

1. Type: Manually-operated horizontal blind conforming to ANSI/WCMA Standard A 100.1 for safety of corded window coverings.
  - a. Slat Width: one inch (1"). Use of two inch (2") width blinds shall be reviewed with the University's Representative.
2. Materials:
  - a. Slats: Minimum 0.008 inch thick spring-tempered aluminum with crowned profile and rounded corners.
  - b. Slat Support: Woven polypropylene, ladder configuration.
  - c. Head Rail Housing: Formed-steel "U" channel, internally fitted with hardware, pulleys, and bearings for blind operation cross braced for rigidity.
  - d. Bottom Rail: Formed-steel box to match slat and reinforced to prevent twisting or sagging. End caps shall be metal.
  - e. Lift Cord: Braided polyester/rayon, continuous loop.
  - f. Tilter: Manufacturer's standard enclosed lubricated worm-and-gear drive actuated by wand with 180-degree tilt range, designed to hold slats at set angle.
  - g. Control Wand: Extruded transparent plastic.
  - h. Equalizers: Self-aligning, nylon, designed to maintain blind slats in horizontal position.
  - i. Accessory Hardware:
    - i. Pocket-type hinged mounting brackets.
    - ii. Valances are not permitted unless they are integral part of head rail housing.
  - j. Finish and Exposed Metal Components: Factory-applied, light-colored.
3. Fabrication and Installation:
  - a. Control wand and lift cord shall be in length sufficient for easy operation from a convenient position and meet required accessibility requirements. Locations shall be specified or indicated on the Drawings.
  - b. Blind height shall not exceed twelve feet (12'-0"). At areas requiring greater height, provide two (2) blinds stacked one above the other.
  - c. Widths shall not exceed seventy-two inches (72").
  - d. Blinds shall be "between jamb" mounted unless face of wall mounting is required by Project conditions.
  - e. Divisions between blinds shall occur only at mullions of continuous windows or openings where more than one (1) blind for one (1) opening occurs.

12 21 16 *Vertical Blinds*

1. Type: Manually-operated, rotating and traversing vertical louver blinds.
  - a. Louvers shall traverse and rotate 180 degrees.
  - b. Slat Width: Nominal 3-1/2 inches.
2. Materials:
  - a. Slats: Minimum 0.010 inch thick curved and spring-tempered aluminum

- b. Headrail: Heavy-duty gear-reduced aluminum channel track with matching end caps.
  - c. Rotation: Nickel-plated brass beaded chain.
    - i. Sprocket and gear rack assembly shall provide not less than 10-to-1 mechanical advantage.
    - ii. Louvers shall remain parallel to each other and rotate in unison.
  - d. Traversing:
    - i. Control shall be a lock-knit polyester cord, stretch resistant, non-fraying and lint free.
    - ii. End caps and traversing mechanism shall lead cord through carrier bodies away from gears.
3. Fabrication and Installation:
- a. Traversing shall conform to Project conditions with direction at each opening shown on Drawings.
  - b. Chain operator shall be in length sufficient for easy operation from a convenient position and meeting required accessibility requirements.
  - c. Blinds shall be inside ceiling mounted unless face of wall mounting is required by Project conditions.
  - d. Divisions between blinds shall occur only at fixed mullions.
  - e. Finish and Exposed Metal Components: Factory-applied, light-colored.

## 12 24 00 Shades

1. General:
- a. Type of shade fabric and method of operation shall be selected to meet specific project requirements.
  - b. Dual shade systems, with both shades located in the same pocket, shall be used where both blackout and light filtering fabrics are required at the same location.
  - c. Use of motor-operated systems shall be reviewed with the Project Manger and shall be considered where bead chain length is excessive or not accessible, or blackout shades are required to interface with A/V equipment.
  - d. Removal of shade shall not require disassembly of shade unit.
2. Materials and Fabrication:
- a. Shade Cloth:
    - i. Shade cloth shall have no seams and hang flat without buckling or distortion.
    - ii. Edge, when trimmed, shall hang straight without raveling.
    - iii. An unguided roller shade cloth shall hang true and straight, without shifting sideways more than 1/8 inch in either direction due to warp distortion or weave design.
    - iv. Shade fabrics shall be certified by an independent testing laboratory to pass NFPA 701 and applicable code requirements.
    - v. Each shade shall fully cover the opening where it occurs.
  - b. Drive Assembly:
    - i. Shall be factory set for size and travel of shades.
    - ii. Shall be adjustable from exterior of shade unit without disassembly of hardware.
    - iii. Shall have a built-in shock absorber system to prevent chain breakage under normal usage conditions.
  - c. Chain at Manual Shades: No. 10 stainless steel bead chain formed in a continuous loop.
    - i. Chain operator shall be in length sufficient for easy operation from a convenient position and meet required accessibility requirements.
  - d. Shade support hardware shall be capable of supporting 150 percent of the full weight of each shade.
  - e. Power Operators:
    - i. Control systems and components shall be approved as a system by either Underwriter Laboratories (UL) or Electrical Testing Laboratories (ETL).

- ii. Motor: Fractional horsepower asynchronous motor with reversible capacitor designed for intermittent operation.
  - 1. Thermally protected, temperature Class A, totally enclosed.
  - 2. Solenoid activated disk brake mechanism shall stop and hold shade in any position and shall have externally adjustable internal limit switches. The brake shall automatically disengage when motor is operating.
  - 3. Electrical Components: CSA and UL Rated.
  - 4. The motor shall be concealed within the shade tube and shall be maintenance free.
- iii. Controls: three (3) position rocker-type wall switch. Locations shall be shown on the Drawings and match other switches provided under Division 26: Electrical.
- iv. Motor Control System: To be coordinated with the University's Representative for specific Project requirements and for interface with low voltage audio-visual systems.

3. Warranty:

- a. Tracks, gear-and-sprocket mechanism, and accessories for shades shall be warranted for five (5) years against defects in materials and workmanship which inhibit proper and intended functioning of products.
- b. Shadecloth shall not deteriorate, sag or warp and will remain fit for use for the full warranty period of not less than ten (10) years.
- c. Motors shall be warranted to be free of defects in manufacture for not less than two (2) years.

12 30 00 Casework

- 1. Casework shall be of the North American Architectural Woodwork Standards (NAAWS) "Custom" grade or/and conform to the most recent edition of the NAAW, as appropriate for their use and type.
- 2. Review with the University's Representative all casework standard requirements.
- 3. Review with the University's Representative requirements for mock-ups.
- 4. Contact the Be Well at Work Ergonomics Program ([ergotf@uhs.berkeley.edu](mailto:ergotf@uhs.berkeley.edu)) for an ergonomics review when designing the following environments: computer workstations, laboratory animal facilities, customer service reception counters/windows, dining facilities, housing facilities, research laboratories, computer labs and loading docks/receiving areas.

12 40 00 Furnishings and Accessories

12 40 00 Furnishing Accessories

12 46 33 Waste Receptacles

Indoor Building Receptacles--For additional and updated information on the following standardized indoor receptacles, please visit <http://zerowaste.berkeley.edu>.

- 1. For all indoor public centralized lobbies, entrances and exits, use Max-R centralized collection units or Forms and Surfaces centralized collection units:
  - a. Max-R centralized collection unit. <http://www.max-r.net/>. Use Item# 88-Berkeley-06 unit.
  - b. Forms and Surfaces centralized collection unit may be used as alternate. <https://www.forms-surfaces.com/triad-litter-recycling-receptacle>
    - i. Use the following FOUR Triad Receptacles as ONE SET with the following receptacles (note: new graphics on the rim plus new graphics on the top are required):
      - 1. Landfill:
        - a. SB: Triad Receptacle
        - b. Capacity: 16 Gallon;

- c. Lid Opening: Triangular;
  - d. Lid Color: Black;
  - e. Lid Graphic Copy/Color: "Landfill" & Symbol/White;
  - f. Lid Graphic Background Color: Black;
  - g. Body Material: Stainless Steel;
  - h. Body Finish: Sandstone;
  - i. Mounting: Freestanding
2. Bottles And Cans:
    - a. SB: Triad Receptacle
    - b. Capacity: 24 Gallon;
    - c. Lid Opening: Bottles/Cans;
    - d. Lid Color: Blue;
    - e. Lid Graphic: Bottles & Cans;
    - f. Lid Graphic Background: Blue
    - g. Lid Graphic Color: White;
    - h. Body Material: Stainless Steel;
    - i. Body Finish: Sandstone;
    - j. Mounting: Freestanding
  3. Mixed Paper:
    - a. SB: Triad Receptacle
    - b. Capacity: 24 Gallon;
    - c. Lid Opening: Paper;
    - d. Lid Color: Blue;
    - e. Lid Graphic Copy/Color: "Paper" & Symbol/White;
    - f. Lid Graphic Background Color: Black;
    - g. Body Material: Stainless Steel;
    - h. Body Finish: Sandstone;
    - i. Mounting: Freestanding
  4. Compost:
    - a. SB: Triad Receptacle
    - b. Capacity: 24 Gallon;
    - c. Lid Opening: Litter;
    - d. Lid Color: Green;
    - e. Lid Graphic: Compost;
    - f. Lid Graphic Background: Green;
    - g. Lid Graphic Color: White;
    - h. Body Material: Stainless Steel;
    - i. Body Finish: Sandstone;
    - j. Mounting: Freestanding
2. For eateries, cafés and restaurants, use Max-R centralized collection unit or Max-R centralized Busser collection unit.
    - a. Max-R centralized collection unit. <http://www.max-r.net/>. Use Item# 88-Berkeley-06 unit.
    - b. Max-R centralized busser collection unit. <http://www.max-r.net/>. Use Item# 88-UC Berkeley-12 unit.
  3. For breakrooms, kitchenettes, and common rooms, use Rubbermaid Slim Jim central collection units.
    - a. Rubbermaid Slim Jim central collection units. <http://zerowaste.berkeley.edu>. Please see Bin List: Standard Sets.
  4. For offices and cubicle spaces, please use Rubbermaid deskside mixed paper mini bin and landfill side saddle.

- a. Rubbermaid Slim Jim central collection units. <http://zerowaste.berkeley.edu>. Please see Bin List: Standard Sets.

5. For outdoor receptacles, see Section 32 33 23 *Site Trash and Litter Receptacles*.

12 50 00 Furniture

12 51 00 Office Furniture

*12 51 16 Case Goods*

1. Contact Be Well at Work Ergonomics Program ([ergotf@uhs.berkeley.edu](mailto:ergotf@uhs.berkeley.edu)) for an ergonomics review when:
  - a. Designing, building or installing computer workstations or computer labs;
  - b. Trying to achieve the LEED credits for following the campus ergonomics strategy for computer workstations;
  - c. Selecting or purchasing office task chairs and stools that are not on the pre-approved products list (<https://uhs.berkeley.edu/facstaff/ergonomics/pre-approved-product-list>)

12 57 00 Industrial Furniture

*12 57 19 Laser Containment Screens*

1. Facilities in which Class 4 laser equipment will be used shall require special design considerations. Coordinate with the University's Representative and the EH&S Laser Safety Officer for special laser facility design requirements.

13 00 00 Special Construction

13 20 00 Special Purpose Rooms

13 25 00 Laboratory Protections

*13 25 13 Lasers*

1. Facilities in which Class 4 laser equipment will be used shall require special design considerations. Coordinate with the University's Representative and the EH&S Laser Safety Officer for special laser facility design requirements. See also *12 57 19: Laser Containment Screens*

*13 25 16 Toxic Gases*

1. Facilities that handle toxic or pyrophoric gases (e.g. silane, carbon monoxide, ammonia, hydrogen, etc.) shall require special design considerations, and storage of cylinders with proper exhaust (e.g. gas cabinets). Coordinate with the University's Representative and EH&S for special construction and/or permit requirements (Bay Area Air Quality Management District, Cal-OSHA, et al). All projects shall comply with the UC Berkeley Toxic Gas Program: <http://www.ehs.berkeley.edu/sites/default/files/lines-of-services/workplace-safety/toxicgasprogram.pdf>

13 29 00 Food Facilities

1. Facilities in which food will be stored, prepared or otherwise handled will require design considerations and construction plans and will need to be approved by the EH&S Sanitarian. Coordinate with the University's Representative and EH&S for design requirements and approvals.
2. Commercial kitchen ventilation systems must comply with Title 24 2013 and shall not be considered as unregulated process loads.

13 30 00 Special Structures

13 34 00 Fabricated Engineered Structures

*13 34 23 Fabricated Structures*

1. Portable structures, mobile units, or small buildings used for permanent or temporary storage are not permitted on campus, in keeping with the University's Policy on Temporary Structures (<http://vpsafp.berkeley.edu/policy-on-temporary-structures>).
2. Variances to this policy may be requested from the Campus Architect: <https://capitalstrategies.berkeley.edu>

13 40 00 Integrated Construction

13 49 00 Radiation Protection

*13 49 13/16 Integrated/Modular X-Ray Shielding Assemblies*

1. Coordinate with the UC Berkeley Environment, Health & Safety Office (EH&S) via the University's Representative.
2. Review with the University's Representative inspection requirements and testing. (See California Code of Regulations, [Title 17](#))

## 14 00 00 Conveying Equipment

### 14 20 00 Elevators

1. Conveying Systems Variance To Code
  - a. No variance to code shall be sought from the State prior to written approval from the University. Copies of variances approved by the State shall be provided to the University's Representative within fourteen (14) days after release.
2. Types Of Elevators
  - a. Provide hydraulic elevators for a maximum rise of fifty feet (50'-0"). Use traction elevators for travel distance over fifty feet (50'-0").
  - b. Minimum of one (1) car shall be designated as a service/freight elevator.
  - c. Stainless Steel or other easily-maintained finish shall be required.
3. Theoretical Traffic Analysis Study
  - a. The Architect shall have the elevator consultant submit to the University's Representative a completed theoretical traffic analysis of the anticipated traffic demands to evaluate the handling demands, based on speed, capacity and type of elevators to be incorporated into the building design.
  - b. Analysis results shall be reviewed with the University's Representative during the Schematic Design Phase and before proceeding to Design Development Phase.
4. Required Features and Products
  - a. Each elevator shall be completely described in the Specifications.
  - b. Provide elevators with the following:
    - i. LED digital floor indicator light in car operating panel with arrows.
    - ii. LED hall position indicator at main lobby floor only landings. Combine with hall lantern. Call buttons at all landings with 100,000-hour LED call button lamps.
    - iii. LED hall lanterns at all floors with electronic chimes (one for up, two for down).
    - iv. Should car-riding lanterns be required, provide LED type (two each car).
    - v. Make accessibility provisions. Specify dimensions and mounting heights in accordance with the most recently adopted California Building Code.
    - vi. Earthquake safety devices: Provide, at a minimum, dual ring and string and seismic switch on traction elevators. Provide, at a minimum, power unit tie-downs on hydraulic elevators. For motors rated 50 horsepower and below, provide hydraulic submersible pump units.
    - vii. An alarm bell at top and bottom of travel and every two (2) floors in between. Alarm to be different tone from classroom or fire alarms.
    - viii. Provisions for a telephone with telephone conduit and box in Machine Room. Run conduit and telephone wire to telephone terminal. Provide and install speaker phone as manufactured by Ram Tech, Model No. R2A-S with DA1 and PD, consisting of a combination speaker/microphone, amplifier, automatic dialer, push button to activate system and off hook switch (off button). Provide telephone unit in standard telephone back box with four (4) tamper-proof screws. Phone system shall be operational with wiring from elevator car to the electrical equipment room. Automatic dialer shall be programmed as directed by the University. The system shall match existing University Ram Tech system without modification.
    - ix. Handrail on rear wall of elevator cab. Through 3/8-inch bolt handrail to back of enclosure with 1/4-inch backing plate.
    - x. Pad hooks and protection pad for all sides of car interior with sectional cut-outs for operating fixtures.

- xi. Heavy-duty door operator. Specify door operator as manufactured by GAL, MCE SmarTraq or ECI, no known equal. Manufacturer recommended diagnostic tools shall be provided.
  - xii. If elevator will not be provided backup or emergency power capable, of running the elevator, controls shall include a battery backup capable of moving the elevator to a predetermined floor and opening the doors.
  - xiii. Electronic scanning type door protection distributed by the The Fixture Company, Model FCu 47 Detector Edge, or Janus Elevator Pana40 Plus, or Tri-Tronics IG-R.
  - xiv. Fire emergency service and products of combustion detectors where travel is twenty-five feet (25'-0") or more.
  - xv. Medeco KeyMark x4 system keys. Refer to Section 08 70 00: Hardware and coordinate keying with University's Representative and. Provide "Adams" Phase I, and Phase II firefighter's service switches. To comply with DSA requirements, car floor buttons or hall call buttons shall not be subject to use of a key type switch to register the call.
  - xvi. Machines shall be Hollister-Whitney. Rollers and guides shall be ElSCO, Elpro, Hollister-Whitney or Torin.
  - xvii. Floor-passing gong. Gong shall operate as each floor is passed per code requirement.
  - xviii. Position indicators shall be manufactured by CE Electronics, ERM, and Adams Elevator Co., no known equal.
  - xix. Certificate holders shall be provided in the car opening panel, in a keyed service panel door.
- c. Confirm with the University's Representative to ensure that the selected car entrance heights and internal cab heights are suitable for the intended movement of materials that require elevator transportation.
  - d. Coordinate miscellaneous metals work relating to elevators including machinery guards (designed and installed compliant to CalOSHA Title 8 3944 and 4186), pit ladders, machine room steps, guardrails in raised areas and at hazardous roof door entrances to machine rooms, sump pit gratings, and hoistway screens.
  - e. Provide door closers and locksets (that cannot be left unlocked) on access door or doors to Machine Room space.
  - f. Security:
    - i. When a building security system is incorporated into the elevator operation with the use of key switches and card readers, the security system shall be arranged to allow elevators to operate as intended by code and allow firefighter's override.
    - ii. To assure compliance, the device shall be tested and witnessed by a Facilities Services representative within thirty (30) days of the elevator being turned over to the University.

## 5. Submittals

- a. Submittals shall include:
  - i. Dimensioned shop drawings showing relationship to finishes and structure including hoistway plan, hoistway section, machine room plan, car and entrance details, mechanical and electrical connections.
  - ii. Product data and finish samples.
- b. Before final payment, the following shall be submitted and provided:
  - i. Wiring diagrams: Five (5) hard copies and electronic version (both PDF and DWG format) of both full line and schematic diagrams. Include nomenclature definitions and symbols key.
  - ii. Five (5) hard copies and electronic version (PDF format) of operation and maintenance manuals, parts list, warranty/guarantee, diagnostic documentation, sequence of operation and manufacturer part numbers



- iii. Five (5) additional hard copies and electronic version (PDF format) of final approved submittals to the University's Representative.
  - iv. Wall Holder For Diagrams: The Contractor shall mount a complete set of wiring diagrams including a definition of all nomenclature and symbols on the Machine Room wall laminated in clear plastic. The mounting method is to be reviewed by the Project Management and Facilities Services Representatives.
  - v. Wire Pull Sheets: These shall be left at the Project site and shall become the Owner's property for the purpose of future trouble-shooting.
- c. Listing of Maintenance Materials to be Furnished by Contractor:
- i. Traction and Hydraulic Elevators:
    - 1. Expendable Parts: The elevator Contractor shall provide a metal cabinet in every machine room on Project premises containing the following expendable parts required for prompt replacement. The metal cabinet and the un-expendable parts shall become the property of the University and remain at the end of the twelve (12) months' warranty/maintenance period.
      - a. Two (2) relays of each type installed. Twenty (20) lamps of each type installed.
      - b. Car and hall buttons with identical graphics installed; six (6) for manufacturer's standard buttons, one (1) of each type for special buttons.
      - c. Twelve (12) fuses of each type installed.
      - d. Other parts required for prompt replacement.
      - e. One (1) digital LED position indicator and one driver board of each type. One (1) directional lantern and chime of each type.

#### 6. Contract Document Coordination

- a. The Contract Documents shall be coordinated to comply with and provide the following items:
  - i. Mechanical and Electrical:
    - 1. Light and GFCI electrical outlet in pit and machine room.
    - 2. Machine room lighting intensities. Electric service sizing to equipment.
    - 3. Emergency power transfer switch prior signal for emergency and normal power operation.
    - 4. Elevator disconnects.
    - 5. Smoke detectors, shunt trips, and heat sensors where required. Telephone provisions in machine room.
    - 6. Utility piping or ducts in shaft is not allowed.
    - 7. Utility piping in machine room is not allowed.
    - 8. Adequate machine room ventilation to prevent heat build-up, in accordance with CBC- Chapter 30, Section 3005.1. Limit temperature range to sixty five to ninety degrees Fahrenheit (65° F to 90° F).
    - 9. Shaft and hoistway ventilation.
    - 10. Drain or provisions for pump in pit including isolation of accumulated waste.
    - 11. Emergency telephone in elevator cab (see Section 4: Required Features and Products, above). Provide heat sensors where required.
    - 12. Provide shunt trip device outside machine room and 120 V supply to operate the shunt trip plunger.
    - 13. Provide auxiliary contacts in hydraulic elevator disconnect, when using battery lowering.
    - 14. Provide two-way conversation between car and readily accessible point outside the hoistway, which is available to emergency personnel, with standby power back-up.
    - 15. Elevator Firefighters Service to override all car security systems.

16. Electrical lights, switches and convenience outlets located below four feet (4'-0") from floor to be NEMA-4 rated equipment.
- ii. Architectural:
  1. Shaft venting shall comply with all prevailing code.
  2. Ceiling height in machine room per code.
  3. Clearance between top of car and roof beam per code.
  4. Stairs (not vertical ladders) for access to, or in, machine room.  
Miscellaneous metals shown and specified: pit ladders, screens, sill angles, railings.  
Telephone provisions in car.
  5. Vandal-resistant handrails and finishes.
  6. Head, jamb, sill details.
  7. Machine room walls/floor/ceiling and hoistway walls minimum STC rating of 50 at occupied spaces. Fire-ratings per code and guideline requirements.
  8. When provided, locate security card readers recessed into car operating panels.
- iii. Structural:
  1. Provide structural supports for guide rails for the full height of each hoistway. Coordinate with the Designated Campus Fire Marshal (DCFM) and other jurisdictional agencies.

## 7. Warranty and Maintenance

- a. The elevator company shall provide a one (1) year warranty including parts and labor and a one (1) year maintenance period conforming to the requirements of the Campus Elevator Maintenance Requirements.
- b. The warranty and maintenance shall cover elevator equipment and controls.
- c. The Contractor shall provide three (3) hours minimum of training for University personnel by a qualified elevator adjuster.
- d. Starting time for warranty and maintenance periods shall be determined at time of elevator acceptance in coordination with the University Representative and Division 1.

## 8. Selection Of Equipment

- a. For University dormitories and housing, consult with the University's Representative for minimum-rated load requirements for passenger elevators due to student tendency to overcrowd cars.
- b. Selection of traction or hydraulic elevators shall be based on an analysis of long-term cost, speed or quality of service, quietness and availability of machine room space. Selected equipment shall be approved by Facilities Services Elevator Shop Lead and the University's Representative.
- c. The Architect shall prepare a vertical clearance diagram indicating travel of the car, top and bottom clearances, height of penthouse and depth of pit, as related to the building structure. Submit this to the University's Representative for approval before proceeding with the Contract Documents.
- d. Controls shall be of the solid-state micro-processor type. Specify controls by Smartrise Engineering, Sacramento, CA or Motion Control Engineering, Rancho Cordova, CA; no known equal. If a field tool is required to service any part of the elevator, the tool and its supporting documentation shall be supplied and become the property of the University. Each system shall incorporate internal diagnostics with a monitor and a keyboard supplied in a locked cabinet.
- e. The disconnecting means for the elevator controller shall be a motor circuit switch rated in horsepower. It shall be fused with current limiting dual element fuses.
- f. Signal fixtures shall be of the vandal-resistant type. Specify fixtures by Adams or ERM-CA-93, Survivor Plus type no known equal. Buttons shall be raised 1/8". Provide a Best on-off key switch for each floor in the car-operating panel subject to Division of the State Architect (DSA) approval of the key switch control of car or lobby buttons.

- g. Cab interiors for classrooms and student housing projects shall be vandal-resistant. Plastic, waffle grid type ceilings shall be avoided.
- h. Cab lighting shall be long-life, UCB Standard size, LED lamps with easy access for lamp replacement.

#### 9. Elevator Pit Drains

- a. Hydraulic elevator pits shall be constructed so as to capture and isolate contaminants such as oil or water from fire sprinkler systems. Equipment related to the water removal system shall not be located in the pit, elevator hoistway, or machine room. There shall be no connection to either sanitary sewer or storm drain systems ([California Code of Regulations, Title 8, Ch. 4, Sub 6](#); EBMUD Ordinance; MS4 WDR 2013-001).
- b. Provide a GFCI outlet for a portable pump.
- c. Electrical lights, switches and convenience outlets located below four feet (4'-0") from floor to be NEMA-4 rated equipment.
- d. Flood water discharge from elevator pits and sumps shall comply with the requirements and procedures included under Division 22.
- e. Elevator pits shall have waterproofing both interior and exterior. Coordinate with Division 7.

#### 10. Machine/Control Room

- a. The elevator machine/control room shall be identified with signage on the door or wall.

#### 11. Equipment Room Ventilation

- a. When an elevator is provided with emergency power operation, the machine room mechanical ventilation shall be provided with emergency power.
- b. See additional requirements for ventilation included in Division 23.

#### 12. Electrical Services

- a. The amperage requirements for elevator machine motors, isolating transformers and controllers, require higher full-load starting and running currents, and, due to distance from power source, are subject to higher voltage drop. These requirements and conditions shall be considered when selecting and sizing conductors.
- b. Obtain the full load current from the elevator manufacturer. Do not exceed voltage drop limitations. For motor voltage rating see Division 26.
- c. Provide lights, light switches and GFCI convenience outlets in pits and all machine room spaces. The car lighting and power circuit disconnect shall incorporate over-current protection.
- d. Provide a continuous grounding conductor from the building ground to the elevator controller/isolating transformer as applicable.

#### 13. Controller Cabinets

- a. Controller cabinet doors shall be capable of key locking.

#### 14. Hydraulic Elevators

- a. Installation of hydraulic elevators shall include:
  - i. Manual pit shut off valve in the fluid line between the pump and jack. Provide second shut off valve in machine rooms.
  - ii. Provide seismic shut off valve in fluid line adjacent to jack to shut off line in the event of a sudden loss of pressure or line rupture.
  - iii. Oil viscosity control.
  - iv. Roller guide shoes.
  - v. Main line strainer.

- vi. Low oil control in the electric control circuit. Discuss the function with the University's Representative.
- vii. Provisions for noise reduction such as sound insulating panels, sound isolating couplings in oil lines, oil hydraulic silencer (muffler), and vibration pads.
- viii. Cathodic protection system for the jack cylinder: 100 psi, PVC liner with sealed bottom, special backfill, and isolated pipe couplings, as required for a complete installation.
- ix. Jack cylinder protective coating of two (2) layers of tape wrap or fiber glass, outer casing of 10 gauge steel with 0.20 percent copper content, inside diameter eight inches (8") greater than outside diameter of buried cylinders, welded steel bottom or concrete plug.
- x. Provide solid state closed transition motor starting. All starters shall be heavy-duty horsepower NEMA rated regardless of horsepower. IEC method of rating starters is not acceptable.
- xi. Electrically-operated scavenger pump to return oil from cylinder head to tank. Provide 3/8-inch copper tubing for return line. Pumps shall be secured to the pit floor to prevent them from overturning if water enters the elevator pit. Scavenger pumps shall be equipped with an external float device that will render the pump inoperable should the pump become submersed.
- xii. Telescoping jacks are not allowed.
- xiii. An auxiliary-power lowering device shall be provided that will, upon failure of the main power supply, allow a hydraulic elevator to descend to the lowest landing and prevent entrapment of passengers.

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## 21 00 00 Fire Suppression

### Part 1 – General

#### 1.1 Scope

- A. The fire sprinkler contractor shall provide a fire sprinkler system throughout the building except as specifically noted in these specifications. The fire sprinkler and standpipe systems shall be designed and installed in accordance with all applicable codes and standards and these specifications. See also Water Utilities Standards.

#### 1.2 Acronyms and Definitions

- A. ACI – American Concrete Institute
- B. A.F.F. – Above Finished Floor level
- C. AHJ – Authority Having Jurisdiction – Campus Fire Marshal
- D. AWWA – American Water Works Association
- E. CBC – California Building Code (including amendments in Chapter 35)
- F. CCR – California Code of Regulations
- G. CEC – California Electrical Code
- H. CFC – California Fire Code (including amendments in Chapter 47)
- I. CFM – UCB Campus Fire Marshal or UCB Deputy Fire Marshal
- J. CMC – California Mechanical Code
- K. EBMUD – East Bay Municipal Utility District
- L. EH&S – Office of Environment, Health & Safety
- M. FS – Facilities Services
- N. FACU – Fire Alarm Control Unit
- O. FDC – Fire Department Connection
- P. FM – Factory Mutual (FM Global)
- Q. NFPA – National Fire Protection Association
- R. UCB – University of California at Berkeley
- S. University – University of California at Berkeley
- T. Approved – Acceptable to the CFM
- U. Control Valve – A valve that controls the supply of water to the fire sprinklers and/or standpipe hose valves and if closed will prevent water from supplying the fire sprinkler system and/or standpipe system. It does not include drain valves, inspector test valves, trim valves on backflow preventers, or system valve trim valves.

#### 1.3 Authority Having Jurisdiction

- A. The Authority Having Jurisdiction shall be the UCB Campus Fire Marshal.

#### 1.4 System Description

- A. The fire sprinkler system shall be a wet pipe system unless otherwise approved by the CFM.
- B. Where a pre-action system is to be installed, the system shall be a single interlocked system with air supervision in the piping.
- C. All sprinkler and standpipe systems shall include all required and necessary equipment and devices required by the design standards identified in these specifications and any other equipment or device required by these specifications.

- D. The fire sprinkler and standpipe systems must be designed such that a fire pump is not needed unless the standpipe is required to be of the automatic wet pipe type. If the sprinkler contractor determines that a fire pump is needed, the sprinkler contractor shall submit preliminary plans and hydraulic calculations to the CFM for review and approval. Should it be determined that an increase in pipe diameter, change in sprinkler spacing, change in the sprinkler K-Factor, or other change in the design will result in a fire pump not being needed, such changes to the design shall be made without additional cost to the University. Additional hydraulic calculations and design required to comply with this section shall be made at no additional cost to the University.

## 1.5 Contractor Qualifications

### A. CA License

1. The Contractor shall possess a valid California C-16 Contractors License issued by the California Contractors State Licensing Board.
2. The Contractor shall maintain the License for the duration of the project. Upon any revocation or suspension of the License, the Contractor shall notify the University's Representative and the UCB Fire Marshal within 48 hours. The contractor shall immediately cease all work and not continue until proof of reinstatement is provided to the University's Representative and the CFM.
3. The Contractor shall submit to the UCB Fire Marshal proof of the proper Certifications and Registrations of all employees installing the fire protection systems as required by the Office of the State Fire Marshal.

### B. Experience

1. The Contractor shall provide sufficient documentation to UCB demonstrating that the Contractor has successfully designed and installed fire sprinkler systems and standpipe systems of comparable size and complexity by providing three (3) references of similar work within the last five (5) years.

## 1.6 Codes and Standards

- A. The Contractor shall comply with all requirements of the Project Specifications and the the most recent edition of the following codes and standards as they relate to fire sprinkler systems, standpipe systems, fire service mains, fire pumps, and water storage tanks and the construction thereof except as modified by these specifications:

1. California Building Code
2. California Fire Code
3. California Mechanical Code
4. California Electrical Code
5. NFPA 13
6. NFPA 14
7. NFPA 20
8. NFPA 22
9. NFPA 24

- B. Where deviations from the requirements of the codes and standards identified in these specifications or from UCB Campus standards, or from manufacturer's recommendations are necessary, the contractor shall submit a Request for Information (RFI). Approval of Capital Projects, Facilities Services (FS), and the Campus Fire Marshal are required prior to the work being started.

- C. Where a requirement in these specifications is different than that in the Codes and Standards identified above, compliance with the more stringent requirement is required. Where a conflict

exists between these Specifications and the requirements of the required Codes and Standards, the final resolution will be made by the UCB CFM. Such discrepancies shall be brought to the attention of the CFM by the fire sprinkler contractor prior to the start of work. Failure to notify CFM prior to start of work will result in the work being performed at no cost to the University.

- D. Severability - If a provision of these Specifications is or becomes illegal, invalid or unenforceable, the validity and enforceability of all other provisions of these Specifications shall remain valid and in effect.
- E. Requests For Information (RFI) shall include:
  - 1. Building name
  - 2. Project number (as established by the University)
  - 3. Project name
  - 4. RFI number
  - 5. The name, company name, address, telephone number of the individual making the request
  - 6. Date of the RFI
  - 7. Description of the request
  - 8. Appropriate section numbers of the codes and standards involved
  - 9. A copy of the manufacturer's opinion or justification (where appropriate)
  - 10. The sheet number(s) of the plans in question
  - 11. A copy of the plans (architectural, shop drawings, etc.) as appropriate
  - 12. A copy of the appropriate section of the specifications
  - 13. A statement of why compliance with the applicable codes, standards, and specifications is not possible.
  - 14. Manufacturer's data sheets for equipment and devices involved in the RFI.

#### 1.7 Fire Sprinkler System Design Criteria

- A. Automatic fire sprinkler systems are required by the University for the following types of buildings:
  - A. All new buildings.
  - B. Existing campus buildings undergoing major remodeling.
  - C. Newly purchased buildings that are to be renovated.
  - D. Discuss small additions and minor remodeling projects with Designated Campus Fire Marshal (DCFM) and Capital Projects (CP).
  - E. Design and installation shall comply California Building Code, California Fire Code, NFPA Standards 13, 14, 20, 22 and 24, and Campus Design Standards.
- B. Hazard Classifications: The fire sprinkler system shall be designed and installed as a hydraulically calculated system as required by NFPA 13 and these specifications for the following Hazard Classifications:

Room/Area	Hazard Class	Density (gpm/sq.ft.)	Remote Area (sq.ft.)	Maximum Protection Area per Sprinkler (sq.ft.)
Office	Light	0.10	1,500	225



Laboratories	Ordinary Group 2	0.17	3,000	130
Cleanrooms	Ordinary Group 2	0.17	3,000	130
Areas outside of Cleanrooms	Ordinary Group 2	0.17	3,000	130
Storage Rooms	Ordinary Group 1 (Minimum) (1)	0.15	1,500	130
Storage Rooms	See NFPA 13 Miscellaneous Storage Requirements			
Mechanical Rooms	Ordinary Group 1	0.15	1,500	130
Electrical Rooms	Ordinary Group 1	0.15	1,500	130
Mobile Compact Shelving (2)				
Library stack areas (3)	Ordinary Group 2	0.20	1,500	130
Library reading areas	Light	0.10	1,500	225
(1) Depending on the floor area, commodities stored, and the storage arrangement, the Hazard Classifications may be increased.				
(2) Mobile Compact Shelving – Consult with the Campus Fire Marshal				
(3) Refer to NFPA 13 for sprinkler spacing and location requirements				

- C. Protection area per Sprinkler - The maximum protection area per sprinkler shall be in accordance with NFPA 13, the sprinkler listing, and these Specifications.
- D. The reduction in operating area for quick-response sprinklers as permitted by NFPA 13: 11.2.3.2.3 shall not be used for new installations.
- E. The Room Design Method as permitted by NFPA 13: 11.2.3.3 shall not be used for new installations except for dormitory sleeping rooms.
- F. When specifically approved by the CFM, sprinklers are not required in the following areas:
  - 1. Rooms or areas identified in NFPA 13
  - 2. Rooms or areas identified in CBC Section 903.3.1.1.1
  - 3. Rooms or areas identified in CFC Section 903.3.1.1.1
- G. Obstructions to sprinkler activation and discharge – NFPA 13: 8.6.5.2.1.4 shall not be used in the design and installation of the fire sprinkler system.
- H. An assembly including all necessary equipment and devices to test the backflow preventer at full system flow shall be installed. The contractor shall provide a pressure gauge immediately upstream and downstream of the backflow preventer. The gauges shall be connected using a 3-way valve.
- I. A master water flow switch shall be installed in the sprinkler piping where the piping enters the building at a location determined by the CFM.
- J. The fire service main supplying the fire sprinkler system and the fire standpipe system shall be dedicated to the fire sprinkler and fire standpipe systems, unless specifically approved by the CFM to also supply the domestic and/or irrigation systems.
- K. The design and installation of all water-based fire protection systems shall include all equipment, assemblies, and devices necessary to conduct acceptance inspections and testing as well as periodic inspection, testing, and maintenance as required by the California Code of regulations, Title 19, Chapter 5.
- L. Where wet pipe system sprinklers are used to protect windows, sprinklers listed for window protection shall be used.

1. The window sprinklers shall be supplied by a separate and dedicated floor control valve assembly. Where multiple levels of window sprinklers are used, each level shall be supplied by a separate and dedicated floor control valve assembly at each respective floor.
  2. Window sprinklers shall be provided on both sides of the window being protected.
  3. The system design shall include hydraulic calculations for a design area for the floor sprinklers as required for the hazard being protected combined with the window sprinklers in the same area. Flows for each system shall be hydraulically balanced at the common point of connection at the riser. The number of window sprinklers shall be all window sprinklers within a length equal to  $1.2\sqrt{\text{Area of operation}}$ .
  4. Additional floor areas shall be calculated as needed in order to determine the hydraulically most demanding area.
- M. Where deluge system open nozzles are used to protect windows on the exterior side of the windows, such nozzles shall be listed for window protection. Closed sprinklers listed for window protection may be used provided the fusible element is removed.
- N. For combined sprinkler/standpipe systems, the hose stream allowance required by NFPA 13 shall be added at the standpipe hose valve nearest to the floor control valve assembly used in the hydraulic calculations.
- O. Hydraulic calculations shall be provided for each floor.
- P. For buildings with multiple risers/systems hydraulic calculations are required for each system.
- Q. For residential occupancies, only concealed sprinklers shall be used, except in spaces not normally open to the public or residents.

## 1.8 Pre-action Systems

- A. Pre-action Systems shall be of the single-interlocked type.
- B. All piping shall be supervised using a minimum of 10 psi air pressure. The high air, low air, and compressor start and stop pressures shall be approved by the CFM.
1. Low air and high air pressure alarms shall be monitored by the FACU as a supervisory signal.
  2. The required air pressure shall be posted at the compressor using a permanent sign.
  3. The high and low air pressure alarm settings shall be posted at the compressor using a permanent sign.
  4. The start and stop pressures for the compressor shall be posted at the compressor using a permanent sign.
- C. Heat detectors shall not be used to trip a pre-action valve unless specifically approved by the CFM.
- D. Smoke/heat detectors that use the cross zoning feature shall be spaced at one-half the required spacing.
- E. All piping shall have provision for drainage.
- F. All piping shall be sloped to drain as required by NFPA 13 for dry pipe systems. Piping shall be designed such that all piping can be completely drained without removing sprinklers or fittings. Draining shall be by drain valves only.
- G. Trapped piping shall include an auxiliary drain incorporating two (2) one-inch drain valves and a 2-inch diameter by 12-inch long pipe between the valves as shown in NFPA 13: Figure 8.16.2.5.3.5 regardless of the volume of the trapped pipe. This drain assembly shall be located in an accessible location not more than 10 feet A.F.F. The drain shall be piped to an accessible location not more than seven (7) feet A.F.F.
- H. Pendant sprinklers shall be of the dry-pendant type. Return bends shall not be used as a substitute for dry-pendant sprinklers. All piping between the sprinkler main and the sprinkler shall be capable of being drained.

- I. The pre-action system shall include a manual release which shall be located in an enclosure adjacent to the pre-action valve or at an alternate location as approved by the CFM. The enclosure shall be labeled “Pre-action System Emergency Activation” or similar wording approved by the CFM. The manual release handle shall not be exposed.
- J. Hydraulic calculations involving galvanized steel pipe used in dry portions of pre-action systems shall use a Hazen-Williams C-Value of 100.
- K. Hydraulic calculations shall be provided for each floor.
- L. For buildings with multiple risers/systems hydraulic calculations are required for each system.

#### 1.9 Fire Sprinkler System Floor Zone Requirements.

- A. Fire sprinkler systems shall be zoned by floor. Each floor shall have a floor control valve assembly. Mezzanines shall be considered as a separate floor for the purposes of this section.
- B. Floor control valve assemblies shall consist of:
  - 1. Indicating Control valve with tamper switch
  - 2. Check valve – with removable face plate
  - 3. Pressure gauges (one on each side of the check valve)
  - 4. Water flow switch
  - 5. 2” Main drain valve
  - 6. Inspector’s test valve with orifice diameter equal to the smallest sprinkler orifice diameter.
  - 7. Signs
  - 8. Hydraulic nameplate
- C. Floor control valve assemblies shall be located such that pressure gauges and the highest operable part is not more than 7 ft.-0 in. A.F.F.
- D. Floor control valve assemblies shall be located in such a manner to facilitate inspection, testing and maintenance. Floor control valve assemblies shall not be located where the door swing will interfere with access to the floor control valve assembly.
- E. Sprinklers on one floor are not permitted to be served by piping located on another floor.
- F. Mechanical rooms elevator machine rooms, and electrical rooms located on the roof shall be supplied by an independent floor control valve assembly dedicated to the roof. Such rooms/areas shall not be supplied by the system on the floor below.
- G. Each floor control valve assembly shall include a 1-inch plugged Tee located downstream of the floor control valve assembly check valve and main drain connection. A 1-inch plugged Tee connection shall be provided in the main drain piping at an approved location. These connections shall be readily accessible for maintenance and tenant improvements so that a vacuum pump can be connected.

#### 1.10 Standpipe System Design Requirements

- A. Class I standpipes shall be of the wet type.
  - 1. For high-rise buildings, the Class I Standpipe shall be an automatic wet system.
  - 2. For all other buildings, the Class I Standpipe shall be a manual wet system supplied by the fire department connection.
- B. Class II standpipes shall be of the automatic wet type supplied by the Campus water mains or EBMUD water mains through either the building fire service or the building domestic water service.
- C. Class III standpipe systems shall comply with both Class I and Class II requirements.
- D. Standpipe hose valves shall be located at the floor landing in stairwells and in corridors at approved locations.

- E. Clearance shall be provided around standpipe hose valves to facilitate removal of the hose valve cap by using a spanner wrench and for operating the hose valve hand wheel. The clearance shall be 12 inches in all directions unless allowed by the CFM.
- F. Standpipes that extend to the roof shall have a minimum of two 2½” hose valves at the roof level.
- G. Hose valves shall be located so as to not encroach on the required exit width of the stair, designated spaces for wheelchairs, the stairway landing so as to interfere with door swings, or where the door swing interferes with access to the hose valve or the deployment of hose lines. The hose valve shall not be obstructed by the door swing. Hose valves shall not be located behind doors.
- H. Class I hose valves shall be installed at a 45 degree angle downward so as to minimize hose kinks.
- I. Class II standpipes shall be located in cabinets with space for a fire extinguisher.
- J. Hydraulic Design Criteria

1. The standpipe system shall be hydraulically calculated. Pipe schedule systems are not permitted.
2. The design of the standpipe system shall be as required by NFPA 14 with 100 psi available at the discharge of the hydraulically most remote hose valve while flowing 250 gpm from the hydraulically most demanding hose valve and simultaneously flowing the standpipe demand from the other hose valves as required by NFPA 14. 500 gpm is required from the hydraulically most demanding standpipe riser plus 250 gpm from each additional standpipe riser to a maximum of 1,000 gpm for buildings protected throughout with a fire sprinkler system and 1,250 gpm for buildings not protected throughout with a fire sprinkler system. A durable and weatherproof sign shall be attached to the hydraulically most demanding hose valve. The sign shall be permanently marked and indicate that it is the hydraulically most demanding hose valve.
3. Where pressure-reducing standpipe hose valves are used, the design shall consider the maximum pressure available as well as the minimum pressure available to the hose valve based on the maximum required flow rate for the standpipe valve and the minimum required flow rate (250 gpm and 150 gpm respectively for Class I standpipe systems) per standpipe hose valve. The sign shall be permanently marked.
4. The hydraulic calculations shall be based on the required standpipe flow rate being supplied at the FDC at 150 psi inlet pressure. The hydraulic calculations shall include the pressure loss through the 5” Storz FDC and the FDC using the 2½” inlets independently of each other.

K. Temporary Standpipes

1. A temporary standpipe shall be installed as required by the CFC.
2. The standpipe system shall be a manual wet system.
3. The location of the standpipe hose valves shall be acceptable to the CFM.
4. The location of the FDC shall be acceptable to the CFM and within 100 feet of a fire hydrant.
5. The FDC shall consist of two 2½” female inlets and a check valve.
6. The design shall be based on 250 gpm from the top 2 hose valve outlets at 100 psi at the hose valve outlet supplied by the FDC at 150 psi.
7. Piping shall be filled with water to the top of the standpipe. Additional pressure beyond the static elevation pressure is not required.

1.11 Fire Pump and Fire Pump Room

- A. The fire pump room and the fire pump assembly shall be designed, installed and tested in accordance with NFPA 13, NFPA 14, NFPA 20, and these specifications.
- B. The fire sprinkler and standpipe systems must be designed such that a fire pump is not needed unless the standpipe is required to be of the automatic wet pipe type. If the sprinkler contractor determines that a fire pump is needed, the sprinkler contractor shall submit preliminary plans and hydraulic calculations to the CFM for review and approval. Should it be determined that an increase in pipe diameter, change in sprinkler spacing, change in the sprinkler K-Factor, or other

change in the design will result in a fire pump not being needed, such changes to the design shall be made without additional cost to the University. Additional hydraulic calculations and design required to comply with this section shall be made at no additional cost to the University.

- C. The fire pump room shall be located in an approved location with a direct entrance/exit to the exterior of the building.
- D. The fire pump room shall be dedicated to the fire pump assembly and controller. There shall be no other utility, pipe, duct, conduit, or other equipment or device in the fire pump room that is not related to the operation of the fire pump.
- E. The door to the fire pump room shall be of a side swinging type which swings in the direction of exit travel. The door shall be of sufficient width to accommodate the removal of fire pump room equipment (including the fire pump, driver, and controller) and to allow for equipment to be brought into the fire pump room without dismantling or disconnecting any pipe, hanger, seismic brace, or any other piece of equipment.
- F. The fire pump room shall have a floor area and ceiling height sufficient to accommodate the fire pump, pump driver, pressure maintenance pump, controllers, automatic transfer switch, piping, valves, pressure regulating devices, and all other equipment and devices for the fire pump assembly.
- G. The fire pump room shall be arranged to allow the safe and expedient passage of personnel from the controllers and the fire pump to the exit door. All piping and equipment shall be located so as to not impede the egress from the fire pump room. All piping shall be arranged so as to not constitute a tripping hazard.
- H. Pressure sensing lines shall be located so that they will not be damaged by personnel walking in the room or by equipment being moved in the room.
- I. The fire pump shall be driven by an electric motor.
- J. The fire pump shall be a horizontal split case pump.
- K. Where a fire pump is needed, the hydraulic calculations shall include a 10 psi safety factor applied at all points on the fire pump curve. This is in addition to the Design Water Supply Data.
- L. A Pressure Regulating Device shall not be installed upstream or downstream of a fire pump unless specifically approved by the CFM. Where an increase in pipe diameters, change in sprinkler K-Factors, change in sprinkler spacing, or other design changes will result in required system pressures to not exceed the pressure ratings of all equipment and devices, a pressure regulating device shall not be permitted. High pressure ratings (e.g., 250 psi or 300 psi) for devices (including standpipe hose valves and sprinklers) shall be provided as needed to meet this requirement. Pressure reducing hose valves for the standpipe system shall not be provided to meet this requirement unless specifically approved by the CFM.
  - 1. Where a gravity tank is used to supply the fire pump and the Campus water mains or EBMUD water mains also supply the fire pump such that the combined pressures of the water main and the fire pump exceed 175 psi, a pressure control valve is permitted to reduce the Campus or EBMUD supply pressure. The pressure control valve is permitted to be installed upstream of the fire pump only.
- M. All equipment and devices necessary to test the fire pump shall be permanently installed.
- N. The circulation relief valve shall discharge directly to a sanitary drain utilizing a 2 inch air gap.
- O. A fire pump test header shall be provided. The test header shall be arranged such that the fire pump suction supply will be tested. The fire pump test header hose valves shall be located on the exterior of the building in a location approved by the CFM. There shall be one 2½” hose valve for each 250 gpm fire pump capacity based on 150% rated capacity of the fire pump. A normally closed electrically supervised control valve shall be installed in the test header piping inside the fire pump room.
- P. Where a listed venturi meter is installed to measure the flow rate to a test header or water supply tank, control valves shall be installed upstream and downstream of the venturi meter at distances

prescribed by the meter manufacturer. Such valves shall be electrically supervised as normally closed.

- Q. Where a venturi meter is used, it shall be capable of measuring the flow rate at not less than 175 percent and not more than 200 percent of the rated pump capacity.
- R. The fire pump and pressure maintenance pump controllers shall be located adjacent to the exit door of the fire pump room in such a manner to facilitate exiting from the room should an emergency occur such as a pipe break.
- S. The pressure maintenance pump need not be listed. The pressure maintenance pump shall be of high quality and capable of repeated starting and stopping.
- T. The suction supply piping to the pump shall be directly connected to the Campus water main system or EBMUD water distribution system.
- U. A fire pump bypass shall be provided. The bypass shall be of the same diameter as the pump suction piping.
- V. The suction and discharge pressure gauges shall be installed using a 3-way control valve.
- W. The maximum rated suction pressure of the fire pump shall be at least 1.25 times the maximum pressure identified in the water supply test report adjusted to the elevation of the suction flange of the fire pump.
- X. The fire pump controller shall display the voltage and current draw readings at each phase on an external display panel.
- Y. The fire pump controller shall be capable of electrically storing all pump starts and pressures and the times of each start. The controller shall be capable of downloading all data using an external means acceptable to the CFM and FS (i.e., without opening the controller).
- Z. The fire pump controller shall not include an automatic stop feature.
- AA. The contractor shall coordinate the design of the fire pump and piping with the structural engineer of record for the building. This includes both gravity loads and seismic forces. The contractor shall include the structural engineer's approval with the fire pump submittal.
- BB. The contractor shall include a hydraulic nameplate or sign in the fire pump room indicating the required flow and pressures at the pump discharge for each area calculated.
- CC. The contractor shall include a nameplate indicating the start and stop pressure for both the fire pump and the pressure maintenance pump.
- DD. All equipment, devices, piping, seismic braces, etc. shall be installed such that inspection, testing, and maintenance will be facilitated. No piece of equipment shall obstruct the accessibility to fire pump equipment, fire sprinkler system equipment, water storage tank equipment, or the inspection, testing, and maintenance of other equipment or devices. The determination of this requirement is at the sole discretion of the CFM. The contractor shall make suitable corrections without cost to the University.
- EE. The fire pump base and the attachment of the pump to the base shall be designed by the structural engineer of record using a horizontal force factor of at least 0.96.
- FF. The contractor shall provide hydraulic calculations to verify the available pressure at the fire pump suction flange while flowing 150% of the rated capacity of the pump.
- GG. Suction and discharge pressure gauges.
  - 1. Pressure gauges shall be installed using a 3-way valve.
  - 2. Pressure gauges shall be installed at the level of the centerline of the pump impeller.

## 1.12 Water Storage Tanks

- A. Where water storage tanks are required or provided, the tank shall comply with NFPA 22, NFPA 72 (for alarm requirements), the appropriate AWWA standard for the type of tank being provided, and these specifications.
- B. Break tanks as defined in NFPA 20 and NFPA 22 are not permitted.

- C. The water storage tank shall be concrete or steel.
- D. The wall thickness shall be designed as required by the appropriate AWWA standard for the type of tank being installed.
- E. The water storage tank shall be dedicated to fire protection systems.
- F. A tank control valve shall be installed on all pipes that penetrate the tank wall.
  - 1. For concrete tanks, the control valve shall be installed without a joint between the valve and the tank wall other than the connection to the valve. The joint between the tank control valve and the tank wall shall be flange by flange.
  - 2. For steel tanks, the valve shall be directly connected to the tank wall by using a flange by flange joint.
- G. A flexible coupling shall be installed immediately downstream of all tank control valves. A minimum 1 degree of angular deflection shall be provided. The Structural Engineer shall be consulted on the degree of deflection.
- H. All check valves shall include a control valve on both sides of the check valve.
- I. The tank shall have a high and low water level alarm per NFPA 72.
- J. The tank shall include an overflow pipe that discharges to a drain. The diameter of the overflow pipe shall be the greater of the following:
  - 1. piping having a diameter of 4 inches, or
  - 2. a pipe having a diameter that will flow the maximum discharge rate from the automatic fill valve without overflowing the tank in locations other than the overflow pipe, or
- K. The tank shall include an automatic fill pipe capable of filling the tank in 4 hours but not less than 4 inches in diameter. The fill pipe shall discharge into the tank on the opposite side of the tank from the fire pump suction pipe (anti-vortex plate). The fill pipe shall terminate inside the tank with a 45 degree or 90 degree downward elbow. Discharge from the fill pipe shall not impinge on the tank wall.
- L. The tank shall include a manual fill pipe capable of filling the tank in 4 hours but not less than 4 inches in diameter. The fill pipe shall discharge into the tank on the opposite side of the tank from the fire pump suction pipe (anti-vortex plate). The fill pipe shall terminate inside the tank with a 45 degree or 90 degree elbow. Discharge from the fill pipe shall not impinge on the tank wall.
- M. The tank shall include a sight glass type water level gauge or an altitude gauge (water level gauge) having a minimum diameter of 6 inches and includes a 3-way shut-off valve.
  - 1. The sight glass gauge shall include valves at both ends so as to facilitate removal of the sight glass for cleaning and maintenance.
  - 2. The sight glass shall be protected from damage.
  - 3. The sight glass shall extend the entire height of the tank.
  - 4. The altitude gauge (water level gauge) shall be located at the level of the anti-vortex plate.
  - 5. The altitude gauge (water level gauge) shall indicate the water level under static and flowing conditions.
  - 6. The altitude gauge (water level gauge) shall indicate the water level in both psi and feet of elevation.
  - 7. The altitude gauge (water level gauge) shall have range from 0 psi (0 feet) to the least maximum range available for the gauge.
  - 8. The altitude gauge (water level gauge) shall include a permanent sign indicating the quantity of water in gallons at 6-inch intervals of height and 0.1 psi. The normal water level, high water level alarm point, and low water level alarm point on the gauge shall be indicated on the sign.
- N. Ladders on the inside of the water storage tank shall be galvanized steel. Ladder rungs shall be non-slip without the use of applied materials to the rungs. Ladders shall extend above the tank to a height as required by CalOSHA but not less than 4 feet. Ladders shall use flat rungs at least 2 inches in width.

- O. The tank lining shall comply with NFPA 22 and the appropriate AWWA standard for the type of tank being provided. The tank lining shall be approved by the CFM. An inspection of the lining is required. Any holidays will be cause for the complete removal of the lining and the reapplication of the lining as determined by the CFM. Tank linings shall not be a thick bituminous coating or other material that will separate from the wall.
- P. Access to the interior of all tanks shall be provided. 2 (two) access openings shall be provided. Each access opening shall have a minimum diameter of 3 feet or 30 inches by 30 inches. A ladder shall be provided for each access opening (see above). A curb 4 inches in height shall be provided around each access opening to prevent debris from entering the tank. A Cal OSHA approved guard rail shall be provided around roof access openings. The location of the access openings shall be determined by the CFM.
- Q. A tank drain shall be provided in the bottom of the tank. A sump drain intended for use with a sump pump is not permitted. The floor of the tank shall be sloped to the drain.
- R. Two ventilation openings shall be provided to permit fresh air to be circulated in the tank. Each opening shall have a minimum diameter of 12 inches.
- S. The anti-vortex plate and its supporting structure shall be galvanized steel having a minimum thickness of ¼ inch. The anti-vortex plate shall be supported from the floor of the tank at all four corners of the plate. The anti-vortex plate shall extend a minimum of 18 inches beyond the edge of the suction pipe.
- T. All bolts and nuts inside the tank shall be stainless steel.
- U. Pipe shall conform to ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless, Type E, Type F, Type S, Grade A, or Grade B manufactured by the open hearth, electric furnace, or basic oxygen process, or it shall conform to ASTM A106, Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service, Grade A or Grade B.
- V. Steel pipe less than 2 inches in diameter shall not be used to penetrate the tank wall.
- W. Steel pipe 2 inches in diameter to 5 inches in diameter that penetrate the tank wall shall be Schedule 80.
- X. Steel pipe 6 inches in diameter and larger that penetrate the tank wall shall be Schedule 40.
- Y. The discharge pipe from the tank shall be at least 6 inches in diameter for tanks that are 25,000 gallons or less, and 8 inches in diameter for capacities larger. In no case shall the pipe be less than the suction pipe required by NFPA 20.
- Z. A vent opening shall be provided having a clear area equal to the larger of the fill pipes or the discharge pipe. Either a goose-neck piping arrangement or a screen shall be provided to prevent debris from entering the tank. The clear area of the screen shall be used to determine the vent area but not less than 1½ times the area of the larger of the fill pipes or discharge pipe.
- AA. The tank manual drain and tank overflow pipe shall discharge to a sanitary drain capable of receiving the combined maximum flow rate without backing up.
- BB. All galvanized steel pipe and plates, pipe threads, and grooved pipe ends on galvanized pipe shall be protected by use of a CFM approved galvanized paint/coating.
  - 1. Welco Super Cold Galvanizing or GlenMartin, Inc 8500 Silver Zinc Cold Galvanizing Compound, or approved equal shall be used.
  - 2. For threaded pipe, the galvanizing paint/coating shall be applied to pipe threads immediately after threaded pipe is installed. For grooved piping, the galvanizing paint/coating shall be applied before the coupling is installed. Any corrosion on the pipe, threads, welds, or grooves shall be thoroughly removed prior to application of the galvanizing paint/coating. Where corrosion penetrates the galvanizing paint/coating, the paint/coating shall be completely removed, the corrosion thoroughly removed, and the galvanizing paint/coating reapplied. This procedure shall be inspected by the CFM.



1.13 Water Supply Test Data

- A. The water supply data for the project shall be established by the CFM.
- B. The Design Water Supply Data must be used for the design of the fire sprinkler system, standpipe system, and fire hydrants. The Design Water Supply Data incorporates an allowance for system pressure fluctuations as stated in NFPA 13: A.24.2.2.
- C. The Water Supply Test Data is as follows:

Actual Data		Design Data	
Flow (gpm)	Pressure (psi)	Flow (gpm)	Pressure (psi)
Maximum Static Pressure (psi)			

- D. Where the Maximum Static Pressure (as determined by the Water Supply Test Data) is greater than 175 psi, all sprinklers, fittings, valves, flow switches, and devices shall be rated for the appropriate pressure.
- E. The Maximum Static Pressure shall be used to determine the hydrostatic test pressure.
- F. The Maximum Static Pressure is to be used to evaluate the pressure rating of devices and fittings including the need for pressure reducing valves for standpipe hose valves.
- G. If a fire pump is to be installed, the maximum rated suction pressure must be based on the Maximum Static Pressure recorded for the Water Supply Test plus an approved allowance for pressure fluctuations and pressure transients.
- H. Field changes to the system design are not permitted to exceed the Design Water Supply Data. The sprinkler contractor is encouraged to incorporate a safety factor in the design to allow for field modifications during installation. Field modifications to the system will require As-Built plans and hydraulic calculations. The Design Water Supply Data is not permitted to be exceeded.
- I. Where a fire pump is not installed, the Maximum Static Pressure shall be used to determine the hydrostatic test pressure.
- J. Where a fire pump is installed, the Maximum Static Pressure plus the shutoff pressure of the fire pump shall be used to determine the hydrostatic test pressure.
- K. Where the water supply data is provided by EBMUD, the CFM shall provide an appropriate factor of safety to be used as the Design Water Supply Data.

1.14 Structural Design Considerations

- A. Hangers and Supports - Structural Engineer Approval: The sprinkler contractor shall coordinate the location of all hangers with the Structural Engineer of Record. The sprinkler contractor shall submit documentation from the Structural Engineer of Record demonstrating compliance with NFPA 13 requirements that the structure can support the weight of the water-filled pipe + 250 pounds at the point of attachment to the structure.

- B. Seismic Bracing - Structural Engineer Approval: The sprinkler contractor shall coordinate the location of all seismic braces with the Structural Engineer of Record. The sprinkler contractor shall submit documentation from the Structural Engineer of Record demonstrating compliance with NFPA 13 requirements that the structure can support the seismic load of the sprinkler system at the point of attachment to the structure.
- C. The design of seismic braces shall use a minimum horizontal force factor ( $C_p$ ) = 1.17.
- D. Fasteners used to attach seismic braces to a concrete structure shall be approved to be used in cracked concrete.

#### 1.15 Submittals

- A. All design work shall be done by a licensed C-16 contractor or a licensed fire protection engineer using 1/8" = 1' 0" minimum scale drawings for fire sprinklers. All drawings submitted for review shall be stamped by the engineer or licensed C-16 contractor. Before starting design work discuss the extent and type of fire protection system required with Designated Campus Fire Marshal (DCFM). Design/Build specifications will be considered; discuss with Designated Campus Fire Marshal (DCFM) and Capital Projects (CP).
  - 1. At least one (1) hard-copy set, as well as electronic files, of fire sprinkler/standpipe plans shall be submitted for approval.
  - 2. At least one (1) hard-copy set, as well as electronic files, of hydraulic calculations, seismic bracing load calculations, and product submittals shall be submitted for approval.
- B. In high-content-value areas, or where water damage must be kept to a minimum, consider the use of a water mist or dry pipe system with early fire alarm and pre-action. See *28 31 00: Fire Detection and Alarm*, and discuss with Capital Projects (CP) and Designated Campus Fire Marshal (DCFM).
- C. Discuss type of protection for special areas such as computer rooms, tape storage areas, free access floor systems, paint or solvent storage rooms, transformer vaults, etc., with Capital Projects (CP) and Designated Campus Fire Marshal (DCFM).
- D. In new construction or major renovation, coordinate lighting/electrical and HVAC system (including diffuser/grille layout) with that of each sprinkler appurtenance and reflected ceiling plan.
- E. Coordinate the location, signage, keying, and access of fire sprinkler shutoff and zone valves with Capital Projects (CP) and the Designated Campus Fire Marshal (DCFM). Access and signage shall be obvious. Visibility shall not be blocked by equipment.
- F. Show a water flow switch for each floor or sprinkler zone. Switch shall have one (1) dual spot (Form C) contact. For specifications relating to alarm wiring, see Division 26: Electrical and 28: Electronic Safety and Security
- G. Show a test valve and drain piping for each flow switch. Terminate the drain pipe at an approved receptor. Show the receptor on the plumbing and sprinkler plans. The main drain piping for the fire sprinkler system shall be directly routed to the inside or the outside of the building. If the main drain is routed to a drain inside the building, the drain systems need to be sized to adequately handle the flow the main drain testing and the drain shall be connected to the sanitary sewer system with an air gap. The Plumbing/Mechanical contractor shall provide a six inch (6") drain pipe with a six inch (6") p-trap and a fixed two inch (2") air gap fitting for the fire sprinkler contractor to tie into with the main drain discharge. If an exterior drain is used it shall be piped directly to a sanitary sewer line.
- H. Coordinate location of drains shown on plumbing drawings with requirements of fire sprinkler system. Show drain locations on fire sprinkler drawings. Provide manufacturer's data sheets for all

devices intended to be installed. The data sheets shall include, but not be limited to, the following components:

- i. Sprinklers and accessories
  - ii. Pipes and fittings
  - iii. Check valves
  - iv. Gauges
  - v. Alarm flow switches
  - vi. Seismic braces
  - vii. Standpipe hose valves
  - viii. Hangers and supports
  - ix. Fasteners and anchors
  - x. Fire department connections
  - xi. Control valves including post indicator valves, gate valves, and butterfly valves
  - xii. Valve supervisory switches
  - xiii. Hose cabinets and spare sprinkler head cabinets
  - xiv. Identification signs
  - xv. CSFM listing numbers (include any tamper alarm supervisory devices)
  - xvi. ICC Evaluation Reports
  - xvii. Manufacturer's installation sheets
  - xviii. Where the equipment or device has a pressure loss, the manufacturer data sheet must include such information
  - xix. Where a manufacturer's data sheet shows multiple model numbers or Sprinkler Identification Numbers, the submittal shall include a check mark or arrow beside the model intended to be used. Devices that are not intended to be used must be crossed out
- I. In addition to the information required by NFPA 13, 14, 20, 22 and/or 24, shop drawings shall include, but not be limited to, the following information, clearly identified:
- i. Design parameters
  - ii. Hydraulic calculations for hydraulically designed systems
  - iii. Complete piping plan and schedule
  - iv. Reflected ceiling plan with all areas clearly designated
  - v. Location and size of all hangers and earthquake bracing
  - vi. Project Location
  - vii. Point of compass
  - viii. Ceiling construction
  - ix. Full length cross section
  - x. Full height cross section
  - xi. Location of fire walls
  - xii. Location of seismic joints
  - xiii. Locations of partitions
  - xiv. Occupancy hazard classification of each area or room including room description (i.e. office, storage, kitchen, electrical room, etc.)
  - xv. Location and size of blank spaces and closets
  - xvi. Any questionable small enclosure that no sprinkler is intended to be installed (shall be clearly identified)
  - xvii. Water supply information – calculate water available from point of connection with water main, upstream of any cross connection device
  - xviii. Other sources of water supply
  - xix. Make, type, number, and nominal orifice size of sprinklers
  - xx. Temperature rating and location of high temperature sprinklers
  - xxi. Total area protected by each system on each floor

- xxii. Number of sprinklers on each riser per floor
  - xxiii. Location of alarm bells
  - xxiv. Total number of sprinklers on each dry-pipe system, pre-action systems, combined dry-pipe/pre-action system or deluge system
  - xxv. Nominal pipe size and cutting lengths or center-to-center dimensions of pipe
  - xxvi. Location and size of riser nipples
  - xxvii. Type of fittings, joints, sleeves, and location of all welds and bends
  - xxviii. Location of all control valves, check valves, drain pipes, test pipes, and their terminals
  - xxix. Size and location of hand hose, hose outlets, and related equipment
  - xxx. Underground pipe size, length, location, weight, material, point of connection to city main, type of valves and meters, and the depth that the top of pipe is laid below grade
  - xxxi. After provisions for flushing, all drains shall be sized to handle a maximum water volume and pressure from test valves and drain valves. Construction and Design (CP) will coordinate with Mechanical/Plumbing Design Engineer regarding drain sizing.
  - xxxii. Additions to an existing system shall include sufficient depiction of the existing system on the drawings as to make all conditions clear
  - xxxiii. Complete name-plate data
  - xxxiv. Name and address of Contractor
  - xxxv. California State Contractor's license stamp and the identity of the designer
  - xxxvi. Mounting height of fire department connections
  - xxxvii. Penetrations of rated assemblies shall be fire-stopped. Fire stopping shall be an approved and listed material.
- J. Require the following general notes on shop drawings submitted for approval to the Campus Building Official (CBO) and the Designated Campus Fire Marshal (DCFM):
1. The automatic sprinkler system shall conform to the requirements of the most recent NFPA 13.
  2. Penetrations of fire-rated assemblies shall be fire-stopped. Fire stopping shall be an approved and listed material.
  3. Installation of the sprinkler system shall not be started until completed plans and specifications (including water supply information and capacity of existing sprinkler system, if any) have been approved by the Campus Building Official (CBO) and the Designated Campus Fire Marshal (DCFM).
  4. Approved plans and specifications shall be kept on the job site and made available to the Designated Campus Fire Marshal upon request.
  5. At various stages and upon completion, the system must be tested in the presence of the Designated Campus Fire Marshal (DCFM).
- K. Submittals having inaccurate hydraulic calculations, content which is illegible, incomplete or unclear, will be returned without review or approval
- L. Record and As-Built Drawing shall be submitted to Facilities Services Fire Prevention Unit, Inspection Services and Designated Campus Fire Marshal (DCFM). Both Record and As-built drawings shall be in PDF and DWG Format, submitted (one copy each) on CD, DVD or Blu-ray disc (as appropriate for file sizes). Where a Project uses East Bay Municipal Utility District (EBMUD) domestic water for a fire protection system, EBMUD shall also receive record and as-built drawings as described above.

#### 1.16 Design to accommodate Inspection, Testing, and Maintenance

- A. The design of the fire sprinkler system, standpipe system, fire service underground piping, fire pump and other water-based fire protection systems shall be such that the design and installation of the system and system components will accommodate acceptance inspection and testing as well as the periodic inspection, testing, and maintenance required by California Code of regulations Title 19.
- B. All valves that are not within 7 feet 0 inches of the finished floor level shall be specifically identified on the plans. Such valves will be required to be moved to within 7 feet 0 inches of the finished floor level if so directed by the CFM at no additional cost to the University.
- C. Any device, equipment, or assembly that is necessary to accommodate inspection, testing, and maintenance shall be provided when directed by the CFM at no additional cost to the University.

#### 1.17 Approved Plans

- A. The fire sprinkler contractor shall maintain a copy of the CFM APPROVED plans, hydraulic calculations, seismic calculations, and material submittal on site during construction. Such documents shall be made available to the CFM when requested. Failure to maintain these documents on site shall be cause to terminate the inspection or test as appropriate.

#### 1.18 Warranty

- A. The sprinkler contractor shall provide a warranty for all equipment and devices not less than that provided by the manufacturer and not less than five (5) years.
- B. The sprinkler contractor shall provide labor to honor the warranty for failure of all equipment and devices without additional cost to the University of California.
- C. The sprinkler contractor shall provide a warranty for one (1) year for workmanship deficiencies that do not involve failure of equipment or devices. Labor involved to repair defects in workmanship shall be provided by the sprinkler contractor at no additional cost to the University.
- D. The warranty period shall not begin until the system has been inspected, tested, approved, and accepted by the CFM, FS, and UCB Capital Projects. This includes acceptance and approval of the as-built plans and hydraulic calculations and receipt of the Contractor's Material and Test Certificate for each type of system.
- E. The warranty period shall not begin until after FS has received the appropriate training from the contractor as required by these specifications (See Part 3).

### Part 2 – Products, Materials, and Installation Requirements

#### 2.1 General.

- A. All equipment and devices shall comply with NFPA 13, NFPA 14, NFPA 20, NFPA 22, NFPA 24, and these specifications.
- B. All equipment shall be new and unused. The date of manufacture shall be not more than one (1) year older than the date of actual installation of the device or equipment.

#### 2.2 Sprinklers.

- A. All sprinklers shall be new and unused. The date of manufacture shall be not more than one (1) year older than the date of actual installation.
- B. All sprinklers shall be listed.
- C. The temperature rating of the sprinklers shall be based on the maximum ambient temperature in the space were the sprinklers are installed. NFPA 13: Table 6.2.5.1 shall be used to determent the

temperature rating of the sprinkler based on the maximum ambient temperature. Where sprinklers are installed near a heat source, the temperature rating of the sprinkler shall be based on NFPA 13: Section 8.3.2.5.

- D. Where the maximum static pressure (as determined by the water supply test) is greater than 175 psi, high pressure sprinklers shall be used.
- E. Quick-response sprinklers shall be used in all areas except in the following locations:
  - 1. Elevator machine rooms and hoistways shall use standard-response sprinklers having an intermediate temperature rating (minimum 200 degrees F).
  - 2. Rooms containing steam piping shall use standard-response sprinklers having an intermediate temperature rating (minimum 200 degrees F).
  - 3. Where chemical fume hoods are required to be protected with sprinklers, sprinklers shall be standard-response sprinklers having an intermediate temperature rating (minimum 200 degrees F).
  - 4. Rooms containing autoclaves, dishwashers, or drying ovens shall use standard-response sprinklers having an intermediate temperature rating (minimum 200 degrees F).
  - 5. Mechanical equipment rooms shall use quick-response intermediate temperature rated (minimum 200 degrees F) sprinklers.
  - 6. Commercial kitchens shall use quick-response intermediate temperature rated (minimum 200 degrees F) sprinklers.
- F. For sleeping rooms, install Quick Response or residential sprinklers.
- G. Corrosion resistant sprinklers shall be installed in the following locations:
  - 1. Loading docks
  - 2. Kitchens
  - 3. Exterior overhangs and eaves
  - 4. Parking garages
  - 5. Chemical fume hoods
  - 6. Areaways providing outside air serving HVAC equipment
  - 7. Freezers and refrigerated rooms
  - 8. Walk-in freezers and refrigerators
  - 9. Any room/area exposed to the outside atmosphere
  - 10. Chemical, biological, and research laboratories.
- H. Corrosion resistant sprinklers shall be Nickel coated, Teflon coated, or Polyester coated. Wax or lead coatings are not acceptable.
- I. Sprinklers shall not be installed under skylights or roof vents that are 4 feet by 8 feet or less. A minimum 2 ft.–0 in. clearance shall be maintained between the sprinkler and the edge of the skylight or roof vent.
- J. The following types of sprinklers shall be installed in the areas indicated:
  - 1. Concealed Sprinklers – To be determined by the design engineer
  - 2. Recessed Sprinklers – To be determined by the design engineer
  - 3. Flush Sprinklers – To be determined by the design engineer
  - 4. Pendent Sprinklers – To be determined by the design engineer
  - 5. Upright Sprinklers – To be determined by the design engineer
  - 6. Sidewall Sprinklers – To be determined by the design engineer
- K. Sprinkler guards shall be installed where the sprinkler is subject to physical impact including the following locations:
  - 1. Where sprinklers are installed less than 7 feet-6 inches A.F.F.
  - 2. Mechanical Rooms
  - 3. Shops
  - 4. Fume Hoods
  - 5. Sports facilities

6. Dormitories including activity rooms, common areas unless concealed or recessed sprinklers are used.
- L. Spare Sprinklers
1. Spare sprinklers shall be provided.
  2. Spare sprinklers shall be located as directed by the CFM.
  3. Spare sprinklers shall be new, unused, and shall have a date of manufacture the same as the sprinklers that are installed or newer.
  4. Spare sprinklers shall be stored in a red metal box permanently mounted to the wall in a location determined by the CFM.
  5. A permanent sign shall be provide at each spare sprinkler box as required by NFPA 13.
  6. Sprinklers shall be in proportion to the number and types installed.
    - a. Not less than 4 spare sprinklers of each type shall be provided where more than 4 sprinklers and less than 20 sprinklers are installed.
    - b. Not less than 6 spare sprinklers of each type shall be provided where 20 or more sprinklers are installed.
    - c. Not less than 2 spare sprinklers of each type shall be provided where 4 or fewer sprinklers are installed.
    - d. Spare cover plates shall be provided for each spare concealed sprinkler.
    - e. A spare sprinkler box(es) shall be provided such that spare sprinklers are located in the appropriate holes or slots in the box.
    - f. A wrench for each type and manufacturer of sprinkler shall be provided in the spare sprinkler box.
    - g. Spare escutcheons shall be provided for each type or manufacturer of sprinkler including one-piece and two-piece escutcheons and escutcheons for recessed sprinklers. The quantity of escutcheons shall be at least equal to the number of spare sprinklers for each type or manufacturer.

### 2.3 Above-Ground Piping

- A. All pipes shall be new and UL Listed or FM Approved.
- B. All pipes shall be steel or copper.
- C. All steel piping 2 inches in diameter or less shall be Schedule 40.
- D. All steel piping 2½ inches in diameter and larger shall be Schedule 10 or Schedule 40.
- E. All copper pipe installed above ground shall be Type M
- F. All copper pipe installed below ground shall be Type K.
- G. Pre-action systems shall use galvanized pipe.
- H. Piping exposed to the following areas shall be galvanized pipe:
  1. Loading docks
  2. Kitchens
  3. Exterior overhangs and eaves
  4. Parking garages
  5. Chemical fume hoods
  6. Areaways providing outside air serving HVAC equipment
  7. Freezers and refrigerated rooms
  8. Walk-in freezers and refrigerators
  9. Any room/area exposed to the outside atmosphere
  10. Chemical, biological, and research laboratories
  11. All piping exposed to outside air or weather
- I. All pipe threads and grooved pipe ends on galvanized pipe shall be protected by use of a CFM approved galvanized paint/coating.

1. Welco Super Cold Galvanizing or GlenMartin, Inc. 8500 Silver Zinc Cold Galvanizing Compound, or approved equal shall be used.
  2. For threaded pipe, the galvanizing paint/coating shall be applied to pipe threads immediately after threaded pipe is installed. For grooved piping, the galvanizing paint/coating shall be applied before the coupling is installed. Any corrosion on the pipe, threads, welds, or grooves shall be thoroughly removed prior to application of the galvanizing paint/coating. Where corrosion penetrates the galvanizing paint/coating, the paint/coating shall be completely removed, the corrosion thoroughly removed, and the galvanizing paint/coating reapplied. This procedure shall be inspected by the CFM.
- J. Insulate water-filled supply piping in areas exposed to freezing, such as under eaves, cold rooms, passageways, etc.
  - K. Plastic pipe shall not be used for the above ground fire sprinkler system unless specifically approved by the Campus Fire Marshal prior to bidding.
  - L. Flanged fittings shall be used at the first connections above grade in exterior locations
  - M. Riser and cross mains shall be steel pipe and joined by welding or by roll grooved pipe and fittings. The minimum nominal wall thickness for roll groove or welded steel pipe and pressures up to 300 psi (20.7 bars) shall be in accordance with Schedule 10 for sizes up to 5 in. (12 mm); 0.134 in (3.40 mm) for 6 in (152 mm); and 0.188 in (4.78 mm) and larger) or Schedule 40 (in sizes less than 8 in. (203 mm) pipe for pressures up to 300 psi (20.7 bars)
  - N. Riser shall be four-inch minimum pipe size from base of risers through the fittings to cross mains serving the first story
  - O. Connections and fittings shall be threaded, flanged, grooved, or welded. Grooveless clamp or saddle fittings are not acceptable
  - P. Grooved clamp tees and bolted branch outlets shall not exceed one-inch branch size and are subject to inspection prior to attachment of branch piping or sprinklers
  - Q. Reducing fittings shall be tapered cast metal products. Where grooved couplings are used, there shall be a separate coupling for each connection to the reducing fitting
  - R. Each sprinkler shall be connected to supply piping via a threaded branch outlet and by a minimum one-inch to one-half inch threaded reducing fitting
  - S. Piping for fire service mains within 5 feet of the building and piping that penetrates the wall or foundation underground shall be cement-lined ductile iron pipe.
  - T. The fire service main shall not be installed under the foundation of the building. The main shall either (1) extend above ground immediately outside of the building adjacent to the exterior wall and enter the building through the exterior wall above grade or (2) enter through the exterior wall below grade.
  - U. Where a rigid seal (such as link seal or similar device) is installed in the exterior wall penetration, a flexible coupling shall be installed on the pipe within 12 inches of each side of the wall.
  - V. Pipe extensions less than 1 inch diameter shall not be used to connect sprinklers to sprinkler piping.
  - W. Pipe less than 1 inch diameter shall not be used in sprinkler system piping that supplies water to sprinklers. Pipe less than 1 inch diameter may be used only in valve trim piping that does not supply water to sprinklers.
  - X. Piping located in an area where piping from a different sprinkler zone is located shall be labeled as to its own zone. This applies to both pipes in the area. Labeling shall be permanently attached to the pipe in an approved manner and spaced not more than 10 feet. Additional labels shall be located at changes of direction. Labels shall have lettering at least 3 inches high with a stroke not less than 1 inch unless specifically approved by the CFM.

## 2.4 Fittings



- A. Plain end fittings shall not be used.
- B. Flexible couplings shall be used to connect pipe to grooved elbow and Tee fittings.
- C. Rigid couplings shall be used to connect straight runs of grooved pipe.
- D. Flexible couplings shall be permitted to connect straight runs of pipe where the pipe penetrates a wall, floor, or beam where clearance is not provided or where angular deflection of piping is necessary.
- E. Flexible and rigid couplings shall be of the same manufacturer as the fittings to which they are connected.
- F. Bushings shall not be used to reduce pipe diameters unless installed in a shell building for temporary sprinklers that will be replaced during a tenant improvement.
- G. Mechanical Tees that use a U-Bolt to connect to the pipe shall not be used.
- H. Adjustable drop nipples are permitted to be used provided they are included in the hydraulic calculations and shown as an equivalent length (i.e., not to be included in the pipe length).
- I. Fittings exposed to the following areas shall be galvanized (NOTE: Welded fittings shall be protected using a galvanizing paint/coating as required by Section 2.3(I) above – including the weld):
  - 1. Loading docks
  - 2. Kitchens
  - 3. Exterior overhangs and eaves
  - 4. Parking garages
  - 5. Chemical fume hoods
  - 6. Areaways providing outside air serving HVAC equipment
  - 7. Freezers and refrigerated rooms
  - 8. Walk-in freezers and refrigerators
  - 9. Any room/area exposed to the outside atmosphere
  - 10. Chemical, biological, and research laboratories.

## 2.5 Hangers

- A. All hangers shall be listed.
- B. Provide in accordance with referenced standards.
- C. Do not mix piping material and hanger material of dissimilar metals.
- D. All beam clamps shall be fitted with steel retainer straps.
- E. Hanger rod of less than 3/8 inch diameter is not permitted.
- F. Sprinkler piping shall be hung with hangers and support independent of any other hanger, support systems or devices.
- G. No non-sprinkler materials may be suspended from or attached to sprinkler piping or components.
- H. Fasteners shall be not less than 3/8 inches in diameter, unless there are at least two (2) fasteners at each location.
- I. All-thread rod shall not be used as a bolt to attach a hanger to a structural member.
- J. Cast-in-place and post-installed anchors installed in concrete shall comply with the CBC and in particular Section 1912 and be designed in accordance with ACI 318 and comply with the appropriate ICC Evaluation Service Report. The anchor shall be listed for use in cracked concrete
- K. Powder-driven studs shall not be used to attach hangers to the structure.
- L. The sprinkler contractor shall coordinate the location of hangers with the Structural Engineer of Record. The Structural Engineer of Record shall review the hanger locations and the suitability of the attachment to the structure. The Structural Engineer of Record shall submit a report to the CFM indicating the acceptance of the method of hanging the sprinkler piping. The report shall indicate the acceptable location of hangers, types of fasteners, and any other stipulation relative to the

structural integrity of the system. The sprinkler contractor shall include the Structural Engineer's report in the fire sprinkler/standpipe submittal.

- M. Trapeze Hangers:
  - 1. The use of wood trapeze or wood blocking shall not be permitted to support piping.
  - 2. All attachments to the trapeze shall be based on the sprinkler pipe being supported.
  - 3. All attachments to the building structure to support the trapeze shall be based on the sprinkler pipe being supported.
- N. Hangers and fasteners exposed to the following areas shall be galvanized.
  - 1. Loading docks
  - 2. Kitchens
  - 3. Exterior overhangs and eaves
  - 4. Parking garages
  - 5. Chemical fume hoods
  - 6. Areaways providing outside air serving HVAC equipment
  - 7. Freezers and refrigerated rooms
  - 8. Walk-in freezers and refrigerators
  - 9. Any room/area exposed to the outside atmosphere
  - 10. Chemical, biological, and research laboratories.

## 2.6 Seismic Braces and Branch Line Restraints

- A. Seismic braces shall be listed.
- B. Cast-in-place and post-installed anchors installed in concrete shall comply with NFPA 13 Sec. 9.3.5.1. Calculations shall be submitted as shown in Section A.9.3.5.9.1.
- C. Cast-in-place and post-installed anchors installed in concrete shall comply with the CBC and in particular Section 1901.3 and be designed in accordance with ACI 318, and comply with the appropriate ICC Evaluation Service Report. The anchor shall be listed for use in cracked concrete.
- D. Powder driven studs shall not be used to attach seismic braces to the structure.
- E. Where the seismic load of the seismic brace listed by the manufacturer includes values determined by Underwriters Laboratories and Factory Mutual, the lower value shall be used in the design and installation of the seismic brace.
- F. The use of wood trapeze or wood blocking shall not be permitted to support seismic braces.
- G. All-thread rod shall not be used as a bolt to attach a seismic brace to a structural member.
- H. Where rods are used to provide branch line restraint, the L/r value shall not exceed 300 unless a second rod is installed on the opposite side of the branch line.
- I. Branch line restraint shall be provided for armovers greater than 3 feet in horizontal length. This includes the combined horizontal length of the armover.
- J. Seismic braces shall be attached directly to the pipe being braced per NFPA 13 Section 9.3.5.11.1. The attachment of a brace pipe to another brace pipe is not permitted.
- K. Seismic separation assemblies shall be listed and be MetraFlex Fire Loop or approved equal.
- L. The sprinkler contractor shall coordinate the location of seismic braces with the Structural Engineer of Record. The Structural Engineer of Record shall review the locations of all seismic braces and the suitability of the attachment to the structure. The Structural Engineer of Record shall submit a report to the CFM indicating the acceptance of the method of bracing the sprinkler piping. The report shall indicate the acceptable location of seismic braces, types of fasteners, and any other stipulation relative to the structural integrity of the system. The sprinkler contractor shall include the Structural Engineer's report in the fire sprinkler/standpipe submittal.
- M. Structural Engineer of Record shall review the seismic brace locations and the suitability of the attachment to the structure. The Structural Engineer of Record shall submit a report to the CFM indicating the acceptance of the method of bracing the sprinkler piping. The report shall indicate

the acceptable location of hangers, types of fasteners, and any other stipulation relative to the structural integrity of the system.

- N. Seismic braces and branch line restraints including the brace pipe/rod, structural attachment, pipe attachment, and fasteners exposed to the following areas shall be galvanized:
1. Loading docks
  2. Kitchens
  3. Exterior overhangs and eaves
  4. Parking garages
  5. Chemical fume hoods
  6. Areaways providing outside air serving HVAC equipment
  7. Freezers and refrigerated rooms
  8. Walk-in freezers and refrigerators
  9. Any room/area exposed to the outside atmosphere
  10. Chemical, biological, and research laboratories.

## 2.7 Valves

- A. All valves and devices (including but not limited to flow switches, pressure switches, drain valves, pressure regulating devices, control valves, check valves, pre-action or dry pipe system trim valves, inspector test valves, pressure gauge valves, etc.) shall be located in a readily accessible location in order to facilitate acceptance inspection and testing as well as periodic inspection, testing, and maintenance (CCR Title 19 Chapter 5). Access doors or panels are required in order to gain access to the valve or device. Access doors and panels shall be of the side swinging type. Access doors and panels shall be provided with locks. A minimum of 8 sets of keys for such locks shall be provided to the University
- B. Subject to the approval of the CFM, a valve or device may be located above a ceiling provided access to the valve or device may be accomplished by the safe use of a step ladder. An extension ladder is not acceptable. The location of such valves and devices shall be subject to the specific approval of the CFM. Plans must show the exact location and elevation A.F.F. of all valves and devices. Access doors/panels are required in areas where lay-in ceiling panels are not provided. Access doors/panels or ceiling tiles shall be appropriately labeled as to the valve or device that is installed above the ceiling.
- C. All control valves shall be listed and rated for the supply water pressure.
- D. Gate Valves:
1. Resilient wedge gates are required for all gate valves.
  2. Four inch pipe size and larger: OS&Y, iron body, and bronze mounted. A valve supervisory tamper switch shall be required.
  3. Three inch pipe size and smaller: OS&Y type, bronze gate with solid wedge. A valve supervisory tamper switch shall be required
- E. Angle Valves: Bronze angle valve with screw-in bonnet, internal seat, and renewable disc.
- F. Globe Valves: Bronze globe valve.
- G. Check Valves: Iron body, bronze mounted, horizontal swing check valve with bolted bonnet. Check valves shall be designed for replacement of internal parts without removal of valve body from piping. Alarm check valves will not be used. All backflow protection devices shall be approved on the most recent "List of Approved Backflow Prevention Assemblies," USC Foundation for Cross-connection Control and Hydraulic Research. Backflow preventers connected to East Bay Municipal Utilities District (EBMUD) mains shall be approved by EBMUD.
- H. All check valves shall have a removable faceplate.
- I. Post indicator valves: Cast iron, bronze mounted, double disc, non-rising stem gate valve with cast iron body indicator post handle shall be secured with Master 2018 padlock (University standard)

and a valve supervisory tamper switch is required. A main control valve needs to be provided in an accessible location.

- J. Butterfly Valves: Bronze body, grooved connection, rubber-coated stainless steel disc and stem, two-inch and larger pipe size with integral tamper switch and geared slow-close mechanism.
- K. Wafer Valves shall not be used.
- L. Control valves (normally open and normally closed valves) shall include a tamper switch compatible with the fire alarm system.
- M. Valves shall be chained and locked unless installed in a locked riser room dedicated exclusively to the riser/floor control valve assembly. The lock shall be provided by the UCB Lock Shop.
- N. Floor control valve assembly shall be installed as follows:
  - 1. The floor control valve assembly shall be installed in the enclosed stairway not more than 7 feet 0 inches and not less than 5 feet above the finished floor/landing.
  - 2. If specifically permitted by the CFM, the floor control valve assembly may be installed in an accessible location above the ceiling. The ceiling panel/access opening shall be properly labeled identifying the floor control valve assembly and the portion of the system it controls.
- O. Chain operated valves are not permitted.
- P. Valves for the underground fire service mains shall comply with the UCB Construction and Design Standards for Underground Water Mains
- Q. Pressure-regulating devices shall be listed and designed based on the maximum and minimum pressures available and the required system pressure at the discharge of the pressure regulating device.
- R. All control valves (including pressure maintenance pump control valves) shall be electrically supervised to the FACU. A supervisory signal shall be indicated on the FACU within 2 complete turns of the valve from the off-normal position.
- S. Control valves located on branch lines serving sprinkler protection in elevator spaces shall be provided with a tamper switch
- T. Underground valves on the fire service mains shall not be supervised or locked where installed with a roadway box. Underground valves located in a vault shall be electrically supervised to the FACU.
- U. Standpipe hose valves shall be 2½ inch brass angle valves with a brass cap and chain. Chrome plating to be determined by the design engineer.
- V. Gate type hose valves shall not be used on wet standpipe systems.

## 2.8 Pressure-Regulating Devices

- A. Where an increase in pipe diameters, change in sprinkler spacing, change in the sprinkler K-Factor, or other change in the design will result in a pressure-regulating device not being needed, such changes to the design shall be made without additional cost to the University.
- B. Where a master pressure-regulating device is provided for the entire system to reduce both the static and residual pressures, the piping arrangement for the pressure control valve shall conform to NFPA 14: Figure A.7.2.4.
  - 1. The hydraulic calculations are to be based on one of the pressure regulating devices being out of service.
- C. In addition to the pressure-control valve assembly, a low flow by-pass pressure-control valve shall be provided.
- D. A pressure-restricting device shall not be installed.
- E. Fire department connection piping shall be connected to the standpipe system piping downstream of any master pressure regulating device that supplies any standpipe hose valve.
- F. Any pressure regulating device that controls the pressure to only a sprinkler system shall be set at the required sprinkler system pressure plus 30 psi but not less than 100 psi nor more than 150 psi, unless otherwise approved by the CFM

- G. Where a pressure-regulating device is installed, a test connection capable of flowing the maximum system demand intended for that device shall be installed downstream of the pressure regulating device. This applies to pressure regulating devices that supply the entire systems and pressure regulating devices that supply individual floors. This does not apply to pressure reducing standpipe hose valves.
  - 1. The discharge shall be piped to a drain that is capable of draining the maximum system demand. The drain shall discharge to the building's sanitary drain.
  - 2. The test connections shall provide for a means to measure the flow rate.
- H. Pressure gauges are required within 1 (one) foot upstream and downstream of each pressure regulating device (other than a pressure reducing hose valve). The gauges shall be installed between the pressure control valve and the control valves. The gauges shall be installed on a 3-way valve.
- I. A pressure gauge shall be installed immediately upstream of all pressure reducing hose valves.
- A. Where a pressure control valve is not also listed as a check valve, a listed check valve shall be installed downstream of the pressure control valve.
  - 1. A pressure gauge with a 3-way control valve shall be installed downstream of the check valve. This gauge is in addition to the pressure gauges required for the pressure control valves.
  - 2. A pressure relief valve shall be installed downstream of the check valve and set to 175 psi (maximum).

## 2.9 Main Drains and Standpipe Drains

- A. Main drains shall be provided downstream of all control valves.
- B. Main drains and main drain valves on risers 2 inches in diameter or larger shall be not less than 2 inches diameter.
- C. Main drains and main drain valves on risers less than 2 inches in diameter shall be not less than 1½ inches in diameter.
- D. Main drain valves shall be secured by chain and lock in an approved manner to prevent tampering. Plastic "zip" ties are not permitted.
- E. Main drains shall be piped to discharge into a sanitary drain of a sufficient size to prevent splashing or overflowing when conducting a main drain test. A 2-inch air gap shall be provided between the drain pipe discharge opening and the sanitary drain inlet. A splash guard shall be provided where splashing occurs.
- F. The sanitary drain shall be designed such that it will not overflow when subjected to the maximum flow rate available from a sprinkler system drain.
- G. The inspector's test valve and piping and the main drain shall be connected to a common sanitary drain.
- H. Where a sump is used to receive the flow from a main drain, the sump and its associated sump pump shall be designed to discharge the water to the sanitary drain without overflowing. The flow rate shall be based on the maximum anticipated flow rate plus 20%.
- I. Where pressure reducing hose valves are used, a 4" diameter drain shall be installed. The drain shall discharge into a sanitary drain of sufficient size to prevent splashing or overflowing when testing the standpipe system. A 2" air gap shall be provided between the top of the sanitary drain inlet and the terminus of the 4" standpipe drain.
  - 1. A 2½" female swivel inlet connection with a threaded brass plug shall be provided at each floor hose valve and two (2) such connections shall be provided at the each roof manifold.
  - 2. The inlet connection shall be located within 3 feet of the standpipe hose valve and at an elevation below the standpipe hose valve.

3. The contractor shall ensure that sufficient space is provided around the inlet connection to allow for the use of a fire department spanner wrench to turn the fitting. A minimum of 12 inches shall be provided.
  4. A guard shall be provided at the top of the sanitary drain to prevent splashing and debris from being dropped into the sanitary drain.
  5. Where a sump is used to receive the flow from a standpipe drain, the sump and its associated sump pump shall be designed to discharge the water to the sanitary drain without overflowing. The flow rate shall be based on the maximum anticipated flow rate plus 20%.
- I. A 4" diameter drain shall be provided for standpipe systems that do not utilize pressure reducing hose valves. The drain shall discharge into a sanitary drain of sufficient size to prevent splashing and overflowing when testing the standpipe system. A 2" air gap shall be provided between the top of the sanitary drain inlet and the terminus of the 4" standpipe drain.
1. Two (2) 2½" female swivel connections shall be provided at the roof manifold. One (1) such connection shall be provided at the base of the drain adjacent to the bottom most hose valve in order to facilitate testing.
  2. Where a standpipe riser does not include a roof manifold, one (1) 2½" female swivel connection shall be provided at the topmost hose valve, the second highest hose valve, and the bottommost hose valve of each standpipe riser.
  3. The inlet connection shall be located within 3 feet of the standpipe hose valve and at an elevation below the standpipe hose valve.
  4. The contractor shall ensure that sufficient space is provided around the inlet connection to allow for the use of a fire department spanner wrench to turn the fitting. A minimum of 12" shall be provided.
  5. A guard shall be provided at the top of the sanitary drain to prevent splashing during main drain testing and standpipe testing and debris from being dropped into the sanitary drain.
  6. Where a sump is used to receive the flow from a standpipe drain, the sump and its associated sump pump shall be designed to discharge the water to the sanitary drain without overflowing. The flow rate shall be based on the maximum anticipated flow rate plus 20%.

## 2.10 Auxiliary Drains

- A. Auxiliary drains shall be provided as required by NFPA 13.
- B. Auxiliary drains shall be located in the bottom of the pipe.
- C. Auxiliary drains located in end-caps (whether grooved or threaded) are not acceptable.
- D. Auxiliary drain valves shall be secured in an approved manner to prevent tampering.

## 2.11 Inspector's Test Valve

- A. An inspector's test valve shall be provided with an orifice equivalent to the smallest orifice sprinkler in the system.
- B. The inspector's test valve shall drain to a sanitary drain.
- C. The inspector's test valve shall be secured in an approved manner to prevent tampering.

## 2.11 Signs

- A. All signs required by NFPA 13, NFPA 14, NFPA 20, NFPA 22, NFPA 24, and these specifications shall be provided as required by this section.
- B. Signs shall be provided for all control valves clearly indicating the portion of the building served by the control valve.

- C. ALL signs, including hydraulic nameplates, shall be permanently marked by stamping, engraving, or factory painted. Ink, felt-tipped pens, Sharpies, pencil, label makers, printed tape and similar devices for marking are not acceptable. ALL signs shall be durable and attached to a wall or ceiling as appropriate for the location.
- D. Where a fire pump is provided, a sign indicating the flow rate and pressure demands of the fire sprinkler system and standpipe system at the fire pump discharge flange shall be provided in the fire pump room.
- E. Where a fire pump is provided, a sign indicating the stop and start pressure settings of the fire pump and pressure maintenance pump shall be provided in the fire pump room.
- F. The hydraulic nameplate shall be provided as required by NFPA 13, CBC, CFC and the following:
  - 1. The hydraulic nameplate shall include the required flow and pressure at the point of connection to the Campus water main or EBMUD water main and at the discharge flange of the fire pump, if a fire pump is provided.
- G. A sign indicating the required pressure at the FDC shall be provided at the FDC as required by NFPA 13 and NFPA 14.
  - 1. A sign indicating the name of the building served by the FDC shall be provided unless the FDC is attached directly to the wall of the building.
  - 2. The sign at the FDC supplying the standpipe shall include the required flow and pressure at the FDC based on the standpipe flow test results.
  - 3. Signs shall have lettering 2 inches high on contrasting background or raised or engraved lettering with the following information:
    - a) Name of building
    - b) "AUTO SPRK STANDPIPE"
    - c) Required flow and pressure at FDC inlet for standpipe systems
    - d) Required flow and pressure at FDC inlet for sprinkler systems if greater than 150 psi.

### 2.13 Pressure Gauges

- A. Pressure gauges shall be provided as required by NFPA 13, NFPA 14, NFPA 20, NFPA 22, NFPA 24 and these Specifications.
- B. All pressure gauges shall be new and unused, and shall be UL listed and labeled 3- ½ inch dial, liquid filled type, 0-300 psi scale, markings not to exceed 5-psi increments.
- C. A pressure gauge shall be installed on the upstream and downstream sides of all check valves except the FDC check valve.
- D. A pressure gauge shall be installed on the upstream and downstream sides of all pressure control valves.
- E. A pressure gauge shall be installed on the standpipe riser at the level of all pressure reducing hose valves.
- F. A pressure gauge shall be installed at the top of each standpipe riser.
- G. A pressure gauge shall be installed at each test pipe.
- H. The pressure gauge shall be located directly on the riser and not on the drain piping.
- I. Pressure gauges shall be installed in a manner that will facilitate periodic inspection, testing and maintenance. Gauges shall be installed such that it is not necessary to remove or modify any piece of equipment or device that is either part of the system (including drain valves and piping) or the building structure in order to remove the pressure gauge.
- J. All pressure gauges shall include a 3-way valve and ¼" test gauge.

### 2.14 Sleeves and Escutcheons

- A. Provide sleeves sized for annular clearance per NFPA 13.
- B. For sleeves set in fire walls and floors, caulk the space between pipe and sleeve with flexible, approved fire-resistive packing compound to achieve rating at least equal to that of the wall or floor penetrated. Sleeves in floor on grade or exterior wall below grade shall be packed with Link-Seal or approved equivalent between pipe and sleeve, flush with top of sleeve for floors and with outer surface for walls. Sleeves at seismic or expansion joints shall not be packed unless located in a fire wall where piping is routed through fire walls which are seismic or expansion joints. Approved swing joints shall be used, and the sleeves appropriately packed as specified above.
- C. In concrete slabs and walls, schedule 40 black steel pipe shall be used as sleeve material.
- D. Sleeves set in walls and slabs with waterproof membrane may be either cast iron or steel and shall be provided with a flashing clamp device and corrosion resistant clamping bolts.
- E. Furnish and install escutcheons of prime-coated steel set screw for exposed pipes passing through walls, floors, and partitions.

#### 2.15 Water Flow Switch

- A. ALL water flow switches shall be listed, vane or paddle type, with dual SPDT (Form C) contacts.
- B. A master water flow switch shall be installed in the sprinkler piping where the piping enters the building at a location determined by the CFM.
- C. The water flow switch shall be compatible with the fire alarm system.
- D. The water flow switch shall be weatherproof if installed outside or in a location subject to the exterior atmosphere (e.g., parking garage, unconditioned stairwell).
- E. The water flow switch shall be installed in a location that will facilitate inspection, testing, and maintenance without use of special equipment or ladders.
- F. All flow switches shall activate the fire alarm system and the exterior bell that is required by the CFC.

#### 2.16 Tamper Switch

- A. The tamper switch shall be listed.
- B. The tamper switch shall be compatible with the fire alarm system.
- C. A tamper switch shall be provided for all control valves including the control valves at a pressure maintenance pump.
- D. A tamper switch shall be provided for valves to the fire pump test header, fire pump test piping using a flow meter, and the fire pump bypass piping. The tamper switch shall be electrically supervised to the FACU and indicate a supervisory alarm within 2 turns of its off-normal position (including normally closed valves).
- E. The tamper switch shall be weatherproof if installed outside or in a location subject to the exterior atmosphere (i.e., parking garage, unconditioned stairwell, etc.).
- F. The tamper switch shall be installed in a location that will facilitate inspection, testing, and maintenance without use of special equipment or ladders.
- G. OS&Y switches shall monitor stem movement and shall be complete with J-bolts.
- H. Plug and loop type tamper switches shall not be used to supervise control valves.

#### 2.17 Alarm Bells

- A. Provide weatherproof, ten inch (10"), 120 VAC electric bell with weatherproof back box
- B. UL or FM approved
- C. Locate on the face of the protected building adjacent to the fire department with a mounting height of eight to ten feet above finished grade



- D. Provide sign directly below the bell. Obtain sign information from the Designated Campus Fire Marshal

#### 2.18 Through Penetration Fire Stops

- A. The sprinkler contractor shall provide through penetration fire stops at all penetrations through walls having a fire resistance rating of any duration.
- B. Through penetration fire stops shall be listed.
- C. The sprinkler contractor shall submit listed details for the through penetration fire stop assembly intended to be installed.
- D. The through penetration fire stop shall comply with the listed design and the requirements of the CBC.

#### 2.19 Backflow Preventer (See also Water Utilities Standards)

- A. An approved backflow preventer shall be installed as required by the UCB Construction and Design Standards for Underground Water Mains. The UCB standard backflow preventer for fire service is the Wilkins 350AST or 350ASTR.
- B. The Wilkins 375AST, 375ASTR, 450AST and 475ASTR backflow preventers are required and acceptable only when there is an on-site fire water storage tank or where antifreeze is used in the fire protection system. Otherwise, only the Wilkins 350AST and 350ASTR are required to be used.
- C. The backflow preventer may be installed inside the building if specifically approved by the CFM and FS.
- D. A suitable assembly shall be installed to properly test the backflow preventer at maximum system demand to ensure the manufacturer's stated pressure drop is not exceeded while flowing the system demand.
- E. A drain as required for main drains shall be provided for the backflow testing device where it is installed inside of the building.
- F. Both OS&Y gate valves or butterfly valves of the backflow preventer shall include a ½" or ¾" test valve with plug. The upstream gate valve shall have the test valve on the upstream side of the gate valve. The downstream gate valve shall have the test valve on the downstream side of the gate valve. As an alternative, the test valves may be located on the piping upstream and downstream of the gate valves. A plug shall be installed in the test valve.

#### 2.20 Fire Department Connection (FDC) – See also Water Utilities Standards

- A. The FDC shall be installed in an approved location and per the UCB standard detail for FDC's.
- B. Where the FDC is located on the wall of the building, the sprinkler contractor shall ensure that it is not located within 10 feet laterally of a window nor below or above a window.
- C. The FDC shall be located such that it is not obstructed by landscaping, doors, retaining walls, fences, etc.
- D. The FDC shall be located at street grade.
- E. The FDC shall consist of a 5 inch Storz X 6 inch NPT fitting.
- F. The Storz connection shall be installed at a 30 degree down angle.
- G. The Storz connection shall include an internal screen, a check valve, and a Storz cap. The internal screen shall be assembled by the manufacturer. The internal screen shall not be installed as an after-market device. The check valve shall be dedicated to the Storz FDC.
- H. The FDC shall consist of 2½ inch female swivel inlets. One 2½ inch inlet shall be provided for each 250 gpm sprinkler system demand or standpipe demand but not less than 2 inlets. The 2½ inch inlets shall be provided with a check valve (dedicated to the 2½ inlets) and either a cap or

plug. Where more than two 2½ inch inlets are used, each inlet shall have an individual clapper or check valve.

- I. Provide a ball drip between the Storz inlet and its associated check valve.
- J. Provide a ball drip between the 2½” inlet and its associated check valve if a threaded plug is used in the inlet.
- K. The FDC check valves shall be located to facilitate inspection, testing, and maintenance. The use of ladders, scaffolding, or similar equipment to access the FDC check valve is not permitted.
- L. The FDC check valve shall be of a type with a removable faceplate to facilitate the backflushing and internal inspection of the FDC.
- M. Provide a 1-inch auxiliary drain valve with plug or cap on each side of the FDC check valve. This drain valve shall be in an accessible location to facilitate maintenance. Each drain valve shall be installed on the bottom of the pipe or check valve to facilitate drainage.
- N. Where a fire protection system includes a pressure regulating device, the FDC piping shall be piped to a point downstream of the FDC. A check valve shall be located between the FDC piping and the pressure regulating device (including the pressure relief valve).

## 2.21 Bollards

- A. Bollards shall be provided where fire hydrants, backflow preventers, FDC’s, PIV’s, and above ground piping are subject to vehicular damage as determined by the CFM and FS.
- B. Bollards shall be designed and installed as required by the CFC and the UCB Construction and Design Standards for Underground Water Mains.

## Part 3 – Execution

### 3.1 Workmanship

- A. The system shall be installed using good workmanship practices.
- B. All manufacturer’s recommendations, dimensions, tolerances, torque requirements, etc. shall be followed.
- C. Sprinkler system components may not be covered or concealed prior to inspection and testing. If covered or concealed, the contractor is required, per CFC, to expose all system components.
- D. Sprinkler system and standpipe system components (pipe, valves, couplings, braces, hangers, etc.) shall not be installed in a wall membrane. Pipe that passes completely through a wall assembly or a wall membrane perpendicular to the wall or membrane is permitted. Clearance as required by NFPA 13 is required.

### 3.2 Schedule

- A. The sprinkler contractor shall maintain the schedule as established by the University and the General Contractor.
- B. Failure of inspections or tests shall not be cause to extend the schedule.

### 3.3 Coordination with Other Trades

- A. The sprinkler contractor shall coordinate the location of piping, sprinklers, hangers, and seismic braces with all other trades.
- B. Conflicts with coordination shall be resolved by the General Contractor with no additional cost to the University.

### 3.4 Work on Existing Systems and Tenant Improvements

- A. When working on existing systems or tenant improvements the contractor shall comply with all University policies and procedures regarding the shutdown of any fire protection system.
- B. The sprinkler contractor shall provide a lock on the lock-out/tag-out device on all valves that have been closed. This is in addition to the FS lock. The lock shall be removed by the sprinkler contractor at the end of the day's work. All piping shall be closed at the completion of the day's work indicating that FS may open all valves.
- C. The contractor shall limit the shutdown of a fire protection system to the minimum time necessary in order to complete the work.
- D. A fire protection system shall not be left in an isolated condition overnight unless a CFM approved fire watch is on duty.
- E. The contractor shall notify FS when work is completed
- F. Clean-up – All floors, walls, ceilings, furniture, equipment, etc. shall be protected from oil, debris, and any other substance that could stain these surfaces or furniture, or equipment.

### 3.5 Installation

- A. The fire sprinkler system shall be installed in accordance with CFC, CBC, NFPA 13, NFPA 14, NFPA 20, NFPA 22, and NFPA 24 and these specifications.
- B. The fire sprinkler system shall be installed in a manner that facilitates inspection, testing, and maintenance.
- C. Provide reducing fittings for all changes in pipe size, and provide fittings for all changes in pipe direction, Riser piping shall be installed plumb with offset fittings used where alignment adjustment is necessary.
- D. Provide unions for pipe sizes below 2 inch and flanged or grooved fittings for sized 2" and above to permit disconnection of equipment and fixtures.
- E. All welded piping shall bear a stamp or imprint of the certified welder and shall be inspected by the Designated Campus Fire Marshal prior to installation. The Contractor shall maintain certified records of welders or fabricators and have available for the Designated Campus Fire Marshal to review at the construction site
- F. Fire sprinkler piping shall not penetrate ducts.
- G. Where fire sprinklers are required to be installed in ducts, fire sprinkler piping is permitted to penetrate the duct. Such penetration shall be sealed in an approved manner to prevent leakage of grease, grease vapors, flammable vapors, dust, toxic gases, etc. The penetration shall be made with flexible couplings sufficient to protect the fire sprinkler system from the effects of a seismic event.
- H. Fire sprinkler piping shall not be installed within 6 inches of a duct unless the duct is required to have sprinklers installed inside of the duct.
- I. Other than sprinkler/standpipe risers, floor control valves (and its associated piping), and piping directly serving sprinklers in a stairway, sprinkler system components shall not penetrate a stair wall.
- J. When adding a new fire sprinkler system to a floor that includes a new floor control valve assembly, the fire sprinkler system shall be shut down for a time period not to exceed the time required to install the floor control valve. The new control valve shall be closed and the fire sprinkler system upstream of the valve shall be restored.
- K. All piping shall be installed to permit thorough drainage.
- L. Install Inspector's test valves and drain valves in conveniently accessible locations and discharge shall be directed to the appropriate drain of adequate size and capacity to handle the full flow.
- M. Each system shall be labeled, with valve numbers and locations posted at main riser.
- N. Labels shall be engraved brass tags affixed with a split ring

### 3.6 Inspections

- A. A minimum 72-hour notice of inspection (not including weekends and holidays) shall be provided by the sprinkler contractor to the CFM prior to all inspections. Timing of the notice shall begin when the CFM receives the Inspection Request.
- B. Inspections shall be for the entire building, or the entire floor, or for the entire tenant space. At the discretion of the CFM, intermediate inspections may be permitted.
- C. Pre-installation piping and equipment inspection.
  1. A pre-installation inspection of sprinklers, piping, welds, fittings, couplings, hangers, seismic braces, fasteners, concrete inserts and anchors, and other equipment that is intended to be installed shall be inspected by the CFM prior to installation.
  2. Welding certificates (including the welder's stamp identification) shall be provided to the CFM at the time of inspection.
  3. All welds shall be identified by use of the welders specific stamped mark.
- D. Rough-in Inspection
  1. A CFM inspection is required for all components of the fire protection system. This includes, but is not limited to:
    - a. Pipe
    - b. Hangers
    - c. Seismic braces
    - d. Anchors (cast in place anchors and post-installed anchors), fasteners, bolts, screws, etc.
    - e. Couplings
    - f. Sprinklers
    - g. Valves (All types)
    - h. Pressure gauges
    - i. Flow switches
    - j. Tamper switches
    - k. All equipment and devices connected to the fire protection system required by the appropriate NFPA Standard, CBC, CFC, CMC, CEC, etc.
  2. The rough-in inspection shall be conducted when all equipment and devices (including sprinklers) are installed.
  3. All equipment and devices shall be readily visible for inspection. Any equipment or device that cannot be observed shall be uncovered at no expense to the University. Ceilings shall not be installed until all inspections are complete and the installation complies with the codes, standards, and these specifications.
  4. Special Inspections:
    - a. Mechanical Tee's installed in the field require a special inspection witnessed by the CFM at the time of drilling the pipe. All coupons shall be attached to the fitting using metal wire.
    - b. Where concealed sprinklers are installed in ceilings that will be painted, a special inspection by the CFM is required after the ceiling has been painted (finished coat) and before the sprinkler cover plate has been installed. Painted sprinklers and cover plates shall be removed and replaced with new sprinklers or cover plates.
    - c. At the discretion of the CFM, an additional inspection for verifying the torque requirements of fittings, couplings, seismic bracing, bolts, etc. may be required without additional cost the University.

- d. Additional special inspections may be required at the discretion of the CFM in order to verify compliance with all Codes and Standards applicable to the project. These special inspections will be made without additional cost to the University.
- E. Through Penetration Fire Stop Inspection
  - 1. Through penetration fire stop assemblies shall be inspected for compliance with the listed detail and the CBC.
  - 2. The sprinkler contractor shall have the approved listed assembly detail available for the CFM at the time of inspection.
  - 3. Where the through penetration fire stop assembly is to be installed in layers such that parts of the assembly will be concealed, the sprinkler contractor shall call for an inspection for each part.
- F. Intermediate Inspections
  - 1. The contractor may request intermediate inspections as needed in order to facilitate the construction schedule.
  - 2. Such inspections shall include the hydrostatic testing of portions of the system to be covered. The contractor is responsible for leaks in concealed areas due to additional hydrostatic testing and when the system is under normal pressure.
- G. Final Inspection
  - 1. A final inspection shall be conducted when all construction is complete.
  - 2. The final inspection must include all devices and equipment required by the CFC, CBC, NFPA 13, NFPA 14, NFPA 20, NFPA 22, and NFPA 24. This includes all Contractor's Material and Test Certificates, spare sprinkler boxes, escutcheons installed, painter's tape is removed, fire alarm connections are complete and fully operational, and any other inspection required by the CFM in order to ensure compliance with the CFC, CBC, NFPA Standards, UCB Campus Standards, etc.
  - 3. All documentation and signs required by the CFC, CBC, NFPA 13, NFPA 14, NFPA 20, NFPA 22, and NFPA 24 shall be inspected.

### 3.7 Acceptance testing

- A. All tests required by NFPA 13, NFPA 14, NFPA 20, NFPA 22, NFPA 24, and these specifications shall be conducted by the sprinkler contractor.
- B. A minimum 72-hour notice of testing (not including weekends and holidays) shall be provided by the sprinkler contractor to the CFM prior to all inspections. Timing of the notice shall begin when the CFM receives the ~~Construction Inspection~~ Work Order Request.
- C. The CFM shall witness all tests.
- D. All equipment and devices shall be readily visible for inspection. Any equipment or device that cannot be observed shall be uncovered at no expense to the University. Ceilings shall not be installed until all inspections are complete and the installation complies with the referenced codes, standards, and these specifications.
- E. Hydrostatic Testing
  - 1. The hydrostatic test shall be conducted as required by NFPA 13, NFPA 14, and NFPA 24.
  - 2. The hydrostatic test pressure shall be 50 psi plus the Maximum Static Pressure (as indicated in the Water Supply Test Data) but not less than 200 psi.
  - 3. All trades working in the area to be hydrostatically tested shall be notified by the sprinkler contractor when a hydrostatic test is to be conducted.
  - 4. The hydrostatic test pump shall be removed from the building or the area being tested during the hydrostatic test.
  - 5. Valves and connections may be sealed by the CFM as appropriate.

6. The system shall not experience a drop in pressure and shall not leak for the duration of the test.
7. The gauge for the hydrostatic test shall be either a digital gauge reading to 0.1 psi or a Burdon tube gauge 0-300 psi with a 3½” diameter face or larger
8. All piping, fittings, sprinklers, and other equipment that will be subjected to water pressure at the completion of the system shall be hydrostatically tested (including underground piping). The use of plugs in lieu of sprinklers is not permitted.
  - a. Where the system has been hydrostatically tested in sections, a hydrostatic test shall be conducted at the completion of the installations when all system devices and components are installed and operational.
9. The standpipe drain piping shall be hydrostatically tested.
10. The piping between the FDC inlets and the FDC check valve shall be hydrostatically tested per NFPA 13.
11. The hydrostatic test shall include all sprinklers, pipe, fittings, valves, and devices that will be subjected to pressure either under normal conditions, under operating conditions, or during testing. ALL connections shall be tested. Plugs in lieu of sprinklers are not acceptable.
12. Each floor shall be hydrostatically tested at 50 psi plus the Maximum Static Pressure (as indicated in the Water Supply Test Data) but not less than 200 psi. The pressure shall be corrected for the elevation above or below the elevation of the Water Supply Test location.
13. Construction that covers or obscures any sprinkler system component shall not be installed until the hydrostatic test has been successfully completed as determined by the CFM.
14. Any system that incurs a leak or drop in pressure during a hydrostatic test shall be cause to fail the test and require a re-test for the entire system being tested. The determination of a failed hydrostatic test shall be at the discretion of the CFM.
15. The test shall be conducted for a minimum of 2 hours. The determination of leaks shall be made at the completion of the 2 hour time duration.

F. Pre-action Valve Test

1. A Hydrostatic test of the pre-action system piping shall be conducted. All water shall be drained from all portions of the pre-action system after the hydrostatic test.
2. Air test – a 24 hour air test at 40 psi shall be conducted prior to the hydrostatic test. The maximum drop in air pressure shall not exceed 1.5 psi.
3. Air compressor test – the air compressor shall be tested to ensure it is capable of supplying the system within 30 minutes of the system being completely exhausted of air.
4. The low air and high air pressure supervisory alarms shall be tested to ensure a supervisory signal is sent to FACU.
5. The compressor start and stop pressures shall be tested to ensure the compressor functions properly.
6. The pre-action system piping shall be completely dry after completion of all testing. This must be witnessed by the CFM.
7. The low air pressure alarm level and the high air pressure level alarm level shall be indicated by use of a sign at the pre-action valve.
8. Non-interlock pre-action system valve test:
  - a. The pre-action valve shall trip upon release of air pressure from the system.
  - b. The pre-action valve shall trip upon activation of a detector while the piping is pressurized with air.
9. Single interlock pre-action system valve test:
  - a. The pre-action valve shall NOT trip upon release of air pressure from the system.
  - b. The pre-action valve shall trip upon activation of a detector while the piping is pressurized with air.
10. Double interlock pre-action system valve test:

- a. The pre-action valve shall trip upon the activation of a detector followed by release of air pressure in the piping.
  - b. The pre-action valve shall trip upon release of air pressure from the piping followed by activation of a detector.
  11. The pre-action valve (regardless of type) shall be tested to ensure that the water delivery time to the inspector's test valve does not exceed the time limit per NFPA 13 Table 7.2.3.6.1 for systems having a pipe volume of more than 500 gallons.
  12. For systems having a pipe volume of not more than 500 gallons the water delivery time is not required.
  13. The pre-action shall be tested by using the manual trip device.
- G. Main Drain Test
1. A main drain test shall be conducted for each main drain in the system, including each floor control valve.
  2. The main drain test shall be witnessed by the CFM.
  3. The sprinkler contractor shall record the results of the main drain tests and submit the results to the CFM.
  4. The following pressures shall be recorded:
    - a. Initial static pressure
    - b. Residual pressure while flowing water with the main drain valve fully open
    - c. Final static pressure
- H. Valve Operation Test
1. All control valves shall be operated through a full open and close cycle.
  2. This test may be conducted in conjunction with the Tamper Switch Test.
  3. The number of turns to open and close the valve shall be recorded.
  4. Control valves that close in less than 5 seconds while operating at maximum speed will not be accepted and must be replaced.
- I. Tamper Switch Test
1. All tamper switches shall be tested by closing the valve no more than two (2) complete turns of the valve operator and a supervisory signal being received by the FACU. For OS&Y valves the supervisory signal shall not be restored until the valve is fully opened. The test shall include placing the tamper switch arm in the groove of the valve stem to ensure the supervisory signal is not restored.
- J. Backflow Preventer Forward Flow Test
1. The backflow preventer shall be tested by flowing the highest system demand. The flow rate shall be measured and the pressure drop across the backflow preventer and flow rate shall be recorded. The inlet and outlet pressures of the backflow preventer shall be recorded. The pressure drop recorded for this test shall be compared to the pressure loss used in the hydraulic calculations and the manufacturer's data sheet.
  2. Where the pressure loss exceeds the pressure loss in the manufacturer's data sheet, the backflow preventer shall be repaired and retested. Where the measured pressure drop results in the system demand exceeding the DESIGN water supply data, the backflow preventer shall be repaired or replaced.
  3. Where the pressure loss exceeds the pressure loss used in the hydraulic calculations, the hydraulic calculations shall be corrected. Where necessary to maintain the required system pressure below the DESIGN water supply data, the backflow preventer shall be repaired or replaced.
  4. The pressure loss and flow rate used for the test shall be posted at the backflow preventer using a permanent sign.

5. Where the pressure drop across the backflow preventer exceeds the pressure loss indicated in the manufacturer's data sheet or the hydraulic calculations, the as-built plans and hydraulic calculations shall reflect the actual pressure loss.
  6. Where a backflow preventer is replaced, a forward flow test shall be conducted for the new device.
- K. Pressure Regulating Device Test (For other than pressure reducing valves at standpipe hose valves)
1. All pressure regulating devices shall be tested as required by the design standards and these specifications. This includes the master pressure regulating device and pressure regulating devices at floor control valve assemblies.
  2. The pressure regulating device shall be tested at the maximum system demand to ensure the device operates properly.
  3. The pressure regulating device shall be tested at low flow rates and at high flow rates as determined by the CFM.
  4. The pressure regulating device shall be tested at low pressures and at high pressures as determined by the CFM.
  5. If the pressure regulating device does not regulate the pressure as required by the design standards and the manufacturer's data, the device shall be repaired or replaced.
  6. The pressure loss and flow rate used for the test shall be posted at the pressure regulating device using a permanent sign.
  7. Where a fire pump is installed, the test shall be conducted while the pump is operating.
  8. The test shall also be conducted using the FDC as a supply where the required pressure at the FDC exceeds 175 psi.

L. Fire Pump Test

1. The fire pump shall be tested as required by NFPA 20 and these specifications. The fire pump assembly shall be inspected and tested in order to verify compliance with NFPA 13, NFPA 14, and NFPA 20.
2. The fire pump shall be tested by flowing at the following test points (minimum):

Test Point	Fire Pump Rated Flow (gpm)			
	500	750	1,000	1,500
0	X	X	X	X
200	X			
300		X		
400	X			
500	X	X	X	X
650	X			
750	X	X	X	X
1,000		X	X	X
1,125		X		
1,250			X	X
1,500			X	X
1,750				X
2,000				X
2,250				X

3. Fire Pump suction and discharge pressure readings shall be recorded at each test point.
4. RPM, current and voltage readings shall be recorded at each flow point.
5. The installing contractor shall submit a hard copy of the certified shop test curve at least one week prior to the pump test to the CFM (faxes and copies of faxes are not acceptable).



6. Pumps that test at 5% or greater below the certified shop test curve at any test point on the curve after being adjusted according to the affinity laws shall be repaired or replaced.
7. Pumps where the current draw for each phase exceeds the product of the full load amp rating of the motor times the service factor at any test point shall be repaired or replaced.
8. Where pumps are supplied by a water tank the test shall be based on the water storage tank as being the supply for the test. The static and residual pressures at the water storage tank discharge shall be recorded for each test point.
9. Where pumps are supplied by the Campus water mains or EBMUD water mains, the test shall be based on the water main as being the supply to the test. The static and residual pressures at the water supply source shall be recorded for each test point.
10. Where an automatic transfer switch is installed, the fire pump test shall include the following:
  - a) a test of the automatic transfer switch with the pump not operating when loss of primary power occurs and
  - b) a test of the automatic transfer switch while the pump is operating.
11. Where pressure regulating devices are installed, the pump test shall include the upstream and downstream pressures at each device and at each test point.
12. The pressure maintenance pump shall be tested by automatically starting the pump 5 times at the required start pressure.
13. The contractor shall provide all necessary equipment and devices to test the fire pump assembly.
  - a) All pressure gauges shall have 1% full scale accuracy and have been calibrated within one year of the test. Verification of calibration shall be provided to the CFM prior to testing.
  - b) Flow measuring devices shall be provided by the contractor of a type that is acceptable to the CFM.
  - c) All piping shall be hydrostatically tested to 200 psi or 50 psi in excess of the maximum static pressure, whichever is greater.
  - d) The contractor shall provide a photo-tachometer to measure pump speed.

M. Flow Switch Test

1. A test of all flow switches shall be conducted by flowing water equivalent to the smallest orifice sprinkler.
2. An alarm signal shall be received at the FACU within 90 seconds of the inspector's test valve being fully opened.

N. Standpipe System Acceptance Test

1. The standpipe system shall be flow tested as required by NFPA 14, these specifications and the UCB document "Standpipe Flow Testing Requirements".
2. All standpipe systems regardless of the type and class shall be flow tested to verify the system design flow rates and pressures.
3. The CFM shall determine whether or not the standpipe system passes or fails.
4. The sprinkler contractor shall provide a standpipe test plan to the CFM detailing the procedure to be used for testing the standpipe system in accordance with NFPA 14 and these Specifications. The test plan shall include all equipment and devices intended to be used.
5. The contractor shall be responsible for the safe discharge of the water used in the test per UCB requirements.
6. The sprinkler contractor shall provide all of the necessary equipment to properly test the system. This includes hoses, fittings, adapters, flow measuring devices, pressure gauges, diffusers (where necessary), and other equipment.

- a. All pressure gauges shall be new or calibrated within one (1) year of the test. The sprinkler contractor shall provide the calibration certificate to the CFM before the test.
  - b. Pressure gauges shall have a minimum 1% Full Scale accuracy
  - c. Pressure gauges shall be either a digital type gauge or a dial type gauge having a minimum 3½ inch diameter face with 2 psi gradations.
  - d. All flow measuring devices shall be new or calibrated within one (1) year of the test. The sprinkler contractor shall provide the calibration certificate to the CFM before the test. The calibration shall be based on the flow rate required for the test.
  - e. A test to verify the consistency of the flow measuring devices and pressure gauges shall be conducted prior to the test as witnessed and approved by the CFM. All pressure gauges shall be connected to a common pressure source simultaneously and the pressure readings at various pressures shall be compared. All pressures shall be within 2 psi of each other. All flow measuring devices shall be within 10 gpm of each other.
7. The test of pressure-reducing hose valves shall verify the Hydraulic Design Criteria of Standpipe Systems as described in these Specifications and as required by NFPA 14.
    - a. The pressure reducing hose valve test shall verify that the hose valve discharge pressures at various flow rates are consistent with the manufacturer's flow/pressure curve for the hose valve. Flow rates and pressures shall be verified at low flow rates and high flow rates as determined by the CFM. Flow rates and pressures shall be verified at low and high pressures as determined by the CFM.
  8. The standpipe test shall ensure that 250 gpm at 100 psi is available at the outlet of each hose valve by flowing the hydraulically most demanding hose valve while simultaneously flowing additional hose valves to achieve the total required flow rate.
  9. The standpipe system shall be tested using both the 2½" FDC inlets and the 5" storz FDC inlet independent of each other.
  10. Where the results of the test indicate that the required pressure (as determined by the system design hydraulic calculations) at the FDC exceeds the required pressure, the necessary corrections as approved by the CFM shall be completed. The standpipe system shall be retested after corrections are completed.
  11. Automatic wet standpipe systems shall be tested using the automatic supply and the FDC. If two or more FDC's are installed for the building, the standpipe test shall test all FDC's separately.
  12. Manual wet standpipe systems shall be tested using the FDC. If two or more FDC's are installed for the building, the standpipe test shall test all FDC's separately.
  13. The standpipe drain riser shall be used for the test.
- O. Flushing
1. The sprinkler contractor shall not install the above ground piping to the underground fire service main until the fire service main has been successfully flushed, chlorinated, bacteria tested, and approved. The CFM shall witness the flushing test. The fire service main shall not be considered successfully flushed until so indicated by the CFM.
  2. The underground fire service main that supplies the building shall be flushed as required by NFPA 24 and NFPA 20 where a fire pump is installed.
  3. The flush shall be through a burlap bag (double bag if necessary). A hole in the burlap bag after flushing shall constitute a failed test and the flushing shall be repeated.
  4. Flushing shall continue until the water runs clear and there is no debris collected in the burlap bag. The flush shall not be considered successfully completed until so indicated by the CFM.

5. The sprinkler contractor is responsible for the safe discharge of the water. This includes ensuring there is no damage to buildings and grounds and the environment.
6. The sprinkler contractor is responsible for contacting the appropriate EH&S personnel and complying with all Campus requirements for the safe discharge of the water. The CFM shall be copied on ALL correspondence between the Project and the City of Berkeley, including e-mails.
7. Where the water will discharge onto the City of Berkeley streets or public ways, the contractor is required to contact the City of Berkeley for additional requirements. The CFM shall be copied on ALL correspondence between the Project and the City of Berkeley, including e-mails.
8. The contractor shall provide all of the necessary equipment in order to successfully conduct the flush.
9. All flow rate measuring devices and pressure gauges shall have been calibrated within the last year. Documentation shall be provided to the CFM. The calibration shall be based on the flow rate required for the flush. Flow measuring devices shall be checked by the CFM for accuracy.
10. Equipment includes, but is not limited to:
  - a. Device(s) to measure the flow rate (including pressure gauges). Such device must be approved by the CFM
  - b. Hoses
  - c. Diffusers where necessary
  - d. Tablets to dechlorinate the water. Such tablets must be approved by UCB EH&S
  - e. Fittings and other equipment
  - f. Holding tank(s) where necessary

### 3.8 Water discharge

- A. The fire sprinkler contractor shall be responsible for the safe discharge of the water during all tests including prevention of damage to buildings and grounds as well as the prevention of water discharge from harming the environment. The fire sprinkler contractor shall abide by all policies and procedures of the University and shall coordinate the test with the appropriate personnel of the Environmental Protection Group of the University's Office of Environment, Health, and Safety.
- B. Where water will be discharged onto City of Berkeley streets, the fire sprinkler contractor shall secure authorization from the City of Berkeley prior to the test. Written verification of this authorization shall be provided to the CFM prior to any discharge.
- C. The contractor shall complete the UCB EH&S form for water discharge.

### 3.9 Final Approval

- A. As-built plans and hydraulic calculations shall be submitted to the CFM for review and approval. Final approval shall not be granted until the as-built plans and hydraulic calculations are approved by the CFM.
  1. As-built plans shall be CAD prepared. Three (3) CD's or DVD's shall be submitted containing the files. Five (5) hard copies of all as-built plans and hydraulic calculations shall be submitted to the CFM.
  2. Where necessary, the CFM will conduct an inspection of the system to ensure the as-built plans accurately reflect the installation.
  3. Two (2) copies of the standpipe test plan shall be submitted to the CFM.
- B. The fire sprinkler contractor shall provide a Contractor's Material and Test Certificate at the completion of the work. This must be approved by the CFM prior to final approval of the system.

Final approval shall not be granted until the Contractor's Material and Test Certificate is approved by the CFM. This includes the Certificates for both aboveground piping and underground fire service main piping.

- C. Signs shall be provided as required by NFPA 13, NFPA 14, NFPA 20, NFPA 22, and NFPA 24 as appropriate.
  - 1. Where valves are installed above a ceiling, signs shall be provided on the ceiling directly below the valve indicating the type of valve (i.e., standpipe isolation valve, fire sprinkler control valve, auxiliary drain valve, inspector's test valve, etc.)
  - 2. The hydraulically most demanding hose valve shall be identified by a sign.
- D. A hydraulic nameplate shall be provided at each floor control valve. For single story buildings, a hydraulic nameplate shall be provided at the system riser (near the control valve if one is installed).
  - 1. The hydraulic nameplate shall include the information required by NFPA 13, the CBC, CFC, and the following:
  - 2. The required flow and pressure at the water supply source identified in the water supply test data.
  - 3. Where a fire pump is installed, the hydraulic nameplate shall also include the maximum system demand (flow and pressure) required at the fire pump discharge gauge.
- E. The fire sprinkler contractor shall provide training for UCB personnel including CFM, FS inspection, testing, and maintenance personnel, plumbers, and electricians. Training shall include a walkthrough of the system showing the location of all equipment including, but not limited to, valves, flow switches, auxiliary drains, hose valves, spare sprinkler box(es), etc.

22 00 00	Plumbing
22 10 00	Plumbing Piping
22 11 00	Facility Water Distribution
22 11 13	<i>Facility Water Distribution Piping</i>

1. Water Piping:
  - a. Determine cold water service and building domestic hot and cold water demands for major buildings by the fixture unit method as outlined in the Uniform Plumbing Code. In addition to those given for sanitary fixtures, use 0.50 fixture unit for industrial cold water outlets over cup sinks in fume hoods and 1.0 fixture unit for each faucet at regular laboratory sinks with hot and cold water.
  - b. Add known continuous demands to the total estimated demand. Discuss the use of a diversity factor with Capital Projects (CP).
  - c. Size water piping with velocities not exceeding 7.5' per second and minimum of 35 pounds per square inch residual pressure at the highest, or last, fixture or hose rack. For copper pipe, size with velocities of 5' to 8' per second.
  
2. Joints
  - a. Joints shall be soldered or braised depending on the size and location of pipe. No PEX pipe joints will be allowed. Grooved (i.e. Victaulic) joints are allowed. Viega ProPress (or approved equal) copper joints are allowed when installed according to the manufacturer's installation instructions.
  
3. Plumbing Isolating Valves
  - a. Show all valves on drawings. Do not rely on a listing in the specifications or a general requirement (where or as required, etc.) clause.
  - b. Arrange and valve all utility services so that each floor and lab can be isolated without interrupting service to other parts of the building.
  - c. Arrange and valve domestic hot and cold water piping so that restrooms can be isolated without interrupting service to other parts of the building.
  - d. Show sectionalizing valves in top center and bottom of risers in hot water supply and return systems.
  - e. Show accessible service isolating valves for laboratory piping at the point of branch connections from mains. Valves need not be provided at the laboratory furniture units except for individual outlet faucets or cocks, not furnished with units.
  - f. Isolate the fire protection system (wet standpipe) by means of a main valve, or valves, at the bottom of the riser, locked open and marked with a suitable warning sign. Install a double check valve after the valve.
  - g. Show isolating valves to permit separate chlorination of the water system in buildings or projects where occupancy may occur in increments, as construction is completed.
  - h. Place valves on each side of a backflow or check valve to permit servicing.
  - i. Show valves on all services left for future connections (tees, stubs, etc.) unless they are in a valved zone, or isolated by other valves, that permit only a minor loss of pipe contents when opened.
  - j. Access panels for valves to be sized and located for service and maintenance.
  
4. Pipe Installation
  - a. Any metal pipe installed below grade shall have an IAPMO-listed corrosion preventive wrapping applied and inspected prior to backfill.
  - b. Di-electric fittings are not permitted. Use six inches (6") minimum of red brass for di-electric isolation between copper and steel components or other components with a potential for electrolysis.

- c. Provide water hammer arrestors in water lines to equipment or fixtures having quick closing or flush valves and any equipment that might produce water hammer. Water hammer arrestors shall be certified by the Plumbing and Drainage Institute (PDI). Show location and size of all water hammer arrestors on plans and access for maintenance or replacement. Provide access panels if required. Do not rely on a general note. Size and locate as recommended by the manufacturer.
- d. Show clean-outs in sewer lines as required by code. In addition, vertical to horizontal changes in main risers that occur above furred ceilings shall have a clean-out extended from the base to a floor clean-out or a wall clean-out above the change in direction.
- e. Specify "Y" pattern strainers for water lines three inches (3") and smaller. Screens shall be Monel with 1/16" perforations. Furnish strainers with caps and gaskets for positive positioning of screens. Screens shall fit into a recess machined into cap and body. Provide a 1/2" plug-type blow off valve with hose end on each strainer. Above three inches (3"), specify basket-type strainers with the same screen and a screwed or clamped cover.
- f. Insulate all plastic and glass piping where it penetrates a floor, wall or ceiling, to prevent flame spread between areas. Insulation and installation method shall be approved by the State Fire Marshal.
- g. Do not embed piping in concrete. Where piping must penetrate concrete at foundations or ground floor slab, coordinate with the appropriate architectural and structural sections and drawings to detail and dimension wrapping and/or sleeve with appropriate flexible seal to concrete.
- h. Specify additional hangers or supports for all plastic piping.
- i. No dielectric unions or fittings are allowed. Use six inches (6") minimum of red brass for di-electric isolation between copper and steel components or other components with a potential for electrolysis. This requirement applies to both Mechanical and Plumbing Systems.

#### 5. Risers

- a. Include a single-line, no-scale, riser diagram of each piping system on the plumbing drawings for all multistory buildings. Riser diagrams shall include soil, waste, vent, hot and cold water, compressed air, gases and distilled water systems.
- b. Riser diagrams shall show pipe sizes, sectionalizing valves, expansion joints, water hammer arrestors and any equipment in the system. Show design quantities and pressure, where applicable, for both branch and riser at each connection point.
- c. Indicate the basis used in sizing the pipes below the title of each diagram.

#### 6. Hot Water Supply

- a. When selecting steam-fired instantaneous water heaters, include the following:
  - i. Add known industrial hot water demands, such as washers, process work, animal room cleaning, etc., to the total fixture demand.
  - ii. Provide hot water temperature regulation to showers, with thermometers on hot and regulated water, for setting maximum temperature.
  - iii. See this Division for water heater information.
  - iv. Provide pumped circulation for all hot water systems.

#### 7. Connections To Kitchen Equipment

- a. Kitchen equipment is normally furnished under the specification section for kitchen equipment.
- b. Include a schedule in the plumbing drawings for the rough-in and final connections to all kitchen equipment.
- c. Coordinate the furnishing of all equipment trim, such as traps, faucets and valves, with the kitchen equipment drawings and specifications.
- d. Provide a pressure regulating valve, pressure gauge, pressure relief valve, thermometer and shock absorber in the 180° rinse line to the dishwasher connection

## 8. Meters

- a. See: 33 05 00: Common Work Results for Utilities, Subsection 10: Metering.
- b. Provide two (2) meters in parallel for each building domestic cold water service. Locate meters inside the building in an accessible location to permit reading and maintenance.
- c. Specify disc or turbine type meters for normal flow and compound type for cases where there is a large range of flow. Provide single or double registers reading in cubic feet.
- d. Provide strainers and isolating valves at meters to permit operation with one (1) meter out of service.
- e. Size each meter for one hundred percent (100%) of the estimated building cold water demand. Do not include fire sprinkler demand. Because of meter failure, one hundred percent (100%) demand on both meters shall be met. Research buildings shall have full demand met at all times.
- f. Meter the cold water makeup to cooling towers if the refrigeration system capacity is greater than fifty (50) tons.
- g. Meter the cold water fill line serving steam to space heating hot water shell and tube heat exchangers (to monitor leaks in the tube bundle).

## 9. Water Pressure Regulations

- a. Provide two (2) Zurn/Wilkins ZW209 or equivalent water pressure regulator valves (PRVs) in parallel for each building, regardless of existing static pressure. System shall maintain a maximum of eighty pounds per square inch (80 psi) at the lowest point of use. See Appendix A: Drawings for standard details.
- b. Locate regulators in the mechanical room for ease of maintenance. Provide proper drainage for pressure relief valve and leaks.
- c. Size each regulator with a rated capacity at the reduced pressure for one hundred percent (100%) of the estimated cold water building demand. No device shall be sized with inlets or outlets smaller than the size of supply piping.
- d. Provide low and high pressure gauges, strainers, pressure relief valves and isolating valves at regulators to permit operation with one (1) regulator out of service.
- e. Adjust pressure differential settings so that one (1) regulator will operate on low demands and the second (or subsequent) will open on increased demands.
- f. Where no regulation is required by present static pressure, set PRVs to no more than present static pressure.
- g. Note that regulators must be provided to meet the building water demand. There may be low, medium and high volume demand at various pressure requirements. As many as three (3) regulators in parallel may be required.
- h. Where a Pressure Reducing Station is included in the design for fire service, it shall comply with the following:
  - i. Where a PRV is installed below grade, a suitable valve pit of sufficient size to accommodate the personnel servicing the PRV shall be provided.
  - ii. Two PRVs of sufficient size to supply the system demand independently of each other shall be installed in series with a bypass around each so that if either PRV is removed, service is not interrupted.
  - iii. A low-flow PRV assembly shall be installed in parallel with PRVs installed below grade. The low-flow PRV assembly shall consist of two, two-inch (2") PRVs installed in parallel, in a similar manner as the main PRV it serves.
  - iv. A pressure gage shall be installed both up- and downstream of each PRV.
  - v. A low-flow bypass PRV shall be installed around the PRVs.
  - vi. A pressure relief valve shall be installed downstream of the PRVs. The design of the fire protection system shall be used to determine the pressure settings of both the PRVs and the pressure relief valve.

- vii. Drainage to sanitary sewer shall be provided for valve pit(s).
- viii. The lid to the valve pit shall be bolted or locked with a campus lock.
- ix. An indicating control valve shall be installed upstream and downstream of each PRV. All control valves shall be monitored by the Fire Alarm Control Unit and chained and locked.

## 10. Back Flow Prevention

- a. The University of California, Berkeley adheres to State requirements (California Code of Regulations Title 17: Group 4) and adopts the standards and recommendations set forth by the *Manual of Cross-Connection Control* (10th edition, or subsequent revisions: USC, Foundation for Cross-Connection Control and Hydraulic Research). The proper design, selection, installation and maintenance of cross-connection control devices is imperative, particularly in a university/mixed-use environment, for the protection of potable drinking water and distribution systems. Appropriate backflow prevention assemblies shall be selected from the most current USC-FCCCHR *List of Approved Backflow Prevention Assemblies* and shall be inspected and tested before being placed into service and periodically tested as specified by the manufacturer by a certified tester in accordance with Title 17 Standards. When installing backflow preventers, contractors shall engage UC Berkeley Facilities Services Utilities Plumbing Shop for coordination and testing (510-642-1032; <http://realestate.berkeley.edu/what-we-do/facilities-services>).
- b. Provide backflow protection at any building water system where there are connections, actual or potential, to a contaminating liquid. Examples include laboratory hose cocks and connection from domestic system to heating hot water (HHW) makeup and cooling towers.
- c. Backflow may be prevented by installing a backflow prevention device at each individual point of possible contamination, where devices such as vacuum breakers or air gaps may be employed, or at a single point where an industrial water piping system is fed from the domestic water piping. Industrial water used in labs for experiments is assumed to be non-contaminated. The industrial system shall be protected from HHW, cooling towers, etc., by additional RP devices.
- d. Select the type of backflow prevention system appropriate to each individual case. Generally, a separate industrial water system will be justified in buildings having numerous outlets that are susceptible to contamination. A chemistry or laboratory building is a good candidate for a separate industrial system.
- e. Discuss the requirements for backflow prevention for any building off campus with Capital Projects (CP) and the utility company.

## 11. Hose Bibs And Landscape Irrigation Service

- a. Provide hose bibs at important outside entrances to a building for washing down purposes. Locate these as inconspicuously as possible consistent with accessibility. Provide a ground level hose bib for wash-down at all large concrete areaways or shafts. Hose bibs shall be supplied from an industrial water system or have a separate RP device or vacuum breaker and backflow preventer on each hose bib.
- b. Landscape irrigation hose bibs and backflow preventer are normally under a separate landscaping contract. Provide a valved branch from the building service outside the building for future connection. Discuss size and location with Capital Projects (CP). Note that all hose bibs require a backflow preventer.
- c. Provide four-inch (4") plastic pipe sleeves below all roads and walks to permit later installation of irrigation system to reach all areas from the service point without cutting new work. Install sleeves with eighteen-inch (18") minimum depth and mark locations.

## 12. Disinfection Of Water Systems



- a. In new construction, specify that the plumbing subcontractor shall be responsible for cleaning and disinfecting the domestic hot and cold water systems, including fire systems connected to the domestic water systems, in accordance with the standards in Division 33: Utilities. For remodeling work, modify the procedure as required to accommodate the occupants.

### 13. Laboratory Piping

- a. Size piping for gas, and industrial hot and cold water in accordance with the laboratory pipe sizing standards in the California Plumbing Code, in consultation with Capital Projects, the Campus Building Department, The Office of Environment, Health and Safety (EH&S) and Designated Campus Fire Marshal's office for appropriate piping sizes for compressed air, vacuum and gas systems such as helium, oxygen and nitrogen.
- b. Size building distribution systems for all compressed gases and vacuum using a maximum of five percent (5%) loss of initial pressure to furthest point of use under maximum demand.
- c. Show a separate natural gas service to any room or area where gas burners are used with other gases, or air, under a greater pressure, such as a glass-blowing room. Provide Reliance Regulator Company, Type Y-183 diaphragm-operated check valve, or equal, to prevent a backflow of the higher pressure gas into the building's natural gas distribution system. Vent check-valve discharge to a safe point.
- d. Affix clear labels to the exterior surface of all pipes installed in mechanical rooms and interstitial spaces that carry natural gas, propane or other flammable / hazardous materials to allow easy and rapid identification.

### 14. Laboratory Outlets

- a. Provide hoods, laboratory tables, etc., with required type outlets manufactured by Water Saver Faucet Company, T&S Brass Company or equal. Provide color index handles.
- b. Specify valves on laboratory benches, tables and other equipment with index handles showing type of service.
- c. Do not use plastic faucets for DI systems as they break frequently. Use appropriately lined metal faucets.

### 15. Connections For Laboratory Equipment And Casework

- a. Include the rough-in for all laboratory equipment and casework (benches) in the plumbing drawings and specifications. Terminate rough-ins with valved services and plugged drains.
- b. Coordinate with laboratory casework and equipment specifications to make sure final plumbing connections are properly accounted for and specified in the appropriate specification section.

### 16. Special Laboratory Gas Systems (Cylinder Supplies)

- a. Coordinate all compressed gas system and storage designs with EH&S.

### 17. Distilled, De-Ionized (DI) and/or Demineralized Water Systems

- a. Consultation between end user, Capital Projects, and Facilities Services is required prior to the design or implementation of DI water systems. University's Representative shall coordinate design charrettes with Facilities Services Plumbing Shop and designer and/or contractor, as appropriate.

### 18. Industrial Water Systems

- a. The term industrial water is defined in this use as water that is not potable due to contamination, either actual or potential.
- b. The industrial water system shall serve all points of water use that could cause contamination by their backflow into the domestic water system.

- c. Where an industrial water system is selected for a project, protect the domestic water system by installation of two (2) approved reduced pressure backflow prevention devices in parallel at the point of connection.
- d. Detail the installation of the devices in an accessible location with the lower a minimum of 1' above the floor and the upper a maximum of five feet (5'-0"). Provide adequate drainage below the devices for testing or malfunction, via floor drains.
- e. Each outlet or connection to the industrial water system shall be posted with a sign reading Industrial Water - Do Not Drink. These may be waterproof cloth tape with printing protected by clear vinyl and self-adhesive back; 1/4" high, black letters on yellow background.
- f. Where hot water outlets are required in an industrialized system, provide either a separate water heater in the industrial system or a separate backflow preventer in all branch connections which may be taken from the domestic hot water system. Selection shall depend on the number, extent and location of hot water outlets requiring industrialized water. If separate backflow devices are specified, give the operating temperature for proper selection. Heat Tape is not allowed.

#### 19. Water-Conserving Equipment

- a. Water conservation shall be the prime consideration in the selection of equipment.
- b. Where possible, provide a flow control device on equipment which uses water for cooling.
- c. Where available, use cooling tower water for water-cooled equipment, or provide a cooling tower where the cooling water demand justifies the installation.
- d. All new construction and major renovations must meet the current UC policy and procedure requirements included in the UC Sustainability Practices Policy: <http://ucop.edu/sustainability/policy-areas/index.html>. The UC Sustainability Practices Policy provides guidance on the required sustainable water systems and on UC's USGBC LEED certification and credit requirements.

#### 22 13 00 Facility Sanitary Sewerage

#### 22 13 16 Sanitary Waste and Vent Piping

1. Kitchen or Food Service Waste System: Design a separate waste system for any lower-floor kitchen or food service where there are toilet rooms above. Keep this system separate and connect at a point in the building sanitary sewer system where a stoppage below the connection will not back sewage up to kitchen or food service floor drains or sinks.
2. Use corrosive-resistant pipe in any location where the waste may contain corrosives. Consult Capital Projects for acceptable piping materials. Keep such waste and vent system separate from the building plumbing soil, waste and vent systems to a point outside the building. In buildings with minor isolated points of corrosive use, discuss the method of handling with Capital Projects and Facilities Services.
3. Use gravity flow for all building drainage systems. Where this is impossible, projects shall obtain prior approval from UCB Facilities Services before installing pump systems.

#### 22 13 19.13 Sanitary Drains

1. The architect shall carefully coordinate with the mechanical engineer in the selection of drains for appearance (as in toilet rooms, shower rooms and other visible locations)
2. Locate toilet room floor drains out of foot traffic below water closet partitions or between urinals.
3. Where floor drains are roughed in for future use, cover with a flush plate and gasket for protection against fume leakage.
4. Provide trap primers to retain trap seals on floor drains. Floor drains in toilet rooms shall have vacuum breaker trap primers.
5. All floor drains to have three-inch (3") or larger traps plus trap primers.

6. All horizontal drain runs shall have cleanouts on the end of the run on every floor. Toilet rooms shall have cleanouts above flood rim of fixture served.
7. Main drain stacks shall have cleanouts installed on each floor.

### *22 13 19.23 Fats, Oils, and Grease Disposal Systems*

1. Grease traps shall be located for easy access and servicing, preferably outside, with proper venting. When considering installation of grease traps or interceptors contact EH&S.

### *23 13.23/26 Sanitary Waste Interceptors/Separators*

1. Provide plaster, sediment or sand traps at sinks that may discharge these materials into the waste system. Examples include sculpture rooms, pottery rooms, earth science and geology laboratories, greenhouse sinks, etc. Consider the use of a single large separator for a series of sinks or an area. All traps or separators located below sinks shall be accessible, with easy-opening tops.
2. Greenhouse Waste System: Design a separate waste system for all greenhouse floor drains, potting sinks, etc., that could receive sand, soil or similar planting materials. Extend this system to an interceptor before discharging into the sanitary sewer system.
  - a. Provide a sand and soil interceptor in all greenhouse waste lines serving floor drains and sinks only. Locate outside where possible and in an accessible location.

### *22 13 29.16 Submersible Sewerage Pumps*

1. See Division 14: Conveyances for elevator pit drains.

### *22 14 00 Facility Storm Drainage*

1. UC Berkeley is currently required to adhere to requirements set forth in the Clean Water Act and San Francisco Bay Region Water Quality Control Plan (also called the Basin Plan). Consultation between design teams, contractors and the Owner's Representative during the planning, design and inspection stages of the project shall be required to ensure that all required Best Management Practices (BMPs) are implemented in accordance with UC Berkeley's Phase II Small MS4 General Permit 2013-0001-DWQ. All BMPs that will be implemented for projects will be reported to the State Water Quality Control Board on an annual basis by UC Berkeley. If you have any questions, contact EH&S at ehs@berkeley.edu or 510-642-3073.

### *22 14 13 Facility Storm Drainage Piping*

1. Rainwater Leaders and Storm Drains: Compute rainwater quantity on the basis of 1.5" rainfall per hour minimum (.935 gallons per hour/square foot horizontal drainage area). Size all piping per the most recent edition of the California Plumbing Code.
2. Roof, Floor And Areaway Drains
  - b. Include provisions in the specifications for coordination of drain and clean-out elevations and other work such as concrete and waterproofing.
  - c. The architect shall carefully coordinate with the plumbing engineer in the selection of drains for appearance (especially in decks, terraces and other visible locations); type of clamping ring (built-up and single-ply roofing); size and type of waterproofing flange (for liquid applied systems); two-level drains; type of strainer, including removable internal strainers or buckets; gravel guards (ballasted or built-up roofs); method of anchorage to roof deck; movement due to seismic or deflection (steel framing systems) - ensure that movement is accommodated in leader below roof, not at roof membrane.
  - d. Specify galvanized beehive- or dome- type roof and areaway drain screens.

- e. Main drain stacks shall have cleanouts installed on each floor.

## 22 30 00 Plumbing Equipment

### 22 35 00 Domestic Water Heat Exchangers

#### 1. Hot Water Circulating Pumps

- a. Pump construction shall be all bronze.
- b. Control pump by immersion aquastat. Provide a thermometer in the return line ahead of the pump for adjusting the aquastat. Set the aquastat for ninety degree Fahrenheit (90°F) minimum return temperature.
- c. Specify inline type pumps, self-lubricating, 3-speed canned rotor design similar to Grundfos Series 6000. Use for plumbing and hot water heating systems. Note that a starter with holding coil is required to interlock with the built-in thermal overload device.

### 22 37 00 Lab-Bench / Laboratory Building Vacuum Systems

1. Only design / install dry house vacuum systems that do not use water for cooling, pumps with water bearings, or drain disposal of aspirant unless specific planned processes in the building (e.g. surgical medical procedures) require such a system.
2. Design house vacuum systems to trap any particulates or liquids in separators / traps prior to attaching house piping to commercially-available skidded vacuum pumps / accumulator.
3. Size skidded house-vacuum systems such that one pump can be shut down and isolated from the others and the house vacuum system for maintenance, while other pumps operate to maintain full vacuum for the building.
4. Install a 4" high by 4" wide berm around the house vacuum system in the mechanical room, and have no floor drains located inside the berm.
5. Ensure house vacuum separator, filter, accumulation tank, muffler, etc. have site-glasses on them, or clear-bowls or housings for in-operation visual inspection.
6. Ensure house vacuum separator, filter, accumulation tank, muffler, etc. have drain-ports available that are at least 24" above the floor or any obstruction under the drain port with ball-valve access for quick open/closed operation with a 1/4 turn of the valve handle.
7. Install house vacuum system components in the following order-of-flow (see Appendix A: Drawings for piping schematic):
  - a. Incoming piping from building
  - b. Tee and pipe with vertical bypass leg at least 12" above the horizontal "flow- through" pipe
  - c. Liquid separator with at least 4-gallon bowl
  - d. Particle separator / filter with full-flow and maximum size 100 microns particulate (or manufacturer's requirement, whichever is more stringent)
  - e. Post Separator / Filter T with vertical leg on the bypass at least 12" above the horizontal "flow-through" pipe Inlet to the skidded vacuum pumps and accumulator commercial package vacuum system the outlet of which Single manifold and outlet piping
  - f. Tee with vertical leg on the bypass at least 12" above the horizontal "flow-through" pipe
  - g. Muffler and vertical leg to building roof
  - h. Post Muffler T with vertical leg on the bypass at least 12" above the horizontal "flow-through" pipe

- i. Rain-guard and associated safe-exhaust piping on the roof with final outlet at least 120” above the roof surface and well-away from any air intakes / make-up air plenums on the roof.

## 22 40 00 Plumbing Fixtures

### 22 42 00 Commercial Plumbing Fixtures

#### 1. Fixtures, General

- a. Specify fixtures using a minimum of water consistent with fixture application. Install flow control devices to limit water use. Conservation of water shall be the prime consideration in the selection of fixtures.
- b. Vitreous ware shall be institutional quality.
- c. The manufacturer's name and numbers listed in the following sections are used only to indicate type and quality. Fixtures of other manufacturers such as Crane, Eljer or Kohler equivalent may be specified. Projects specifying other than listed fixtures shall consult with Capital Projects in advance.
- d. Specify fixtures complete with trim, where applicable. Exposed trim shall be coordinated with the finish of plumbing fittings.
- e. Coordinate accessible fixtures, fittings, and mounting heights with the architectural drawings.
- f. Provide stops in hot and cold water lines serving all fixtures, including hose bibs.

#### 2. Fixture Connections

- a. Specify the following items:
  - i. Exposed water supply pipe, tubing and waste piping connections shall be chrome-plated brass.
  - ii. Fit supply pipe, tubing, and other connections with chrome-plated brass escutcheons at walls.
  - iii. Cover exposed bolt heads in floor flanges of any fixture, in the back of any fixture, or in the fixture itself, with porcelain bolt caps securely attached.
  - iv. Fit fixtures tight to walls and seal joint. Coordinate sealant with architectural drawings.
  - v. Specify red brass for all nipples from copper water lines to fixture stops. Galvanized nipples shall not be used.

### 22 42 13 Commercial Water Closets, Urinals, and Bidets

#### 22 42 13.13 Commercial Water Closets

1. In general, water closets shall be the wall-mounted type with flush valves. Tank type may be used at single installations where water pressure is low, provided they are approved in advance by the University's Representative and achieve accessibility requirements.
2. Wall Mounted: Elongated American Standard, Kohler or equal with blowout flushing action, and Smith or equal appropriate foot support with short foot securely bolted to floor. Specify commercial wall carrier.
3. Floor Mounted: American Standard, Toto, Kohler or equal; all to be elongated.
4. Tank Type: American Standard or equal; Elongated.
5. For new construction or renovation, automatic flush-valves shall be provided. They shall be powered by AC/DC transformer, not batteries.
6. Water Closet Seats: Solid plastic, white, open front, less cover. Seats shall be self-raising in men's toilet rooms without urinals.
7. Flush Valves: Non-hold-open diaphragm type with screwdriver stop and vacuum breaker.

#### 22 42 13.16 Commercial Urinals

1. American Standard or equal, vitreous china urinal with top spud. Specify with two inch (2") waste to prevent clogging. Flush Valve: Non-hold-open diaphragm type with screwdriver stop and vacuum breaker. Specify commercial wall carrier or floor-mounted carrier as appropriate.

#### 22 42 16 Commercial Lavatories and Sinks

##### 22 42 16.13 Commercial Lavatories

1. American Standard Lucerne 20" x 18" vitreous china with two-handle mixing faucets or equal. Where required for accessible use, provide single-lever mixing faucets. Specify commercial wall hanger for wall mounted lavatories.
2. For new construction or renovation, commercial sensor faucets shall be provided. They shall be powered by AC/DC transformer, not batteries.

##### 22 42 16.16 Commercial Sinks

1. Trap Standard-Mounted: American Standard Lakewell or equal, with plain back.
2. Floor-Mounted: Fiat molded-stone type, size as required.

#### 22 45 00 Emergency Plumbing Fixtures

##### 1. Emergency Showers And Eyewash Station Locations

- a. The scope and application of the updated Cal/OSHA regulations are expanded from corrosive liquids to all hazardous substances, including materials that are harmful and likely to cause injury.
- b. Contact EHS ([ehs@berkeley.edu](mailto:ehs@berkeley.edu) or 510-642-3073) if unsure of emergency eyewash /shower requirements. In general, because research may change, all laboratories should have a combination emergency eyewash /shower or easy access to one close by.
- c. All emergency eyewash and showers shall comply with CCR Title 8, Section 5162, ANSI standard Z358.1-1981 and the following:
  - i. An emergency eyewash/shower shall be provided in work areas where the eyes and/or body may come into contact with hazardous substances. The eyewash and shower shall be located such that they can be reached from any point in the laboratory within ten (10) seconds and be used simultaneously. Eyewash and shower shall be readily visible (using signs, bright paint, etc.) and area shall be well lighted. Eyewash and shower may be located between laboratories, ancillary spaces or corridors, provided ANSI standards are met.
  - ii. The floor space below an emergency shower/eyewash must be kept free and clear of obstructions at all times for a distance of thirty-inch (30") diameter circle. In addition, the free floor space shall be delineated by two inch (2") wide yellow tape.
  - iii. Personal eyewash/shower equipment (i.e., squeeze bottles, hand held drench hoses, etc.) may be installed to support shower and eyewash units but shall not be substituted for them.
  - iv. All equipment shall be connected to a potable water supply with 1-1/2" minimum pipe size.
  - v. All units require valve hold-open devices. Water flow must be intentionally shut off.

##### 2. Emergency Shower And Eyewash Station Products

- a. Types:
  - i. Wall-Mounted: Haws eyewash or equivalent, mounted with 42" rim height. Eye washes shall be provided with drains, trapped and connected to a waste system. Emergency shower shall be Haws or equivalent.
  - ii. Pedestal-Mounted: Haws or equivalent. Use only in remodeling projects or where wall-mounted type is not practical.
- b. Features and Installation:

- i. The eyewash basin must drain to a plumbed drain, not to the floor.
- ii. Provide chrome-plated tubing “P” traps only where the eyewash station trap is vented and the waste discharges into a sanitary sewer system.
- iii. No drum traps are allowed.
- iv. Provide trap primers at all eyewash stations and floor drains serving emergency showers. Trap primers must be easily serviceable for maintenance from an adjacent floor-mounted access plate or by other means without having to access associated plumbing from the floor below.
- v. Securely brace and anchor pedestal-mounted units to wall (coordinate with architectural drawings for blocking at stud walls).
- vi. Provide an accessible shutoff valve in the line serving both the eyewash station and the emergency shower.

#### 22 47 00 Drinking Fountains and Water Coolers

- 1. Electric bottle fillers/drinking fountains shall be wall-mounted type, with minimum cooling capacity of six gallons (6 US gal.) per hour of fifty-degree Fahrenheit (50°F) drinking water at an inlet water temperature of seventy-degree Fahrenheit (70°F) and ambient temperature of eighty-degree Fahrenheit (80°F). Supply water temperature shall be adjustable. Drinking fountains shall be Haws, Elkay or a Facilities Services pre-approved equivalent.
- 2. Where possible, locate drinking fountains out of corridor traffic. The architect shall coordinate location, accessible mounting requirements, finish and color with Capital Projects (CP) and Facilities Services.

#### 22 50 00 Pool and Fountain Plumbing Systems

##### 22 52 00 Fountain Plumbing Systems

- 1. Ornamental Pools
  - a. In designing the mechanical system, use the following design criteria:
    - i. Place the pool circulating pump below the pool water level for a flooded suction.
  - b. Provide dual suction strainers in parallel, valved so that either may be isolated for cleaning. Specify quick-removal covers.
  - c. Where the pool does not have direct public access or is in a controlled area not subject to great amounts of paper, trash, bathers, dogs, etc., install a sand filter and water treatment feeders in the circulating system.



## 23 00 00 Heating, Ventilating, and Air Conditioning

### 23 05 00 Common Work Results for HVAC

#### 1. Codes and Standards

- a. All mechanical systems shall be designed, constructed and commissioned to meet:
  - i. Most recently adopted version California Code of Regulation Title 24 (Building, Mechanical, Electrical, Fire and Life Safety, and Energy Efficiency Requirements) and Title 8 (Occupational Health and Safety requirements).
  - ii. American Society of Heating, Refrigeration and Air-Conditioning Engineers Standard 62 - Ventilation for Acceptable Indoor Air Quality. (ASHRAE Standard 62).
  - iii. American Society of Heating, Refrigeration and Air-Conditioning Engineers Standard 55 - Thermal Environmental Conditions for Human Occupancy, which establishes acceptable temperature, relative humidity and air movement rates for occupied spaces. (ASHRAE Standard 55).
- b. California Energy Code compliance forms and other documentation required to verify compliance with code requirements shall be submitted with bid and/or contract documents.

#### 2. Overview

- a. Occupant comfort, healthful indoor air quality and energy efficiency shall be the prime considerations in any proposed design. In addition, the designer must also satisfy requirements for future expansion, provide ease of maintenance, and minimize life-cycle cost. Because of the required longevity of University buildings and the great expense of modifying or replacing existing mechanical systems, the designer shall strive to ensure that the proposed systems are capable of meeting the long term needs of the building in which they are installed.
- b. Project shall consult with Facilities Services Energy Office early in the design process, but no later than the Design Development (DD) phase.
- c. The heating and ventilating systems of a building are dependent upon its size, shape and occupancy and it is important that proposed type or types of systems be presented during the preliminary planning stage. Carefully select building orientation, materials, and systems for control of heat gain and loss in the building. During schematic design, evaluate the life-cycle cost of several design alternatives. Design the control system to provide optimal operation of the entire system.
- d. All projects, regardless of size, shall engage Facilities Services (including, but not limited to: Energy Office, Engineering, Asset Management and relevant maintenance shops) at project initiation, to confirm scope of work, design parameters, to align project work with campus requirements, and avoid future changes.
- e. It is important that the architect retain a mechanical engineer to permit their participation in the building study and design to avoid later changes that could affect the structure, or that would require modifications of the system to fit the structure.
- f. The architect shall coordinate with the mechanical and electrical consultants and Capital Projects (CP) on the selection of the type of systems.
- g. All systems shall be commissioned and tested to meet or exceed Mechanical Acceptance Test Criterion as defined in the most recently adopted versions of the California Mechanical and Energy Codes. In applications not covered by MATC, consultation with Facilities Services on required functional performance test and/or optimized sequences shall be required.
- h. All new construction and major renovations must meet the current UC policy and procedure requirements included in the UC Sustainability Practices Policy: <http://ucop.edu/sustainability/policy-areas/index.html>. The UC Sustainability Practices Policy provides guidance on the required energy standards and on UC's USGBC LEED certification and credit requirements.



### 3. Mechanical System Diagrams

- a. Include a single line, no scale, diagram of each mechanical system, including supply and exhaust air, fume hood exhaust, hot water heating, steam, chilled water and cooling water on the mechanical plans of all buildings. Show equipment names, sizes, flow rates, dampers, valves, and direction of flow arrows. Show normal position for each valve, either normally open (NO) or normally closed (NC).
- b. Include riser diagrams of supply and exhaust duct systems. Show equipment names, sizes, cubic feet per minute, velocities, fire dampers and volume control devices (dampers, splitters, etc.) Individual room outlets need not be shown.
- c. Include a riser diagram of the hot water heating system, showing pipe sizes, gallons per minute, balancing devices and direction of flow arrows.
- d. Indicate size and design quantities on these diagrams for each branch connection to a riser and for the riser at that point.
- e. Indicate the basis for sizing pipes or ducts below the title of each diagram.
- f. Include control diagrams clearly indicating hard wired points and mapped points for each piece of each assembly for systems or equipment added or modified within the scope of the project

### 4. Redundancy

- a. Redundancy shall be provided for the following HVAC system components.
  - i. Heating Hot Water Heat Exchangers - provide two (2) heat exchangers, each capable of handling fifty percent (50%) of the system capacity. Each heat exchanger shall have two (2) steam control valves to provide for a full range of steam flow controllability.
  - ii. Heating Hot Water Pumps - provide two (2) pumps, each capable of handling one hundred percent (100%) of the system capacity.
  - iii. Chilled Water Pumps - provide two (2) pumps, each capable of handling one hundred percent (100%) of the system capacity.
  - iv. Tower Water Pumps - provide two (2) pumps, each capable of handling one hundred percent (100%) of the system capacity.

### 5. Criteria for Determining HVAC Loads

- a. The following outside air and indoor space temperatures shall be used to determine HVAC loads for spaces where occupant comfort is the sole consideration for the thermal environmental conditions:

Season	Outside Air Temperature	Space Temperature
Summer	85°F db, 64°F wb	75°F
Winter	34°F	70°F

- b. Allowance for load safety factor shall not exceed ten percent (10%).
- c. The maximum allowance for pickup loads is as follows:

Building Operating Schedule	Heating Pickup Load, Maximum	Cooling Pickup Load, Maximum
less than 24 hours/day	25%	0%
24 hours/day	15%	0%

- d. An allowance for future loads may be permitted. Consult with Capital Projects (CP) when future additional loads are likely to occur.

### 6. Air Requirements

- a. Determine minimum outside air required according to the most recently adopted California Mechanical and Energy Codes.
- b. In determining heating and ventilating supply air quantities, consider all of the following factors that may affect the quantity and use the largest resulting quantity:
  - i. Air required by law or code, or campus health and safety requirements.
  - ii. Air required to heat or cool the space or control humidity.
  - iii. Make up air required for non-recirculated spaces, fume hoods, kitchen hoods, or other special exhausts.
  - iv. Air required for combustion in fuel burning equipment.
- c. Criteria for supply air volume for heating shall be based on the reduction of objectionable air currents in the occupied zone per ASHRAE Standard 55. The supply air temperature required to meet the space-heating load should not exceed one hundred and five degrees Fahrenheit (105°F). Air required to cool a space which is not mechanically cooled shall be based on a maximum allowable temperature rise (DB) within the occupied zone of not more than ten degrees Fahrenheit (10°F) above the coincident outside air temperature. Where operable windows are present the required air volume may be provided from the combined volumes of mechanically supplied and natural ventilation. For purposes of this calculation, all heat sources, gains and losses, must be properly accounted for, with due regard to diversity and timing of intermittent loads. Where determined air change rates are excessive or exceed twenty (20) per hour, consult with Capital Projects (CP). Provide mechanical ventilation for enclosed stairwells, trash rooms, elevator machinery rooms, mechanical equipment rooms and electrical equipment rooms as follows:
  - i. Supply and exhaust electrical and elevator equipment rooms with air quantities sufficient to prevent a temperature rise that would impair proper equipment operation. Filter supply air if it is not from the filtered building system. Evaluate mechanical cooling for rooms with high heat gains requiring large air volumes.
  - ii. Except for stairs designed as smoke-proof enclosures per UBC requirements, design stairwell ventilation as follows: Supply air from the top of stairwell to prevent stagnation and odor buildup and to overcome the stack effect in winter. Provide one (1) air change per hour minimum, based on the total volume of the stairwell. Do not exhaust stairwell. However, pressure required to open exit doors shall conform to code requirements. Provide required fire dampers in ductwork.
  - iii. Exhaust only for trash rooms, giving a negative pressure in the room to confine odors.
  - iv. Provide sufficient supply and exhaust ventilation to mechanical equipment rooms to prevent temperatures above ninety degrees Fahrenheit (90°F). Use a minimum of one cubic foot per minute per square foot for cool rooms and two (2) cubic feet per minute per square foot for hot.

## 7. Air Conditioning and Cooling

- a. Air conditioning, for occupant comfort only, shall only be authorized for those spaces which qualify under the University Energy Use Policy. Non-mechanical options shall be considered before development of mechanical cooling options in such spaces. Where conditions indicate potentially high internal or solar heat loads, discuss air conditioning, or provisions for its future addition, with Facilities Services Energy Office and Capital Projects (CP). Discuss temperature and humidity control, where required to meet laboratory or process requirements, with Facilities Services Energy Office and Capital Projects (CP) to establish a clear understanding of operating limits, loads and control features required.
- b. Cooling is required for all ventilation supply air to spaces for animal occupancy. Obtain temperature requirements from Capital Projects (CP).
- c. Select chiller based on lowest life cycle cost. Consider absorption, vapor compression and thermal storage type systems and include the costs of auxiliary equipment. For electrical systems compute

energy costs using actual time of use rates including demand charges and include differential cost of larger electrical system components (e.g. transformers). Ensure high-efficiency operation of the chiller plant at a range of low load conditions calculated for outside air temperatures between 55°F and 65°F.

- d. For vapor compression type systems priority shall go to systems with the lowest CFC content. Review preliminary selection of chiller equipment with Capital Projects (CP), as regulations change and previously used refrigerants may no longer be acceptable. Such systems shall provide safe maintenance and access points for removal of hazardous materials. Consult EH&S ([ehs@berkeley.edu](mailto:ehs@berkeley.edu) or 510-642-3073) for access and sampling port locations, location of site-glasses (if needed), and drain requirements.
- e. Variable Refrigerant Flow (VRF) systems shall be considered for areas approved for air conditioning. These systems shall use brazed copper tubing. Manufacturer shall be Mitsubishi or approved equal. VRF systems shall be designed with shutoff valves as required to service individual zones without the need to turn off the entire system and remove and recover the entire system refrigerant charge.
- f. Areas within buildings which require 24/7 cooling such as telecom or server spaces shall be considered to be cooled by individual split system air conditioning units of VRF systems depending on size and quantity of cooling required.
- g. Chilled water piping shall be schedule 40 with welded or Victaulic style fittings for sizes larger than 2". Sizes 2" and smaller shall be screwed. Viega ProPress with the appropriate sealing element for chilled water systems may be approved on a case-by-case basis. Consult with Facilities Services and Capital Projects.
- h. Pumps for building condition shall be Bell and Gossett or equal.
- i. All fans and pumps with 5 horsepower and above shall have motors equipped with VFD control.

## 8. Recirculation

- a. With the following exceptions, recirculation of HVAC system air is useful to reduce peak loads and energy requirements. During occupied periods system dampers/controls shall be configured to provide at least the required minimum outside air requirements by utilizing a separate minimum outside air damper section and actuator. Controls for systems with mechanical cooling shall include an economizer sequence.
- b. Exhaust ventilation for the rooms listed below or any other room with airborne hazardous materials shall not be recirculated:
  - i. Laboratory spaces and storage rooms where hazardous materials are used or stored
  - ii. Chemical laboratories
  - iii. Noxious laboratories or rooms
  - iv. Welding or soldering areas or shop areas where hazardous materials are used or stored
  - v. Animal areas
  - vi. Toilet rooms
  - vii. Athletic locker rooms
  - viii. Trash and garbage rooms
  - ix. Janitors closets
  - x. Duplicating rooms using volatile solvents
- c. For other occupancies, discuss air quality of recirculated supply air with Capital Projects (CP).
- d. To reduce ductwork and the number of exhaust fans, consider grouping or stacking areas with common exhaust fans.
- e. Where recirculation is used, install smoke detection equipment as required by Title 24 2013 as applicable to the installation. When smoke is detected, dampers go to the 100% exhaust position.

## 9. Clean Room Recirculation

- a. Where clean rooms are included in the building program, type, filter efficiency, cooling and ventilation air requirements shall be obtained from Capital Projects (CP).
- b. Prefabricated clean rooms, modules or benches are preferred where their use will meet requirements.
- c. Select equipment, air velocities, plenum and duct sizes for minimum noise generation within the work area.
- d. Provide a method for introducing test media into the room fan return plenum and for sampling the test media density above room filters. Discuss with Capital Projects (CP).
- e. The testing of clean rooms, to check their compliance with specifications, shall be done by the University.
- f. Clean rooms require special consideration and design. Drawings and specifications shall cover, in detail, all points of construction, installation and sealing.

## 10. Cold Rooms

- a. A minimum quantity of outside air shall be supplied to cold rooms to provide a safe working environment. Review at earliest design stage with Capital Projects (CP) and Environment, Health and Safety (EH&S).
- b. Cold rooms shall be designed with desiccant dehumidifiers when design requirements require precise humidity control.
- c. Cold rooms shall be designed for access of condenser and associated components at ground level and as approved by Facilities Services. Condenser and associated components shall not be located above cold rooms.
- d. Cold box control systems shall be capable of trending for two week minimum and shall be able to communicate with building automated control system to download trends and receive alarms.

## 11. Air Compressors

- a. Size laboratory building compressors using 0.15 cubic feet per minute free air per lab outlet. Minimum compressor size shall be twenty cubic feet per minute (20 cfm) capacity at forty pounds per square inch (40 psi) receiver pressure. Discuss diversity factor with Capital Projects (CP).
- b. Where there are other known demands, such as air centrifuges, air-operated equipment that has a high demand with intermittent operation or high pressure, discuss the supply with Capital Projects (CP).
- c. Select air compressors to operate with the minimum allowable receiver pressure, using a single stage if possible.
- d. Where calculated capacity is greater than thirty cubic feet per minute (30 cfm), consider using two (2) compressors of fifty percent (50%) capacity each for reliability. A single large receiver may be used for two compressors.
- e. Receivers shall be an ASME standard pressure vessel.
- f. Where two (2) compressors are installed, arrange the piping and valves so that either or both may be used.
- g. Do not locate compressor air inlet in a hot area where the moisture in the air may cause objectionable condensation in the lines. Specify and show a Dollinger Model D or equivalent filter in the suction line.
- h. Provide Dollinger Model CPHS or equivalent filter with automatic drain in the supply line from the receiver.
- i. Specify compressors equipped with a refrigerated air dryer.
- j. Provide a pressure-reducing valve sized for the designated system use and operating pressure, with low-side pressure gauge and pressure relief valve set for minimum pounds per square inch over reduced pressure. Maximum pressure for laboratory and shop use is 30 pounds per square inch.

## 12. Vacuum Pumps.

- a. Size laboratory building vacuum pumps, using 0.10 cubic feet per minute per lab outlet. Vacuum pump minimum capacity shall be ten cubic feet per minute (10 cfm) at 27" Hg receiver vacuum. Discuss diversity factor with Capital Projects (CP).
- b. Where the calculated capacity is greater than 20 cubic feet per minute, consider installation of two vacuum pumps of 50% capacity each for reliability. A single large receiver may be used for two vacuum pumps.
- c. Receiver and separator shall be ASME stamped for vacuum use.
- d. Where two (2) pumps are used, arrange piping and valves so that either or both pumps may be used.
- e. Provide a liquid separator with a valve in the suction line. Provide Dollinger Model CVH, or equivalent, vacuum filter in the suction line after separator.
- f. Vacuum pump exhaust shall have a muffler with discharge extended through the roof to prevent objectionable odors or contamination in the mechanical room and to prevent entrainment into the building fresh air ventilation system. Size discharge pipe large enough to minimize vacuum pump capacity reduction.

## 13. HVAC Piping

- a. Di-electric fittings are not permitted. Use six inches (6") minimum of red brass for di-electric isolation between copper and steel components or other components with a potential for electrolysis.

## 14. Variable Frequency Drives Serving HVAC Equipment.

- a. See also, Section 26 29 33, *Variable-Frequency Motor Controllers*
- b. Specify only the following variable frequency drive (VFD) manufacturers to ensure compatibility with campus staff training and inventory: ABB, or approved equal. Discuss specification language with CP University's Representative to comply with campus requirements.
- c. Warranty: All equipment and installation shall be warranted for a minimum period of twelve (12) months from the date of Final Acceptance. This warranty shall include all costs of repair during the warranty period including transportation and shipping costs.
- d. Standard Products: All materials and equipment furnished shall be new and of standard design and model. In addition, they shall be the manufacturer's latest standard design that is current at the time of delivery, except for such modifications from the manufacturer's standard product as may be required to conform to specification requirements.
- e. VFD System: Provide a complete variable frequency drive system.
  - i. Each system shall consist of:
    1. A power input circuit breaker.
    2. A drive power unit safety disconnect (service switch).
    3. A rectifier.
    4. Filter and inverter with regulator and controls (drive power unit).
    5. Inverter with regulator and controller.
    6. Motor overload heaters.
    7. Transducers and instrumentation.
    8. User input/output terminals.
    9. A system control panel and system enclosure(s).
  - ii. The output waveform of the drive power unit shall be sine-coded, pulse width modulated.
  - iii. The systems shall be installed as variable speed controllers for existing induction motor driven fans.
- f. Standards, Codes and References: Design, construction and fabrication shall be in accordance with good engineering practice and workmanship and in compliance with the following standards and codes as applicable.
  1. National Electrical Manufacturers Association (NEMA).

2. Institute of Electrical and Electronic Engineers (IEEE).
3. Occupational Safety and Health Act (Cal/OSHA).
4. NFPA National Electrical Code (NEC).
5. Underwriters' Laboratory (UL) or Electrical Testing Laboratory (ETL).
6. State of California and all Local Laws and regulations.
7. Drawings:

8844B-E1-0	Typical control schematic for single motor variable frequency drive.
8844B-E2-0	Typical control schematic for dual motor variable frequency drive.
8844B-E3-0	Variable frequency drive control interface diagram.

- g. Each variable frequency drive unit shall bear the approval sticker of a nationally recognized testing laboratory such as Underwriters' Laboratory (UL) or Electrical Testing Laboratory (ETL).
- h. Submittals to the University shall include three (3) copies of the following items for each different size and/or model system:
  - i. Dimensional drawings showing all pertinent dimensions and total unit weights for the variable frequency drive system equipment.
  - ii. A complete set of drive power unit connection diagrams.
  - iii. A complete set of elementary and schematic drawings for all electric and electronic circuits.
  - iv. A complete set of wiring drawings showing schematics of each printed circuit board and all components both by circuit connection and position on board, and all component values.
  - v. A complete manual including all necessary installation, operation, and maintenance instructions.
  - vi. A recommended spare parts list and a parts price list.
- i. General VFD requirements: The drive power unit shall be of sufficient capacity and shall provide a quality of output waveform to achieve the full rated output of the driven motors listed in Part 3. In addition, the variable frequency drive system shall include the following ratings and parameters.
  - i. Efficiency: Minimum drive unit efficiency shall be 94% at 100% speed and not less than 80% at 50% speed.
  - ii. Input Voltage: The input voltages shall be 3-phase, 240 or 480 volts + 10%, -5%, 60 HZ±5%, as required by location.
  - iii. Rating: The drive unit rating basis shall be 100% continuous with a service factor of 1.0.
  - iv. Input Circuit Protection (main circuit breaker): A properly rated thermal-magnetic molded case circuit breaker or a circuit breaker/current limiting fuse combination that provides the short circuit protection required below, shall be provided on the incoming power line.
    1. The circuit breaker shall be rated 200,000 amperes at 240 volts or 100,000 amperes at 480 volts interrupting capacity RMS for short circuit protection.
    2. The circuit breaker shall be lockable in the off position and shall be interlocked with enclosure door, with provision for defeating the interlock.
  - v. Drive Power Unit: The variable frequency drive power unit shall consist of converter, filter and inverter sections.
    1. The converter section shall be a full wave, 3-phase diode bridge that shall provide a voltage source with output that is regulated and limited.
    2. The output of the converter shall feed a filter capacitor section.
    3. The inverter section shall convert the DC output to an approximate sine wave current waveform at an adjustable frequency.
  - vi. Bypass Equipment: By-Pass capability shall require the following equipment to be supplied as part of the variable frequency drive package to ensure a coordinated system:

1. Two (2) AC motor controllers, with 115 volt coils, mechanically and electrically interlocked for inverter or bypass output.
  2. Inverter and bypass contactor control relays for transferring output from the inverter to the bypass and vice versa.
  3. Thermal motor overload devices with auxiliary contacts, wired into the output to provide motor overload protection in both inverter and bypass mode.
  4. Auxiliary contacts on the inverter and bypass contactors and control relays as per the drawings.
  5. Where the variable frequency drive is required to drive two (2) motors; two (2) pairs of controllers (four [4] total), each pair mechanically and electrically interlocked, and two thermal motor overload devices shall be provided.
- vii. Control Power Transformer: A 120 volt control power transformer with primary and secondary protective fuses shall be provided for remote and local controls.
- viii. Enclosure:
1. The enclosure shall be a rigid wall-mounted or freestanding National Electrical Manufacturers Association (NEMA) 1 Type for indoor applications. NEMA 3R enclosures shall be specified for outdoor applications. Outdoor applications shall be installed with weatherproof doors covering readout panels which do not require the opening of the entire panel.. Operation, maintenance and parts replacement shall be from the front of the unit enclosure. No access from the sides or rear of the panel shall be required. Replacement type filters shall be used on all ventilation openings. Changing of filters shall be done without the opening of any enclosure doors.
  2. The enclosure shall house all electrical and electronic components.
  3. The equipment shall contain drive data nameplate mounted inside the housing with the following information: input voltage, full load current, drive horsepower rating, service factor, frequency range, maximum output voltage, model number, serial number, and shop order number.
- ix. Controls, Control Relays, Pilot Lights and Indicators:
1. Panel mounted controls and pilot lights shall be National Electrical Manufacturers Association (NEMA) Type 13 oil tight.
  2. Pilot lights shall be push-to-test transformer type with 6.3 volt lamps.
  3. Control relays shall be industrial grade control type relays.
  4. Indicators shall be industrial type panel meters, digital or analog as indicated.
  5. All wires shall be marked on both ends with the number shown on wiring diagrams. Output terminals shall be continually numbered with no repetition. Wire markers shall be heat shrinkable or interlocking sleeve type.
- j. Technical Requirements: Design Criteria and Features: The drive power unit shall provide the following:
- i. Rated output voltage shall be 3-phase 208 or 480 volts, 60 Hz.
  - ii. Output frequency control variable over a 40:1 speed ratio range.
  - iii. Long term frequency stability shall be one percent (1%) or better for any given twenty-four (24) hour period.
  - iv. Speed regulation at the motor shaft shall be three percent (3%) or better with standard National Electrical Manufacturers Association (NEMA) Design B induction motor, without special slip compensation.
  - v. Overall rating shall be 150% of drive rating for one (1) minute.
  - vi. Electronic start into running motor protection.
  - vii. Auxiliary outputs prewired to terminals for purchaser's use:
    1. A normally closed fault summary dry contact that opens on any variable frequency drive internal fault or AC power failure.

2. A 0 to 6 volt or 0 to 10 volt direct current output signal proportional to 0 to 150% speed.
  3. A 0 to 6 volt or 0 to 10 volt direct current output signal proportional to 0 to 150% current output.
- viii. The inverter regulator section shall include:
1. Adjustable current limit (60-110%).
  2. Adjustable volts per hertz for output power (+/- 10%).
  3. Adjustable minimum and maximum speed or frequency (0-100% and 100-0%).
  4. Torque limit adjustable from 50 to 100% of full drive rating. When torque limit is exceeded, output frequency shall decrease until load is within continuous torque rating limit at which point the speed shall stabilize. If minimum frequency is reached before the torque is reduced to a safe value, then the inverter output shall de-energize within sixty (60) seconds. Operation with torque limit control engaged shall be visually indicated.
- ix. The drive shall be capable of follower operation from a 0 to 10 volt direct current signal that may be either positive or negative and either grounded or ungrounded.
- x. Sealed contacts for all switched regulator and reference signals are required.
- xi. The door of each variable frequency drive power unit shall include a control panel consisting of:
1. Lockable input power disconnect handle (main circuit breaker).
  2. Lockable drive power disconnect (service switch) that may be accessible only from inside the enclosure.
  3. *Off-hand-auto* control select switch.
  4. *Bypass-inverter* output selector switch.
  5. *Start in auto* (computer control) push-button.
  6. *Manual* (Hand) speed adjusting potentiometer.
  7. *Power on* indicating light.
  8. *Inverter fault* indicating light.
  9. *Motor on inverter* indicating light.
  10. *Motor on bypass* indicating light.
  11. Speed or frequency meter (output, 3 digit LCD or LED digital, scaled 1 to 150%).
  12. Ammeter (input current, analog only, scaled 0 to 150% of full load current).
  13. Normal-test switch.
  14. Voltmeter (input line voltage, analog only, scaled 0 to 150% of nominal).
- xii. Independently adjustable acceleration and deceleration rates extendible up to thirty (30) seconds, with torque limit override acceleration protection and regeneration protection during deceleration.
- xiii. Selectable coast-to-stop or ramp-to-stop control.
- xiv. "Normal-Test" switch that shall prevent closing of the bypass or inverter output contactors, to permit no-load on-line testing of variable frequency drive components. The normal-test switch shall be located inside the variable frequency drive cabinet, accessible to qualified maintenance personnel only.
- k. System Protection: The following design, operation and maintenance features shall be incorporated in the drive power unit.
- i. A disconnecting device shall be supplied to disconnect all drive power unit internal wiring from the input power supply. The device shall be operated by a door-mounted handle that shall be lockable in the off position and shall be mechanically interlocked with the enclosure door. The locking safety mechanism shall be defeatable to allow for opening the enclosure without de-energizing the equipment.



- ii. The current limit capability of the converter section shall react sufficiently fast to protect against a sudden random short circuit at the output terminals of the converter section.
- iii. The converter shall be provided with high speed, current limiting input line fuses to protect against internal faults.
- iv. Phase-to-phase and phase-to-ground short circuit protection.
- v. Additional protection shall be provided for:
  - 1. Input power failure.
  - 2. Phase current imbalance.
  - 3. Under-voltage.
  - 4. Incorrect phase rotation shall be provided.
    - a. Transient suppression for protection of internal components from line and load transients.
  - 5. Ground fault.
  - 6. Electronic motor overload (IT) protection, adjustable from 60 to 100% of drive full load ampere rating.
- vi. Heat sink temperature switches shall be supplied and an orderly shutdown shall occur on over temperature conditions.
- vii. DC bus voltage clamp circuitry shall be provided to prevent damage due to AC line overvoltage. Excessive motor regenerative voltage shall not cause inverter to trip or damage components but shall decelerate motor to a safe operating mode.
- viii. Instantaneous electronic overcurrent trip circuitry shall be provided for protection of inverter section power electronic devices independent of protective fusing. This circuitry shall include visual indication, in the regulator section, of any instantaneous overcurrent trip.
- ix. The filter capacitors shall have automatic discharge circuitry that will cause discharge within approximately three (3) minutes after the drive system is de-energized.
- x. The inverter section shall be provided with high-speed current limiting fuses to protect against internal faults.
- xi. Inverter overload protection shall provide shutdown on an inverse time basis dependent on the extent of the overload.
- xii. Two (2) second power outage ride-through capability: The inverter shall maintain constant volts per hertz at motor terminals during outage. Rundown time is determined by system inertia and losses only.
- xiii. The inverter shall not trip due to supply system AC transient spikes when in the bypass run mode or when OFF. The drive manufacturer shall provide electronic circuitry that prevents such a trip, or an electrically operated isolation Contractor on the supply side of the inverter.
- 1. System Test and Troubleshooting:
  - i. The variable frequency drive system equipment shall include a display for system malfunction identification and troubleshooting. At a minimum, the following indicators shall be provided:
    - 1. Overcurrent trip.
    - 2. Overvoltage trip.
    - 3. Torque limit.
  - ii. A diagnostic fault microprocessor shall be utilized to perform all diagnostic testing.
- m. Mode of Operation: The system shall provide for operation as follows:
  - i. *Off-Hand-Auto* control selector and Bypass-Inverter output selector switches:
    - 1. In *off* position there shall be no output from the variable frequency drive system. The inverter cannot be started and the bypass contactor cannot be closed.
      - a. When moved to *off* from *hand* position, variable frequency drive system output shall cease, subject to the following: If the output selector switch is on

- bypass, the inverter output shall be disconnected and power to the fan motor shall derive from the bypass contactor and circuit.
- b. If the output selector switch is on inverter, the *inverter* shall immediately open.
2. In *hand* position the fan motors shall run from bypass or inverter output, according to the setting of the output selector switch.
    - a. If the output selector switch is on bypass, the *inverter* output shall be disconnected and power to the fan motor shall derive from the bypass contactor and circuit.
    - b. If the output selector switch is on *inverter*, the inverter shall operate and power to the fan motor shall derive from the inverter. Speed shall be controlled by the front door-mounted speed control.
  3. In *auto* position the fan motors shall be controlled by remotely sourced computer-controlled inputs. The variable frequency drive system output shall be inverter or bypass, according to the setting of the output selector switch. The *on* signal shall be provided by momentary closure of a remote dry contact. The *off* signal shall be provided by momentary opening of a remote dry contact. Speed control shall be provided by a 0 - 10 volt analog signal.
    - a. If the output selector switch is in *bypass*, the inverter shall be disconnected and power to the fan motor shall derive from the bypass contactor and circuit. Start-stop functions shall be remotely controlled.
    - b. If the output selector switch is in *inverter*, the drive shall operate and power to the fan motor shall derive from the inverter. Both start-stop functions and speed set-point shall be remotely controlled.
    - c. The inverter output frequency shall increase or decrease at the preselected rate when *on* or *off* signals are received or when changes in speed control are made while in both *auto* and *inverter* modes. When an *off* signal is received, the inverter contactor shall not open until the speed has ramped to near zero. When an *on* signal is received, the inverter contactor shall close before the speed is ramped up to the preset or input speed.
  4. When switching from *hand* to *auto* and vice-versa, when in *inverter* output, the control system shall be so configured that the drive shall not go through complete shut down while making any speed adjustments.
    - ii. *Start in Auto, Push-button* Switch: This momentary contact switch shall functionally parallel the computer controlled *on* signal when the control selector switch is in *auto*. It shall provide for restarting the fan motor whether in bypass or inverter output mode.
    - iii. *Normal-Test* Switch: This maintained contact switch shall disconnect the bypass and inverter contactor coils from control power when in *test* position to permit no-load testing and adjustment of variable frequency drive components.

## 23 05 93 Testing, Adjusting, and Balancing for HVAC

### 1. Summary

- a. Air and water balancing shall be performed by an independent Test and Balance Agency retained either as a direct Subcontractor to the General Contractor or separately by the Owner. Coordinate an appropriate procurement method with the Capital Projects during the design phase. Require that the General and Mechanical Contractors provide all tests, inspections, and preparations necessary to facilitate activities of the Test and Balance Agency. Final test and balance report shall be submitted to appropriate UCB Facilities Services staff (Campus Building Department,

HVAC, Electrical, Engineering, Energy Office) and approved prior to project Substantial Completion.

- b. See also, Section 23 08 00 *Commissioning of HVAC*, below.

## 2. Quality Assurance

- a. Test and Balance Agency shall be a certified member of the Associated Air Balance Council with at least ten (10) years of experience in the testing and balancing of HVAC systems. The Test and Balance Agency shall be regularly engaged and specialize in the testing and balancing of HVAC systems. Testing and balancing shall be performed in complete accordance with the "National Standards for Total System Balance," as published by the Associated Air Balance Council (AABC).
- b. Personnel Qualifications: Require that the Test and Balance Agency assign personnel that have experience in projects of similar type and scope. Require submittal of names, qualifications, and project experience of all personnel proposed to perform testing and balancing.
  - i. Field supervisor with day-to-day responsibility for the work shall be an AABC Certified Test and Balance Engineer with at least ten (10) years of testing and balancing experience in related projects. Qualifications shall include at least five (5) recent projects of similar size, type, complexity, and regulatory requirements supervised and/or executed by the individual proposed for the Project. The approved AABC Certified Test and Balance Engineer shall directly supervise day-to-day activities and shall be on the job site every day that testing and balancing work is performed.
  - ii. Technicians performing work shall be AABC Certified Test and Balance Technicians with at least five (5) years of testing and balancing experience in related projects. Qualifications shall include at least five (5) recent projects of similar size, type, complexity, and regulatory requirements executed by technicians proposed for the Project.
  - iii. Apprentices used for this work shall have at least three (3) years of testing and balancing experience in related projects. Qualifications shall include at least three (3) recent projects of similar size, type, and complexity executed by apprentices proposed for the Project. Apprentices shall at all times work under the full-time direction and guidance of AABC Certified Test and Balance Technicians or Engineers.
  - iv. No testing, adjusting, balancing, or measurements shall be performed by personnel who are not approved by the Owner's Representative. The Owner's Representative retains the right to reject the qualifications of any personnel proposed for this project based on a reasonable review of submitted qualifications. Where specific personnel are rejected, the submittal of alternate personnel with acceptable qualifications is required.
- c. Instrumentation: Require that instruments have the maximum field measuring accuracy and are best suited to the function being measured. Scale ranges shall be appropriate for the value being measured. Utilize instruments with minimum scale and maximum subdivisions available for each measurement.
- d. Performance Guarantee: Require the submittal of an "AABC National Performance Guarantee" for each project. The guaranty shall certify that all systems are balanced to optimum performance within the limits of the design and installation. The Test and Balance Agency shall furnish all labor and material to restore system performance, to the satisfaction of and at no cost to the Owner, any system that fails to maintain optimum performance during the warranty period.

## 3. Submittals

- a. Preliminary submittals shall include:
  - i. Qualifications of the Test and Balance Agency and of personnel to be assigned to the Project. Detailed procedures for the Project.

- ii. Report forms filled out for the Project.
- b. Intermediate submittals shall include:
  - i. Written reports describing any system deficiencies or components which do not function properly.
  - ii. Intermediate test and balance reports, as specified below, shall be submitted to appropriate UCB Facilities Services staff (HVAC, Electrical, Engineering, Energy Office)
- c. Final submittal shall include:
  - i. Test and balance report typed in final form, including drawings identifying locations of every air outlet and inlet and pitot traverse. A draft report shall be submitted for review by the Owner's Representative and the project Mechanical Engineer. The final report shall address all comments and be approved by the project Mechanical Engineer.
  - ii. Fan and pump curves with design and actual operation points plotted. Certificates of calibration for all instruments used.
  - iii. HVAC controls coordination report.
  - iv. Performance Guarantee.
  - v. The AABC Certified Test and Balance Engineer who supervised and is responsible for the work shall sign the final balance report, certifying the accuracy of the results and that work has been performed in accordance with specified standards and procedures.
  - vi. Test and Balance report shall also verify nameplate information as provided in Building Equipment Matrix Logs (See Item 3 of Section 01 78 39 *Project Record Documents*).

#### 4. Renovation Projects

- a. Pre-demolition Measurements: Evaluate the impact of new work on the air and water balance in adjacent areas and, where appropriate, require the following measurements before demolition begins or as soon as ceiling access is made available.
  - i. Measure airflow in every duct entering or leaving the Project area as close as possible to the Project boundary, unless this information is not pertinent
  - ii. Measure airflows in other spaces outside the Project area that will be affected by demolition or new work.
  - iii. Where connection to existing ducts will be made, measure available static pressure at the points of connection.
  - iv. Where new ducts are connected to existing supply or exhaust fan systems, measure and report fan and motor data. Notify the Owner's Representative in writing if existing fan system(s) are operating close to capacity and not able to adequately serve the Project area.
- b. Intermediate Air Balancing: Whenever demolition, capping of existing ducts, or connection of new ductwork to existing systems causes airflows to change outside of the project area, provide immediate air balancing to adjust the fan speed, main duct dampers, and branch dampers so that existing airflows and pressure relationships are maintained outside of the project area. Intermediate test and balance reports are to be submitted within 24 hours after completion of duct modifications that affect airflows in other areas. Handwritten documentation on approved AABC forms will be acceptable only for intermediate test and balance reports.

#### 5. Preparation

- a. Require the following pre-balance preparation by the Test and Balance Agency:
  - i. Review the Drawings and Specifications and notify the Owner's Representative in writing if the installation poses any potential balancing problems or if any additional balancing devices that are not shown or specified are necessary for a total system balance.

- ii. Review shop drawings to verify that all necessary balancing devices will be provided. Confirm final schedule and coordination issues. Identify the times and scope of any intermediate air balancing required during the construction.
- iii. Identify Testing Locations: After rough-in of ducts, piping, and equipment is complete, identify traverse locations, access requirements, and final placement of all balancing devices.
  - 1. Drill minimum 1/2-inch diameter holes in ductwork for temperature, pressure, and velocity readings. Drill test holes in the following locations:
    - a. Each side of each filter, fan, coil, and multi-blade damper 0.6 inches on center for traverse readings in all main ducts. In each new branch duct connecting to an existing duct. As directed in the field.
  - 2. Install a “Ventlok 699” Instrument Test Hole with red painted cap in each hole. Trim and vapor seal duct insulation around all test holes.
  - 3. Test holes shall be fully visible and accessible from the ceiling access openings.
  - 4. Indicate above-ceiling testing locations in the final test and balance report.
- b. Require the following pre-balance preparation by the Contractor and trade subcontractors:
  - i. Provide ceiling access as necessary for pre-demolition airflow measurements specified below.
  - ii. Install all dampers and other balancing devices shown or specified and check to be sure they are properly installed, fully open, and in good working order.
  - iii. Complete all punch list items that will affect balancing of the system.
  - iv. Fully coordinate with electrical and HVAC controls subcontractors the readiness, correctness, and the safety of the electrical power and control systems before starting any equipment.
  - v. Start-up and test new and modified systems. Place all systems in automatic operation. Operate the systems for a minimum of 72 consecutive hours without shutdown with all equipment in good working order.
  - vi. Schedule work of other trades to eliminate system shutdowns once balancing is started, and assure uninterrupted access to mechanical equipment and conditioned spaces.
  - vii. Air Systems:
    - 1. Clean interior of all plenums, air handler casings, and ducts.
    - 2. Check that duct volume damper and fire smoke dampers are fully open. Verify that air filters are in place. Calibrate and adjust air filter gauges. Check for correct fan rotation.
    - 3. Check for adequate motor horsepower to start and run fans.
    - 4. Check for proper lubrication.
    - 5. Check sheave alignment and belt tension at all fans.
    - 6. Remove adjustable pitch pulleys from the motor shaft. Clean and lightly oil the shaft and pulley threads, and remount the pulley. Final adjustment shall be by the Test and Balance Agency.
    - 7. Check fans for stable and quiet operation at design RPM.
    - 8. Set sheaves to provide indicated capacities at specified static pressures. Furnish and install replacement sheaves as directed by the Test and Balance Agency during system balance.
    - 9. Provide holes in drive guards that will permit tachometer readings without removing guards.
  - viii. Water Systems:
    - 1. Comb heating and cooling coil fins and prove water flow to all coils.
    - 2. Remove air from water systems.
    - 3. Clean all system strainers. Remove temporary strainer liners.

4. Check that isolation valves, automatic control valves, and circuit balancing valves are 100 percent open.
5. Verify completion of pump alignment, pre-operating checks, and preliminary testing.

6. Testing and Balancing Activities

- a. Require that all work conform to standard requirements and procedures contained in the AABC "National Standards for Total System Balance" and "Test and Balance Procedures", and recommended procedures contained in the ASHRAE HVAC Applications Handbook. Test and Balance Agency shall perform all recommended procedures, tests, measurements, and adjustments indicated in these standards, whether specified or not, as required for a total system balance.
- b. Where the Project is to be completed in phases, require complete testing and balancing at the end of each phase of work, so that spaces may be occupied according to the Project Schedule.
- c. Balancing Criteria and Requirements:
  - i. Air inlets and outlets of 200 CFM or less shall be balanced to within plus ten percent to minus zero percent (10-0%) of design; larger inlets and outlets shall be balanced to within plus five percent to minus zero percent (5-0%) of design. Fans shall be balanced to within plus ten percent to minus zero (10-0%) percent of design. Temperature readings shall be accurate to within one half degree Fahrenheit (0.5°F). Water flow readings shall be accurate to within 5 percent. Pressure readings shall be accurate to within 0.5 psi for water systems and 0.01 in.w.g. for air systems.
  - ii. Instruments shall have been calibrated within the last six (6) months and checked for accuracy prior to starting the balancing procedure. Make velocity readings with an instrument that does not require a separate timer.
  - iii. All readings, measurements, and observations shall be recorded on printed AABC data sheets and tabulated with appropriate calculations.
- d. Air System Balancing:
  - i. The intent is to obtain design CFM at all outlets and inlets with minimum possible fan speed and system static pressure, and with acceptable noise levels in occupied areas. At least one main zone volume damper and one branch volume damper in each zone shall be fully open at the end of balancing. Final position of manual dampers shall be plainly marked after balancing is complete.
  - ii. Test and Balance Agency shall make special note wherever abnormal installed conditions (such as crimped flexible ducts, tight offsets, and unusual tap-ins or fittings) do not permit a proper air balance without increasing main duct static pressure or fan speed. Abnormal conditions shall be reported as early as possible, preferably during preliminary observations, and submitted with static pressure and airflow measurements that will permit analysis and identification of necessary corrective actions.
  - iii. Test and Balance Agency shall make allowance for air filter resistance at the time of the tests. Air handling systems shall be balanced with the final (dirty filter) air resistance imposed using blank-off plates.
  - iv. Test and Balance Agency shall fully balance variable air volume systems and equipment at scheduled maximum and minimum flow conditions.
  - v. Test and Balance Agency shall make adjustments at diffusers and registers to prevent drafts at the occupant level in the space.
  - vi. Positive or negative pressure relationships between supply and exhaust CFM shall be achieved in spaces wherever shown on the Drawings or required by Code. Required air pressure relationships are absolute and shall be met regardless of allowed tolerances for airflow adjustments.

- vii. Require that the final test and balance report include static pressure profiles of all balanced air handling systems, including static pressure measurements across fans, filters, main heating and cooling coils, sound traps, main duct modulating control dampers, in main and branch ducts near riser shafts, and upstream of variable air volume boxes. Include diagrams and/or drawings to document system static pressures.
  - viii. Require that the following measurements be made at duct smoke detector locations:
    1. Differential pressure measurements across duct smoke detector sampling tubes.
    2. Velocity profiles with air velocity measurements at six-inch (6") intervals at sampling tube locations.
    3. Any other measurements requested by the Owner's Representative or authorities having jurisdiction to ensure that duct smoke sensors are installed in accordance with their listing requirements.
  - ix. Include detailed instructions in the Specifications or on the Drawings so that special balancing activities are addressed and included in the final test and balance report. These might include:
    1. The establishment of minimum outside air and exhaust airflows at air handling units with variable air volume or economizer controls.
    2. The establishment and calibration of maximum and minimum duct static pressure and airflow setpoints.
    3. The establishment of normal and default speed setpoints for variable frequency drives.
    4. Constant volume and variable air volume fume hood certification in accordance with UCB EH&S requirements, ASHRAE Standard 110, and other appropriate reference standards.
    5. Sound testing for HVAC noise in sensitive areas. Vibration measurements of rotating HVAC equipment.
    6. Smoke control system testing shall include the detailed testing and adjustment of airflows as required to attain floor pressurization and room pressurization required to meet the code required door opening force and floor to floor pressure differentials. This additional balancing is not possible to engineer on contract documents and the scope must be clearly defined on documents.
- e. Water System Balancing:
- i. Require that chilled and heating hot water mains and branches be adjusted to flow rates as shown on the Drawings or as required to obtain required thermal performance. Before adjusting system circuit balancing valves, verify that normal design differential pressures exist in water lines at heating and cooling coils. Prohibit the use of service isolation valves for balancing.
  - ii. Require preliminary measurements and multiple readings of pump performance in accordance with requirements elsewhere in this section. For systems in which pump impellers will be trimmed for efficient operation, require that final measurements be made after pump impellers have been ground and reinstalled.
  - iii. The final test and balance report shall include design and measured flow rates and pressure drops at each point where design flow quantity is shown or scheduled on the Drawings, and water temperatures leaving and entering all coils when coils have had both air and water flows balanced.
- f. Equipment Performance and Capacity Checks:
- i. Require that complete equipment performance documentation and test measurements be submitted in accordance with AABC "National Standards for Total System Balance" to demonstrate that all new and modified equipment is operating in accordance with

scheduled performance criteria and manufacturer's published ratings. Where equipment is not performing in accordance with scheduled criteria or published ratings, analyze deficiencies and direct the Contractor to make appropriate corrections to allow equipment to perform efficiently and at required capacity.

- ii. Seasonal Checks: During the first year of operation, if the Owner's Representative determines that heating or cooling capacities are not up to their expectation, require that the Test and Balance Agency provide additional system testing during periods of peak heating or cooling at no additional cost to the Owner. Based on the results of this testing, direct the Contractor to make appropriate corrections so that heating and cooling systems provide required capacities.

## 7. HVAC Controls Coordination and Commissioning

- a. Require that the Test and Balance Agency cooperate with HVAC controls installer and other trades in making HVAC control system adjustments necessary to accomplish commissioning and the required sequence of operation.
- b. Where sequences require establishment of minimum and maximum airflows, multiple setpoints, reset schedules, or other variable conditions, the Test and Balance Agency shall provide all testing and balancing necessary to establish required setpoints. System performance shall be documented under all possible operating conditions.
- c. Clearly delineate aspects of the control system installation and performance to be checked or tested by the Test and Balance Agency. Activities will vary with each project, but may include:
  - i. Temperature and pressure readings to verify that control devices are properly calibrated and that sensors are properly positioned to read intended temperatures and pressures.
  - ii. Airflow measurements to verify control system setpoints at maximum and minimum airflows.
  - iii. Temperature measurements to verify that room temperature sensors and thermostats are properly calibrated and installed to avoid erratic operation due to air diffuser short circuiting or cold walls.
  - iv. Room and building pressurization measurements to verify that lobbies, laboratories, odorous rooms, clean spaces, and other sensitive areas have the correct air balance and pressure relationships.
  - v. Automatic controllers and thermostats operate the correct control valves. Controller, thermostat, and control valve actions are correct.
  - vi. Setpoints meet the intent of the Sequence of Operation.
  - vii. System interlocks operate properly.
- d. The final test and balance report shall include a checkout spreadsheet to document pertinent control system checking. Spreadsheet should include sensor and actual readings, device tag numbers, system, location, ranges, and other information.

## 8. Final Acceptance

- a. At the time of final inspection, require the Test and Balance Agency to recheck, in the presence of the Owner's Representative, specific and random selections of water and air quantities and other data as recorded in the final test and balance report. Measurement and test procedures shall be the same as approved for the work.
- b. Selections for recheck should not exceed twenty-five percent (25%) of the total number tabulated in the final report, except that one hundred percent (100%) of air inlets and outlets in sensitive areas may be checked.
- c. If random tests elicit a measured flow deviation of ten percent (10%) or more from that recorded in the final test and balance report in ten percent (10%) or more of the selected recheck stations, the report shall be automatically rejected. In the event the report is rejected, all systems shall be



readjusted and tested, new data recorded, a new test and balance report submitted, and new inspection tests made, all at no additional cost or time to the Owner.

- d. Final settings of all balancing valves, splitters, dampers, and other adjustment devices shall be permanently marked and locked in position and recorded by the Test and Balance Agency so that adjustment can be restored if disturbed at any time. Final balancing valve and damper positions shall be recorded in the final test and balance report.

23 07 00 HVAC Insulation

23 07 19 HVAC Piping Insulation

Table 1: HVAC Piping Insulation

Service	Material	Remarks
Heating Water, Hot Water, Cold Water and Chilled Water Piping	(a) Inside Buildings: See Note No. 2. Molded glass fiber with All-Purpose white jacket and PVC Zeston fittings covers. Seal all gaps.	Manville Flame-Safe - AP
	(b) Outside Buildings: Molded glass fiber with 0.016" aluminum jacket applied over pipe and fitting insulation. Aluminum jacket shall be sealed watertight with seams directed downwards and caulked	Manville Flame-Safe - ML All laps to provide watershed.
Cooling Tower Water Piping		No insulation required. Piping shall be galvanized or painted to prevent surface corrosion
Refrigeration Piping (Suction Lines)	(a) Closed-cell foam.	Armaflex or equivalent, paint or UNI-JAC jacket for exterior installations.
	(b) Closed-cell foam plastic.	Manville Aerotube
Steam and Condensate Piping	(a) General inside building (to maximum 300°F): Molded glass fiber with All-Purpose white jacket and PVC Zeston fittings covers. Seal all gaps.	Manville Flame-Safe - AP
	(b) General outside building (to maximum 300°F): Molded glass fiber with 0.016" aluminum jacket applied over pipe and fitting insulation.	Manville Flame-Safe - ML All laps to provide watershed
	(c) In mechanical rooms, underground ducts (above 300°F): Molded calcium silicate with 0.016" aluminum applied over piping and fitting insulation.	Manville-Thermo-12 with Metal-On jacket
Duct Insulation	(a) Exterior insulation: See Note No. 4. Fiberglass blanket with density of 2 lbs. per cubic foot and flame resistant Foil-Scrim-Kraft vapor barrier.	Manville Microlite with FSK facing
	(b) Interior insulation (lining): Fiberglass duct liner with air stream surface covered with black plastic coated mat facing.	Manville Linacoustic

Equipment-Hot	Molded hydrous calcium silicate.	Finish with 6 oz. canvas. See note No. 3.
Equipment-Cold (below 50°F)	Foamed polystyrene	Finish with 6 oz. canvas. See note No. 3.
	Cellular glass	Finish with 6 oz. canvas. See note No. 3.
	Flexible foamed plastic sheet/tubing	Paint finish where exposed. See note No. 3.

(Footnotes next page)

Footnotes:

1. Manville and Pittsburg-Corning have been named as reference standards. Other manufacturers and methods may be specified where their use is suitable.
  - a. Describe thickness and application methods for selected material in the specifications. Fiberglass lining in the interior of any air duct system is prohibited unless coated to preclude erosion of fibers into the air system.
  - b. Discuss other materials or methods with Capital Projects.
  - c. Where two (2) finish coats are specified on finish jacketing, they shall be of different colors for checking.
  - d. Protect all glass fiber and non-rigid pipe insulation from crushing in hangers by means of an 18 gauge metal shield 12" minimum length x 120°F minimum arc outside of insulation.
2. Apply on cold water only in concealed or warm areas where condensation might occur.
3. Where 6 oz. canvas is indicated as FINISH, secure with Foster's or Arabol lagging adhesive. If the finish is not to be painted, apply a second coat without thinning.
4. Vapor barrier may be omitted if air is not cooled.
5. Steam valves, traps, strainers, and pressure reducing valves shall be insulated with removable insulation blankets

23 08 00 Commissioning of HVAC

1. General

a. Work Included

- i. Systems and equipment testing and start-up.
- ii. Validation of proper and thorough installation of mechanical systems and equipment and electrical systems that support them, where appropriate.
- iii. Systems balancing verification.
- iv. Pre-functional performance testing of equipment and systems.
- v. Documentation of tests, procedures, and installations.
- vi. Coordination of Training Events.
- vii. Generic Start-Up Procedures for mechanical systems and equipment.

2. General Description

- a. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.

- b. Commissioning Authority (CxA) is retained by the Owner and shall work with the Contractor and the Design Engineer to direct and oversee the Cx process and perform functional performance testing.
- c. This Section outlines the Cx procedures specific to the Division 23 Contractors. Requirements common to all Sections are specified in Section 019113 and the Commissioning Plan.

### 3. Scope

- a. The following are included in the Scope of Commissioning on this project (**University's Representative to indicate, as appropriate**):
- b. Mechanical/HVAC Systems
- c. Chillers (CHs)
- d. Pumps (Ps)
- e. Air Handling Units (AHUs)
- f. Air Flow Measuring Stations (AFSs)
- g. Indirect Evaporative Coolers (IDECs)
- h. Fan Coil Units (FCUs)
- i. Variable refrigerant flow systems (FCUs & CUs)
- j. Supply Fans (SFs)
- k. Exhaust fans (EFs)
- l. Transfer fans (TFs)
- m. Variable Frequency Drives (VFDs)
- n. Variable Air Volume Boxes (VAVs)
- o. Underfloor Fan Terminals (UFTs)
- p. Building Automation Systems
- q. DDC control system
- r. VRF control system
- s. Domestic Hot Water Systems
- t. Heat Exchangers (HEXs)
- u. Gas Water Heaters

### 4. Related Work and Documents

- a. Commissioning Plan: The Commissioning Plan (Cx Plan) outlines the commissioning process beyond the construction specification. All Contractor responsibilities are outlined in Specifications. Cx Plan is available to the Contractor to understand the context of their responsibilities but does not define any additional responsibilities of the Contractor
- b. Section 01 91 13 *General Commissioning Requirements* details the common Cx requirements common across all Divisions beginning with the Construction Phase. Focus is on Contractors responsibilities for the Cx process.
- c. Section 26 08 00 *Commissioning of Electrical Systems* details the systems commissioning scope and procedures specific to Division 26 work.

### 5. Definitions and Abbreviations

- a. Refer to Section 01 91 13 *General Commissioning Requirements* and the Project Commissioning (Cx) Plan.

### 6. Reference Standards

- a. ASHRAE Guideline 1-1996, "Guideline for Commissioning HVAC Systems"
- b. ASHRAE Guideline 4-1993, "Preparation of operating and Maintenance Documentation for Building Systems"
- c. NEBB - Procedural Standards for Building Systems Commissioning

d. [ASHRAE Standard 110 – Method for Testing Laboratory Fume Hoods]

## 7. Documentation

- a. In addition to the documentation required in Section 01 91 13, Contractor shall provide to the CxA the following per the procedures specified herein, in the Cx Plan, and in other Sections of the specification:
- b. Balancing Plan: The plan shall include the following:
- c. Certifications on all instrumentation to be used throughout the testing. This must document certification within the last 6 months.
- d. Résumés and Certification of individuals who will be balancing systems
- e. Detailed step by step plans for each procedure to be performed.
- f. Sample forms to be used for each measurement
- g. Sample balancing report
- h. All referenced charts such as applicable manufacturer’s balance valves, vibration severity chart and room noise criteria (NC) curves.
- i. Vibration Severity Charts
- j. Factory Test Reports: Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to Acceptance Phase. Factory Test Reports should be provided in PDF electronic format. These may include, but are not limited to:
  - i. Air Handling Units
  - ii. VRF Fan Coil Units
  - iii. VRF air-cooled Condensing Units
- k. Field Testing Agency Reports (other than TAB): Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in PDF electronic format. These may include but are not limited to:
  - i. Refrigerant Pipe Pressure Testing
  - ii. Duct Leakage Testing
  - iii. Noise Level Testing
- l. Completed Test and Balance Reports. CxA shall review prior to Functional Performance Testing.

## 8. Sequencing And Scheduling

- a. Refer to Section 01 91 13 and the Cx Plan.

## 9. Coordination Management Protocols

- a. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 91 13 and the Commissioning Plan, but shall be refined and documented in the Construction Phase Cx Kick-Off meeting. Contractor shall have input in the protocols and all Parties will commit to scheduling obligations. The CxA will record and distribute.

## 10. Contractor responsibilities

- a. Refer to Section 01 91 13. Detailed Contractor responsibilities common to all Divisions are specified in Section 01 91 13. The following are additional responsibilities or notable responsibilities specific to Division 23:
  - i. Construction Phase
    1. Provide skilled technicians qualified to perform the work required.
    2. Provide factory-trained and authorized technicians where required by the Contract Documents.
    3. Prepare and submit required draft Start-Up Procedures and submit along with the manufacturer’s application, installation and start-up information.

4. The following should be merged into the TAB Section. If you have the opportunity to do that, simply reference the section here. Where not include it all here.
  5. TAB: Specifically as it relates to Cx:
  6. Attend Cx kick-off meeting and Cx progress meetings during Acceptance Phase.
  7. Submit Balancing Plan as indicated above
  8. Meet with Cx Team to review TAB procedures and documentation required.
  9. As called by CxA, participate in CxT demonstrations of balancing procedures for repetitive procedures such as zones.
  10. Participate in applicable Action Item resolution
  11. Provide all documentation electronically.
  12. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.
  13. Start-up, and test/adjust/balance systems and equipment prior to functional performance testing by the CxA. Start-Up Procedures shall be in accordance with Contract Documents, reference or industry standards, and specifically elsewhere in Part I of this Section.
  14. Record Start-up Procedures on start-up procedure forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above. Each task or item shall be indicated with the Party actually performing the task or procedure.
- ii. Acceptance Phase
1. Assist CxA in Functional Performance Testing if requested. Assistance may generally include the following:
  2. Manipulation of systems and equipment to facilitate testing (as dictated in Section 019113 and the Cx Plan);
  3. Provide any specialized instrumentation necessary for functional performance testing;
  4. Manipulation of BAS and other control systems to facilitate functional performance testing (as dictated Section 01 91 13 and the Cx Plan).
  5. Attendance of Cx meetings as required to resolve issues and answer questions. Meetings shall be on an as-needed basis and will not exceed (12) twelve one hour meetings.
- iii. Warranty Phase
1. Maintain record documentation of any configurations, set ups, parameters etc, that change throughout the period.
  2. Provide representative for off-season testing if necessary.
  3. Respond to Warranty issues as required by Division 1 and the General Conditions.

11. Equipment Supplier Responsibilities

- a. Refer to Section 01 91 13.

12. Contractor Notification AND SCHEDULING

- a. Refer to Section 01 91 13.

13. START-UP procedures and documentation

- a. Refer to Section 01 91 13.

14. Equipment Nameplate Data

- a. Refer to Section 01 91 13 and Item 3 of Section 01 78 39 *Project Record Documents*.

## 15. BAS Trending requirements

- a. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be interval recordings of system I/O parameters or Change-of-Value-based trends that record when a system value changes by more than a specified threshold.
- b. CxA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The specific requirements of the trending are specified with the 'generic' FPT procedures in the specifications. Contractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CxA.
- c. Trend data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at 15 minute intervals and be presented in a maximum of two separate two-dimensional formats with time being the vertical axis and field name being the horizontal axis. Data shall be forwarded in one of the following formats.
  - i. Microsoft Excel Spreadsheet (.xls)
  - ii. Comma Separated Value (.csv or .txt) preferably with quotes delimiting text fields and # delimiting date/time fields
- d. Sample times indicated as COV ( $\pm$ ) or change of value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When output to the trending file, the latest recorded value shall be listed with any given time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.
- e. Contractor shall provide the CxA with required passwords, phone numbers, and any other information needed to allow the CxA access to the trend log data and allow downloading to a remote location, if applicable. Contractor shall also provide step-by-step written instructions for accessing the data.

## 16. Functional Performance Testing (FPT)

- a. Contractor shall participate in the initial samples of Functional Performance Testing as stipulated in Section 01 91 13 and the Cx Plan.

## 17. FPT Acceptance Criteria

- a. Acceptance criteria for tests are indicated in Section 01 91 13, the specification Sections applicable to the systems being tested, and/or the Cx Plan. Generally, unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device.

## 18. Training

- a. Contractors, Subcontractor, Vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of the individual Specifications sections.

## 19. Systems Manual Content - Preparation and Logistics

- a. Refer to Section 01 91 13 and individual Specifications.

## 20. Products

- a. Instrumentation
  - i. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of + or - 0.1°F.
2. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.
4. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems shall be provided by CxA.
5. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.
- 6.

## 21. Execution

### a. Start-up Procedures – General

- i. This Section outlines 'generic' or minimally acceptable Start-Up Procedures (delineated as Start-Up Checks and Start-Up Tests) and individual systems Training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per normal quality control practices. These items shall provide a minimum or guideline for required Contractor development of Start-Up Procedures. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized Start-Up Procedures specific to the equipment and systems installed on this project.

### b. Procedures Common to All Systems

- i. The following start up verifications/procedures are common to all systems
  1. Checkout shall proceed from devices to the components to the systems.
  2. Verify labeling is affixed per spec and visible
  3. Verify prerequisite procedures are done.
  4. Inspect for damage and ensure none is present.
  5. Verify system is applied per the manufacturer's recommendations
  6. Verify system has been start up per the manufacturer's recommendations
  7. Verify that access is provided for inspection, operation and repair
  8. Verify that access is provided for replacement of the equipment
  9. Verify the record drawings, submittal data and O&M documentation accurately reflect the installed systems
  10. Verify all gages and test ports are provided as required by contract documents and manufacturer's recommendations
  11. Verify all recorded nameplate data is accurate
  12. Installation is done to ensure safe operation and maintenance.
  13. Verify specified replacement material/attic stock has been provided as required by the Construction Documents
  14. Verify all rotating parts are properly lubricated
  15. Verify all monitoring and ensure all alarms are active and set per Owner's requirements
  16. Complete all nameplate data and confirm ratings conform with the design documents

### c. Valves

- i. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:

1. Operate all valves, manual and automatic, through their full stroke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
  2. Verify actuators are properly installed with adequate clearance.
  3. Verify all valves are labeled per the construction documents. Confirm that concealed valves are indicated on the finished building surface.
  4. For automatic pneumatically-operated valves, verify spring range and adjust pilot positioners where applicable. For electronically operated valves, check the stroke and range. For all automated valves controlled by a program, ensure that the minimum and maximum stroke and ranges on the valves are coordinated with the limits entered in the program.
- d. Meters And Gages
- i. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:
    1. Adjust faces of meters and gages to proper angle for best visibility.
    2. Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint. For meters and gages requiring temporary manual connection of readout device such as pressure taps on a flow measuring device, ensure threads are clean and that connection can be made easily.
    3. Meters and gages requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.
- e. Mechanical Identification
- i. Start-Up Checks: Perform the following checks:
    1. Verify all valve tags, piping, duct, and equipment labeling corresponds with drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.
    2. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
    3. Cleaning: Clean face of identification devices, and glass frames of valve charts.
- f. Mechanical Insulation
- i. Start-Up Checks: Examine all piping, systems and equipment specified to be insulated.
    1. Ensure quality of insulation. Patch and repair all insulation damaged after installation.
    2. Ensure the integrity of vapor barrier around all cold surfaces.
- g. Refrigerant Piping – General
- i. Start-Up Checks: These Procedures apply to refrigerant piping systems:
    1. Inspect all piping for proper installation, adequate support (with appropriate vibration isolation where applicable), and insulation as required.
    2. Provide notification of pressure testing
    3. Pressure and/or leak test all applicable systems in accordance with the manufacturer's requirements as applicable.
    4. Submit documentation that the pressure testing complies with manufacturer's requirements
    5. Provide notification of evacuation procedures
    6. Evacuate all applicable systems in accordance with the manufacturer's requirements as applicable.
    7. Submit documentation that the evacuation procedures complies with manufacturer's requirements
    8. Verify the operation of applicable safety relief valves, operating controls, safety controls, etc. to ensure a safe installation.
- h. AC Motors



- i. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:
  - 1. Verify proper alignment, installation, and rotation.
  - 2. Verify properly sized overloads are in place
  - 3. Start-Up Tests: Perform the following tests, measurements, or procedures during start-up and as specified in manufacturer's instructions:
  - 4. Measure insulation resistance, phase balance, and resistance to ground.
  - 5. Measure voltage available to all phases. Measure amps and RPM after motor has been placed in operation and is under load.
  - 6. Record all motor nameplate data.
- i. Air-Cooled Condensing Units
  - i. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.
  - ii. Start-Up Checks: Perform the following inspections/checks before start-up:
    - 1. Ensure unit is level
    - 2. Coils are undamaged and fins are combed
    - 3. Condenser fan rotates freely and check rotation direction
    - 4. Start-Up Tests: Perform the following before or during start-up:
    - 5. Start-up condensing units, in accordance with manufacturer's start-up instructions.
    - 6. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
    - 7. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.
  - iii. Functional Performance Tests: This generally refers to a systematic testing of system operation from component-level, to system-level, to integrated systems-level testing to demonstrate compliance with Contract Documents. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.
  - iv. Training: Factory-authorized representative shall train Owner's maintenance personnel including:
    - 1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
    - 2. Familiarization with contents of Operating and Maintenance Manuals.
- j. Exhaust Fans
  - i. General: Contractor to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.
  - ii. Start-Up Checks: Perform the following inspections/checks before start-up:
    - 1. Inspect the field assembly of components and installation of fan system including ductwork, and electrical connections.
    - 2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
    - 3. Adjust and lubricate dampers and linkages for proper damper operation.
    - 4. Verify unit is secure on mountings and supporting devices and that connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
    - 5. Ensure vibration isolation integrity is maintained with the fan installation and the connections to it

6. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
7. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
8. Stroke all dampers to ensure free and full travel
- iii. Functional Performance Tests: This generally refers to a systematic testing of system operation from component-level, to system-level, to integrated systems-level testing to demonstrate compliance with Contract Documents. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.
- k. Training: Contractor shall train Owner's maintenance personnel including:
  - i. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
  - ii. Familiarization with contents of Operating and Maintenance Manuals.
- l. Building Automation And Control Systems
  - i. Start-Up Checks: Perform the following checks before start-up and as specified. Packaged control systems embedded in furnished equipment such as variable refrigerant flow systems is included in this requirement:
    1. Repair and/or replace any damaged equipment or sensors
    2. Point-to-point checkout
  - ii. Start-Up Tests: This generally requires manufacturers authorized representative to start-up, test, adjust, and calibrate direct digital and other microprocessor-based control systems and demonstrate compliance with requirements. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.
  - iii. Functional Performance Tests: This generally refers to a systematic testing of system operation from component-level, to system-level, to integrated systems-level testing to demonstrate compliance with Contract Documents. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.
- m. Testing, Adjusting, And Balancing
  - i. Reference: Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the respective section and the referenced standards.
  - ii. Start-Up Checks: In addition to specifications, perform the following at a minimum:
    1. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
    2. Patch insulation, ductwork, and housings, using materials identical to those removed.
    3. Seal ducts and piping, and test for and repair leaks.
    4. Seal insulation to re-establish integrity of the vapor barrier.
    5. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
    6. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.
    7. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.
- n. Training:
  - i. Train the Owner's maintenance personnel on troubleshooting procedures and testing, adjusting, and balancing procedures.
  - ii. Review for the Owner's personnel the locations of TAB reports and data.
  - iii. Sequencing Illustration; Reference Section 01 91 13.

### 1. Heating and Ventilating Controls

- a. Control systems for heating, ventilation and air-conditioning shall include provisions for fully automatic direct digital control by the Energy Management System (EMS). All controllers that activate pneumatic or electrically driven devices shall be as specified by or provided by EMS and shall be included in the Contract Documents. EMS devices shall include, but not be limited to: motor starter and speed controls, temperature sensors, start-stop stations, steam flow and condensate meters, status indicators, PE or EP switches and transducers.
- b. Show control diagrams on the drawings. Bid documents shall include detailed sequences of operations tailored specifically for each piece of equipment specified in systems. General sequences of operations are not acceptable. Use selected manufacturer's catalog numbers to identify components. Include the final sequence of operation in the operation and maintenance manual submittal.
- c. Specify clearly on contract documents which points are required to be hard wired to equipment and which points are allowed to be mapped through communication wiring ( ie. BACNET communication). Typically start/stop, alarm, and setpoints are required to hard wired points to equipment. Variable frequency drives shall be hard wired to start/stop, speed reset, speed feedback, alarm, and fire/life safety interlocks. Other points such as amperage, output frequency, and drive temperature may also be required.
- d. Show any humidity control by means of a skeleton psychometric chart on the drawings.
- e. Show a graphic chart on the drawings where control sequences are difficult to describe or specify. Indicate the position of valves, dampers, etc., or temperatures under variations in controlled or controlling conditions.
- f. Indicate all design temperature and pressure settings on control diagrams. The Contractor shall initially set controls at these temperatures and pressures and then make any changes required to meet the actual operating conditions. Record all deviations from design settings on the Project Record Drawings.
- g. Individual room heating and ventilating controls shall be conventional pneumatic, or direct digital control via the EMS, as determined by the building program.
- h. Divide large open areas into separate zones for each exposure.
- i. Where a number of rooms with similar exposures or heat gains are included in a single zone or where it may not be practical to install individual room controls, locate the zone thermostat in a common return or exhaust duct from the zone.
- j. At animal rooms and similar hose down spaces, provide bulb-type, completely waterproof thermostats that can be hosed with high-temperature water or utilize an exhaust duct sensor.
- k. Provide thermometers near each controlled point for setting of the control and checking its operations except at room thermostats.
- l. Provide pressure gauges in main and branch air lines at each major pneumatic control device including EMS electric/pneumatic transducers.
- m. Provide non-electric automatic modulating valves where single or double occupancy rooms are heated by under-window convectors. Provide pneumatic or EMS control for larger areas. Provide shutoff valves to isolate each convector.
- n. Specify normally-closed-type heating control valves for any research area, such as animal, insect or plant rooms, to prevent overheating in case of air or control failure. Discuss questionable areas with Capital Projects (CP).
- o. See Division 1 for other specification requirements.

## 2. Control Air

- p. For reliability, two (2) control air sources are preferred on large or complex control installation. These may be the typical control air compressor, with a reduced building air supply set to cut in automatically upon loss of control air. Where no building supply is available, consider two (2) smaller compressors with receivers, or with a single receiver. Size all receivers, pipes and valves, so that either or both compressors may be used. Building backup air shall be connected upstream of the refrigerated air dryers.
- q. Provide a refrigerated air drier in the control air system between the compressor and receiver. Include size, type and operation in the drawings and specifications.
- r. Where new large, complex or critical control systems are to be installed in an existing building, determine if the existing control air source is adequate and of acceptable quality. If there is doubt, provide a new control air compressor, with cross connection to existing.
- s. Specify copper for all control air tubing in exposed areas, and in concealed areas where elevated temperatures might damage plastic air tubing. Plastic control air tubing is acceptable in other areas, with the following installation precautions:
  - i. Do not allow short radius bends.
  - ii. Do not allow plastic caps on copper tubing.
  - iii. Properly space supports to prevent sag.
  - iv. Tubing installed in plenums shall be type FR only.
  - v. Tubing routed in inaccessible areas shall be hard drawn copper.
  - vi. Pressure test control tubing at 35 psi.

### 23 30 00 HVAC Air Distribution

### 23 31 00 HVAC Ducts and Casings

#### 23 31 13 *Metal Ducts*

1. Specify galvanized steel ductwork and plenums. Aluminum is acceptable if it complies with the requirements of the SMACNA Heating, Ventilating and Air Conditioning Duct Construction Standards.
2. Duct fabrication, installation and support shall conform to the requirements of SMACNA Heating, Ventilating and Air Conditioning Duct Construction Standards.
3. Support exposed ducts with rods bolted to duct angle stiffeners or to steel angle or channel cradles. Support vertical risers at each floor level with intermediate guide support midway between floors.
4. Provide factory-fabricated hardware for manual dampers, plenum doors and access doors as manufactured by Vent Fabrics or DuroDyne.
5. Provide grease hood exhaust ducts with welded grease-tight seams and joints. Pitch duct back to hood and provide for drainage.
6. Provide for water-tightness and moisture elimination in high-humidity exhaust ducts.
7. Outdoor ducts shall be sealed watertight and top of duct shall be sloped to prevent water pooling.
8. Provide capped instrument test holes on each side of heating coils, fans and units with duct connections. Location shall be visible and accessible for taking accurate measurements of static pressures and air velocities.
9. Labels:
  - a. In mechanical rooms, label or stencil ducts leaving the mechanical room to identify the areas or rooms served. (Match LKS Example in Mechanical Mezzanine)
  - b. Label each duct connection to a fume hood with the exhaust fan number serving it, using one-inch (1") minimum height black lettering. Label each exhaust fan corresponding to the fan number in the construction drawings in a visible location with two-inch (2") minimum height letters of contrasting

color. Where a fan serves more than one fume hood, list the rooms, using one-inch (1") minimum height black lettering.

- c. See Section 23 50 00: Central Heating Equipment for other label requirements.

## 23 33 00 Air Duct Accessories

### 23 33 13 Dampers

1. Show accessible manual volume dampers at major divisions in all duct systems to permit balancing of air quantities. Each supply outlet and each exhaust branch shall have a damper.
2. Provide locking quadrant-type damper operators. Provide standoff brackets to locate operators at outside surface of wrapped ducts.
3. Use supply or exhaust grille face dampers only for minor air balancing to avoid objectionable noise in occupied areas.

#### 23 33 13.16/19 Fire/Smoke Dampers

1. Fire/Smoke dampers:
  - a. Provide fire dampers which are California State Fire Marshal listed and Underwriters' Laboratory (UL) listed.
  - b. Provide safe overhead access for maintenance personnel to visually inspect and repair each fire damper and fusible link (CalOSHA Title 8, 3270). Provide access panels sufficient to access the duct smoke detector and all devices associated with the damper (including the damper blades, motor, actuator, disconnect switch, reset switches, etc.). Consider placement of damper actuators and links at floor level above damper separation for reduced costs and safe access.
  - c. Provide a disconnect switch immediately adjacent to the damper motor in a location that is readily accessible. The switch shall be labeled as to the damper it controls.
  - d. Label all dampers by number as follows Floor Number - Damper Number.
    - i. For example: A damper labeled "01-04" indicates that it is the 4th damper on the 1st floor.
  - e. Provide local fire/smoke damper power disconnect to allow for maintenance of individual dampers without de-energizing the entire circuit.
  - f. Fire damper installation shall be in accordance with the listing agency.
  - g. Where fire/smoke dampers are located in main air conveying ducts where closure may cause damage to ductwork, provide pressure relief doors shown on drawings with pressure set-points.

## 23 34 00 HVAC Fans

1. Fans
  - a. Centrifugal fans should be specified for most applications. Select size and type of fan based on life cycle cost and noise level considerations. Selected fans shall have performance characteristics capable of future flow increases of at least ten percent (10%). Due to their high noise levels axial fans should not be specified without prior consultation with Capital Projects (CP).
  - b. Fans used in supply and return air applications with air quantities of 5000 cfm or greater shall be comprised of multiple wall-style plug fans for redundancy. Fans shall be equipped with individual backdraft dampers. Multiple variable frequency drives shall be provided for redundancy. Each fan in such a system shall be monitored with a current switch to alarm the energy management system of a fan failure (switch contacts shall be normally closed wired in series to indicate a single point general fan alarm). Fan monitoring shall be provided for each variable frequency drive.
  - c. Select fans which meet Air Moving and Conditioning Association (AMCA) construction and capacity rating standards.
  - d. Fans shall comply with section 01 60 00 *General Product Requirements* of these design standards.

- e. Provide flexible connections between fans and ductwork.
  - f. Fan bearings shall have a minimum of 100,000 (L<sub>10</sub>) hr life
  - g. Provide safety guards described in this Division.
  - h. Provide bearings described in this Division.
  - i. General utility fans for exhaust applications shall be Cook or approved equal.
2. Fan Drives
- a. Provide safe overhead access for maintenance personnel to each fan drive (CalOSHA Title, 3270).
  - b. Provide V-belt drives with ratings of not less than 150% of motor horsepower.
  - c. Provide motors of five (5) horsepower and smaller and not more than two (2) drive belts with an adjustable pitch motor sheave. The midpoint of the adjustment range shall produce the specified fan revolutions per minute.
  - d. Provide motors larger than five (5) horsepower and drives with more than two (2) belts with a sheave which produces the specified fan revolutions per minute.
  - e. After testing the ventilating system, the Contractor shall make, without additional cost, one (1) change in the size of the non-adjustable sheave and belts to obtain the desired air quantities.
  - f. All motors with VFDs should be inverter duty (not continuous duty) motors.
3. Variable Frequency Drives
- a. Coordinate with Section 26 29 23 *Variable-Frequency Motor Controllers*

### 23 37 00 Air Outlets and Inlets

#### 23 37 13 Diffusers, Registers and Grilles

1. Supply registers: Adjustable double-deflection type with opposed blade dampers. Do not locate where the air supplied is directed toward a fume hood face.
2. Diffusers: Adjustable pattern, blade type with opposed blade damper.
3. Return exhaust and transfer air grilles and registers: Horizontal or vertical fixed blade type for wall locations and 1/2" x 1/2" x 1/2" aluminum grid for ceiling locations with opposed blade dampers.
4. Minimum free area on any grille or register: 70% of face area or greater. Labs and other engineered systems may have different requirements. Consult Capital Projects and the office of Environment, Health and Safety.
5. Coordinate finishes with the architect.

### 23 38 00 Ventilation Hoods

1. Coordinate with Section 11 53 13 *Laboratory Fume Hoods*.
2. Fume Hood Exhaust Fans
  - a. Up to 27" wheel diameter: Westinghouse Industrial Series 400 or equal with air handling wheel.
  - b. Above 27" wheel diameter: Westinghouse series 8000, or equal, with backward inclined airfoil wheel.
  - c. All fans shall have upblast discharge. Discharge shall meet Cal/OSHA requirements enumerated in CCR, Title 8, Section 5154.1.
  - d. Provide bearings described in this Division.
  - e. Install weatherproof housing over motor and drive where exhaust fans are exposed to weather.
  - f. Protect interior of fan and wheel with coating as specified. Rebalance wheel after coating.
  - g. Locate fans so that negative pressure exists in all fume hood ducts within the building. Where this is not feasible, discuss mitigating measures with Capital Projects (CP).
  - h. Provide neoprene-coated glass fiber flexible connections at duct connections to fume hood fans.
  - i. Coordinate with the architect for vibration control and roof-mounting. The architect shall detail equipment curbs, supports at roof, roof penetrations, and flashing for roof-mounted equipment.

### 3. Duct System Design

- a. To reduce static and velocity pressure loss, turbulence and noise in the ventilating system, comply with the following:
  - i. Do not use plenums for connecting fans or main ducts to multiple branch ducts.
  - ii. Use properly designed transitions, radius turns, vaned miter elbows and/or extractors at changes in duct size and direction.
  - iii. Provide sufficient duct-mounted volume dampers to properly balance the completed system.

#### 4. Duct Air Velocities

- a. Size ducts for maximum selected velocity only at the fan connection. Duct size shall be immediately increased after this connection to minimize noise generation and static pressure required at fan. Reduce this velocity to the minimum acceptable as air quantity and pressure decreases in relation to distance from the fan using the equal friction method of duct design.

#### 5. Makeup Air for Fume Hoods

- a. Provide adequate makeup and exhaust air for new fume hoods installed in existing buildings. Where the existing building system was not designed for fume hoods, and cannot be modified to handle the added requirements, or the existing exhaust duct system is not chemically-resistant, provide a new makeup and exhaust system. Where approved, a heating and ventilating unit may be provided to supply tempered makeup air to the room.

#### 6. Fume Hood Ductwork

- a. See Division 11 53 00: Laboratory Equipment.
- b. Combine several hoods in a building into fume hood exhaust systems, with one (1) exhaust fan serving the system where permitted by code. All fume hoods on any one (1) exhaust system shall have the same supply fan. Because they operate continuously, consider these fume hood exhaust systems a part of the building heating and ventilating exhaust. Size fume exhaust ducts for a velocity consistent with design noise levels, duct static pressure and size limitations.
- c. Where corrosive fumes are anticipated, construct ductwork of Plasite-coated black steel and drain back to fume hood.
- d. Where most of the building exhaust system is via fume hoods, as in a chemistry building, consider making the exhaust system for all potential laboratory areas of coated, fume-type ductwork for future remodeling flexibility.
- e. Where practicable, ducts shall be accessible for maintenance.
- f. Install balancing dampers for fume hoods.

#### 7. Canopy Hoods

- a. In general, canopy hoods are not acceptable for exhausting as hazardous vapors may be found in laboratories. Where feasible, locate kitchen hoods and equipment at wall rather than at island for better efficiency. Proposed canopy hoods shall be discussed with Capital Projects (CP).

#### 8. Industrial Exhaust Systems

- a. Design industrial exhaust systems for woodworking machinery, grinders, dust collecting, paint spraying or welding fumes, etc., with adequate provisions for entrainment and safe removal of any dangerous substances. Systems shall be designed in accordance with the recommendations of the Industrial Ventilation Manual published by the American Conference of Governmental Industrial Hygienists (ACGIH).

### 23 40 00 HVAC Air Cleaning Devices

#### 1. Duct Access Panels and Doors



- a. Provide sufficient access panels to permit cleaning of interior of all duct systems. Pay particular attention at points where ducts contain or are directly connected to louvers, screens, turning vanes, coils, heating and ventilating units, etc., and at any point in grease hood exhaust duct where grease could accumulate.
- b. The following warning sign shall be stenciled in one-inch (1") high minimum, red letters on opening side (or both sides on walk-through) of access doors and panels between areas or in ducts where there is a positive or negative differential pressure above 0.5" WC:

WARNING  
DOOR (OPENS) (CLOSES) ABRUPTLY  
UNDER (POSITIVE) (NEGATIVE) PRESSURE

- c. Provide an airlock vestibule entrance at any plenum where the pressure differential is a hazard to personnel using a single door.

## 2. Air Filters

### a. Building Ventilation

- i. All building ventilation air filters shall be the replaceable type. Use twenty-four by twenty-four inch (24" x 24") size unless otherwise approved by Capital Projects (CP). The filter system shall be two-inch (2") HE-60 prefilters in front of 85% efficient bag filters. Filter frames shall be made from Kraftboard or equivalent to withstand exposure to moisture. Air filters must carry a Maximum Efficiency Reporting Value (MERV) rating of eleven (11) or greater, as determined by the ASHRAE 55.2. air filter test.
- ii. Provide louvers, screens, etc., as necessary to keep filters dry and free from debris. Discuss any special filtering requirements with Capital Projects (CP).
- iii. Clearly show selected filters on the drawings with actual number, efficiency, type and size of filter cells in each bank. Show total air quantity to be filtered. Do not leave selection of size and number to the Contractor.
- iv. Provide a corrosion-resistant material or galvanized finish for all filter frames.
- v. Limit height of filter bank to eight feet (8'-0"). Where a higher filter bank is unavoidable, coordinate with the architect for a permanent ladder and catwalk detailed and specified under the miscellaneous metals section.
- vi. Provide a floor drain for wash-down in each filter plenum.
- vii. Coordinate with electrical to provide non-incandescent illumination on each side of bank for servicing.
- viii. Specify that the system shall not be operated during construction without the filters in place. Contractor shall be responsible for cleaning of ductwork if system is operated before building is clean and ductwork cleanliness is compromised. Where the filter static pressure at the time of balancing would adversely affect the results, specify that the Contractor shall replace the media before balancing or acceptance.
- ix. Provide dial-type draft gauges for all filter banks, with scale range to suit static conditions anticipated. Provide shutoff cocks at all gauges to allow calibration. To assure proper operation and accurate draft readings, show the location of Pitot heads on the plans.
- x. Provide a sign below each gauge giving clean and dirty readings anticipated with the installed filters.

### b. Special Laboratory Exhaust

- i. Provide special filtering for any laboratory exhaust, as required, that may contain radioactive, infectious or otherwise potentially hazardous materials. Discuss type and installation methods with Capital Projects (CP) and Environment, Health and Safety (EH&S).



- ii. Design and detail the filter bank leak-tight and sufficiently stiff to prevent excessive deflection at design airflow and static pressure.
- iii. Design for ease and safety of periodic maintenance activity; contaminated filters shall be changed while wearing personal protective equipment.

### 3. Air Inlets and Exhausts

- a. The building ventilation system outside air inlet shall be located away from ground-level pollution sources and building exhausts. Preferred location is high-up on the prevailing wind side of building (west side). Keep intakes away from loading docks, porte-cocheres and vehicular areas, parking lots and trash areas.
- b. Exhaust potentially contaminated air vertically at least seven feet (7'-0") above roof level at twenty-five hundred feet per minute (2,500 fpm) velocity for dispersion and dilution. Exhaust recirculatable-quality air at any point where the discharge will not be objectionable. Coordinate locations with the architect during early design stages. Early discussion of these locations with the architect and Capital Projects (CP) will prevent later design changes.
- c. Coordinate with the architect on louvered supply and exhaust performance data including free area ratio. Design for a velocity below manufacturer's recommended maximum to exclude rain.
- d. Do not locate low louvers where air will blow on plants.
- e. Do not locate louvers or grilles in corridor doors or walls with required fire ratings.
- f. Provide louvers and screens at all ventilation air inlets. Screen exhaust outlets only where required for safety. Do not specify or show any screen with smaller than one-inch (1") minimum mesh.
- g. Provide duct access from within the building for maintenance and cleaning of all louvered or screened openings from the inside.

### 4. HVAC Cleaning

- a. Coordination
  - i. Coordinate schedule and requirements with Capital Projects (CP).
  - ii. Capital Projects (CP) shall notify the building occupants of the work to be done, the schedule, the contact person in case of complaints, and the availability of protection covers (to be provided by the Contractor) for those who want them. Work shall be scheduled when the areas are unoccupied, whenever possible.
- b. Drawings
  - i. Provide a current heating and ventilating plan showing all existing systems.
  - ii. Show the fans, coils, ducts and outlets to be cleaned.
  - iii. Access shall be provided to all duct interiors, coils, fans and dampers. Where new access doors are required, show the locations. Where ceiling access doors will be required, coordinate finishes and products for existing construction.
  - iv. Coordinate with Capital Projects (CP) for areas that require special protection and indicate these on the drawings.
  - v. If more than one (1) supply fan is involved, define the areas served by each fan.
- c. Specifications:
  - i. Determine and indicate the hours when the work may be performed, when the fans will be turned on and off, and who is responsible. Specify when the supply fan will be run in order to observe if any visible dirt is deposited in the areas served.
  - ii. Duct cleaning shall use the negative pressure method which draws air away from occupied spaces as the ductwork is being cleaned to avoid contamination of occupied areas in building.
  - iii. Access Doors

1. Duct: Door shall be 20-gauge galvanized steel slide-gate type secured with parker screws and 1/2" flange to serve as handle and stop, or round galvanized steel spun into a round opening. Size as required by duct size.
  2. Ceiling: Select product suitable for existing finishes and fire ratings.
- iv. The Contractor shall conspicuously mark the initial setting of any air control devices that must be moved to properly clean the duct system. After cleaning, return each device to its original marked position and secure in place.
  - v. Clean all ducts using an industrial-type vacuum cleaner. Inspect cleaning work in all portions of ducts. Remove, brush and vacuum supply diffusers or grilles, including damper or volume control, at completion of duct cleaning.
  - vi. Clean all coils using an industrial-type vacuum cleaner on the entering air side of the coil and a high pressure air jet (fifty pounds per square inch [50 psi] minimum) blowing back from the leaving air sides. Continue until all passages are clear.
  - vii. Before each section of duct, coils, fan and outlets is cleaned and before the system fan is turned on, cover each outlet with a filter. Filters shall be a minimum of 1/2" thick fiberglass filter mat covered and held in place with cheese cloth and duct tape or other appropriate method. The filters shall remain in place until the cleaning is completed and accepted.
  - viii. After all outlet filters are in place and before leaving the building, turn on supply fan serving the area for one (1) hour maximum. The Contractor shall check all areas served by this fan for any visible dirt entering through loose or improperly installed outlet filters.
  - ix. While fan is operating, the Contractor shall clean furniture, floors, and other surfaces showing visible dirt that has been discharged through loose or faulty outlet filters.
  - x. Carefully place all removed dust and dirt in plastic trash bags, close and securely tie. Specify storage location and responsibility for disposal.
  - xi. The Contractor shall provide the University with protection sheets to be distributed by the University to the building occupants. Coordinate with Capital Projects (CP) and specify the size and number to be provided.
  - xii. Bidding shall include a per-hour unit price for room cleaning exceeding contract requirements.
  - xiii. The Contractor shall prepare a checklist of all rooms and areas affected by the Project. The checklist shall be used to check room cleanup, furniture in original position, and outlet filters in place. The checklist shall be maintained by the Contractor's superintendent, for each work period.
  - xiv. Submittals shall include:
    1. Ceiling and duct access doors.
    2. Outlet filters.
    3. Filter fastening method.
    4. Protection sheets for furnishings.
    5. Fan system filters.
    6. Work schedule and number of workers.
- d. Filters
- i. Replace all fan system filters. Clean supply and intake plenums, louvers, bird screens, and filter banks.
  - ii. Replace worn, missing, or damaged filter frame gaskets.
  - iii. Replace broken filter clips and change or adjust filter clips to fit the University's standard filters. Filter clips shall have wire loop end for securing filter frame.

## 1. Hot Water Heating Systems

- a. Provide for maintenance and repair work in the piping of hot water heating systems. Provide low point drains and high point vents, both constructed of ball valves with hose adaptors and hose caps. Provide a safe, accessible drain as required in this Division. Coordinate on location of drain.
- b. Provide manual air vents at high points in hot water piping systems. Show or specify a valve ahead of all automatic air vents to facilitate replacement.
- c. Show compound vacuum-pressure gauge and vacuum breaker on all hot water converters.
- d. All building hot water heating systems shall be design for six pounds (6 lbs) steam supply. Higher pressures are only acceptable for autoclave or distribution functions.

## 2. Water Heating (Steam)

- a. Where steam is available for water heating, provide a shell and tube heat exchanger (use plate type where applicable) meeting the following requirements:
  - i. All components in the heating hot water system shall be rated to two-hundred fifty degrees Fahrenheit (250°F).
  - ii. Heater: one hundred twenty-five pounds per square inch (125p/in<sup>2</sup>), ASME stamped steam heat exchanger.
  - iii. Materials: Non-ferrous for all parts having contact with potable water; and ferrous, cast iron or steel for all parts having contact with steam or condensate.
  - iv. Controls:
    1. Control temperature shall maintain hot water set point temperature within plus or minus three degrees Fahrenheit (+/-3°F) for all flows from two (2) gallons per minute through specified capacity.
    2. Provide a high limit control that will shut off steam supply to heat exchanger with a ten degree Fahrenheit (10°F) maximum rise of outlet temperature above set point.
  - v. Provide each heat exchanger with the following:
    1. Compound pressure and vacuum gauge.
    2. Vacuum relief valve.
    3. Pressure relief valve on both steam and heating hot water systems prior to any means of heat exchanger isolation valves.
    4. Thermometers in hot water outlet and return lines.
    5. Drain valves (ball-type) with hose thread adapter to drain shell and tubes.
    6. Thermowells in hot water supply and return lines to suit temperature sensors specified or provided by the Energy Management Control System. Install calibration wells (self-sealing test connections) adjacent to each thermowell location.
  - vi. Design heater steam supply, condensate piping and trap to prevent coil flooding. Condensate lift is not allowed from heat exchanger or steam coils. As such, elevate the heat exchanger sufficiently to ensure that condensate from the outlet of the heat exchanger can flow by gravity, down toward the condensate trap and then a connection to the campus low-pressure steam condensate piping system. Provide isolating valves, unions, and fittings, to permit easy removal of coils or heater.

## 3. Piping System Cleaning

- a. Steam and condensate piping shall be thoroughly flushed before placing in service, to remove dirt, rust, scale or other contaminants. Consult with Facilities Services to formalize cleaning procedures for each Project. All cleaning work shall be done with the inspector present.

#### 4. Steam Pressure Regulators

- a. Where a building program requires more than one (1) pressure service, discuss the use of secondary regulators with Capital Projects (CP).
- b. Provide steam pressure regulation and reducing stations in parallel pairs including unions, strainers, and gauges at both stations sized to match building feed line with adequate isolation valves to allow repair without interruption of building service. Include high, intermediate (if used) and low pressure gauges.
- c. Regulators shall be 3/4" minimum and two-inch (2") maximum size, for all design loads of 1,000 lbs steam per hour and greater. Provide the number of regulators required for estimated load.
- d. Locate regulators in a safe location, accessible without the use of ladders or staging.
- e. Provide rigging bar above pressure-reducing valves to facilitate repair and replacement.
- f. Detail the piping with effective unions or flanges, to permit easy removal of any regulator without disturbing other regulators or equipment. Do not provide bypasses at regulators. See Appendix A: Drawings for typical install details.
- g. Load Estimation:
  - i. Average steam demand for all UC Berkeley campus buildings is 37 lbs of steam per hour per 1,000 square feet of gross area. If the estimated demand exceeds 40 lbs per hour per 1,000 square feet discuss this with Capital Projects (CP).
  - ii. Do not add a warm-up factor to the estimated building demand as University buildings operate 24 hours per day. Do not limit the size of drip-traps, as the device aids with start-up.

#### 5. Water Treatment

- a. Untreated water shall not be used in testing heating, ventilating and air conditioning piping systems. Water used for pressure testing in system without circulating pumps operational shall be filled with pre-mixed water with acceptable levels of corrosion and biological inhibitors. Test results from this water shall be submitted for review and records.
- b. All circulating water shall receive chemical treatment as follows:
  - i. Heating hot water and chilled water for corrosion and stabilization.
  - ii. Condenser and cooling tower water for microbial growth, corrosion and stabilization.
- c. Discuss chemical feed devices with Capital Projects (CP). Specify and detail approved chemical feed devices on the drawings.
- d. The contractor shall notify the University and produce monthly water quality reports of water treatment of all systems.

#### 6. Gas Fired Heating Units

- a. Provide gas-fired heating units with all necessary safety devices, including the following:
  - i. Intermittent electric spark ignition with a thermocouple-energized device that will automatically shut off all gas flow to the main and pilot burners in the event that ignition is not achieved.
  - ii. Electrically operated control valve that will close, shutting off all gas to the unit, in the event that the temperature in the heater should rise above a safe point.
  - iii. Gas pressure regulator to maintain correct gas pressure at the burners.
  - iv. Manual shutoff valve to shut off all gas service to the heating unit. This valve shall be a safe distance from the burners.
- b. Provide gas-fired steam boilers with safety devices described above. In addition, provide a low water alarm and fuel shutoff system similar or equal to McDonnell and Miller. Include manual and automatic reset, low water and high temperature controls, dual gas valves, and other code-required items.
- c. Separately vent each piece of gas-fired equipment. Size according to UMC.

## 7. Heating Coils

- a. Water is the preferred media for heating coils. Steam or electric heating coils shall receive prior approval from Capital Projects (CP) and Facilities Services.
- b. Provide hot water heating coils with copper tubing and copper fins where the unit is capable of 100% outside air or aluminum fins for recirculating units with minimum outside air.
- c. If steam is selected, provide distributing type coils. Take particular care with the piping, trap and control installation details to prevent flooding of the coils with condensate. As such, elevate the coil sufficiently to ensure that condensate from the outlet of the coil can flow by gravity, down toward the condensate trap and then a connection to the campus low-pressure steam condensate piping system. Also, pitch the coil down toward the condensate outlet. Heating coils shall have a maximum of twelve (12) fins per inch. Use of this spacing reduces early coating with airborne dust, eventual plugging and facilitates cleaning when necessary.

## 8. Bearings

- a. The installer of equipment having bearings of any type shall protect and properly lubricate the bearings before operation of the equipment. Give special attention to bearings in any equipment that has been delivered to the job site, or installed, in advance of completion.
- b. Motors
  - i. Motors smaller than 1-1/2 horsepower driving mechanical equipment shall have bearings as normally furnished by the equipment manufacturer.
  - ii. Motors 1-1/2 horsepower and larger driving mechanical equipment shall have regreasable ball or roller bearings with a grease filling and relief plug for purging during lubrication.
- c. Fans shall have enclosed, greasable, self-aligning ball bearings which are accessible for inspection, maintenance and lubrication
- d. Heating and ventilating units shall have enclosed, greasable, self-aligning ball bearings that are accessible for inspection, maintenance and lubrication.
- e. For special equipment, obtain bearing requirements from Capital Projects (CP).
- f. Bearing Lubrication
  - i. Bearing lubrication points shall be both visible and safely accessible after installation of equipment.
  - ii. Where extension pipes are needed to meet the above access requirement:
    1. Vent oil lubricated bearings and extend oil fill pipe to a suitable sight glass. Install at proper elevation to indicate oil level in bearing.
    2. Extend both supply and purge pipes for greasable ball bearings. Fit with proper lubrication fittings, and fill each pipe with proper lubricant before installing.
- g. Include the following requirements in the operations and maintenance manuals for each type of equipment with regreasable or oil-lubricated bearings:
  - i. Equipment and its type of bearing.
  - ii. Replacement number, name or size of bearing.
  - iii. Recommend type of lubricant and lubrication period.
  - iv. Proper belt tension on belt driven equipment and instrument for measuring it.

## 9. Machinery Guards

- a. Protect all moving equipment parts, such as belt drives and drive couplings, with guards and clearances as required by CalOSHA (Title 8, 3944 and Title 8, 4186).
- b. All accessible fan inlets or exhaust openings shall be covered with wire mesh guards. Size mesh to give 90% free area minimum, with two-inch (2") maximum openings. Provide easily removable access panels of same material for bearing check, lubrication or tachometer readings.

## 10. Unions, Couplings and Nipples

- a. Show unions at all threaded connections to equipment, regulators, controls and steam traps that may have to be removed or replaced and at all points where necessary for the disassembly of piping for maintenance. Detail piping and unions to allow removal of equipment without springing pipe.
- b. Di-electric fittings are not permitted. Use six inches (6") minimum of red brass for di-electric isolation between copper and steel components or other components with a potential for electrolysis.
- c. When specifying, or approving, grooved pipe with clamp couplings for piping, check or note that the following items are included:
  - i. Proper gasket for anticipated operating temperature. In heating hot water systems, no grooved pipe systems are allowed, due to the high temperature of the campus steam system.
  - ii. Recommended gasket lubrication.
  - iii. Torque bolts to manufacturer's specifications.
- d. Threaded nipples shall be made of schedule 80 steel pipe or standard weight brass pipe.
- e. Threaded nipples used in high pressure steam systems shall be schedule 160 steel pipe.
- f. Specify reducing fittings wherever changes in pipe size occur. No bushings will be permitted. In steam systems, specify eccentric reducing fittings wherever necessary to provide free drainage of lines.
- g. Flanges in steam systems shall be specified with metal wound spiral gaskets similar to Flexitaulic style CG API 601 304SS with Grafoil fill gaskets.
- h. Studs and nuts used in steam applications shall be ASTM A193, B7 studs with ASTM A194, 2H nuts.

## 11. Flexible Pipe Sections

- a. Rubber flex joints are not permitted on heating hot water pumps. Use stainless steel braided flex joints.
- b. Corrugated metal hose with a braided cover is preferred as a flexible pipe section between vibrating equipment and piping systems.
- c. To prevent an improper application, include a schedule of the required flexibility in the contract documents listing the following:
  - i. Application (pump, air compressor, etc.)
  - ii. Media to be handled.
  - iii. Temperature of media.
  - iv. Operating pressure.
  - v. Material.
  - vi. Required live length for proper flexing of offset motion anticipated.
  - vii. Detail the location and position (horizontal or vertical) required to allow offset motion anticipated.
  - viii. HVAC equipment shall be braced according to code and industry best practices. In addition, hard piping shall be utilized wherever possible.

## 12. Piping

- a. Steam Condensate Piping. Two inches (2") and smaller, downstream of trap assemblies: ASTM B88 seamless, Type K, hard-drawn copper tubing with brazed joints
  - i. Fittings: ANSI B16.22 wrought copper. For fittings not available in copper, ANSI B16.18 cast bronze. No mechanically formed fittings.
  - ii. Unions: Class 250, threaded or brazed ends.
  - iii. Flanges: ANSI B16.24, Class 150, cast copper alloy
- b. Low-Pressure Steam Piping (0 to 15-psig). Two inches (2") and smaller: ASTM A53 Grade B, schedule 40 carbon steel threaded
  - i. Fittings: 125 lb threaded cast iron fittings

- ii. Unions: Cast Iron 150/125 lb
- c. Low-Pressure Steam Piping (0 to 15-psig). Two and one-half inches (2 ½”) and larger: ASTM A53 Grade B, Type E, schedule 40 carbon steel, welded.
  - i. Fittings: ASTM A234 Grade WPB/ANSI B16.9, standard weight, seamless, carbon steel, welded.
  - ii. Flanges: Refer to Section 10 G, below.
- d. High-Pressure Steam Piping (15 to 125-psig). Two inches (2”) and smaller piping. ASTM A106, Grade B, Schedule 80 carbon steel, threaded.
  - i. Fittings: ASTM A105 Grade II/ANSI B16.11, 3,000 lb forged steel, socket welded or Class 150 flanged
  - ii. Unions: Forged steel, Class 3,000.

### 13. Miscellaneous Piping Products

- a. Gaskets for high pressure steam systems shall be Flexitauclic Style CG,API601, spiral wound 304SS with Grafoil fill.
- b. Fittings for steam service over 15 psig larger than two inches (2”) shall be class 300 forged carbon steel weld neck flanges.
- c. Fittings for steam service over 15 psig for piping two inches (2”) and below shall be socket welded or Class 150 flanged. Screwed fittings on schedule 160 nipples are allowed at steam traps and related components such as strainers, unions and associated valves.

### 14. Valves

- a. Specify replaceable, packing-type gate valves for shutoff valves. Gate valves to be rising, stem-union bonnets. “O-ring” sealed ball valves are not permitted. Butterfly valves to be lugged-type.
- b. Show all valves on the drawings. Do not rely on a general note in the specifications or on the plans to install valves where or as required.
- c. Specify valves in accordance with the following valve standards.
- d. For steam and condensate service on systems over 15 psig, specify steam valves to be 800# forged steel outside screw and yoke gate valves with rising stem, bolted bonnet for all sizes, class 300. Steam strainers shall be forged steel for pressures over 15 psig.
- e. For steam pressures under 15 psig, valves two inches (2”) and under shall be class 150 screwed bronze gate rising stem, union bonnet and welded pipe shall utilize flanged outside screw and yoke ductile iron gate valves
- f. High pressure globe valves shall be 800 psig forged steel, bolted bonnet, threaded for sizes two inches (2”) or under.
- g. Check valves shall be 800 lb. forged steel screwed for sizes two inches (2”) and below and class 300 flanged for sizes above two inches (2”). Separation between low and high pressure will be at gate valve after steam trap and test tee assembly. Gate valve shall be 800lb rated when serving steam systems over 15 psig.
- h. Where coil size is more than 10% of building heating and cooling load, chiller water and hot water coils valves shall have a valve capable of energy monitoring. Reference Div 33. Add Valves in Div 33.

### 15. Traps, Returns, Condensate Receivers and Monitoring Equipment

- a. Steam piping to be graded toward a drip trap, one-eighth inch (1/8”) per foot minimum.
- b. Condensate-return piping to be graded to a condensate pump, one-eighth inch (1/8”) per foot minimum.
- c. No condensate lift will be allowed from a heat exchanger or steam coil.
- d. Arrange heat exchangers and coils to allow gravity return to a condensate receiver.
- e. High-Pressure drip traps to be piped to a flash tank prior to flowing into the condensate receiver.

- f. Steam trap assemblies to include:
  - i. High-side isolation valve constructed of 800# forged steel
  - ii. Strainer
  - iii. Union
  - iv. Steam trap
  - v. Union
  - vi. Test tee and test valve with plug
  - vii. Check valve
  - viii. Low side isolation valve constructed of 800# forged steel
- g. See Appendix A: Drawings for typical details.
- h. Directly following the steam condensate receiver assembly, each system shall have a hardness probe and controller for silica level monitoring.
- i. Steam system gaskets to be metal type, Flexitallic or equivalent. See ASME B16.20.
- j. Condensate receivers shall be equipped with a trapped overflow to prevent condensate back-up in steam system which could potentially damage steam consuming equipment.
- k. Condensate return units shall be duplex type with each pump selected for maximum 30% operation.
- l. Discharge from condensate return units with pumps shall be equipped individual inlet isolation valves and plug cock valves at each pump discharge for flow modulation.
- m. Condensate receiver manufacturer shall be Bell and Gossett or equal, duplex type.
- n. Heat exchangers shall be Bell and Gossett or equal.

16. Steam distribution valves (Utility Lines) shall be ANSI Class 300 steel gate valves with raised face flanged connections, rising stem (outside screw and yoke), and valves 6 inches or larger shall have a bypass/warm-up valve. Valves smaller than three inches (3") shall have a screwed union bonnet. Condensate distribution valves shall be ANSI Class 150 gate valves with raised face flanged connections and rising stem (outside screw and yoke); valves smaller than three inches (3") to have screwed union bonnet.

#### 17. Isolating Valves

- a. Provide isolating valves in heating hot water, chilled water, steam, and other systems.
- b. Locate valves so that it is possible to isolate separate floors, separate wings, toilet rooms, machinery rooms and other natural subdivisions of the building.
- c. Provide isolating valves for laboratory piping at the branch connection to the main.
- d. Provide valves on each side of equipment to permit servicing or removal without draining system.
- e. Provide valves at all services left for future connections (tees, stubs, etc..) unless they are in a valved zone, or can be isolated by existing valves with minor loss of pipe contents when opened.
- f. Coordinate with Plumbing for the installation of a suitable drain at all drain valve locations.
- g. Provide system drain valves with 3/4" hose thread adapters at all low points.

#### 9. Steam Traps

- a. Size all steam traps, in specifications or on drawings, by required capacities and pressure differentials.
- b. Low-pressure (0 to 15-psig) steam traps at heat exchangers: Armstrong Series J and M (or approved equal) float and thermostatic type, ASTM A48, Class 30 cast iron body rated for 175-psig saturated steam, all stainless steel internal, "welded parts" including the float. All internal parts shall be removable and replaceable without breaking pipe connections.
- c. Vacuum return systems: Steam traps shall be Armstrong model TTF-1 (or approved equal) float and thermostatic type with thermostatic air vent with Type 304L stainless steel body, beryllium-copper bellows, stainless steel internal "welded parts" rated for 200-psig steam.



- d. High-pressure (15 to 125-psig) steam traps at drip and mud-legs: Steamguard (or approved equal) fenturi nozzle trap with integral strainer, Class 300, forged steel.
- e. Specify extra-heavy Schedule 80 pipe nipples for low pressure steam systems. Nipples in high pressure systems shall be Class 160. Use at least six inches (6") of brass pipe between steam trap assembly low-side isolation valve and copper return piping.

#### 10. Steam Pressure Regulating Valves (PRVs):

- a. Armstrong Model GP-2000 (or approved equal), ANSI Class 250.300 flanges, stainless steel trim, rated for 250-psig at 450°F, with Armstrong K-1 air operated remote pilot (or approved equal) for automatic capacity control from zero flow to full-rated capacity. PRV station shall provide ninety-seven percent (97%) accuracy in downstream pressure control.

#### 11. Strainers

- a. Provide strainers ahead of all regulators, pumps, controls and equipment that could be damaged or rendered inoperative due to foreign matter in the piping. Size screen opening for degree of protection required by downstream equipment. Specify in each section the requirements for purging lines and cleaning strainers at completion before acceptance. Install full-size blow-down valve with nipple and cap.

#### 12. Relief Valves

- a. Provide relief valves where required by code or to protect pressure vessels, equipment, or piping systems against dangerous pressure. The set pressure shall be indicated on the valve with a waterproof tag and have externally-operated lever lift handles. Pipe discharge to a visible location outside mechanical rooms and outdoors. The discharge of steam relief valves to be piped to a drip elbow.
- b. Specify ASME-certified relief valves to comply with The Boiler Code or The Unfired Pressure Vessel Code sized to handle full BTUh capacity of equipment served.
- c. Specify minimum capacity of steam pressure relief valve or valves to provide for full discharge of the capacity of the largest regulating valve without allowing the lower pressure to rise more than six percent (6%) above the highest pressure at which any valve is set. No relief valve will be required where a further reduction in pressure is made, unless such steam is for laboratory use. In such cases, the same rule will apply for the lower pressure.
- d. Show discharge piping of steam relief valves extended to open air, preferably through the roof or wall to a safe discharge area. Do not allow discharge into any room or area within the building.
- e. Show discharge piping from water relief valves extended to open safe drain with adequate capacity for anticipated maximum discharge.

#### 13. Gauges and Thermometers

- a. Provide gauges and/or thermometers (not self-sealing test connections) in the following locations:
  - i. Draft gauges around main building air filters.
  - ii. Pressure gauges at all pressure reducing valves to indicate both high and reduced pressures.
  - iii. Pressure gauges at all pump suction and discharges.
  - iv. Thermometers on heating and domestic hot water systems to indicate supply and return temperature, including main building or tempering coils, five inch (5") round bi-metal type.
  - v. Thermometers on heating and ventilating systems to indicate temperatures at outside air inlet, tempered supply and cooled air if used.

- vi. Provide other gauges and thermometers wherever needed to give pressures and temperatures necessary or desirable for maintenance and troubleshooting.
- b. Pressure gauges shall have a range that will read mid-scale at normal operating pressure.
- c. Locate all thermometers and gauges so that they are both visible and readable from an accessible and safe location.
- d. Shutoff valves for steam system gages shall match specifications for system served. High pressure steam systems shall be equipped with 800 lb. forged steel gate valves, O,S and Y with bolted bonnet. Pressure gauges shall be equipped with pigtailed and isolation valves. Shutoff valves for hot and chilled water system gages shall be ball valves. Needle valves or pet cocks are not allowed.

#### 14. Flow Measurement/Balance Valves

- a. Consider the installation of primary differential producers, such as venturi tubes or orifice plates, in main risers and branch lines of heating hot water, chilled water and cooling tower water systems. Discuss proposed locations and type with Capital Projects (CP).
- b. Indicate the calculated or required flow at each point where flow measuring devices are shown and specified.
- c. Provide a thermometer well at each flow measuring device and provide two (2) thermometers to the University.
- d. Include readout type balance valves for all coils and any branch lines where balancing may be required for accurate system balance. Require the Contractor to provide pressure-flow conversion charts in Operations and Maintenance (O&M) manuals for all models installed and one (1) gauge set.

#### 15. Pipe Supports

- a. Support all pipe with common trapeze-type hangers where feasible. Coordinate design of pipe supports with the piping of different specification sections. Indicate which specification section provides the hangers.
- b. Specify pipe supports - do not leave to the Contractor's discretion. Take particular care with vertical pipe supports to allow for expansion and contraction. Support all risers from the floor at their base so that the weight is not carried at wall brackets or riser clamps.
- c. Do not allow valves or equipment to support the weight of any pipe.
- d. Provide special supports for plastic piping.
- e. Isolate all non-insulated copper and glass pipe by means of a felt-lined hanger or manufactured isolating item.
- f. Protect all insulated pipe from crushing at supports by means of a calcium-silicate isolation block.
- g. All concrete inserts for pipe hangers shall be hot-dipped galvanized and pull-tested in accordance with current code.
- h. Pipe support locations with resultant forces to the structure shall be required to be submitted for review and acceptance by structural engineer of record. All submitted documents shall be stamped and signed by a structural engineer licensed in the State of California.
- i. Pipe seismic bracing shall be calculated, designed, and submitted with detailed drawings indicating reaction forces to structure for review by the structural designer of record

#### 16. Condensate Meters

- a. See Section 33 05 00, *Common Work Results for Utilities* for further requirements.
- b. Provide separate condensate meters with isolating valves and a valved bypass for each building using steam. Discuss the type and location with Capital Projects (CP). Provide a meter with a valved bypass in the condensate return line ahead of the return pump.

- c. Locate condensate meters in the mechanical room in an accessible location for reading and servicing.
- d. Where the estimated condensate volume is greater than 10,000 lbs per hour, discuss the type of metering with Capital Projects (CP).
- e. For buildings with a peak design load greater than 2,000 pounds per hour provide an annubar steam meter in the low pressure steam supply line. Include a digital totalizer for local readout, and an analog output flow signal connected to the Building Energy Management System (EMS) and Obvius data acquisition server.

#### 17. Motors

- a. Determine the environment and operating conditions such as dusty, wet, damp, high temperature, continuous or intermittent operation, starting torque, etc., and specify a motor with frame and characteristics to meet those conditions. Motors which are controlled by the Energy Management Control System shall be rated for intermittent service. All motors shall be premium efficiency models. Consult with Facilities Services to obtain minimum requirements. Provide a table on construction drawings listing required minimum efficiency for each motor size, 1/2 horsepower and larger.
- b. Voltage
  - i. Motors smaller than 3/4 horsepower shall be single phase, 60 cycle, with 115 volt rating for 120 volt service and 200 volt single voltage rating for 208 volt service.
  - ii. Motors 3/4 horsepower and larger shall be three phase with the following requirements.
    - 1. Single voltage rating for 208 volt service.
    - 2. A 230/460 voltage rating or 460 volt single voltage rating for 480 volt service for motors smaller than 125 horsepower.
    - 3. Single voltage rating for motors 125 horsepower and larger.
- c. Specify bearings as indicated in this division.

#### 18. Compression Tanks

- a. Label the tank with proper air charge
- b. Sealed diaphragm-type tanks are acceptable.
- c. Expansion tank(s) shall be equipped with isolation valves with lockshield protection.

#### 19. Identification Of Pipes and Equipment

- a. Identify all piping in accordance with pipe and conduit identification standards in Appendix A: Drawings.
- b. Identify all equipment, including the following, with printed plastic or vinyl labels using the following designation that shall be used on the construction drawings.
  - 1. CT = Cooling Tower
  - 2. CA = Air Compressor
  - 3. Cs = Control Systems (Instruments)
  - 4. Gb = Gas Boilers (Natural Gas Fired) (Heaters)
  - 5. B = Boilers (Heating Plant Steam Generators)
  - 6. HX = Heat Exchanges (Hot Water Heaters)
  - 7. PV = Pressure Vessels (Air Receivers, Etc.)
  - 8. PE = Pool Equipment
  - 9. M = Meters (Gas, Water, Air, Etc.)
  - 10. MH = Manhole (Give Location And Equipment)
  - 11. O = Other Than What Is On This Card
  - 12. CP = Condensate Pump
  - 13. HP = Heating Pump (Hot Water)

- 14. SP = Sump Pump
- 15. VP = Vacuum Pump (Labs)
- 16. WP = Water Pump
- 17. EF = Exhaust Fan
- 18. HF = Hood Fan
- 19. SF = Supply Fan
- 20. F = Filter (Air)
- 21. AB = Absorber Chiller
- 22. AC = Air Conditioner (Mechanical)
- 23. RF = Refrigeration

- c. Clearly show and label on the drawings all main sectionalizing and isolating valves so that maintenance personnel can easily identify them in an emergency. This need not include small valves in which their use is evident in rooms, labs, or by equipment served. Numbered tags with corresponding lists shall not fulfill labeling the requirements of this Division.

#### 20. Insulation for Duct, Plenum and Pipe

- a. Provide insulation on piping, ducts and equipment as required by the insulation standards in this Division. Do not insulate pipe unions.
- b. Specify thermal insulation for ventilation ducts and plenums only where the design air temperature in the duct is below sixty degrees Fahrenheit (60°F) or above eighty degrees Fahrenheit (80°F). Do not specify insulation for ducts supplying air above sixty degrees Fahrenheit (60°F), exposed and within the controlled space or area.
- c. Specify sound-attenuating devices with clean-out doors where noise from fans or equipment may be objectionable. Any insulation inside ducts shall be adequately sealed to prevent erosion.
- d. Discuss other spaces requiring special ventilating acoustical treatment, such as music rooms, language labs, speech, etc., with Capital Projects (CP).

#### 21. Noise and Vibration Control

- a. Comply with the following standards for design:
  - i. Health Hazard: Refer to most recent CalOSHA rules regarding maximum noise level for repeated and/or long exposures.
  - ii. Non-Health Hazard: The following guides and standards shall be used for design:
    - 1. ASHRAE Guide and Data Book.
    - 2. AIHA Industrial Noise Manual.
    - 3. Handbook of Noise Measurement (General Radio Company).
    - 4. Speech Interference Level (SIL): noise levels that produce interference with normal and effective conversation for various activities.
    - 5. Noise Criteria Curves (NC Curves): maximum permissible noise level for each frequency band for various conditions.
- b. Provisions for monitoring noise levels:
  - i. Where the noise level of an area is critical, such as a lecture room, study area, music room, private office, design for and indicate on the drawings the maximum decibel rating.
  - ii. Where a maximum noise level is designed for an area, or equipment, specify test method, test conditions and person(s) responsible for the tests and documentation of results.
- c. Design standards for noise reduction:
  - i. Coordinate location of mechanical equipment in early design stages with the architect and the acoustical consultant (if one is retained).

- ii. Select and specify equipment having quiet operating characteristics at its design capacity and speed. Avoid installation in, near, or on the roof above, an occupied area. Configure and size ducts and piping to have velocities below noise producing levels.
- iii. Pay particular attention to vibration-producing equipment. Coordinate with structural in the early design stages.
- d. Sound attenuation and isolators:
  - i. Specify sound attenuation measures for ducts, pipes and equipment, if required, to meet each specific condition.
  - ii. Where the equipment manufacturer recommends the use of vibration isolators, or the equipment and location indicates its need, specify isolators by size, type, and manufacturer. Specify 1" average deflection for spring type isolators. Applications where sound generated is an issue shall incorporate two inch (2") deflection isolators.
  - iii. Provide sound absorbing pads between equipment and structure where equipment is to be installed without vibration isolators, such as pumps, compressors, vacuum pumps, etc.
  - iv. Place flexible sections in all connections between vibration producing equipment and the building system it serves.

## 23 60 00 Central Cooling Equipment

### 1. Cooling Water

- a. Cooling water from an industrial system or cooling tower does not require double check valves at equipment connections.
- b. Chillers shall use R-134A refrigerant.
- c. Chillers specified shall use condenser water flow modulation to control refrigeration system head pressures.
- d. Chillers shall be magnetic bearing high-efficiency type. Manufacturer shall be Multistack or approved equal.
- e. Designer shall provide analysis of chiller systems proposed to determine the most efficient system considering maintenance energy consumed in the Berkeley local climate. Discuss type of system proposed with UC Berkeley Construction and Design prior to system design.
- f. Where cooling water is supplied from a domestic cold water system, provide an approved backflow prevention device, installed before the point of connection to the equipment.
- g. Pipe domestic or industrial cooling water waste to the sanitary system. For cooling water requirements, see Division 11.
- h. Where cooling water with a high degree of purity is required for computer rooms, electron microscopes, or other sensitive equipment, provide a closed loop system with a plate-type heat exchanger or a separate refrigerated system. Discuss with Capital Projects (CP).

### 2. Cooling Coils

- a. Provide chilled water cooling coils with copper tubing and copper.
- b. Provide a condensate drain pan piped to drain for all cooling coils. Ensure that the drain pan is adequately pitched toward the drain to prevent standing water in the pan. Show a detail of the drain pan and drain lines where static pressure of the system may affect drain performance.
- c. Coil casings and drain pans shall be coated galvanized steel or stainless steel.

### 3. Refrigerant Leak Detection Systems

- a. All chillers shall comply with the most recently adopted California Fire Code and California Mechanical Code.

- b. Panels for Refrigerant Leak Detection Systems shall be located outside of chiller equipment room adjacent to entry door.
- c. Detection System shall provide multiple alarm levels:
  - i. Lower level to transmit alarm to Building Automation System
  - ii. High level to transmit to Fire Alarm Control Unit as a Fire Alarm signal resulting in building evacuation.
- d. Each building where a chiller is located shall have, as part of its Digital Alarm Communicator Transmitter (See: *28 31 13 Fire Detection and Alarm Control, GUI and Logic Systems*) a dedicated contact for the Refrigerant Leak Detection System alarm to UCPD. It shall be identified as "Refrigerant Leak Alarm."
- e. Sensing tubes shall be constructed of either:
  - i. Plastic tubing in conduit, as specified by the manufacturer's installation requirements, or;
  - ii. Copper tubing, appropriately sized for the detection system it serves.
- f. Panels for Refrigerant Leak Detection Systems shall display the refrigerant gas concentration at each sampling point.
- g. Sampling points shall be provided at locations where the refrigerant gas is likely to collect and where the sampling ports can detect the gas.
- h. Horn strobes shall be provided in the chiller room so that the strobes are visible to all locations in the room. The horn shall have a sound pressure level of fifteen decibels (15dB) above the ambient level.
- i. Strobes shall be yellow. The spacing of the strobes shall be based on the candela rating of the strobe.
- j. Horns shall sound a continuous sound which is not similar to the fire alarm system horns.
- k. The panel shall include a switch to silence the horn/strobes
- l. Signs shall be posted at the entry door(s) to the chiller room stating:  
"IF REFRIGERANT LEAK ALARMS ARE SOUNDING/FLASHING, DO NOT ENTER"
- m. Signs shall be posted in the chiller room stating:  
"IF REFRIGERANT LEAK ALARMS ARE SOUNDING/FLASHING, LEAVE THE ROOM IMMEDIATELY"
- n. Signs shall be posted at each horn/strobe stating:  
"REFRIGERANT LEAK ALARM. IF HORN/STROBES HAVE ACTIVATED, LEAVE THE ROOM IMMEDIATELY."
- o. Refrigerant leak detection panels shall not be located outside unless approved by the Designated Campus Fire Marshal. Panels located outside shall be weather protected. Panels using plastics that will degrade or discolor when exposed to UV radiation are not permitted. Panels shall be located such that the temperature within the panel enclosure does not exceed the temperature rating of the equipment.

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## 25 00 00 Integrated Automation

### 25 10 00 Integrated Automation Network Equipment

Note to Designers: The campus has standardized, through a bid process, on the Automated Logic Control (ALC) platform for HVAC system control and monitoring. The ALC platform replaces the Barrington Systems platform, the former campus standard. All following standards and requirements in this section pertain to the ALC platform.

#### 1. General

- a. Section Includes:
  - i. Building Controller (BC)
  - ii. Advance Application Specific Controller (AAC)
  - iii. Application Specific Controller (ASC)
- b. Procurement
  - i. The BAS and digital control and communications components installed as work of this contract shall be an integrated distributed processing system of the following communication protocol. No other products will be considered as substitutions.
    1. Native BACnet Communication: System components shall communicate using native BACnet in accordance with the latest edition of ASHRAE Standard 135 and all current addenda and annexes, including all workstations, all building controllers, and all application specific controllers. Gateways, either hardware or software, to other communication protocols are not acceptable.
  - ii. The BAS and digital control and communications components manufacturer shall have a minimum of 3 separate vendors. These vendors shall each be located within a 90 mile radius of UC Berkeley or have a guaranteed on-site response time of 12 hours or less.
- c. Product Line Demonstrated History: The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of 5 years since date of final completion in at least 10 installations. The Building Controllers (BCs) for the proposed product line shall have a 5-year installation history without major modification to the hardware. Submittals shall document these requirements with references.
- d. All future generations of the DDC hardware and software product line shall be guaranteed backward-compatible to the present generation product line.

#### 2. Products

- a. Stand-Alone Functionality
  - i. General: These requirements are for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone capability is specified with the controller and for each Application Category specified in Part 3. This item refers to acceptable paradigms for associating the points with the processor.
  - ii. Functional Boundary: Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. When referring to the controller relative to the standalone functionality, reference is specifically made to the processor. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.
  - iii. The following configurations are considered acceptable with reference to a controller's standalone functionality:
    1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).



2. Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
3. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.
4. I/O point expansion devices connected to the main controller board via wiring and as such may be remote from the controller and that communicate via a sub LAN protocol. These arrangements to be considered standalone shall have a sub LAN that is dedicated to that controller and include no other controller devices. All wiring to interconnect the I/O expander board shall be:
  - a. Contained in the control panel enclosure;
  - b. Or run in conduit. Wiring shall only be accessible at the terminations.
- iv. The following configurations are considered unacceptable with reference to a controller's standalone functionality:
  1. Multiple controllers enclosed in the same control panel to accomplish the point requirement.
  2. General purpose LonMark I/O devices or Smart Devices
- b. Building Controller (BC)
  - i. General Requirements:
    1. The BC(s) shall provide fully distributed control independent of the operational status of any Operator Workstation (OWS) or Control System Server (CSS). All necessary calculations required to achieve control shall be executed within the BC independent of any other device. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.
    2. BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions. BCs shall share information with the entire network of BCs and AACs/ASCs for full global control. Each controller shall permit multi-user operation from the multiple workstations and portable operator terminals connected either locally or over the Primary Controller LAN. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure. BCs shall be programmable from an operator workstation, portable operator terminal, or hand held operating device. BCs shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
    3. BCs shall be connected to a controller network that qualifies as a Primary Controlling LAN. This LAN may be Ethernet 10/100BaseT (IEEE802.3) or a separate high speed peer-to-peer LAN used in conjunction with an Inter-building LAN Interface Device. The LAN Interface Device shall employ native TCP/IP on the Ethernet 10/100BaseT (IEEE802.3) physical layer for connection to existing University provided Ethernet routers in each building. The LAN Interface Device shall not require third party routers, gateways or translators for TCP/IP protocol.
    4. All BCs shall be protected from any memory loss due to a loss of power by one or a combination of the following:
      - a. Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five years. Self-diagnostic routine shall report an alarm for a low battery condition.
      - b. EEPROM, EPROM, or NOVRAM non-volatile memory

5. In addition BCs shall provide intelligent, standalone control of HVAC functions. Each BC shall be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices. Refer to standalone functionality specified above.
6. The BC shall provide for point mix flexibility and expandability. This requirement may be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Refer to stand alone functionality specified above.
7. All BC point data, algorithms and application software shall be modifiable from the Operator Workstation or Control System Server.
8. Each BC shall execute application programs, calculations, and commands via a microprocessor resident in the BC. The database and all application programs for each BC shall be stored in non-volatile or battery backed volatile memory within the BC and will be able to upload/download to/from the OWS and/or CSS.
9. Each BC shall provide buffer for holding alarms, messages, and trends.
10. Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.
11. Each BC shall contain software to perform full DDC/PID control loops.
12. For systems requiring end-of-line resistors those resistors shall be located in the BC.
13. Input-Output Processing
  - a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 Vac or Vdc, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and a manual hand off or auto switch to allow for override. Provide feedback to remotely indicate the HOA is not in the Auto position. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
  - b. Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10 Vdc, 0-20 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
  - c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.
  - d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
  - e. Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable only with Owner approval (Generally these will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.). Where these are allowed, transducer/actuator shall be

- programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 10 bits.
- f. Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/P transducer, or digital to pneumatic transducer are acceptable. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the BC and provide individual feedback. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.
  - g. Pulsed Inputs: Capable of counting up to 8 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.
14. A communication port for operator interface through a terminal shall be provided in each BC. It shall be possible to perform all program and database back-up, system monitoring, control functions, and BC diagnostics through this port. Standalone BC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or workstations.
  15. Each BC shall be equipped with a loop tuning algorithm for precise proportional, integral, derivative (PID) control. Loop tuning tools provided with the Operator Workstation software are acceptable. In any case, tools to support loop tuning must be provided such that P, I, and D gains are automatically calculated.
  16. All analog output points shall have a selectable failure setpoint. The BC shall be capable of maintaining this failure setpoint in the event of a system malfunction, which causes loss of BC control, or loss of output signal, as long as power is available at the BC. The failure setpoint shall be selectable on a per point basis.
  17. Slope intercepts and gain adjustments shall be available on a per-point basis.
  18. BC Power Loss:
    - a. Upon a loss of power to any BC, the other units on the primary controlling network shall not in any way be affected.
    - b. Upon a loss of power to any BC, the battery backup shall ensure that the energy management control software, the Direct Digital Control software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours. An alarm diagnostic message shall indicate that the BC is under battery power.
    - c. Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
    - d. Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via the network, and connected computer. In addition, the Owner shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via the local area network,

or via the telephone line dial-up modem where applicable, or to the laptop PC via the local RS-232C port.

19. BC Failure:
  - a. Building Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer BCs shall recognize the loss, report alarm and reconfigure the LAN.
  - b. BC Hardware Failure: BC shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.
20. Each BC shall be equipped with firmware resident self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.).
21. BCs may include LAN communications interface functions for controlling secondary controlling LANs.
22. A minimum of four levels of password protection shall be provided at each BC.
23. BCs shall be mounted on equipment, in packaged equipment enclosures, or locking wall mounted in a NEMA 1 enclosure, as specified elsewhere.
24. In the last month of the warranty period, all controller firmware, software, drivers, etc. will be upgraded to the latest release (version) in effect at the end of the Warranty Period.
25. BACnet Building Controller Requirements: The BC(s) shall support all BIBBs defined in the BACnet Building Controller (B-BC) device profile as defined in the BACnet standard.
- c. Advanced Application Specific Controller (AAC) and Application Specific Controller (ASC)
  - i. General Requirements:
    1. AACs and ASCs shall provide intelligent, standalone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and will continue to operate all local control functions in the event of a loss of communications on the ASC LAN or sub-LAN. Refer to standalone requirements by application specified in Part 3 of this section. In addition, it shall be able to share information with every other BC and AAC /ASC on the entire network.
    2. Each AAC and ASC shall include self-test diagnostics that allow the AAC /ASC to automatically relay to the BC, LAN Interface Device or workstation, any malfunctions or abnormal conditions within the AAC /ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.
    3. AACs and ASCs shall include enough memory to perform the specific control functions required for its application and to communicate with other devices.
    4. Each AAC and ASC shall be connected to the Primary Controller LAN or a separate ASC LAN using peer-to-peer communication at a minimum speed of 38.4 kbps. Any LAN Interface Device needed to communicate between the ASC LAN and the Primary Controller LAN shall not require third party routers, gateways or translators.
    5. Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum 8 bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty- (50) hrs with a battery life of five years.

6. All point data, algorithms, and application software within an AAC /ASC shall be fully modifiable from the Operator Workstation.
7. Each AAC and ASC shall provide buffer for holding alarms, messages, and trends.
8. In the last month of the warranty period, all controller firmware, software, drivers, etc. will be upgraded to the latest release (version) in effect at the end of the Warranty Period.
9. AAC and ASC Input-Output Processing
  - a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each DO shall be discrete outputs from the AAC/ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
  - b. Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10Vdc, 0-20Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 8-10 bits depending on application.
  - c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.
  - d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
  - e. Electronic Analog Outputs (AO) as required by application: voltage mode, 0- 5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable only with Owner approval (Generally, PWM will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.). Where PWM is allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 8 bits.
  - f. Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/P transducer, PWM/P transducer, or digital to pneumatic transducer are acceptable. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the AAC /ASC and provide individual feedback. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.
10. BACnet AAC(s) and ASC(s) Requirements: The AAC(s) and ASC(s) shall support all BIBBs defined in the BACnet Building Controller (B-AAC and B-ASC) device profile as defined in the BACnet standard.
  - ii. Terminal Box Controllers: Terminal box controllers controlling damper positions to maintain a quantity of supply or exhaust air serving a space shall have an automatically initiated function that resets the volume regulator damper to the fully closed position on a scheduled basis. The controllers shall initially be set up to perform this function once

every 24 hours. The purpose of this required function is to reset and synchronize the actual damper position with the calculated damper position and to assure the damper will completely close when commanded. The software shall select scheduled boxes randomly and shall not allow more than 5% of the total quantity of controllers in a building to perform this function at the same time. When possible the controllers shall perform this function when the supply or exhaust air system is not operating or is unoccupied.

### 3. Execution

#### a. Inspection:

- i. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

#### b. System Access:

- i. Provide an Ethernet connection and a 5 port hub at each panel housing a controller or controllers that provides access to the Local Supervisory LAN and to the Control System Server for all Controllers, other than an Application Category 1 Controllers. The user shall be able to access each controller on the system using this connection via the Control System Server database for graphics, schedules, programming, controller configuration etc.

#### c. Installation of Control Systems:

- i. General: Install systems and materials in accordance with manufacturer's instructions, specifications roughing-in drawings and details shown on drawings. Contractor shall install all controllers in accordance with manufacturer's installation procedures and practices.

#### d. Hardware Application Requirements

- i. General: The functional intent of this specification is to allow cost effective application of manufacturers standard products while maintaining the integrity and reliability of the control functions. A Building Controller as specified above is generally fully featured and customizable whereas the AAC/ASC refers to a more cost- effective unit designed for lower-end applications. Specific requirements indicated below are required for the respective application. Manufacturer may apply the most cost-effective unit that meets the requirement of that application.
- ii. Standalone Capability: Each Control Unit shall be capable of performing the required sequence of operations for the associated equipment. All physical point data and calculated values required to accomplish the sequence of operations shall originate within the associated CU with only the exceptions enumerated below. Refer to Item 2.01 above for physical limitations of standalone functionality. Listed below are functional point data and calculated values that shall be allowed to be obtained from or stored by other CUs or SDs via LAN.
- iii. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.
- iv. Application Category 0 (Distributed monitoring)
  1. Applications in this category include the following:
    - a. Monitoring of variables that are not used in a control loop, sequence logic, or safety.
    2. Points on BCs, AACs, and ASCs may be used in these applications as well as SDs and/or general-purpose I/O modules.
    3. Where these points are trended, contractor shall verify and document that the network bandwidth is acceptable for such trends and is still capable of acceptable and timely control function.
- v. Application Category 1 (Application Specific Controller):

1. Applications in this category include the following:
  - a. Fan Coil Units
  - b. Airflow Control Boxes (VAV and Constant Volume Terminal Units)
  - c. Misc. Heaters
  - d. Unitary equipment <15 tons (Package Terminal AC Units, Package Terminal Heat Pumps, Split-System AC Units, Split-System Heat Pumps, Water- Source Heat Pumps)
  - e. Induction Units
  - f. Dual Duct Zone Dampers
2. ASCs may be used in these applications.
3. Standalone Capability: Provide capability to execute control functions for the application for a given setpoint or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Value
Scheduling Period	Normal
Morning Warm-Up	Off (cold discharge air)
Load Shed	Off (no shedding)
Summer/Winter	Winter
Trend Data	N/A

4. Mounting:
  - a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use.
  - b. ASCs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
  - c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
  - d. Any LAN Interface Device needed to communicate between the ASC LAN and the Primary Controller LAN shall be mounted in a control panel no higher than 6' AFF.
  - e. Section 15953 contractor may furnish ASCs to the terminal unit manufacturer for factory mounting.
5. Programmability: Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, interstage timing parameters, and mode settings. Application-specific block control algorithms may be used to meet the sequence of operations. The ability to customize the control algorithm is not required unless specifically indicated otherwise.

6. LAN Restrictions: For networks operating at 38.4 kbps or less, limit the number of nodes on the network to meet all system performance criteria and to no more than 80% of the maximum recommended by the manufacturer. For networks operating at greater than 38.4 kbps limit the number of nodes on the network to meet all system performance criteria up to the maximum recommended by the manufacturer.
- vi. Application Category 2 (General Purpose Terminal Controller)
1. Applications in this category include the following:
    - a. Unitary Equipment  $\geq$  15 tons (Air Conditioners, Heat Pumps, Packaged Heating/Cooling Units, and the like)
    - b. Small, Constant Volume Single Zone Air Handling Units
    - c. Constant Volume Pump Start/Stop
    - d. Misc. Equipment (Exhaust Fan) Start/Stop
    - e. Misc. Monitoring (not directly associated with a control sequence and where trending is not critical)
  2. BCs may be used in these applications.
  3. ASC's may be used in these applications provided the ASC meets all requirements specified below. This category requires a general-purpose ASC to which application-specific control algorithms can be attached.
  4. Standalone Capability: Only the following data (as applicable) may be acquired from other ASCs via LANs. In the event of a loss of communications with any other ASCs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC/ASC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Delay Time	Default Value
Outside Air Temperature	3 Minutes	80° F
Outside Air Humidity	3 Minutes	60% RH
Outside Air Enthalpy	3 Minutes	30 Btu/LB
Trend Data		N/A
Cooling/Heating Requests	3 Minutes	None

5. Mounting:
  - a. ASCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the contractor) or in a nearby mechanical/utility room no higher than 6' AFF, in which case it shall be enclosed in a NEMA 1, locking enclosure.
6. Programmability: Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, interstage timing parameters, and mode settings. Operator shall be able to address and configure spare inputs for monitoring. Operator shall be able to address and configure spare outputs for simple single loop control actions or event initiated actions. Application-specific block control algorithms shall used to meet the sequence of operations. The ability to customize the control algorithm is not required unless specifically indicated otherwise.



7. LAN Restrictions: Limit the number of nodes servicing any one of these applications on the AAC/ASC LAN to 32.
- vii. Application Category 3 (Advanced Application Controller)
  1. Applications in this category include the following:
    - a. Steam Pressure Reducing Station Control
    - b. Steam Converter Control
    - c. Large Constant Volume Air Handlers
    - d. V A V Air Handlers
    - e. Dual Duct Air Handlers
    - f. Multizone Air Handlers
    - g. Self-Contained V A V Units
    - h. Air Handlers serving critical areas
    - i. Central Cooling Plant
    - j. Central Heating Plant
    - k. Cooling Towers
    - l. Sequenced or Variable Speed Pump Control
    - m. Local Chiller Control (unit specific)
    - n. Campus Loop Chilled Water Control
  2. BCs shall be used in these applications
  3. LAN Restrictions: Comply with 2.01, Stand-Alone Functionality, above.

## 25 50 00 Integrated Automation Facility Controls

Note to Designers: The campus has standardized, through a bid process, on the Automated Logic Control (ALC) platform for HVAC system control and monitoring. The ALC platform replaces the Barrington Systems platform, the former campus standard. All following standards and requirements in this section pertain to the ALC platform.

1. Part I. General
  - a. Section Includes
    1. System Software
    2. Programming Description
    3. Control Algorithms
    4. Energy Management Applications
    5. Password Protection
    6. Alarm Reporting
    7. Trending
    8. Data Acquisition and Storage
    9. Point Structuring
    10. Dynamic Color Graphics
    11. Communication Performance Requirements
  - b. Description of Work:
    - i. Fully configure systems and furnish and install all software, programming and dynamic color graphics for a complete and fully functioning system as specified.
  - c. Licensing
    - i. Include licensing for all software packages at all required workstations.
    - ii. There shall be no restrictions to the number of simultaneous internet browser access users.
    - iii. Provide or upgrade all licensing for all software packages at all required workstations. BAS licensing shall allow unlimited simultaneous users for access to all aspects of the

system including system access, workstations, points, programming, database management, graphics etc. No restrictions shall be placed on the licensing. All operator interfaces, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.

- iv. All software should be available on all Operator Workstations or CSSs provided, and on all Portable Operator Terminals. Hardware and software keys to provide all rights shall be installed on all workstations. At least 2 sets of CDs shall be provided with backup software for all software provided, so that the Owner may reinstall any software as necessary. Include all licensing for workstation operating systems, and all required third-party software licenses.
- v. Provide licensing and original software copies for each OWS or CSS.
- vi. Provide licensing and original software copies for each remote graphic workstation. Licenses shall allow for access to any site and shall not be restricted to accessing, database management, configuring, etc. only the LANs or Sites included in this project.
- vii. In the last month of the warranty period, upgrade all software and firmware packages to the latest release (version) in effect at the end of the Warranty Period.

## 2. Part II: Products

### a. System Software-General

- i. **Functionality and Completeness:** Contractor shall furnish and install all software and programming necessary to provide a complete and functioning system as specified. Contractor shall include all software and programming not specifically itemized in these Specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.
- ii. **Configuration:** The software shall support the system as a distributed processing network configuration.
- iii. **Internet Browser Access:** System shall provide for full access to view all system graphics and graphical programming logic with real-time data via a standard internet browser. System shall also provide the ability to modify all point configuration data, schedules, and trend configuration data via a standard internet browser.

### b. Controller Software

- i. **BC Software Residency:** Each BC as defined below shall be capable of control and monitoring of all points physically connected to it. All software including the following shall reside and execute at the BC:
  - 1. Real-Time Operating System software
  - 2. Real-Time Clock/Calendar and network time synchronization
  - 3. BC diagnostic software
  - 4. LAN Communication software/firmware
  - 5. Direct Digital Control software
  - 6. Alarm Processing and Buffering software
  - 7. Energy Management software
  - 8. Data Trending, Reporting, and Buffering software
  - 9. I/O (physical and virtual) database
  - 10. Remote Communication software
- ii. **AAC/ASC Software Residency:** Each AAC/ASC as defined below shall be capable of control and monitoring of all points physically connected to it. At a minimum, software including the following shall reside and execute at the AAC/ASC. Other software to support other required functions of the AAC/ASC may reside at the BC, with the restrictions/exceptions per application provided in BAS Hardware Sections:
  - 1. Real-Time Operating System software

2. AAC/ASC diagnostic software
  3. LAN Communication software
  4. Control software applicable to the unit it serves that will support a single mode of operation
  5. I/O (physical and virtual) database to support one mode of operation
- iii. Stand Alone Capability: BC shall continue to perform all functions independent of a failure in other BC/AAC/ASC or other communication links to other BCs/AACs/ASCs. Trends and runtime totalization shall be retained in memory. Runtime totalization shall be available on all digital input points that monitor electric motor status. Refer also to Section 15953 for other aspects of stand-alone functionality.
  - iv. Operating System: Controllers shall include a real-time operating system resident in ROM. This software shall execute independently from any other devices in the system. It shall support all specified functions. It shall provide a command prioritization scheme to allow functional override of control functions. Refer also to Section 15953 for other aspects of the controller's operating system.
  - v. Network Communications: Each controller shall include software/firmware that supports the networking of CUs on a common communications trunk that forms the respective LAN. Network support shall include the following:
    1. Building Controller/Primary LAN shall be a high-speed network designed and optimized for control system communication. If a Primary LAN communications trunk is severed, BCs shall reconfigure into two separate LANs and continue operations without interruption or Operator intervention.
    2. Controller communication software shall include error detection, correction, and re-transmission to ensure data integrity.
    3. Operator/System communication software shall facilitate communications between other BCs, all subordinate AACs/ASCs, Gateways and LAN Interface Devices or Operator Workstations. Software shall allow point interrogation, adjustment, addition/deletion, and programming while the controller is on line and functioning without disruption to unaffected points. The software architecture shall allow networked controllers to share selected physical and virtual point information throughout the entire system.
  - vi. Point Database/Summary Table: All points included in the typical equipment point list must be represented to Owner's WAN in a common, open protocol format. Naming conventions for these points and network addressing are discussed in Part III of this section. Point/system database creation and modification shall be via a user- friendly, menu-driven program. System software shall support virtual or logic point (points not representing a physical I/O) creation. Software shall support virtual points with all services specified herein. Database software shall support definition of all parameters specified in Part III of this section for a given point type. If database does not support all of these parameters, then a software module shall be created and attached to the points which accomplish the respective function.
  - vii. Diagnostic Software: Controller software shall include diagnostic software that checks memory and communications and reports any malfunctions
  - viii. Alarm/Messaging Software: Controller software shall support alarm/message processing and buffering software as more fully specified below.
  - ix. Application Programs: CUs shall support and execute application programs as more fully specified below:
    1. All Direct Digital Control software, Energy Management Control software, and functional block application programming software templates shall be provided in a 'ready-to-use' state and shall not require (but shall allow) Owner programming.

- x. Security: Controller software shall support multiple level password access restriction as more fully specified below.
  - xi. Direct Digital Control: Controller shall support application of Direct Digital Control Logic. All logic modules shall be provided pre-programmed with written documentation to support their application. Provide the following logic modules at a minimum:
    1. Proportional-Integral-Derivative (PID) control with analog, PWM and floating output
    2. Two Position control (Hi or Low crossing with dead band)
    3. Single-Pole Double-Throw relay
    4. Delay Timer (delay-on-make, delay-on-break, and interval)
    5. Hi/Low Selection
    6. Reset or Scaling Module
    7. Logical Operators (And, Or, Not, Xor)
  - xii. Psychrometric Parameters: Controller software shall provide preprogrammed functions to calculate and present psychrometric parameters (given temperature and relative humidity) including the following at a minimum: Enthalpy, Wet Bulb Temperature.
  - xiii. Updating/Storing Application Data: Site-specific programming residing in volatile memory shall be uploadable/downloadable from an OWS or CSS connected locally, to the Primary LAN, to the Local Supervisory LAN and remotely via the internet and modem and telephone lines as applicable but all must be available. Initiation of an upload or download shall include all of the following methods; Manually, Scheduled, and Automatically upon detection of a loss or change
  - xiv. Restart: System software shall provide for orderly shutdown upon loss of power and automatic restart upon power restoration. Volatile memory shall be retained; outputs shall go to programmed fail (open, closed, or last) position. Equipment restart shall include a user definable time delay on each piece of equipment to stagger the restart. Loss of power shall be alarmed at operator interface indicating date and time.
  - xv. Time Synchronization: Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device, devices on a single network, or all devices simultaneously. Automatic time synchronization shall be provided.
  - xvi. Misc. Calculations: System software shall automate calculation of psychrometric functions, calendar functions, kWh/kW, and flow determination and totalization from pulsed or analog inputs, curve-fitting, look-up table, input/output scaling, time averaging of inputs and A/D conversion coefficients.
- c. Application Programming Description
- i. The application software shall be user programmable.
  - ii. Application programming shall be provided by the following method:
    1. Graphical Block Programming: Manipulation of graphic icon 'blocks', each of which represents a subroutine, in a functional/logical manner forming a control logic diagram. Blocks shall allow entry of adjustable settings and parameters via pop-up windows. Provide a utility that shall allow the graphic logic diagrams to be directly compiled into application programs. Logic diagrams shall be viewable either off-line, or on-line with real-time block output values.
    2. The following programming methods are not acceptable:
      - a. Pre-programmed application specific programs that allow limited customization via 'fill-in-the-blanks' edit fields.
      - b. Line Code Programming.

- iii. Provide a means for testing and/or debugging the control programs both off-line and on-line.
- d. Energy Management Applications
  - i. System shall have the ability to perform all of the following energy management routines via preprogrammed function blocks or template programs. At a minimum provide the following whether or not required in the software:
    1. Time-of-Day Scheduling
    2. Calendar-Based Scheduling
    3. Holiday Scheduling
    4. Temporary Schedule Overrides
    5. Optimal Start/Optimal Stop-based on space temperature offset, outdoor air temperature, and building heating and cooling capacitance factors at a minimum
    6. Night Setback and Morning Recovery Control, with ventilation only during occupancy
    7. Economizer Control (enthalpy or dry-bulb)
    8. Peak Demand Limiting / Load Shedding
    9. Dead Band Control
  - ii. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. Programs shall be applied to building equipment as described in the Section entitled ‘Sequence of Operation’.
- e. Password Protection
  - i. Multiple-level password access protection shall be provided to allow the Owner’s authorized BAS Administrator to limit workstation control, display and database manipulation capabilities as (s)he deems appropriate for each user, based upon an assigned user name with a unique password.
  - ii. All passwords for the system shall be provided to the Owner including administrator, dealer, or factory level passwords for the systems provided under this project.
  - iii. Passwords shall restrict access to all Control Units.
  - iv. Each user name shall be assigned to a discrete access level. A minimum of five levels of access shall be supported. Alternately, a comprehensive list of accessibility/functionality items shall be provided, to be enabled or disabled for each user.
  - v. A minimum of 250 user names shall be supported per Owner’s direction.
  - vi. Operators shall be able to perform only those commands available for the access level assigned to their user name.
  - vii. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving interface device software on-line.
- f. Alarm and Event Management Reporting
  - i. Alarm management shall be provided to monitor, buffer, and direct alarms and messages to operator devices and memory files. Each BC shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall a BCs ability to report alarms be affected by either operator activity at an Operator Workstation or local handheld device, or by communications with other panels on the network.
    1. Alarm Descriptor: Each alarm or point change shall include that point’s English language description, and the time and date of occurrence. In addition to the alarm’s descriptor and the time and date, the user shall be able to print, display

and store an alarm message to more fully describe the alarm condition or direct operator response.

2. Alarm Prioritization: The software shall allow users to define the handling and routing of each alarm by their assignment to discrete priority levels. A minimum of ten priority levels shall be provided. For each priority level, users shall have the ability to enable or disable an audible tone whenever an alarm is reported and whenever an alarm returns to normal condition. Users shall have the ability to manually inhibit alarm reporting for each individual alarm and for each priority level. Contractor shall coordinate with the Owner on establishing alarm priority definitions.
  3. Alarm Report Routing: Each alarm shall be associated with a priority level and unique user-defined list of operator devices including any combination of local or remote workstations, printers, workstation disk files, e-mail addresses, and pagers. All alarms associated with a given priority level shall be routed to all operator devices on the user-defined list associated with that priority level. For each priority level, alarms shall be automatically routed to a default operator device in the event that alarms are unable to be routed to any operator device assigned to the priority level. For priority level 1 alarms, initial notification shall be to the assigned primary operator device. If the initial notification is not acknowledged within an adjustable time window, the alarm notification shall be sent to the assigned secondary operator device. If the notification to the secondary operator device is not acknowledged within an adjustable time window, the assigned third operator device shall be notified.
  4. Auto-Dial Alarm Routing: For alarm priority levels that include a remote workstation (accessed by modem) as one of the listed reporting destinations, the BC shall initiate a call to report the alarm, and shall terminate the call after alarm reporting is complete. System shall be capable of multiple retries and buffer alarms until a connection is made. If no connection is made, system shall attempt connection to an alternate dial-up workstation. System shall also be able to dial multiple pagers upon alarm activation.
  5. Alarm Acknowledgment: For alarm priority levels that are directed to a workstation screen, an indication of alarm receipt shall be displayed immediately regardless of the application in use at the workstation, and shall remain on the screen until acknowledged by a user having a password that allows alarm acknowledgment. Upon acknowledgment, the complete alarm message string (including date, time, and user name of acknowledging operator) shall be stored in a selected file on the workstation hard disk.
- ii. It shall be possible for any operator to receive a summary of all alarms regardless of acknowledgement status; for which a particular recipient is enrolled for notification; based on current event state; based on the particular event algorithm (e.g., change of value, change of state, out of range, and so on); alarm priority; and notification class.
  - iii. Alarming Services: All alarms and events shall be implemented using standard event detection and notification mechanisms. The workstation shall receive alarm and event notifications from any gateway or controller in the system and display them to an operator. The alarm shall be linked to the system graphic it corresponds to. Either intrinsic reporting or algorithmic change reporting may be used but the intrinsic reporting method is preferred. The workstation shall also log alarms and events, provide a way for an operator with sufficient privilege to acknowledge alarms, and log acknowledgements of alarms. It shall be possible for an operator to receive, at any time, a summary of all alarms that are currently in effect at any site whether or not they have

- been acknowledged. Operators shall also be able to view and change alarm limits for any alarm at the appropriate password level
- iv. Alarm Historical Database: The database shall store all alarms and events object occurrences in an ODBC or an OLE database-compliant relational database. Provide a commercially available ODBC driver or OLE database data provider, which would allow applications to access the data using standard Microsoft Windows Data Services.
- g. Trending
- i. The software shall display historical data in both a tabular and graphical format. The requirements of this trending shall include the following:
    - 1. Provide trends for all physical points, virtual points and calculated variables.
    - 2. BACnet Trend Objects are allowed and all trend data shall be stored in relational database format as specified in herein under Data Acquisition and Storage.
    - 3. In the graphical format, the trend shall plot at least 4 different values for a given time period superimposed on the same graph. The 4 values shall be distinguishable by using unique colors. In printed form the 4 lines shall be distinguishable by different line symbology. Displayed trend graphs shall indicate the engineering units for each trended value.
    - 4. The sample rate and data selection shall be selectable by the operator.
    - 5. The trended value range shall be selectable by the operator.
    - 6. Where trended values on one table/graph are COV, software shall automatically fill the trend samples between COV entries.
  - ii. Control Loop Performance Trends: Controllers incorporating PID control loops shall also provide high resolution sampling in less than six second increments for verification of control loop performance.
  - iii. Data Buffering and Archiving: Trend data shall be buffered at the BC, and uploaded to hard disk storage when archival is desired. All archived trends shall be transmitted to the on-site OWS or CSS as applicable. Uploads shall occur based upon a user- defined interval, manual command, or automatically when the trend buffers become full.
  - iv. Time Synchronization: Provide a time master that is installed and configured to synchronize the clocks of all devices supporting time synchronization. Synchronization shall be done using Coordinated Universal Time (UTC). All trend sample times shall be able to be synchronized. The frequency of time synchronization message transmission shall be selectable by the operator.
- h. Dynamic Plotting
- i. Provide a utility to dynamically plot in real-time at least 4 values on a given 2-dimensional dynamic plot/graph with at least two Y-axes. At least 5 dynamic plots shall be allowed simultaneously.
- i. Data Acquisition and Storage
- i. All points included in the typical equipment point list must be represented in a common, open or accessible format.
  - ii. Data from the BAS shall be stored in relational database format. The format and the naming convention used for storing the database files shall remain consistent across the database and across time. The relational structure shall allow for storage of any additional data points, which are added to the BAS in future. The metadata/schema or formal descriptions of the tables, columns, domains, and constraints shall be provided for each database.
  - iii. The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to

- the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried by the BAS.
- iv. The database shall be ODBC or OLE database compliant. Provide a commercially-available ODBC driver or OLE database data provider, which would allow applications to access the data via Microsoft Windows standard data access services.
  - v.
  - j. Totalization
    - i. The software shall support totalizing analog, digital, and pulsed inputs and be capable of accumulating, storing, and converting these totals to engineering units used in the documents. These values shall generally be accessible to the Operator Interfaces to support management-reporting functions.
    - ii. Totalization of electricity use/demand shall allow application of totals to different rate periods, which shall be user definable.
    - iii. When specified to provide electrical or utility Use/Demand, the Contractor shall obtain from the local utility all information required to obtain meter data, including k factors, conversion constants, and the like.
  - k. Equipment Scheduling
    - i. Provide a graphic utility for user-friendly operator interface to adjust equipment-operating schedules.
    - ii. All operators shall be able to view the entries for a schedule. Operators with sufficient privilege shall be able to modify schedule entries from any workstation.\
    - iii. Scheduling feature shall include multiple seven-day master schedules, plus holiday schedule, each with start time and stop time. Master schedules shall be individually editable for each day and holiday.
    - iv. Scheduling feature shall allow for each individual equipment unit to be assigned to one of the master schedules.
    - v. Timed override feature shall allow an operator to temporarily change the state of scheduled equipment. An override command shall be selectable to apply to an individual unit, all units assigned to a given master schedule, or to all units in a building. Timed override shall terminate at the end of an operator selectable time, or at the end of the scheduled occupied/unoccupied period, whichever comes first. A password level that does not allow assignment of master schedules shall allow a timed override feature.
    - vi. A yearly calendar feature shall allow assignment of holidays, and automatic reset of system real time clocks for transitions between daylight savings time and standard time.
  - l. Operator Interface Graphic Software
    - i. Graphic software shall facilitate user-friendly interface to all aspects of the System Software specified above. The intent of this specification is to require a graphic package that provides for intuitive operation of the systems without extensive training and experience. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis.
    - ii. Graphic software shall support multiple simultaneous screens to be displayed and resizable in a 'Windows'-like environment. All functions excepting text entry functions shall be executable with a mouse.
    - iii. Graphic software shall provide for multitasking such that third-party programs can be used while the OWS software is on line. Software shall provide the ability to alarm graphically even when operator is in another software package.
    - iv. The software shall allow for Owner creation of user-defined, color graphic displays of geographic maps, building plans, floor plans, and mechanical and electrical system schematics. These graphics shall be capable of displaying all point information from the



- database including any attributes associated with each point (i.e., engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse
- v. Operating system software shall be Microsoft Windows 2000 Professional, or later release.
  - vi. Hidden Alarms and Messages: Alarms and Messages descriptions and text shall be hidden on the Graphic screen by use of text and fill colors to match the background color of the graphic screens where located so text and information is only visible when the message or alarm is active.
  - vii. Screen Penetration: The operator interface shall allow users to access the various system graphic screens via a graphical penetration scheme by using the mouse to select from menus or 'button' icons. Each graphic screen shall be capable of having a unique list of other graphic screens that are directly linked through the selection of a menu item or button icon.
  - viii. Dynamic Data Displays: Dynamic physical point values shall automatically updated at a minimum frequency of 6 updates per minute without operator intervention. Point value fields shall be displayed with a color code depicting normal, abnormal, override and alarm conditions.
  - ix. Point Override Feature: Each displayed point shall be individually enabled/disabled to allow mouse-driven override of digital points or changing of analog points. Such overrides or changes shall occur in the control unit, not just in the workstation software. The graphic point override feature shall be subject to password level protection. Points that are overridden shall be reported as an alarm, and shall be displayed in a coded color. The alarm message shall include the operator's user name. A list of points that are currently in an override state shall be available through menu selection.
  - x. Dynamic Symbols: Provide a selection of standard symbols that change in appearance based on the value of an associated point.
    1. Analog symbol: Provide a symbol that represents the value of an analog point as the length of a line or linear bar.
    2. Digital symbol: Provide symbols such as switches, pilot lights, rotating fan wheels, etc. to represent the value of digital input and output points.
    3. Point Status Color: Graphic presentations shall indicate different colors for different point statuses. (For instance, green = normal, red = alarm, gray (or '???') for non-response.
  - xi. Graphics Development Package: Graphic development and generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
    1. The Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), mechanical system components (e.g., pumps, chillers, cooling towers, boilers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
    2. The Graphic Development Package shall use a mouse or similar pointing device to allow the user to perform the following:
      - a. Define symbols
      - b. Position items on graphic screens
      - c. Attach physical or virtual points to a graphic
      - d. Define background screens
      - e. Define connecting lines and curves
      - f. Locate, orient and size descriptive text
      - g. Define and display colors for all elements

- h. Establish correlation between symbols or text and associated system points or other displays.
    - i. Create hot spots or link triggers to other graphic displays or other functions in the software.
  - m. Remote Personal Computer Workstation Graphic Software
    - i. Remote graphic operator software shall provide all the functionality specified for the local graphic software. It shall also provide for dial-up communications using the specified modems via commercial telephone lines to connect to the Local Supervisory or Primary LAN, and using the Internet.
    - ii. Software shall not require graphic images to be sent across the phone lines or 56Kbps or slower Internet connection. Graphic images shall reside on the remote operator workstation hard drive and all licenses must be provided for the graphic software on the remote machine. Exceptions to this requirement include:
      - 1. System configuration uses an Internet server and presents web pages that can be pulled up using a standard browser.
      - 2. System configuration uses an Internet server and presents the standalone application running locally but controlled via a remote browser. Operator Interface Graphical Software application must therefore support multi-instancing to allow multiple simultaneous remote connections and use of the graphic software.
    - iii. Software shall be capable of initiating communication to the any LAN, upon user command, to perform all specified functions. Software shall be capable of initiating communication to the LANs in accordance with user-programmed time schedules to upload trend and report data. Software shall be capable of communicating from the LAN in accordance with user-programmed time schedules to report alarms, upload trend, and report data. Software shall automatically terminate the communication whenever all applications requiring modem connection are closed.

### 3. PART III: Execution

- a. System Configuration
  - i. Contractor shall thoroughly and completely configure BAS system software, supplemental software, network communications, CSS, OWS, remote operator workstation, portable operators terminal, printer, and remote communications.
- b. Site-Specific Application Programming
  - i. Provide all database creation and site-specific application control programming as required by these Specifications, national and local standards and for a fully functioning system. Contractor shall provide all initial site-specific application programming and thoroughly document programming. Generally meet the intent of the written sequences of operation. It is the Contractor's responsibility to request clarification on sequence issues that require such clarification.
  - ii. All site-specific programming shall be fully documented and submitted for review and approval, both prior to downloading into the panel, at the completion of functional performance testing, and at the end of the warranty period.
  - iii. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the project will be the property of the Owner and shall remain on the workstation(s)/server(s) at the completion of the project.
- c. Password Setup
  - i. Set up the following password levels to include the specified capabilities:
    - 1. 1. Level 1: (Owner's BAS Administrator)
      - a. Level 2 capabilities

- b. View, add, change and delete user names, passwords, password levels
      - c. All unrestricted system capabilities including all network management functions.
    - 2. Level 2: (Programmer)
      - a. Level 3 capabilities
      - b. Configure system software
      - c. Modify control unit programs
      - d. Modify graphic software
      - e. Essentially unrestricted except for viewing or modifying user names, passwords, password levels
    - 3. Level 3: (Senior HVAC Technician)
      - a. Level 4 capabilities
      - b. Override output points
      - c. Change setpoints
      - d. Change equipment schedules
      - e. Exit BAS software to use third party programs
    - 4. Level 4: (Junior HVAC Technician)
      - a. Level 5 capabilities
      - b. Acknowledge alarms
      - c. Temporarily override equipment schedules
    - 5. Level 5: (HVAC Technician Trainee)
      - a. Display all graphic data
      - b. Trend point data
  - ii. Contractor shall assist Owner's operators with assigning user names, passwords and password levels.
- d. Point Parameters
  - i. Provide the following minimum programming for each analog input:
    - 1. Name
    - 2. Address
    - 3. Scanning frequency or COV threshold
    - 4. Engineering units
    - 5. Offset calibration and scaling factor for engineering units
    - 6. High and low alarm values and alarm differentials for return to normal condition
    - 7. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
    - 8. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary and/or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides, or failure of any network over which the point value is transferred.
    - 9. Selectable averaging function that shall average the measured value over a user selected number of scans for reporting.
  - ii. Provide the following minimum programming for each analog output:
    - 1. Name
    - 2. Address
    - 3. Output updating frequency
    - 4. Engineering units
    - 5. Offset calibration and scaling factor for engineering units
    - 6. Output Range

- 7. Default value to be used when the normal controlling value is not reporting.
- iii. Provide the following minimum programming for each digital input:
  - 1. Name
  - 2. Address
  - 3. Engineering units (on/off, open/closed, freeze/normal, etc.)
  - 4. Debounce time delay
  - 5. Message and alarm reporting as specified
  - 6. Reporting of each change of state, and memory storage of the time of the last change of state
  - 7. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
- iv. Provide the following minimum programming for each digital output:
  - 1. Name
  - 2. Address
  - 3. Output updating frequency
  - 4. Engineering units (on/off, open/closed, freeze/normal, etc.)
  - 5. Direct or Reverse action selection
  - 6. Minimum on-time
  - 7. Minimum off-time
  - 8. Status association with a DI and failure alarming (as applicable)
  - 9. Reporting of each change of state, and memory storage of the time of the last change of state.
  - 10. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
  - 11. Default value to be used when the normal controlling value is not reporting.
- e. Trends
  - i. Contractor shall establish and store trend logs. Trend logs shall be prepared for each physical input and output point, and all dynamic virtual points such as setpoints subject to a reset schedule, intermediate setpoint values for cascaded control loops, and the like as directed by the Owner.
  - ii. The Owner will analyze trend logs of the system operating parameters to evaluate normal system functionality. Contractor shall establish these trends and ensure they are being stored properly.
    - 1. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field or single date stamp. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate 2-dimensional formats with time being the row heading and field name being the column heading.
  - iii. Sample times indicated as COV () or change-of-value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When output to the trending file, the latest recorded value shall be listed with any given time increment record. The samples shall be filled with the latest values also if the points include different time intervals. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.
  - iv. Trending intervals or COV thresholds shall be dictated by the Owner upon system start-up.
  - v. The Contractor shall demonstrate functional trends as specified for a period of 30 days after successful system demonstration before final acceptance of the system.
- f. Trend Graphs

- i. Prepare controller and workstation software to display graphical format trends. Trended values and intervals shall be the same as those specified
  - ii. Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.
  - iii. Indicate engineering units of the y-axis values; e.g. degrees F., inches w.g., Btu/lb, percent open, etc.
  - iv. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.
  - v. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.
  - vi. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend period.
  - vii. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.
- g. Alarms
- i. Override Alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as a Level 3 alarm.
  - ii. Analog Input Alarms: For each analog input, program an alarm message for reporting whenever the analog value is outside of the programmed alarm limits. Report a 'Return-to-Normal' message after the analog value returns to the normal range, using a programmed alarm differential. The alarm limits shall be individually selected by the Contractor based on the following criteria:
    - 1. Space temperature, except as otherwise stated in sequence of operation: Level 3
      - a. Low alarm: 64°F
      - b. Low return-to-normal: 68°F
      - c. High alarm: 85°F
      - d. High return-to-normal: 80°F
    - 2. Controlled media temperature other than space temperature (e.g. AHU discharge air temperature, steam converter leaving water temperature, condenser water supply, chilled water supply, etc.): Level 3 (If controlled media temperature setpoint is reset, alarm setpoints shall be programmed to follow setpoint)
      - a. Low alarm: 3°F below setpoint
      - b. Low return-to-normal: 2°F below setpoint
      - c. High alarm: 3°F above setpoint
      - d. High return-to-normal: 2°F above setpoint.
    - 3. AHU mixed air temperature: Level 4
      - a. Low alarm: 45°F
      - b. Low return-to-normal: 46°F
      - c. High alarm: 90°F
      - d. High return-to-normal: 89°F
    - 4. Duct Pressure:
      - a. Low alarm: 0.5" w.g. below setpoint
      - b. Low return-to-normal: 0.25" w.g. below setpoint
      - c. High alarm: 0.5" w.g. above setpoint
      - d. High return-to-normal: 0.25" w.g. above setpoint
    - 5. Space humidity:
      - a. Low alarm: 35%
      - b. Low return-to-normal: 40%
      - c. High alarm: 75%
      - d. High return-to-normal: 70%

- iii. HOA Switch Tampering Alarms: The Sequences of Operation are based on the presumption that motor starter Hand-Off-Auto (HOA) switches are in the ‘Auto’ position. If a motorized equipment unit starts without a prior start command from the FMS, (as sensed by status sensing device), then FMS shall perform the remaining sequence as specified. BAS shall also enunciate the following Level 5 alarm message if status indicates a unit is operational when the run command is not present:
  - 1. DEVICE XXXX FAILURE: Status is indicated on {the device} even though it has been commanded to stop. Check the HOA switch, control relay, status sensing device, contactors, and other components involved in starting the unit. Acknowledge this alarm when the problem has been corrected.
- iv. Communication Failure Alarms: Enunciate Level 2 alarms when a controller has lost communication to the BAS
  - 1. DEVICE XXXX HAS LOST COMMUNICATION. Communication with this device has failed.
- v. Maintenance Alarms: Enunciate Level 5 alarms when runtime accumulation exceeds a value specified by the operator
  - 1. DEVICE XXXX REQUIRES MAINTENANCE. Runtime has exceeded specified value since last reset.
- h. Graphic Screens
  - i. Floor Plan Screens: The contract document drawings will be made available to the Contractor in AutoCAD LT 2002 format upon request. These drawings may be used only for developing backgrounds for specified graphic screens; however the Owner does not guarantee the suitability of these drawings for the Contractor’s purpose. Graphic Screens shall be submitted for approval.
    - 1. Provide graphic floor plan screens for each floor [wing] [tower] {other} of each building. Indicate the location of all equipment that is not located on the equipment room screens. Indicate the location of temperature sensors associated with each temperature-controlled zone (i.e., VAV terminals, fan-coils, single-zone AHUs, etc.) on the floor plan screens. Display the space temperature point adjacent to each temperature sensor symbol. Use a distinct line symbol to demarcate each terminal unit zone boundary. Use distinct colors to demarcate each air handling unit zone. Mechanical floor plan drawings will be made available to the contractor upon request for the purpose of determining zone boundaries. Indicate room numbers as provided by the Owner. Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor plan screens to each corresponding equipment schematic graphic screen.
    - 2. Provide graphic floor plan screens for each mechanical equipment room and a plan screen of the roof. Indicate the location of each item of mechanical equipment. Provide a drawing link from each equipment symbol shown on the graphic plan view screen to each corresponding mechanical system schematic graphic screen.
    - 3. If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views and/or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.
    - 4. Provide a graphic site plan with links to and from each building plan.

- ii. System Schematic Screens: Provide graphic system schematic screen for each HVAC subsystem controlled with each I/O point in the project appearing on at least one graphic screen. System graphics shall include flow diagrams with status, setpoints, current analog input and output values, operator commands, etc. as applicable. General layout of the system shall be schematically correct. Input/output devices shall be shown in their schematically correct locations. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse. Indicate all adjustable setpoints on the applicable system schematic graphic screen or, if space does not allow, on a supplemental linked-setpoint screen.
  - 1. Provide graphic screens for each air handling system. Indicate outside air temperature and enthalpy, and mode of operation as applicable (i.e., occupied, unoccupied, warm-up, cool-down). Link screens for air handlers to the heating system and cooling system graphics. Link screens for supply and exhaust systems if they are not combined onto one screen.
  - 2. Provide a graphic screen for each zone. Provide links to graphic system schematic screens of air handling units that serve the corresponding zone.
  - 3. Provide a cooling system graphic screen showing all points associated with the chillers, cooling towers and pumps. Indicate outside air dry-bulb temperature and calculated wet-bulb temperature. Link screens for chilled water and condenser water systems if they cannot fit onto one cooling plant graphic screen.
  - 4. Link screens for heating and cooling system graphics to utility history reports showing current and monthly electric uses, demands, peak values, and other pertinent values.
- iii. Bar Chart Screens: On each graphic Bar Chart Screen, provide drawing links to the graphic air handling unit schematic screens.
  - 1. Provide a graphic chilled water valve screen showing the analog output signal of all chilled water valves in a bar chart format, with signals expressed as percentage of fully open valve (percentage of full cooling). Indicate the discharge air temperature and setpoint of each air handling unit, cooling system chilled water supply and return temperatures and the outside air temperature and humidity on this graphic. Provide drawing links between the graphic cooling plant screen and this graphic screen.
  - 2. Provide a graphic heating water valve screen showing the analog output signal of all air handling unit heating water valves in a bar chart format, with signals expressed as percentage of fully open valve (percentage of full heating). Indicate the temperature of the controlled medium (such as AHU discharge air temperature or zone hot water supply temperature) and the associated setpoint and the outside air temperature and humidity.
- iv. Alarms: Each programmed alarm shall appear on at least one graphic screen. In general, alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, chiller alarm shall be shown on graphic cooling system schematic screen). For all graphic screens, display analog values that are in a 'high alarm' condition in a red color, 'low alarm' condition in a blue color. Indicate digital values that are in alarm condition in a red color.

## 26 00 00 Electrical

### 26 05 00 Common Work Results for Electrical

#### 1. Code Compliance

- a. Work and materials shall comply with the latest rules of applicable codes and regulations including, but not limited to, the following:
  - i. California Electrical Code
  - ii. California Title 8, Chapter 4 California Occupational Safety and Health Act (COSHA).
  - iii. NFPA No. 70 - National Electric Code (NEC).
  - iv. NFPA No. 101 - Life Safety Code.
  - v. NESC - National Electrical Safety Code
  - vi. All other applicable Federal, State and local laws and regulations.
- b. Code compliance is mandatory. Nothing in the Drawings and Specifications permits work not conforming to these codes. Where work is shown to exceed minimum code requirements, comply with Drawings and Specifications.
- c. No work shall be concealed until after it is inspected and approved by the proper authorities. If work is concealed without inspection and approval, the Contractor shall be responsible for all work required to open any concealed areas, and to restore them to their pre-construction condition in addition to all required modifications.

#### 2. Design Criteria

- a. Coordination between electrical engineer and designers of other systems shall pay particular attention to the proper sizing of equipment so that motors are not routinely run at frequencies higher than 60 hZ. This leads to slip increase, higher current draw, thermal stress and premature failure.
- b. Engineers and other system designers shall investigate Variable Frequency Motor Controllers where appropriate. Reference 26 29 23 *Variable-Frequency Motor Controllers* and 23 05 00 *Common Work Results for HVAC*, Subsection 13, *Variable Frequency Drives Serving HVAC Equipment*

#### 3. Green Building

- a. All new construction and major renovations must meet the current UC policy and procedure requirements included in the UC Sustainability Practices Policy: <http://ucop.edu/sustainability/policy-areas/index.html>. The UC Sustainability Practices Policy provides guidance on the required sustainable energy standards and on UC's USGBC LEED certification and credit requirements.

#### 4. Material Approval

- a. The design, manufacture and testing of electrical equipment and materials shall conform to or exceed latest applicable National Electrical Manufacturers Association (NEMA), Institute of Electrical and Electronics Engineers (IEEE) and American National Standards Institute (ANSI) standards.
- b. All materials shall be new and bear Underwriters' Laboratories, Inc. (UL) label. Materials that are not covered by UL testing standards shall be tested and accepted by an independent testing laboratory or a governmental agency, which laboratory shall be acceptable to the University's Representative and code enforcing authority.

#### 5. Coordination

- a. Division 23: HVAC and Division 26: Electrical, shall provide coordination for a complete installation of equipment and components to produce a proper, fully operational system.



- b. Coordinate work with other trades to avoid conflict and to provide correct rough-in and connection for equipment furnished under trades that require electrical connections. Inform Contractors of other trades of the required access to and clearances around electrical equipment to maintain serviceability and code compliance.
- c. Verify equipment dimensions and requirements with provisions specified under this Section. Check actual job conditions before fabricating work. Report necessary changes in time to prevent needless work. Changes or additions subject to additional compensation, which are made without written authorization and an agreed price, shall be at the Contractor's risk and expense.
- d. Participate in the preparation of coordination drawings that are to be used by other trades for work coordination prior to start of any work. At a minimum, coordinate information related to the size, elevation, routing, and clearance requirements of electrical equipment and wiring to be installed under Division 26: Electrical, prior to installation or work. Special attention shall be given to areas containing work of many trades, with special attention paid to avoiding any situation where areas, appliances or installations that may require maintenance access are blocked or otherwise made inaccessible by the work of another discipline.

#### 6. Acceptance Demonstration

- a. Upon completion of the work, at a time to be designated by the University, the Contractor shall demonstrate the operation of the installation including any and all special items installed by the Contractor or installed under the Contractor's supervision. Allow an appropriate amount of demonstration time as determined by CP University's Representative and Campus Electrical Engineer and Facilities Services Electrical Shop.
- b. This demonstration by the Contractor is in addition to the general commissioning requirements set forth in Division 01 91 13.

#### 7. Arc Flash Study

- a. In addition to the NEC required short circuit and coordination study, an arc flash study, in accordance with NFPA-70E, shall be performed. The completed one-line drawings of the arc flash study shall be provided to the Campus Electrical Engineer in the most recent version of SKM PowerTools for Windows. Electronic and hard copies of all studies are to be provided. Firms or engineers who wish to substitute an equivalent software application must seek approval of the Campus Electrical Engineer prior to the commencement of work. Not all Arc Flash Hazard Analysis software is compatible with existing campus modeling.
- b. Based on the results of that study, field labeling shall be performed on all switchboards, panel boards, industrial control panels and motor control centers in the work. Field labeling must comply with the required arc flash study according to NFPA-70E.
- c. The specifications shall require the contractor to provide a short circuit study, coordination study and arc-flash hazard analysis to be submitted for approval by the University Representative. The studies shall be prepared by a California registered electrical engineer. The short circuit study shall be based on criteria preset by design engineer. All equipment in the power system shall be rated to withstand 110% of available short circuit current at equipment location. Short circuit current, together with the equipment short circuit rating, shall be indicated for all equipment on the Contractor's Electrical Single-Line Diagram. Electrical distribution system shall be fully rated (series rating is not allowed). The Coordination study shall verify that the power system is coordinated with upstream and downstream devices. The Arc Flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2012, Annex D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (substations, switchboards, switchgear, motor-control centers,

panelboards, busway, etc.) where work could be performed on energized parts. The Arc-Flash hazard analysis shall start at medium voltage through 480V locations and significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kV A. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering incident energy of 1.2 cal/cm<sup>2</sup>. Upon approval of the Arc Flash Study by the University Representative, Arc-Flash hazard warning labels shall be produced and applied to the electrical equipment. Coordination study and Arc Flash hazard analysis shall be based on actual distribution equipment being provided, and shall be reviewed and approved by the University prior to the building being energized with permanent power.

- i. Studies to be provided in both hard copies and electronic copies.
  - ii. Distribution equipment shop drawing submittals final approval is subject to approved power systems studies by the University engineer. Even if the equipment was approved before the power systems studies were submitted, contractor is still liable to update equipment ratings and others per systems studies results and recommendations
- d. Special requirements
- i. Where electric water heaters (such as tankless Insta-Hot or similar) are used, special attention is to be paid with respect to the breaker coordination. In a building where the main breaker and/or feeder breakers have ground fault protection, the coordination study must demonstrate that the phase protection for the branch circuit feeding the water heater coordinates with all upstream ground fault protection. If selective

#### 8. Wire Connectors

- a. For CTs, PTs, control, protection, etc., use only terminal blocks. No splices are allowed.
- b. For wires size #8 AWG and smaller: insulated pressure type (with live spring) rated 105 deg. C, 600V, for building wiring and 1000V in signs or fixtures; Scotchlok, Ideal, or equal.
- c. For wires size #6 AWG and larger: compression type with tape insulation; 3M #33, Plymouth, or equal.
- d. Outdoors and below grade: All sizes to be compression type with heat shrink style watertight splice covers; Raychem CTE series, T&B “shrinkon” series, or equal.

#### 9. Terminal Cabinets

- a. Fabricate from code-gauge steel with flush latch and concealed hinge. Minimum size shall be twenty inches (20”) wide by twenty-four inches (24”) high by six inches (6”) deep. Finish shall be American National Standards Institute (ANSI) 61 light gray enamel.
- b. Provide inside terminal cabinet and terminal strips, two terminal points for each wire within the terminal cabinet. Provide engraved rigid plastic nameplate on cabinet face as to system, e.g. “Fire Alarm Terminal Cabinet.”

#### 10. Distribution Panels

- a. Bus shall be copper. Aluminum is not allowed. Power panel boards shall be dead front, totally enclosed, convertible type, with circuit breakers. See 26 27 00: Low-Voltage Distribution Equipment for additional requirements.
- b. All spaces shall be furnished with breaker mounting hardware.
- c. Provide a grounding bus in all distribution panel boards. The grounding bus shall be easily distinguishable from the neutral bus.

#### 11. Equipment Mounting and Support Hardware

- a. Steel channels, bolts, washers, etc., used for mounting or support of electrical equipment shall be galvanized type. Where installed in a corrosive environment stainless steel hardware shall be used.

- b. Where motors, pumps or other equipment is mounted, provide a lifting eye above the equipment capable of lifting one and one half times (1.5x) the weight of the piece of equipment, within ten degrees (10°) of vertical. Coordinate with structural drawings to ensure proper support and attachment to structure.

12. Handholes

- a. Use concrete or steel covers. There shall not be more than one (1) extension box on any handhole. Box must have base rock in the bottom at least two inches (2"). Conduit shall be bonded and extended five inches (5") above base rock.
- b. Maintain adequate space for conductors between top of conduits and bottom of cover to avoid abrasion of insulation.

13. Basic Materials and Methods:

- a. Specify 600 volt copper NEC standard conductors with Underwriters' label, for secondary power and light distribution. Color coding, application and types as listed below. Deliver to job in unbroken packages.
- b. All wiring to be copper only.
- c. Requirements for conductors:
  - i. Color coding shall be as follows:

Voltage	Phase	A	B	C	N	Ground
120/240	1 Ø 3W	black, red	none	none	white	green
120/208	3 Ø 4WY	black	red	blue	white	green
120/240	3 Ø 4W	black	orange	blue	white	green
277/480	3 Ø 4WY	brown	orange	yellow	white or gray	green
480	3 Ø 3W	brown	orange	yellow	white or gray	green
Note: Orange is reserved for Delta installations that have a "stinger" only on 208V delta systems.						

- ii. Provide type THWN or THHN wire and cable #4/0 AWG size and smaller in dry locations.
  - iii. Provide type THWN wire and cable larger than #4/0 AWG size in wet locations.
  - iv. Provide type RHW, THW or XHHW wire and cable larger than #4/0 AWG size installed in damp locations or in concrete in contact with the ground.
  - v. Do not use conductors smaller than No. 12 AWG for lighting or receptacle circuits.
  - vi. Low voltage wiring shall be No. 14 AWG size or larger.
  - vii. Fire alarm detector wire shall be type TFN, 18 AWG SBC MAX OPER V. 600 solid or maximum of seven (7) strands. Fire alarm annunciator lamp wires may be No. 20 AWG if cabled.
  - viii. Wire pulled in flexible metal conduit shall be stranded when flexibility is required.
  - ix. Specify separate ground conductor as being mandatory in all branch receptacle circuits.
  - x. Specify copper bus duct with silvered joints.
  - xi. High voltage cable (4160 volt and 12000 volt systems) shall be 5KV and 15KV, EPR type, with 133% insulation and shall be warranted for forty (40) years. Specify Kerite, Okonite, General Cable or equal, minimum 4/0 size.
- d. Wire Joints and Connections
- i. Specify all connections to circuit breakers, switches and joints in wires as follows:

- a. Connections to Circuit Breakers and Switches: No. 12 wire; formed around binding post or screw. No. 10 and No. 8 wire; Buchanan Termend, or equal, locking tongue lug. No. 6 wire and larger-Burndy Qiklug Type QDA, Penn Union, or equal, round flange solderless lug.
  - b. Connections to Fixtures: Make circuit wiring connections to fixture wire with insulated electrical spring connectors. Threaded-type wire nuts, porcelain or bakelite are not acceptable.
  - c. Wire Joints: No. 6 and larger; Burndy Type QPR, Penn Union, or equal. No. 8 and smaller - pigtail splices as described below, or made with insulated electrical spring connectors.
  - d. Where underground and high moisture area connections are required to be insulated, use approved moisture-proof epoxy resin splicing kits.
  - e. Insulate uninsulated solderless connections for wires to the same insulation values as the conductors.
- e. Outlets
- i. Use cast metal conduit bodies with threaded hubs for outlets in exposed wet and/or hazardous locations, in vaults and/or manholes; and sheet steel boxes with sherardized or galvanized finish in concealed locations.
  - ii. Sheet Steel Boxes: Standard one-piece knockout boxes of the shape best suited to the particular location and of sufficient size to contain all wires and connections without crowding. Where outlets are installed in concrete slabs, use concrete type boxes of depth sufficient to avoid interference between reinforcing bars and conduit runs, and to keep such conduit runs in proper place in slabs. Do not use boxes less than four inches (4") square and two and one-eighth inches (2-1/8") deep except for concrete ceiling outlets, which may be four inches (4") octagonal.
  - iii. Cast-Metal Conduit Bodies: Crouse-Hinds condulets, Appleton unilets, or equal. Arrange boxes with threaded connections for rigid conduit. Provide all conduit boxes with suitable covers and gasket for all exterior and/or moist locations and in vaults and/or manholes.
  - iv. Support all boxes with approved box support brackets (side box fastening is not acceptable).
- f. Receptacles and Caps
- i. Specify receptacles and caps in accordance with National Electrical Manufacturers Association (NEMA) standards. Where weatherproof mounting is required, mount in a cast metal conduit fitting and cover with gasketed, spring type, door. See this division for ground fault protection requirements.
  - ii. Specify hospital-grade receptacles for patient contact areas.
  - iii. Colors and finishes for receptacles shall be as specified as selected by the architect.
  - iv. Specify the height of each outlet as fifteen inches (15") above floor to conform with accessibility requirements or as indicated on the drawings.
  - v. Receptacle circuits shall not be dependent upon device connections for continuity except circuits that are terminated at the receptacle.
  - vi. Install receptacles in mechanical rooms and at roof mounted equipment so that no piece of equipment is more than twenty-five feet (25'-0") from a receptacle.
  - vii. Provide special receptacles as required by specific equipment.
  - viii. Identify all receptacles connected to emergency power.
- g. Tumbler Switches
- i. Specify quiet type flush mounted wall type tumbler switches rated at 20 amperes, 120-277 volt AC, screw terminals. Specify color and finish as selected by the architect.
  - ii. Attach to each switch yoke used on 277 VAC, a one-inch (1") diameter red tag reading "Caution - 277 VAC". Tag shall not be metal or metal edged.
- h. Cover Plates

- i. Provide commercial quality. Color and finish for plates, switches and receptacles shall be specified as selected by the architect (coordinate with the architect).
- i. Painting
  - i. See 09 90 00: Painting and Coating.
- j. Electrical Equipment Identification
  - i. See 26 05 00: Common Work Results for Electrical (Materials and Methods, Section 24).
- k. Alarms Identification
  - i. Whenever a warning system with visible or audible alarm is installed for any reason, a sign containing the following information shall be posted below it (See 28 31 00: Fire Detection and Alarm for fire alarms):
    - 1. Cause of the alarm.
    - 2. Instructions or procedure to follow.
    - 3. Person(s) to contact. This shall be provided by Capital Projects (CP).
    - 4. Telephone number(s). This shall be provided by Capital Projects (CP).

#### 14. Electrical Vaults

- a. Vaults close to buildings and 12.47 kV switching stations shall have a sump pump, light and service receptacle
- b. Use round manhole covers of cast iron construction. Cover to be marked "UC Electrical" with the manhole number provided by Facilities Services
- c. Duct banks leading to and from each vault to contain, at a minimum:
  - i. Three (3) five inch (5") conduits (two for 12.47 kV use, one spare)
  - ii. Two (2) two inch (2") conduits (low voltage control circuits)
  - iii. One (1) one and one-quarter inch (1¼") conduit (power conduit for items listed in A, above)
- d. Conduits for the items in (a), above shall be three-quarter inch (¾") rigid PVC. Boxes shall be malleable iron, Appleton or equal.

#### 15. Main Electrical Room

- a. Vacuum Break Selector Switch(es), 12.47 kV tap blocks (if any) and medium voltage switches shall be in a fenced area with a lockable gate, separate from any low-voltage equipment. Ensure that gate of fence, when opened to facilitate switching operations does **not** inhibit emergency egress.
- b. Maintain at least seven feet (7') of clearance in front of the Vacuum Break Selector Switch. The switch shall be smooth and level.
- c. Provide two (2) means of egress from the medium voltage equipment area. The clearance width of these egresses shall be at least twenty-four inches (24")
- d. Questions regarding the above requirements should be directed to the Campus Lead High Voltage Electrician.

#### 16. Special Requirements for Medium Voltage Systems

- a. In all manholes, vaults and electrical rooms, exposed medium-voltage cable shall be wrapped with arc-proofing (fireproofing) tape.
  - i. Strips of fireproofing tape approximately one-sixteenth of an inch (1/16<sup>th</sup>) thick by three inches (3") wide shall be wrapped tightly around each cable spirally in a half-lapped wrapping, or in two butt-joined wrappings with the second wrapping covering the joints in the first. The tape shall be applied with the coated side toward the cable and shall extend one inch (1") into the ducts. To prevent unraveling, the fireproofing tape shall be random wrapped the entire length of the fireproofing with pressure-sensitive glass cloth tape. Application of fireproofing tape over multiple conductors of the same circuit is acceptable. Ten feet (10') before entry to equipment, fireproofing tape shall be applied to each single conductor to facilitate termination.

- b. In all locations where medium-voltage cable enters or leaves a conduit, the conduit shall be sealed with copper mesh and polyurethane foam. Spare conduits in the vicinity of medium voltage conduits shall be sealed similarly.
- c. All conduits that contain medium voltage cables inside of buildings shall be constructed of rigid galvanized steel. Appropriate grade PVC may be used in concrete work when encased within a rebar cage.
- d. Medium voltage cables shall be full looped inside the manhole and supported in accordance with design.

## 17. Special Requirements for Energizing Electrical Systems

- a. Scope:
  - i. The following requirements are for the cabling, medium voltage vacuum selector switches, medium-voltage transformers, load interrupter switches, main switch gear, and manholes.
- b. Electrical power studies such as short circuit, coordination and arc-flash studies shall be performed and submitted to the UC Berkeley Electrical Engineer for review at least two (2) weeks prior to acceptance testing.
- c. Electrical equipment shall be tested, the trip settings properly adjusted, and the report documenting such submitted to the UC Berkeley Electrical Engineer for review at least two (2) weeks prior to energizing.
- d. The 12.47 kV fuses for medium voltage vacuum selector switches and/or load interrupters shall be sized according to the power system study.
- e. The following is a typical list that shall be tested by a NETA certified testing company:
  - i. 15 kV cables
  - ii. Medium voltage vacuum selector switch(es)
  - iii. 12 kV load interrupter switch(es)
  - iv. Power transformer set for 12.3 kV
  - v. Main switchboard(s), including any ground fault performance testing (per NEC 230-95[c])
  - vi. Circuit breaker testing
  - vii. Meter and relay testing
- f. Any problems found by the testing company shall be corrected immediately.
- g. The equipment shall be thoroughly cleaned before energizing.
- h. All required inspections shall be completed before energizing.
- i. Outdoor equipment or equipment in areas subject to condensation shall be equipped with heaters. Heaters to be connected to power source, with thermostats set to approximately sixty-eight degrees Fahrenheit (68°F).
- j. Areas around equipment shall be clear and free of debris or storage.
- k. Areas around high-voltage equipment shall be secured, accessible to UC Berkeley High-Voltage Electricians at all times. Locks shall be provided by UC Berkeley.
- l. Breakers, switches and cabinet doors must be lockable and able to provide lockout-tagout functionality in accordance with *Occupational Safety and Health Standards, Subpart: J, General Environmental Controls, Standard Number: 1910.147 The control of hazardous energy (lockout/tagout) Appendix: A* and the most recent version of the National Fire Protection Association (NFPA) 70E, *Standard for Electrical Safety in the Workplace*.
- m. Arc flash and identifying labels shall be installed as required by relevant sections of these standards.
- n. All empty conduits shall be filled to a depth of four inches (4") by copper mesh and polyurethane foam.
- o. Check all manholes for:
  - i. Grounding
  - ii. Racking
  - iii. Labels

- iv. Fire tape on all wires
- v. Ladders installed
- vi. Lights, plugs, pumps, sump discharge
- vii. Cleanliness
- viii. Switch boxes in manholes shall always be at forty-eight inches (48") above finished floor or one foot (1'-0") above the highest medium voltage conduit in the manhole.
- p. All equipment shall be in a de-energized state, verified by a UC Berkeley High-Voltage electrician.
- q. Clearances for all equipment shall be verified
- r. All keys, breaker lifts, wrenches and/or special tools shall be turned over to UC Berkeley High-Voltage electricians before the equipment is energized
- s. Lockable fencing for separate high-voltage equipment shall have the swing of doors/gates painted on the floor.

#### 18. Special Requirements for Connection of Temporary Power for Construction Projects

- a. Any temporary tie-ins to the campus 12.47 kV system shall be performed in such a way as continuous power is maintained should either the "A" leg or "B" leg of the system be de-energized. In most cases, this will require a 12 kV vacuum break selector switch.
- b. Temporary power equipment (vacuum break selector switches, transformers, etc.) shall be installed so that sufficient clearance exists for safe operation of the equipment.
- c. Temporary power equipment (vacuum break selector switches, transformers, secondary distribution switchboards, etc.) shall remain accessible to UC Berkeley High-Voltage electricians but secured from non-electrical construction personnel and the public.
- d. A full complement of spare fuses shall be available for all temporary power equipment.
- e. All equipment utilized for temporary power shall meet NEC, NEC, ANSI and other standards specified in this Division
- f. All switches shall be lockable in the "off" position.
- g. All switches and circuits shall be labeled with designated circuit number and function.
- h. All power derived from the campus power system shall be metered with a utility-grade kilowatt-hour meter. A UC Berkeley meter reader shall have access on a monthly basis so the meter may be read.
- i. If any UC equipment is utilized for temporary power, it must be tested before it is returned to the University. Any damage shall be paid for by the Contractor.

#### 19. Special Requirements for Connection of Temporary Generators During Power Outages

- a. Any generator tie-ins to campus or building power distribution centers on a temporary basis shall be performed in conjunction with UC Berkeley electricians and inspected by the Campus Building Department.

### *26 05 19 Low-Voltage Electrical Power Conductors and Cables*

#### 1. Materials:

- a. Conductor: Stranded copper. Minimum size: #12 AWG, unless specified otherwise.
- b. Insulation: THWN for wet or underground locations and THHN for dry or damp locations. Other insulation may be specified, depending on use.

#### 2. Installation Of Wires

- a. Pull no wire into any portion of the conduit system until all construction work which might damage the wire has been completed.
- b. Install all wire continuous from outlet to outlet or terminal to terminal. Splices in cables when required shall be made in handholes, pull boxes or junction boxes. Make branch circuit splices in outlet boxes with six inches (6") of correctly color-coded tails left in the box.

- c. Splices in wires and cables shall be made utilizing materials and methods in keeping with current code and industry best-practices.
- d. All cables and wires passing through manholes and handholes shall be full looped inside the manhole and handhole and supported in accordance with design. No cables or wires shall be in contact with the floor of the manhole.
- e. Make all ground, neutral and line connections to receptacle and wiring device terminals as recommended by the manufacturer. Connect branch circuit grounding conductor to the metal box with a green machine screw. Sheet metal screws are not acceptable. Provide separate ground jumper from outlet box to ground terminal of devices.
- f. Code-size, green ground wire shall be installed in all raceways, secured using approved methods to each pole box, junction box, and equipment housing. Number 12 THHN stranded minimum. Green tape is acceptable for identification on number 4 and larger.
- g. All neutrals in branch circuits must comply with code provisions for non-linear loads.
- h. Megger testing of all feeders is required. Test shall be done in the presence of the University Representative. A 500 volt megger shall be used on wire and cable rated for 600 volts.
- i. Provide wire markers for all new conductors in any box, indicating circuit numbers. Neutral conductor shall be marked with the circuit number(s) it is sharing. The junction boxes themselves shall also be marked with the panel name and circuit number(s). Labels shall be printed, fade- and weatherproof plastic or vinyl.
- j. Conduits containing cables entering buildings below grade shall be sealed using copper mesh with polyurethane foam to prevent rodents from entering the building.

3. Wire Color Code

- a. Color code all conductors. Wire sizes #6 AWG or smaller shall have integral color coded insulation. Wire sizes #4 AWG and larger may have black insulation but identified by color coded electrical tape at all junction, splice, pull, or termination points. Color tape shall be applied 1/2 lap to at least six inches (6”) of conductor.
- b. Color Code wires as follows (confirm with University’s Representative):

Conductors	120/208 Volts	277/480 Volts
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray or White
Ground	Green	Green
Note: Orange is reserved for Delta installations that have a “stinger” only on 208V delta systems.		

- c. Color coding of wires used for signal and communication systems are specified under the respective sections for these systems.

4. Mounting Heights Of Devices

- a. Specify the height of each outlet to meet accessibility requirements or as indicated on the Drawings.
- b. Install all receptacles uniformly; Twist lock and power receptacles, ground up; If horizontally mounted, neutral up; or as directed by architect.

5. Connections To Equipment

- a. General:



- i. Furnish and install required power supply conduit and wiring to all equipment. See below for other wiring required.
  - ii. Mount all motor starters and provide all power wiring to them, including those furnished under other sections of specifications.
  - iii. Furnish and install all magnetic motor starters that are shown on the electrical drawings or specified under other Divisions to be furnished under this Division of work. Verify equipment nameplate ratings prior to installation and furnish adequately rated starters for the loads.
  - iv. Furnish and install manual thermal protection for all motors not integrally equipped with thermal protection.
  - v. Furnish 120-volt power to each control panel and time switch requiring a source of power to operate.
- b. Heating, Ventilating and Air Conditioning Equipment:
- i. Line and low voltage temperature control and interlock wiring and conduit and required connections thereto are a part of other Divisions unless specifically shown or noted on the electrical drawings to be furnished under this section.
  - ii. Provide 120-volt power supply to temperature control panels furnished and install under other Divisions of work.
- c. Plumbing and Other Contractor-Furnished and University-Furnished Equipment:
- i. All required power and control conduit, wiring and connections are included under this section of the work.
  - ii. Control sensing and alarm devices shall be furnished under the respective section of the contract supplying the equipment unless noted otherwise. Where these are located in pipes, ducts, vessels, tanks, etc., they shall be mounted in place by the Contractor furnishing the devices. All others shall be mounted under this section of the Work.
- d. Control Panels:
- i. Control panels for packaged equipment shall be furnished under the respective Section of the contract supplying the equipment unless other wise noted.
  - ii. Installation and connection of the control panels shall conform to the general identification and labeling requirements of circuits and wiring provided by this Division.

#### *26 05 19.23 Manufactured Wiring Assemblies*

- 1. Metal Clad (MC) type cable is allowed in concealed locations (within walls, under raised floors and above ceilings) for branch circuits only.

#### *26 05 33.13 Conduit for Electrical Systems*

- 1. Conduits And Other Raceways
  - a. Provide fittings and accessories approved for the purpose and equal in all respects to the conduit or raceway. Conduit connectors and couplings shall be compression type.
    - i. Rigid Steel: Hot-dipped galvanized or PVC coated.
      - 1. Steel compression locking ring type fittings can be used in damp or wet locations. Steel setscrew type fittings are acceptable in dry locations.
      - 2. Die cast fittings are not acceptable.
    - ii. Electrical Metallic Tubing (EMT): Electro-galvanized.
    - iii. Plastic: Schedule 80 PVC (or Schedule 40 PVC when encased in concrete), approved for use as non-metallic raceway for 90 deg. C conductors. Carlon, CertainTeed, Kraloy, or equal.
    - iv. Metal Wireways: Sheet metal troughs with hinged or removable covers for housing and protecting electrical wires:

1. Surface metal raceways: metallic raceway that is intended to be mounted to the surface of a structure with associated couplings, connectors, boxes, fittings for the installation of electrical conductors.
    - a. Minimum size is 3/4" x 2&1/32".
    - b. Pre-wired assemblies are not acceptable.
    - c. Divided raceway for power and signal or data shall be considered on a case by case basis in consultation with Campus IS&T.
    - d. Shall be UL-listed.
  2. Surface Nonmetallic Raceways: nonmetallic raceway that is intended to be mounted to the surface of a structure with associated couplings, connectors, boxes, and fittings.
    - a. Nonmetallic Raceways shall only be used for low-voltage telecommunication wiring applications, in accordance with Division 27: Telecommunications
    - b. Nonmetallic Raceways for line-voltage electrical installations is not permitted.
  - v. Flexible conduit (flex): Galvanized spiral steel is only permissible with Facilities Services pre-approval. Liquid-tight type (preferred) shall have protective PVC jacket.
  - vi. All field-manufactured joints shall be coated to maintain surface continuity.
  - vii. Paint conduits only if required for aesthetic purposes.
2. Specify rigid steel, galvanized, or sherardized conduit. Aluminum may be specified for rigid conduit larger than 1-1/4" IPS in dry locations, provided suitable precaution is taken against physical damage during construction. Non-metallic conduit and intermediate metal conduit are allowed underground in a concrete envelope.
  3. In general, enclose underground conduits and ducts in a red-dyed (high voltage only) concrete envelope. Duct banks shall have steel reinforcing bars of proper size and spacing. Trenching, backfilling and concrete work shall be completed commensurate with the specifications pertaining to that section of the work. Use plastic conduit for Main Power and Telephone Underground Feeders, or if directed by Capital Projects (CP), rigid steel conduit, protected with plastic tape wrap or plastic coat in thickness as specified in lieu of concrete envelope. Specify factory wrapping or .020" thickness, 1/2 tape width overlap if field wrapped.
  4. Use rigid conduit with threaded couplings in concrete slab or wall construction. Electrical metallic tubing with insulated throat connectors may be used in furred spaces and areas not subject to damage and in sizes not over two inches (2"). Specify steel compression locking ring type connectors for wet locations. Set screw or indenter type fittings are not acceptable for dry locations.
  5. Use flexible steel conduit for connection to all movable motors and to vibration producing equipment. Specify sufficient length to provide for anticipated movement and to prevent transmission of any vibration to the building. Use flexible steel conduit for light fixtures in suspended ceilings. Specify use of liquid-tight flexible conduit for all damp or wet locations. Flexible steel conduit may be used on rehabilitation work only where rigid conduit is not possible or practical to install. Discuss all proposals for this use with Capital Projects (CP). Install code compliant equipment ground in all flexible conduit.
  6. Keep conduits within the furring lines established on the architectural drawings, unless conduits are shown exposed.
  7. Provide all necessary sleeves and chases required where conduits pass through floors or walls. Seal all openings with approved fire stopping material to maintain integrity of wall or floor being penetrated. Finish shall match adjacent surfaces after installation.

8. Do not locate conduit in the following construction:

- a. In concrete slab where conduit has an outside diameter greater than one-third (1/3) of slab thickness.
  - b. In a concrete slab less than 3-1/2" thickness. Local offsets are an exception.
  - c. Between concrete slab reinforcing steel and bottom of slab.
9. Install seal fittings on conduits penetrating walls of cold rooms.
10. Run all exposed conduits parallel to building walls and ceilings.
11. Support conduit runs to the structure with clamps, hangers, or a trapeze, spaced according to code requirements. Conduit raceways shall not be supported by other building piping systems.
12. Support vertical conduit runs by means of adequate clamps at each floor, or as required by code.
13. Use 3/4" minimum conduit size for power wiring. Switch legs may use 1/2" size.
14. Conduit Hangers
- a. For individual conduit runs not directly fastened to the structure, use rod hangers that shall be supported independent of ceiling and equipment supports.
  - b. For multiple conduit runs, use trapeze type structural channel conduit support designed for maximum deflection not greater than 1/8 inch.
15. Conduit Support
- a. EMT: Vertical unsupported runs are not acceptable.
  - b. Rigid Conduit: Vertical unsupported runs maximum five feet (5'-0"). Runs shall be securely fastened at both top and bottom.
  - c. Surface Mounted Conduit: When subject to mechanical damage shall be clamped every five feet(5'-0").
  - d. In new construction, conduits installed inside of walls shall have UL or equivalent approved clamp supports. No twisted wire allowed.
  - e. Provide additional support as required to make secure.
16. Installation Of Conduits:
- a. General:
    - i. Run all conduits concealed unless otherwise noted or shown.
    - ii. Run exposed conduit parallel to or at right angles to center lines of columns and beams.
    - iii. Penetrations shall be at right angles to slab surfaces.
    - iv. Install conduits above ceilings to avoid obstructing removal of ceiling tiles, lighting fixtures, air diffusers, access openings, etc.
    - v. Conduits shall not cross any duct shaft or area designated as future duct shaft horizontally.
    - vi. Conduit risers when allowed in the duct shaft shall be coordinated with Mechanical work to avoid any conflict
    - vii. For indoor and outdoor, install 1/8 inch diameter yellow polyline pull line and true tape in all conduits provided under this contract that are intended for future use, Tag pull lines for item served.
    - viii. Provide all boxes where shown or as required to limit any conduit run to a maximum of the equivalent of three (3) ninety-degree (90°) bends. Avoid U-bends.
    - ix. Where appropriate and where space permits, always use full size condulets.
    - x. The installation of surface raceways shall provide proper access to any and all junction boxes in the wall or surface mounted by mounting and mechanically securing an extension adapter

- box or extension ring over the concealed box. Full access to the concealed box opening shall be maintained.
- xi. No more than one (1) extension box shall be added to an existing or new junction box.
- b. Conduit Supports:
- i. Support conduits with UL listed steel conduit supports at intervals required by the NEC. Wires or sheet metal strips are not acceptable for conduit support. Use conduit hangers for all conduits not directly fastened to the structure and for all multiple conduit runs. Provide seismic bracing for all conduit racks using structural channel approved for the purpose.
  - ii. Conduits shall not be attached to ceiling support wires.
  - iii. Avoid attaching conduit to fan plenums. When it is necessary to support conduit for the fan plenum, provide a length of liquid-tight flexible conduit between the portion attached to the fan plenum and portion attached to the building to minimize transmission of vibration to the building structure.
- c. Conduit Penetrations: All underground conduits and ducts two-inches (2”) and larger shall be proven clear by pulling through a mandrel 0.25 inch smaller than the inside diameter.
- i. Penetrating foundation wall below floor slab: Install conduit in conduit sleeve or block-out with minimum one-inch (1”) space around the conduit.
  - ii. Penetrating basement perimeter wall: Conduit shall be cast in concrete or installed in sleeve or block-out. Seal penetrations watertight with sealant approved in advance by Facilities Services.
  - iii. Penetrating slab on grade: Cast in concrete.
  - iv. Penetrating concrete floor slab above grade: Install conduit in conduit sleeve or block-out or in core drilled hole. Seal penetrations with sealant.
  - v. Conduits penetrating fire rated walls and floors shall have the penetrations sealed to preserve the “F” and “T” ratings. All products shall be approved by the Designated Campus Fire Marshal (DCFM) for the specific application.
  - vi. Penetrating roof or exterior wall: Avoid penetrating the roof or exterior wall where possible.
  - vii. Where penetrations are necessary, the building weatherproof integrity shall be preserved.
  - viii. Penetrating sound insulated or fan plenum wall: Install conduit in sleeve and seal penetration.
  - ix. Penetrating Non-Fire Rated Dry Wall: Conduit sleeves are not required. Penetrations shall be sealed prior to painting. Penetrations made after wall finish is applied shall be as small as possible and provided with escutcheons, one (1) on each side of the wall.
  - x. Penetrating Suspended Ceiling: Cut hole as small as possible to permit conduit penetration. Provide escutcheon for each conduit below ceiling.

### *26 05 33.16 Boxes for Electrical Systems*

1. Outlet Boxes, Junction And Pull Boxes
- a. Outlet boxes: Hot-dipped galvanized of required size, four inches (4”) square, minimum, for flush mounted devices and lighting fixtures. Cast type with gasketed covers for outdoor or wet locations.
  - b. Junction and pull boxes: Use outlet boxes with appropriate covers (with gaskets if used outdoors) as junction boxes. Larger junction and pull boxes shall be fabricated from sheet steel, sized according to code, with screw-on covers, finished with gray baked enamel

### *26 05 36 Cable Trays for Electrical Systems*

1. Cable Trays
- a. Ventilated ladder type with four-inch (4”) minimum loading depth, nine-inch (9”) rung spacing, made of galvanized steel. Width as shown on Drawings. NEMA load/span class designation:
    - i. 12-inch wide trays: 12A (50 lbs. at 12 inch span)

- ii. 18-inch and 24-inch wide trays: 12B (75 lbs. at 12 inch span.)
- b. Trays shall be galvanized after fabrication.
- c. Tray side hangers shall be turned out to avoid abrading cables.
- d. Fittings and accessories shall be hot-dipped galvanized finish and shall be provided to form a complete raceway system. When installed in a corrosive environment, stainless steel shall be used.
- e. Bends, tees, and crosses shall provide cables with a smooth bending radius without diminishing the cable-laying capacity of tray.
- f. Provide seismic bracing for all tray runs and supports. Supports shall be structural channel approved for the purpose.

## 26 05 53 *Identification for Electrical Systems*

1. Identification and Signage, Electrical Equipment Identification
  - a. Provide signing and/or marking as follows for existing work in cable boxes and for all new work provided.
  - b. Raceway Entrances: Apply a stenciled label on the wall to identify the destination of raceways. Use building name, equipment name, manhole number, or cable box number.
  - c. Feeders: Provide and apply suitable permanent feeder tags with correct name to each Feeder and apply cable phase marker to each cable.
  - d. Cable Boxes and Equipment Vaults: Provide markings showing box or vault number. Cable Box and vault covers shall be identified as "Electric."
  - e. Pad Mount Transformers: Provide and apply lamacoid nameplate and lamacoid warning signs for each transformer.
  - f. Service Distribution Panels: Provide and apply lamacoid nameplate at each meter.
2. Standards and Codes
  - a. National Electric Code latest University approved Edition, with current California amendments.
3. Engraved Bronze Plates
  - a. Box Markers: Bronze plate, machine engraved with box designation in 3/8-inch high capital letters. Marker attached with epoxy adhesive to the cover.
4. Engraved Lamacoid Plates
  - a. Nameplates: Plastic lamacoid plate, two (2) layer 1/16<sup>th</sup> inch minimum thickness, machine engraved with white lettering, all caps, on black background. Lettering 3/8ths inches high.
  - b. Warning Signs: Plastic lamacoid plate, two (2) layer, 3/16ths inch minimum thickness, machine engraved with white lettering, all caps, on red background. Lettering two-inches (2") high.
  - c. All plates shall be affixed using long lasting adhesives.
5. Stencils
  - a. Raceway Entrance Identification: Stencils made with 1/2-inch letters, machine cut in heavy Kraft paper, complete designation on a single sheet of paper.
6. Phase Markers
  - a. Cable Phase Markers: Brady, Seton, or equal with clear plastic over wrap-to-wrap 1 to 1-1/4 times (minimum) around cable. Label colored per color-coding with phase letter printed one-inch (1") high.
7. Wire Markers

- a. Slip-on Wire Markers: Brady, Seton, or equal, PVC wire marker with permanent machine printed or embossed lettering.
8. Plastic Signs
- a. Heavy-duty plastic or PVC with printed letters, self-adhesive back, for outdoor application; Brady, Seton, or equal.
9. Arc Flash Labels
- a. All labels shall be made of chemical resistant vinyl.
10. Distribution Equipment
- a. The Contractor shall identify all switchboards, separately-mounted circuit breakers, panel boards, motor starters, motor control centers (MCC) disconnect switches, relays, relay control cabinets, and all apparatus used for the operation or control of power circuits, appliances or building support equipment, by means of descriptive engraved nameplates specifying the equipment being controlled and panel and circuit # feeding same.
  - b. Specify fade- and weatherproof plastic or vinyl labels and a permanent method of securing to the equipment.
  - c. Use red nameplates on all emergency equipment. Do not use adhesives for this purpose.
11. Machinery and Equipment
- a. Identify all motors driven and other pieces of electrically-operated building support equipment, (pumps, fans, etc), with 3/4-inch minimum height painted stencil or self adhesive letters / numbers.
  - b. Labels should reflect designated titles given on prints or by Engineer.
  - c. Color to contrast with background color.
12. Controls and Appliances
- a. Disconnect switches, separately mounted motor starters, relays shall be labeled with P-Touch or equal identifying labels specifying the equipment being controlled and panel and circuit # feeding same.
13. Devices, Fixtures and Appliances
- a. Provide permanent P-Touch or equal identifying labels on all lighting switches, convenience and special purpose receptacles and permanently installed / hardwired appliances and junction boxes to show panel and circuit number to which the device is connected.
  - b. This includes remote or un-switched equipment, such as local exhaust fans, hand dryers, exit and emergency lighting, photo cells, exterior light fixtures, etc.
14. General, Miscellaneous
- a. Junction boxes shall be marked to indicate circuits that are contained within. Junction boxes may be marked with a permanent marker on the box cover.
  - b. Identify all telephone and signal outlets with P-Touch or equal identifying labels.
  - c. Identify remote control switches by engraving descriptive markings on flush plates.
  - d. Labels shall be fade- and waterproof plastic or vinyl. Submit sample labels systems to the engineer or Campus representative before installing.

*23 05 83 Wiring Connections*

- 1. General Conditions:
  - a. Cables shall be looped in all pullboxes.

- b. Before making any low voltage connections that require power interruption to existing facilities notify the University at least eleven (11) working days in advance. Service interruptions shall be performed by the Facilities Services Electrical Shop.
  - c. Install wiring in raceways, unless specifically shown otherwise.
  - d. Sizes for conduits, unless specifically shown otherwise, are determined by the National Electrical Code (NEC).
  - e. Minimum indoor conduit size shall be 3/4-inch from the panel to the first distribution box.
  - f. Minimum one inch (1") PVC coated steel or PVC only for outdoor and underground installations.
  - g. Electric conduit or ducts shall be at least ten feet (10'-0") from steam lines unless engineered to prevent heat damage.
2. Conduit shall be rigid steel, EMT, or PVC as follows:
- a. Above ground: Use rigid steel or EMT. EMT shall not be run below four feet (4'-0") in height unless mechanically protected (example: inside a wall).
  - b. Damp and wet locations including outdoor service yards and on roof: Rigid steel or EMT. In manholes use rigid steel.
  - c. Hazardous Locations: Rigid steel conforming to NEC requirements.
  - d. Locations Subject To Mechanical Injury: Rigid steel only.
  - e. In Concrete Walls or Block Walls: Rigid steel only.
  - f. Dry Locations Not Subject to Mechanical Injury: EMT, or rigid steel conduit.
  - g. Underground: Use rigid steel or PVC. Rigid steel conduit in direct contact with earth shall be double-wrapped with 3M 10-mil tape or equal.
  - h. PVC conduit 1-1/2-inch size and smaller shall be installed on two inches (2") of sand base and covered by twenty four inches (24") of sand backfill. In unpaved areas provide a two-inch (2") concrete cap. Multiple runs shall maintain three-inch (3") minimum separation between runs. Larger than 1-1/2-inch conduit, install two-inch (2") sand base and cover by three-inch (3") minimum concrete envelope.
3. Under Buildings or Building Slab: Use rigid steel or plastic conduit.
- a. Install PVC conduit on a two-inch (2") sand base and cover with twenty four inches (24") of sand backfill. Maintain three-inch (3") minimum separation between runs. Do not install plastic conduit in rock base.
  - b. Underground conduit entering building shall be provided with one ten-foot (10'-0") section of rigid steel conduit at the point of penetration of the foundation, footing or basement wall, with approximately equal lengths inside and outside building line. Rigid steel conduit in direct contact with earth shall be double-wrapped with 3M 10-mil tape or equal.
4. Make all risers to grade with rigid steel conduit and rigid steel elbow fittings only. Risers to begin eighteen inches (18") below grade and extend sixteen inches (16") above grade. Encase in concrete underground portion of steel conduit or fittings. Burial depth of conduits shall be as follows:
- a. Concrete encased: Twenty-four-inch (24") minimum for 600V or lower systems to top of concrete encasement. Thirty-six-inch (36") minimum for systems above 600V.
  - b. Concrete capped: Twenty-four-inch (24") minimum to top of conduit.
  - c. Conduits without concrete encasement or cap: Twenty-four-inch (24") minimum to top of conduit.
  - d. When installed under buildings, the above minimum depth shall be six inches (6") below bottom of floor slab.
5. Use flexible conduits (Liquid-tight type preferred), with a three feet (3'-0") maximum length in the following applications and install a code sized ground.
- a. Recessed lighting fixtures.

- b. Motor connections.
  - c. Connection between fan plenum and structure.
  - d. At expansion joints.
  - e. At transformers and other equipment which produces vibration.
  - f. At damp and wet locations or where exposed to weather, flexible steel conduit shall be liquid tight.
  - g. For renovations only, in inaccessible locations. 3/4 inch minimum for connections to existing panels. 1/2 inch conduit permitted for branch circuits. Connect to EMT or rigid conduit within six feet (6'-0") of inaccessible location.
  - h. Corridors and corridor ceilings: three-quarter inch (3/4") minimum conduit diameter.
6. See 26 05 19.23: Manufactured Wiring Assemblies for restrictions on the use of Metal Clad (MC) type cable.

## 26 08 00 Commissioning of Electrical Systems

### 1. Testing

- a. Apply insulation integrity tests also to all feeders and subfeeders. Make such tests with a Megger capable of ringing through at least one hundred mega-ohms (100 M-ohms) and with a maximum applied voltage of five hundred volts (500 V).
- b. The resistance between conductors and between conductors and ground shall not be less than the values required by code.
- c. After the installation is complete, take voltage and ampere readings at the mains of each panel with all connected equipment turned on. Correct any phase unbalance shown from these tests. Check all circuits to insure that each circuit is connected to the proper neutral. Comply with code for insulation resistance.
- d. Meter Wiring Verification: The Contractor shall engage an independent firm, or individual, with the proper equipment and qualifications necessary to perform the following work:
  - i. Verify that the meters are properly connected, with due attention to phase and direction of rotation.
  - ii. Verify that the proper multiplier, if any, appears on the nameplate.
  - iii. Verify that the registered KWH and KVARH of the system, if included, is within the accuracy of the factory tolerance. Perform this work after installation and energizing of the switchboard or motor control center on which the meters are mounted and before final acceptance of the electrical portion of the contract. Demonstrate verification of the work in the presence of the architect. Furnish written certification to the University.
- e. Fire alarm tests shall be witnessed by the Designated Campus Fire Marshal (DCFM).
- f. Specify that before final acceptance of the Project can be made, the Contractor shall submit Form NFPA 72D, *Fire Alarm System Certification and Description*, signed by a factory certified technician. Certify that the fire alarm system has been installed, tested and will function in accordance with the manufacturer's specifications and the State Fire Marshal's requirements.
- g. Specify acceptance testing for electrical power distribution equipment and systems in accordance with the National Electrical Testing Association acceptance testing specifications. Test shall include but is not limited to the following:
  - i. Power and distribution transformers.
  - ii. Medium voltage circuit breakers and switches.
  - iii. Adjustable-trip low voltage power circuit breakers.
  - iv. Metal-enclosed switchgear.
  - v. Protective relays and associated current and potential transformers.
  - vi. Switchgear instrumentation.
  - vii. Cables rated over 600 volts.



- viii. Grounding systems.
- ix. Ground fault systems.
- x. Automatic transfer switches and other emergency devices.
- xi. Generators.
- xii. Motor Control Centers (MCCs).

## 26 10 00 Medium-Voltage Electrical Distribution

### 1. Overview

- a. Electrical power is distributed around the Berkeley campus at 12.47 kV. There are a total of seven (7) switching stations on campus that operate at 12.47 kV. All switching stations are of double-ended configuration with A side and B side busses, and a tie breaker. The switching stations consist of 12.47 kV vacuum circuit breakers. The breakers and switchgear have a seven hundred fifty Megavolt ampere (750 MVA) short circuit rating.
- b. With several exceptions, where voltage drop and/or load considerations require larger cable sizes, the feeders from the switching stations to the building load groups are #4/0 American Wire Gauge (AWG) copper. Assuming 100% load factor and three (3) circuits per duct bank, the #4/0 AWG cable is capable of delivering five Megavolt amperes (5 MVA). In general and by design, each set of #4/0 AWG feeder cables serves approximately five (5) major buildings with connected loads not exceeding 5 MVA.
- c. The cables linking the switching stations and the feeder cables to buildings have copper conductors, 133% ethylene propylene rubber (EPR) insulation, copper tape shields and PVC jackets. A service life of forty (40) years is expected
- d. The redundancy of the double-ended switching stations is extended to the major buildings. Through a fused vacuum selector switch installed in the building transformer vault (preferred location) or in an adjacent manhole (not acceptable for future installations), all building transformers (with just one exception) have access to two (2) feeders. Each transformer may be fed from either the A side or from the B side of the switching station bus. By using the selector switch, the building transformers can be fed by an alternate feeder in case of a cable fault. The selector switches can be used to balance the loads on the A and B sides of the switchgear. The selector switches are of the "make before break" design so that selection can be made with no power interruption.
- e. Immediately ahead of each transformer with a medium voltage primary there shall be a visible means of disconnect. This may be either a load break air switch or an alternative approved by the campus electrical engineer
- f. Building electrical systems shall be 480/277 volts, 3 phase, 4 wire and/or 208/120 volt, 3-phase, 4-wire for lighting and power unless otherwise directed by the Utilities or Electrical shops of Facilities Services.
- g. Connection to the existing Campus electrical system shall be coordinated with Facilities Services Utilities shop.

### 2. Standards and Codes

- a. Work and materials shall be in compliance with and according to the requirements of the latest revision of the following standards and Codes:
  - i. National Electric Code latest with California Amendments (CEC)
  - ii. California Code of Regulations, Title 8
  - iii. State of California Public Utilities General Order 95
  - iv. State of California Public Utilities General Order 128
  - v. National Electrical Safety Code (NESC)

### 3. Medium Voltage Cable

- a. Medium voltage cable (4160 volt and 12,470 volt systems) shall be shielded 15KV, EPR type, with 133% insulation rated for conductor temperatures of one hundred and five degrees Celsius (105°C) continuous and one hundred twenty degrees Celsius (120°C) emergency, and shall be warranted for forty (40) years when installed in accordance with the manufacturer's requirements. Cable shall be shielded with copper tape and jacketed over shield. Specify Kerite, Okonite, General Cable or equal, minimum 4/0 size.
  - b. Conductor Size For Underground Distribution:
    - i. 12KV Distribution Loop-2-#750 mcm copper
    - ii. Building Feeder--1-#4/0 copper
4. 15 KV Cable Splices
- a. Types: Splice kits shall be of the heat-shrinkable elastomeric type or other separable connector elbow type.
  - b. Materials: Cable splice kits shall contain materials that are completely compatible with the conductors, insulations, shields, and jackets and which are approved by the cable manufacturer.
  - c. Cable splices shall be suitable for continuous immersion in water.
  - d. Cable splice kits shall be the standard product of a single manufacturer. Manufacturer shall be:
    - i. Heat-Shrinkable Splice: Raychem HVS-15205 Series or equal
    - ii. Separable Connector Elbow Splice: Elastimold 655LR Series or equal
5. Medium Voltage Separable Connectors
- a. Provide ESNA-type connectors with insulated bushings. Elastimold (Non-Load Break). Provide capacitance test point. Connectors shall satisfy requirements of IEEE 386 and shall be designed for use with the specific cable and type of installation required. The manufacturer shall provide all components and at least three (3) copies of complete directions for assembling, and putting the unit into service, (two [2] of which shall be submitted for record).
  - b. Stress Cones (Raychem) shall be required at switchgear, etc.
6. Distribution and Installation
- a. See Special Requirements for barricades at trenches and for utility shutdowns and scheduling. See Divisions 1, 2 and 33 for additional electrical requirements including route approval, service locations, demolition, excavation scheduling, and backfill requirements.
    - i. The campus underground primary system is 12.47 kV Delta. Unless otherwise noted, all new campus electrical systems shall be 12.47 kV.
    - ii. New building projects shall include the installation of two (2) 3 phase, 3 wire feeders, the splicing into the campus distribution system, and a feeder selector switch. If the local distribution system does not have the needed capacity, the Project shall also include the installation of the feeders to the substation and the feeder switches in the substation. If a building is being replaced with a new building, feeders and substation switches may be reused if they are adequate. The Project shall also include the installation of a new duct bank if spare conduits are not available in existing duct banks.
    - iii. High Voltage Duct Banks: Duct banks containing 4160 volts or higher may include conduits for other services such as communication, computer, fire alarm, and street lighting units, provided they terminate in separate hand-holes and they DO NOT run through the high-voltage manholes.
    - iv. High Voltage Equipment Rooms: High voltage electrical rooms shall be dedicated to high voltage equipment and their accessories ONLY. Separate rooms shall be provided to include utilities such as telephone, energy monitoring and communication equipment.
    - v. Mechanical equipment and piping shall not be installed inside or run through high voltage electrical rooms.

## 7. Building Electrical Distribution

- a. The campus building electrical distribution system standard is 120/208 or 277/480 volts, 3-phase, four-wire, for lighting and power, unless otherwise directed by Capital Projects (CP).

## 8. Main Switchboard

- a. Main switchboards shall be copper bus units for metal clad switchgear. Main circuit breaker(s) shall be of the drawout type when the building supply transformer is 750 kVA or larger.
- b. Where ground fault protection at the main breaker is required by the NEC or these standards, the first level of downstream protection from the main breaker shall also be equipped with ground fault protection, so that there will be at least two levels of ground fault protection. This will avoid nuisance tripping of the main breaker for ground faults downstream of the feeder breakers. See additional requirements in this division. The coordination study shall establish pick-up and time settings for a coordinated building system.
- c. All applicable requirements in this Division also apply to switchboards.

## 9. Metering Equipment

- a. See Division 33 05 00: Common Work Results for Utilities, Subsection 10: Utility Metering.

## 10. Motor Disconnect Switches

- a. Specify heavy duty HD disconnect switches. Thermal overload type switches may act as a disconnect where used to protect small single-phase motors.

## 11. Distribution Panels

- a. The bus shall be copper, no aluminum allowed. Power panelboards shall be dead front, totally enclosed, convertible type, with circuit breakers. See this Division for additional requirements. All spaces shall be furnished with breaker mounting hardware. Provide a grounding bus in all distribution panel boards. The grounding bus shall be easily distinguishable from the neutral bus.

## 12. Lighting and Receptacle Panel Boards

- a. Specify general purpose 20 AMP minimum bolt-on circuit breakers for 120/208 and 277/480 volt panel boards, Eaton, Siemens, Schneider/SquareD, or equal. Minimum interrupting capability shall be 10,000 amperes for 120/208 volts and 14,000 amperes for 277/480 volts. Confer with the Campus Electrical Engineer for available fault current levels.
- b. Provide main circuit breakers in panel boards unless directed not to do so by Capital Projects (CP). When more than one panel board is fed by the same feeder, provide a main circuit breaker in each panel board.
- c. Locate all busses in the rear of the panel board cabinet. Mount circuit breakers on suitable supporting members at the front of the cabinet and connect with suitable straps or lugs to the bussing in the rear of the cabinet. Individual circuit breakers shall be removable from the cabinet without disturbing the bussing in any way. Specify door-in-door arrangement. Adjustable trim clamps are not acceptable. Surface mounted panel boards may have the front mounted on a piano hinge on the right side, with double locked doors.
- d. Specify all locks on panel boards in a single building so that all the outer locks of the door-in-door assembly are keyed alike and all the inner locks of the door-in-door assembly are keyed alike, but different from the outer locks.
- e. Detail the layout and dimensions of special-sized panel boards on the drawings.
- f. Labels shall be fade- and waterproof plastic or vinyl and permanently attached.

- g. Show three (3) one-inch (1") spare conduits from panel boards to the accessible space above furred ceilings, to allow for use of spare circuits or spaces provided in the panel boards. Spare conduits shall be capped off in the accessible space above furred ceilings.
- h. The percentage of spares and spaces in panel for future growth shall be twenty percent (20%). Provide hardware and bus taps for the installation of future breakers in spaces provided in panel board.
- i. Specify bolted copper bussing. No aluminum allowed.
- j. The Contractor shall balance phases during normal building operation.

#### 13. Ground Fault Protection

- a. Specify ground fault circuit interruption (GFCI) receptacles for circuits serving wet or hazardous areas including outdoor branches, bathrooms and laboratories with sinks. Discuss with Capital Projects (CP) for other potential hazardous areas.

#### 14. Electrical Rooms

- a. Lighting in the main electrical room shall be on emergency power circuit where emergency power is available, or a battery backup fixture where not.
- b. At least two (2) one-hundred twenty volt (120V), twenty amp (20A) duplex receptacles, fed from different circuits shall be in main electrical room, on the emergency power circuit where emergency power is available.

#### 15. Medium Voltage Transformers, Selector Switches, And Load Interrupter Switches

- a. Indoor Locations: Specify transformers as dry type, three phase, 60 cycle, primary and secondary voltages as required, with two (2) full capacity 2.5% taps above and two (2) 2.5% full capacity taps below rated voltage. Transformers shall operate under full load with noise level not to exceed American National Standards Institute (ANSI) and National Electrical Manufacturers Association (NEMA) standards. Transformers shall have 220°C insulation, 115°C rise. Primary shall be 95 KV BIL. Enclose primary terminals. Extend secondary terminals through the case by means of silvered copper bus bars, include lugs and bolts for cable termination. Check these details with Capital Projects (CP). Design and build transformers in accordance with National Electrical Manufacturers Association (NEMA), ASA and AIEE standards with minimum of four percent (4.0%) impedance.
- b. Outdoor Locations: Specify transformers as liquid-filled. Liquid to be less flammable as determined by Underwriters Laboratory (UL) and FM Global. Liquid shall be biodegradable. Transformers to be 95kV BIL primary and 30kV BIL secondary. Temperature rise to be fifty-five degrees Celsius (55°C).
- c. Final selection shall be based on building use, available space, energy losses, maintenance and first cost. Conduct life cycle analysis to select optimal transformers. Discuss these items with Capital Projects (CP) and the Campus Electrical Engineer for approval of the final selection before preliminary drawings are started.
- d. Factory Tests shall include the following:
  - i. Resistance measurement
  - ii. Ratio Test
  - iii. Polarity and phase relationship test
  - iv. No load loss at rated voltage
  - v. Exciting current at rated voltage.
  - vi. Impedance and load loss
  - vii. Quality control impulse
- e. Buildings with critical loads shall utilize double ended unit substations.
- f. The medium voltage selector switch(es) shall be located in the building in the same vicinity as the building transformer(s). Medium voltage selector switches shall not be located in manholes.

- g. Test results shall be furnished to the Campus Electrical Engineer.
- h. For indoor installations use a Vacuum Break Selector Switch which shall feed an air switch before the transformer. See Appendix A: Drawings for typical details and specifications.
- i. Place all main electrical equipment serving a project or building such as primary switch, transformers and main switchboard in a separate room or vault, which will be accessible only to qualified electrical personnel. Do not locate other equipment in this room. Follow code strictly in the design and provide adequate and legal working space and clearances. Pay attention to accessibility at the rear of the switchboard.
- j. Seismic Bracing and Mounting: Provide calculations stamped and signed by a registered civil or structural engineer which certifies that the equipment construction and the manufacturer's recommended method of mounting shall comply with Title 24 seismic requirements. Documentation shall show anchors, bolt sizes, quantities and embedment.
- k. Building Low Voltage Main Circuit Breakers and Tie Breakers (where applicable) shall be Draw-Out Type, when main building transformer is 750 kVA or larger.
- l. All medium voltage switch & transformer equipment and installations shall be approved by the Campus Electrical Engineer.

16. High Potential Tests (New Cables Only)

- a. After cables are installed, a high potential test shall be performed on each conductor. An initial voltage shall be applied and increased in no less than five (5) uniform steps up to the maximum test voltage. The minimum time at each step shall be no less than required for test current to stabilize. The high potential test shall be a DC test. If the applied voltage is interrupted at any time during the test on a conductor, the test shall be started again from the beginning. Hold final voltage for ten (10) minutes.
- b. Test Potentials shall be as follows (Unless recommended otherwise by the manufacturer):

	Nominal Cable Rating	DC Test
Initial Voltage	15KV	15KV
Final Voltage	15KV	55KV

- c. Reports of voltage test results shall be submitted for review with three (3) copies of each report prepared in the following format and detail:
  - i. A separate 8-1/2 by 11-inch report sheet shall be prepared for each separately tested section of high voltage cable.
  - ii. Each report shall be headed with the project identification.
  - iii. The following additional data shall appear on each report sheet:
    - 1. Date
    - 2. Name of operator performing the test
    - 3. Name of company employing the operator
    - 4. Section of cable tested
    - 5. Type of cable insulation
    - 6. Cable length
    - 7. Nominal rating of cable
    - 8. Cable manufacturer and product identification
    - 9. Size of conductor
    - 10. Identification of test equipment
    - 11. Test type
  - iv. The test results shall be plotted on a log-log graph and shall have microamperes on the left and kilovolts across the bottom. The graph shall also provide a current vs. time test to be recorded in one (1) minute intervals after the final test voltage has been reached.
  - v. Each test report shall be signed by the operator of the test equipment.

vi. Each report sheet shall be endorsed by the Contractor or its authorized representative.

#### 17. Selector Switch Insulation Resistance Tests

- a. Electrical insulation resistance tests shall be made by the Contractor in the presence of the University's Representative for all new selector switches using a constant voltage 5 kV megger capable of measuring at least 2,000 megohms. Tests shall be made between phase conductors and grounded phase conductors. Insulation resistance shall not be less than 750 megohms. Additionally, the vacuum bottles shall be high-potential tested across the open contacts. The voltage shall be 30kv d.c. and shall be held for one (1) minute. Maximum leakage shall be two (2) micro-amps per bottle. The Contractor shall furnish the University's Representative with a record of all insulation resistance measurements.

#### 18. Raceway Types Required

- a. All raceways for medium voltage cable run underground shall be installed with spacers and encased as specified in this section.
- b. Concrete Encased Raceway: PVC Type 40 duct.
- c. Exposed in Vaults and Elsewhere: Rigid Steel conduit or racks or cable trays.
- d. Low voltage wiring in areas where there is medium voltage shall be run in rigid steel conduit.

#### 19. Concrete Duct Bank Construction

- a. Provide plastic spacers at a maximum of ten feet (10'-0") on center to maintain three inch (3") spacing between conduits.
- b. Anchor the conduits to prevent floating during the concrete pour as specified by the design engineer.
- c. Construct a re-bar cage for reinforcement of concrete. The design engineer is to specify cage to suit site conditions.
- d. 12KV duct banks to include red dye. See Appendix A: Drawings for typical duct bank cross section.
- e. Provide a three-inch (3") wide yellow "Electric Line," T& B, Westline or equal plastic warning tape six inches (6") above duct bank. Provide one (1) warning tape for each twelve-inch (12") width of concrete duct bank or fraction thereof. Minimum ground cover for concrete duct bank shall be two feet (2'-0").

#### 20. PVC Conduit

- a. PVC shall be type 40, and comply with Underwriters' Laboratories, Inc. (UL) Standard 651, National Electrical Manufacturers Association (NEMA) TC2-1978, Federal Specification WC - 1094A National Electric Code, Latest Edition: Underground Installations, Article 300 Rigid Non-Metallic Conduit, Article 347.
- b. End Bells: PVC type 40.
- c. Elbows: Factory made. Use a minimum radius of sixty inches (60") or as required by the cable manufacturer or design engineer for medium voltage cable raceways.
- d. Schedule 40 PVC shall not be installed exposed under any conditions.

#### 21. Rigid Steel Conduit

- a. All Bends: Factory made, minimum radius of six (6) times trade size or as required by the cable manufacturer or design engineer.

#### 22. Encasement

- a. Raceways with Medium Voltage Cables or Intended for Medium Voltage Cable: Reinforced red concrete.
- b. Over Rebar: Three inches (3") of concrete, minimum.

## 23. Grounding

- a. Description Of Work
  - i. The grounding system shall provide this major function:
    1. A connection to earth for the system derived neutrals, for the service equipment enclosures, and for the distribution cable-shield drain wires.
- b. Main Ground Bus
  - i. Terminate system grounding conductors, including transformer neutral, U-fer, building steel, water piping, and concrete encased electrode, at an accessible bus adjacent to the main service. This bus shall also be used for grounding of telecommunications and related systems. Supplementary grounding systems shall be bonded to the Main Ground Bus. Ground rods that are not connected to the main Ground Bus are not permitted.
- c. Made Electrodes
  - i. Made Electrodes shall have a resistance of five (5) ohms or less.
- d. Branch Circuits And Feeders
  - i. Provide a code sized, green insulated, equipment grounding conductor within every branch circuit and feeder raceway. Bond the grounding conductor to grounding terminals and metallic enclosures.
  - ii. All distribution panels shall contain a ground bus.
- e. In the core campus area, install a 2/0 copper conductor (or larger) in all HV duct banks. The 2/0 conductor shall be attached to the ground rods placed in the duct bank system. Ground rods shall be installed in splice locations and all equipment and material in these locations shall be bonded to the 2/0 copper cable.
- f. Duct bank design shall be by an engineer and include provisions for pulling tension and sidewall pressure limits given by the cable manufacturer. Cable guarantee is only valid if manufacturer's installation requirements are followed and documented.
- g. Refer to Appendix A: Drawings for typical concrete encased 6-way duct bank.

## 24. Sealing of Conduits Entering or Exiting Medium Voltage Equipment

- a. All conduits associated with Medium Voltage Equipment are to be sealed to prevent the entrance or migration of rodents. Sealing is to be accomplished by using a combination of copper mesh and polyurethane foam.

## 26 13 00 Medium Voltage Switchgear

### 1. Scope

- a. Medium Voltage load interrupters shall be used in indoor locations only.

### 2. References

- a. The medium voltage load interrupter switchgear and all components shall be designed, manufactured and tested in accordance with the latest applicable standards including the following:
  - i. ANSI/IEEE C37.20.3
  - ii. ANSI/IEEE C37.20.4
  - iii. ANSIC37.22
  - iv. ANSI C37.57, C37.58
  - v. CSA22.2 No.31-M89
  - vi. EEMAC G8-3.3
- b. Listing by Underwriters Laboratories Inc. (UL) or Canadian Standards Association (CSA) shall be provided for 5 kV or 15 kV class medium voltage load interrupter switchgear.

### 3. Qualifications

- a. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through Zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a five percent (5%) minimum damping factor, CBC: a peak of 2.15g's, and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.
- b. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards:
  - i. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a civil or structural engineer licensed in the State of California. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.
  - ii. The equipment manufacturer shall certify that the equipment shall withstand and function following the seismic event, including both vertical and lateral required response spectra, as specified in the above codes.
  - iii. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

4. Operation and Maintenance Manuals

- a. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component. Provide three (3) hard copies and one electronic copy (PDF format on CD, DVD or Blu-Ray disc, as appropriate for file sizes).

5. Manufacturers

- a. Acceptable Manufacturers:
  - i. Eaton
  - ii. Siemens
  - iii. Square D
- b. The listing of specific manufacturers above does not imply acceptance of their products, especially those that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting requirements of these Design Standards.

6. Ratings

- a. Switchgear assembly ratings shall be as follows:

Nominal System Voltage	12.47 kV three-phase three wire
System Grounding	1000A @ 12.47 kv available
Available System 3-Phase Short Circuit	25 kA Symmetrical Current
Maximum Design Voltage	15 kV
BIL	95kV
Main Cross Bus Continuous Current	600A
Main Cross Bus Momentary Current (10 Hz)	40 kA Asymmetrical
Main Cross Bus 2-Second Current	25 kA Symmetrical
Non-Fused Switch Fault close (3 times, minimum)	40 kA Asymmetrical
Non-Fused Switch (Continuous and Load Break)	600 Amperes
Fused Switch Fault close	100 kA Asymmetrical



## 7. 15 KV Construction

- a. The metal-enclosed load interrupter switchgear shall consist of deadfront, completely metal-enclosed vertical sections containing load interrupter switches and fuses (where shown) of the number, rating and type noted on the drawings or specified herein.
- b. The following features shall be supplied on every vertical section containing a three-pole, two-position open-closed switch:
  - i. A large, eight inch by sixteen inch (8" x 16") high-impact viewing window that permits full view of the position of all three switch blades through the closed door.
  - ii. The window shall not be more than fifty-eight inches (58") above the switch pad level to allow ease of inspection.
  - iii. The door shall be interlocked with the switch so that:
    1. The switch shall be opened before the door can be opened.
    2. The door shall be closed before the switch can be closed.
  - iv. A hinged grounded metal barrier bolted closed in front of every switch to prevent inadvertent contact with any live part, yet allow for a full-view inspection on the switch blade position.
  - v. Provision for padlocking the switch in the open or closed position.
  - vi. Green OPEN, Red CLOSED switch position indicators with the words "Open" and "Closed."
  - vii. A hinged cover with rustproof quarter turn nylon latches over the switch operating mechanism to discourage casual tampering.
  - viii. The Switch shall be removable as a complete operational component.
- c. Vertical section construction shall be of the universal frame type using die-formed and bolted parts. All enclosing covers and doors shall be fabricated from steel whose thickness shall be equal to or greater than those specified in ANSI/IEEE C37.20.3. No other removable hardware for covers or doors shall be thread-forming type. To facilitate installation and maintenance of cables and bus in each vertical section, a split removable top cover and split removable rear covers with rustproof nylon handles or pad-lockable hinged rear door held closed by bolts shall be provided. A G90 grade galvanized base shall isolate equipment from contact with the concrete pad providing protection from rust. Heavy-duty hot dipped galvanized anchor clips shall be provided to anchor the switchgear to the concrete pad.
- d. Each vertical section containing a switch shall have a single, full-length, flanged front door and shall be equipped with two (2) rotary latch-type pad-lockable handles. Provision shall be made for operating the switch and storing the removable handle without opening the full length door.
- e. Each load interrupter switch shall have the following features:
  - i. Three-pole gang-operated mechanism.
  - ii. Manual quick-make/quick-break over-toggle-type mechanism that does not require the use of a chain or a cable for operation, and utilizes a heavy-duty coil spring to provide opening and closing energy.
  - iii. The speed of opening and closing the switch shall be independent of the operator, and it shall be impossible to tease the switch into any intermediate position under normal operation.
  - iv. Separate main and break contacts to provide maximum endurance for fault close and load interrupting duty.
  - v. Insulating barriers between each phase and between the outer phases and the enclosure.
  - vi. A maintenance provision for slow closing the switch to check switch blade engagement and slow opening the switch to check operation of the arc interrupting contacts.

## 8. Bus

- a. All phase bus conductors shall be silver-plated copper.

- b. Ground bus conductor shall be silver-plated copper and be directly fastened to a galvanized metal surface of each vertical section, and be of a size sufficient to carry the rated (2-second) current of the switchgear assembly.

9. Bus Insulation System

- a. All bus shall be supported utilizing a High Strength and High Creep, finned support providing ten and one-half inches (10.5”) of creep distance between phases and ground.
- b. All standoff insulators on switches and fuse mountings shall be Glass Polyester.

10. Wiring/Terminations

- a. One (1) terminal pad per phase shall be provided for attaching the contractor-supplied cable terminal lugs for a maximum of two (2) conductors per phase. Sizes shall be indicated on the Drawings. Sufficient space shall be allowed for the contractor supplied electrical stress relief termination devices.
- b. Small wiring, fuse blocks and terminal blocks within the vertical section shall be furnished and indicated on the Drawings. Each control wire shall be labeled with wire markers. Terminal blocks shall be provided for the Owner's connections to other apparatus.

11. Fuses

- a. Fault protection shall be provided by fuses with continuous ratings shown in the Contract Documents.
- b. The fuses shall be Cutler-Hammer CLE current limiting type or equivalent. Furnish three (3) spare fuses for each fused switch. Fuse/switch integrated momentary and fault close ratings specified shall be verified by test and UL and CSA certified.

12. Accessories

- a. Key interlocks, if applicable, shall be shown on the Drawings.
- b. 12 kV distribution class surge arresters shall be connected at the incoming terminations and securely grounded to the metal structure.
- c. Space heaters of sufficient size to prevent condensation.

13. Indoor Enclosures

- a. Enclosures shall be constructed per IEEE/ ANSI C37.20.3 indoor specifications, meeting or exceeding NEMA 1.
- b. Each vertical section shall be ventilated at the top and bottom, both front and rear, to allow airflow to provide cooling and to help prevent buildup of moisture within the structure.

14. Outdoor Enclosures

- a. Medium Voltage Air Switches shall not be installed outdoors.

15. Nameplates

- a. A nameplate shall be mounted on the front door of each switch vertical section. This requirement shall be shown and detailed on the Drawings.

16. Finish

- a. Prior to assembly, enclosing steel shall be thoroughly cleaned and phosphatized. A powder coating shall be applied electrostatically and fused-on by baking in an oven. The coating is to have a thickness of not less than 1.5 mils.
- b. The finish shall have the following properties:

Impact resistance (ASTM D-2794)	60 direct/60 indirect
Pencil hardness (ASTM D-3363)	H

Flexibility (ASTM D-522)	Pass 118-inch mandrel
Salt spray (ASTM B117-85 [20])	600 hours
Color	ANSI 61 gray

#### 17. Factory Testing

- a. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
- b. The manufacturer shall provide three (3) certified copies of factory test reports.

#### 18. Field Quality Control

- a. The services of a qualified factory-trained manufacturer's representative shall assist the Contractor in installation and start-up of the MVS equipment for a period of one working day per switch. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, corrections and adjustments, and testing of the assembly and components contained therein.
- b. The Contractor shall provide three (3) copies of the manufacturer's field start-up report.

#### 19. Manufacturer's Certification

- a. The Contractor shall provide a qualified factory-trained manufacturer's representative who shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.
- b. The Contractor shall provide 3 copies of the manufacturer's representative's certification.

#### 20. Training

- a. The Contractor shall provide a training session for the Owner's Representatives for one (1) workday (eight [8] hours) at a jobsite location determined by the Owner.
- b. The training session shall be conducted by a manufacturer's qualified representative and consist of instruction on the assembly, switches and major components.

#### 21. Installation

- a. The Contractor shall install equipment in accordance with the manufacturer's recommendations and the Contract Drawings.
- b. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

### 26 13 19 *Medium-Voltage Vacuum Interrupter Switchgear*

#### 1. Part 1 – General

- a. Scope
  - i. This specification applies to liquid insulated 15 kV 60 Hz class three phase gang operated padmounted load interrupting switches with maximum continuous ratings of 600A and liquid immersed fuse assemblies with maximum continuous ratings of 200A for use on underground distribution systems utilizing dead front equipment.
- b. Definitions
  - i. The definitions of terms contained in this specification, or in other standards referred to in this document, are not intended to embrace all the legitimate meanings of the terms. They are applicable only to the subject treated in this specification. Any documents or industry standards referred to shall be of the latest revision.
    1. ASTM: American Society for Testing and Materials
    2. ANSI: American National Standards Institute

3. IEEE: Institute of Electrical and Electronic Engineers
4. NEMA: National Electrical Manufacturers Association
5. IEC: International Electrotechnical Commission
6. AISI: American Iron and Steel Institute
7. Bus: Solid conductor located within the Padmounted Switch
8. Dead Front Padmounted Switchgear: An assembly in which all energized parts are insulated and completely enclosed within a grounded shielded system when separable connectors are in place
9. Way: A three phase circuit entrance to a switching assembly
10. Switched Way: A way connected to the bus through a three pole group operated switch
11. Tapped Way: A way solidly connected to the bus
12. Fused Way: A way connected to the bus through a liquid immersed fuse assembly

## 2. Part 2 – Products

### a. Manufacturers

- i. EATON/Cooper switchgear type RVAC, Padmount, liquid insulated, 15 kV, 3-way, 2-ways switched and fused, one way solid tap. Two switched and fused ways with 600A bushings, and solid tap with 200A bushing wells and 200A Loadbreak bushing inserts installed.

### b. Units Shall Be Rated As Follows:

- i. 15.5 kV maximum design, 95 kV BIL across open contacts, 95 kV BIL phase to phase and phase to ground. Interrupting rating is based on the selected fuses for the application voltage. It is intended that the switch will utilize Cooper ELSG fuses. Cooper ELSG Fuses are rated 50,000 A maximum interrupting current (RMS symmetrical) and rated for 15.5 kV wetwell holders.
- ii. Switches shall be three way: Two ways switched and fused; one way non-switched and non-fused. The switched and fused ways shall be incoming circuits. The non-switched and non-fused way shall be the outgoing circuit.
- iii. Fuse wells to be 200 amps maximum continuous rating. External hardware of fuse wells shall be stainless steel.
- iv. Enclosure shall be of #304L stainless steel.
- v. The 600 A Deadfront Apparatus Bushings shall have a short time rating of 25,000 A (symmetrical RMS).
- vi. The switching devices located within the Padmount Enclosure shall be vacuum bottles, located between the bushings and the fuse holders. The vacuum bottles shall have a fault making rating of 12,500 A (symmetrical RMS) and a 1 second momentary rating of 12,500 A (symmetrical RMS).
- vii. Switch shall be arranged for one (1) outgoing feeder.
- viii. Switch shall be completely assembled and factory filled with Envirotemp FR3 liquid insulation.
- ix. In order to change any fuse, it shall be necessary to open both switches associated with the incoming ways.
- x. Switch to be designed in conformance with IEEE Std. C37.74 standard.

### c. Construction

- i. Vacuum switches shall be enclosed in all welded type 304L corrosion resistant stainless steel tank completely welded using ANSI 308 filler to maintain corrosion resistant properties. Each assembled switch shall be found free from leaks.

- ii. Terminations shall be 600A non-loadbreak on the line side and 200A on the load side. Termination on the load side shall be of the universal bushing well type that can accommodate a loadbreak connector.
  - iii. All bushings and switch handles shall be accessible from the front of the switch.
  - iv. Switch shall include a drain valve with sampler that will allow samples of the insulating fluid to be drawn for laboratory testing.
  - v. Switch shall include padlockable front door(s). In addition, at least one of the front doors must be secured by a penta-head bolt of standard size for utility switchgear applications.
  - vi. Switch shall include a liquid level indicator.
  - vii. Switch shall include removable drip pans under the wet well fuseholders
  - viii. The exterior of the switch shall be finished in a green color which conforms to Munsell 7GY 3.29/1.5 Green. The coating shall meet the following specifications: IEEE Std C57.12.28-2005 standard, ASTM B1117 1000-hour humidity test, ASTM G53 500-hour ultraviolet accelerated weathering test and ASTM D2794 impact test
  - ix. Switch shall include a solid copper ½” diameter grounding rod located along the front of the switch, near the bottom. This will permit grounding of the switch and elbow drain wires to be simple and convenient.
- d. Manual Operating Provisions
- i. The direction of operation of a manual operating handle shall be apparent. Handles shall be moved “in” to close and “out” to open.
  - ii. The vacuum switch mechanism shall be designed to that operation does not require any special skills, and closing and opening speeds of the contacts are independent of the speed at which the operating handle is moved.
  - iii. Manual operating handles shall be capable of being padlocked in the open and in the closed position.
  - iv. The switch shall be designed so that switching of the incoming feeders can be done without any interruption of power to the load (outgoing circuit). Internal vacuum bottle switches shall be able to be operated independently to allow paralleling of feeders without power interruption.
- e. Insulating Medium
- i. Insulating medium shall be Envirotemp FR3.
- f. Switch Nameplate
- i. Nameplate shall contain a single line representation of the internal connections and devices within the switch.
- g. Product Enhancements
- i. Switch to be pressurized with 1-2 p.s.i.g. of dry nitrogen.
  - ii. Switch to include pressure/vacuum gauge that will allow reading of the nitrogen pressure.
  - iii. Switch to include a valve that will allow re-pressurizing of the switch should nitrogen pressure be lost.
  - iv. Switch to include a Pressure Relief Device (PRD) for venting sudden increases in gas pressure within the tank due to electrical faults. PRD to be Qualitrol 206 or equivalent.
- h. Production Testing
- i. Before shipping, switchgear to be fully assembled, filled with insulating fluid, and subjected to the following factory tests:
    - 1. Continuity testing to ensure correct internal connections

2. Hi-Pot testing to ascertain dielectric integrity
  3. Leak tested to ensure that tank is completely sealed
  4. Resistance testing to ensure positive electrical connections
  5. Mechanical operations test of the switches to ensure problem-free operation
- i. Labels/Nameplates For Each Switched Way
    - i. Engraved nameplates, sized two inches (2") by five and one-half inches (5.5"), black with white letters are required. Nameplates shall be securely fastened on each switched way.
  - j. Spare Fuses
    - i. Supply six (6) spare fuses in addition to the six (6) fuses necessary for normal operation. If there are two (2) or more switches with identical fuse sizes, six (6) spare fuses shall be sufficient.
  - k. Multiple Switches In One Building
    - i. For situations where more than one switch is required in a building, the incoming 12 kV circuits shall be connected to junction blocks, one per phase, with one set of blocks for the 12 kV "A" circuit, and one set of blocks for the 12 kV "B" circuit. The 12 kV circuits shall then split at each junction block in order to feed each switch as required. It is not permissible to double-stack elbows on the Vacuum Break Selector Switches.
    - ii. Junction blocks to be rated at 15 kV, 600 amp. Junction blocks to utilize copper contacts.
    - iii. Junction blocks to be Elastimold 675J or equal.
  - l. Installation
    - i. Switches with wet-well fuses that are mounted on a stand shall not be mounted on a housekeeping pad. Stands shall be anchored directly to the concrete floor. The floor shall be constructed of reinforced concrete.
    - ii. Switches with dry-well fuses shall be mounted on a housekeeping pad. The housekeeping pad shall be constructed of reinforced concrete.
    - iii. Cable installation: Incoming "A" circuit to be connected at left side of switch; incoming "B" at right.

## 26 13 26 *Medium-Voltage Metal-Clad Switchgear*

1. Metal Clad Switchgear
  - a. This section applies to medium voltage 750 MVA switchgear that will be installed on the main campus. In order to match the switchgear and circuit breakers found in the 12kv switching stations, any additional switchgear and breakers must be manufactured by Powell Electrical Manufacturing, Inc. This will ensure compatibility of parts, accessories, maintenance tools, and operator's familiarity. The switchgear and circuit breakers shall meet the specifications outlined below.
2. General
  - a. The intent of this specification is to have the manufacturer furnish the equipment and material specified herein complete and operable.
  - b. All standard accessories to the equipment specified shall be supplied even if not specifically mentioned in this specification.
  - c. Material used in the fabrication of the specified equipment shall be new, unused, and of the highest quality available.

### 3. Scope

- a. Furnish metal-clad switchgear as detailed below.
- b. Any drawings or data sheets attached shall be considered part of this specification.
- c. The equipment shall be complete and operable.
- d. Provide production tests and inspections as detailed below.
- e. To reasonably prevent the possibility of shipping damage, the manufacturer shall prepare the equipment for transportation to the jobsite and monitor the load out of this material.
- f. It shall be the responsibility of the manufacturer to furnish all material, connections, splices, links, special tools, and information required to completely reassemble the switchgear in the field or to facilitate the installation of the switchgear when performed by an electrical contractor.
- g. Guarantee the performance of the switchgear during a reasonable warranty period. This warranty shall, at a minimum, cover the equipment for eighteen (18) months from the time of shipment or twelve (12) months from date of energization whichever occurs first.
- h. Supply all drawings, documentation, and information detailed below.

### 4. Applicable Codes and Standards

- a. The applicable codes and standards listed below shall be considered as part of this requirement.
- b. The latest revision in effect at time of contract issuance shall apply for all standards referenced:
  - i. National Electrical Manufacturers Association (NEMA)
  - ii. Institute of Electrical and Electronic Engineers (IEEE)
  - iii. National Electric Code (NEC)
  - iv. American National Standards Institute, Inc. (ANSI)
    1. ANSI C37.04
    2. ANSI C37.06
    3. ANSI C37.09
    4. ANSI C37.20.2
  - v. Underwriters Laboratories (UL)
- c. It shall be the manufacturer's responsibility to be knowledgeable of these standards and codes.

### 5. Service and Environmental Conditions

- a. Unless otherwise specified, this equipment is intended for use in ambient temperatures that do not exceed a maximum of forty degrees Celsius (40°C [104°F]) or a minimum of negative thirty degrees Celsius (-30°C [-22°F]).
- b. Construction shall be for indoor or outdoor installation as specified.

### 6. Basic Construction

- a. The equipment supplied shall be of metal-clad construction using welded, industrial-riveted, or bolted sheet steel. The construction shall be self-supporting and free standing. All metal work shall be free from burrs and sharp edges.
- b. The equipment shall be suitable for industrial or utility service and constructed with an enclosure as specified on the drawings or data sheets.
- c. Each front and rear compartment door shall be provided with a formed steel hinged door with hand operated door latches. Each door shall have provisions for padlocking.
- d. The switchgear shall be capable of extension from either end at a future date without modification to existing structural members.
- e. It shall be the manufacturer's responsibility to coordinate all necessary alignment and interconnection between component sections. The entire assembly shall be electrically and mechanically assembled into one single line-up prior to final inspection and shipment.
- f. The equipment shall be shipped complete, without missing components or "ship shorts".
- g. Purchaser may waive this requirement upon request prior to shipment.

- h. Shipping sections shall be as specified by UCB in the design.
- i. Power circuit breakers shall be shipped and packaged separately from the switchgear structure unless equipment is installed within a PCR (Power Control Room), in which case the bottom located circuit breakers shall be shipped in place.
- j. Louvers may be provided in the switchgear for ventilation or cooling purposes. These openings shall be filtered to retard the entrance of dust. Filters shall be easily removable for maintenance. Louvers and filters, when present, shall be located on the front and rear doors.
- k. The depth of the finished equipment shall be sufficient to allow for entrance, bending, and termination of power cables. Individual units shall be provided for top or bottom entrance as specified. A minimum of twenty-six inches (26") of clearance between terminal pads and the cable entrance shall be provided.
- l. Each switchgear cubicle shall have, at a minimum, 11-gauge sheet steel side panels. This provides two (2) steel sheets between adjacent sections so as to minimize the chance of fault propagation between sections.
- m. Power circuit breakers and voltage transformer assemblies shall be drawout construction to provide maximum operator safety.
- n. Safety interlocks and barriers as required by ANSI standards shall be provided to prevent personnel from inadvertent exposure to the bus while the switchgear is energized.
- o. A continuous silver plated copper ground bus measuring five inches by two inches (5" x 2") shall be provided for the full length of the switchgear assembly. The ground bus shall be capable of carrying the rated short circuit current of the installed circuit breakers for a minimum of two (2) seconds.
- p. In order to minimize condensation, each cubicle shall have a space heater.
  - i. Space heaters for each switchgear bus section may be wired with other space heaters in parallel and shall be provided with a single adjustable thermostat to maintain cubicle temperature at desired levels.

## 7. Power Circuit Breakers

- a. The power circuit breakers shall be electrically operated, three-pole, drawout type. The interrupting medium shall be vacuum.
- b. The circuit breakers shall have an ANSI rating structure based on a K factor of 1.0 and interrupting rating of 36kA at 15kV.
- c. The basic insulation level (BIL) of the power circuit breakers shall be not less than 95kV for 15kV applications.
- d. The continuous current capacity of each power circuit breaker shall be 1200A, 2000A, or 3000A as indicated on the drawings or data sheets.
- e. Primary line and load connections shall be self aligning.
- f. The drawout mechanism shall hold the power circuit breaker rigidly in the fully connected position.
- g. The drawout mechanism shall require less than twenty-five (25) turns to move the circuit breaker from the connected to the disconnected positions.
- h. Each circuit breaker will have four (4) wheels to allow for easy maintenance and movement.
- i. No lift truck, rails, ramps, channels, or transport device of any kind shall be required in order to move a circuit breaker from floor level to the fully connected position in a one-high structure or the bottom located circuit breaker in a two-high structure.
- j. Interlocks shall be provided to prevent the circuit breaker from disconnecting from the main bus stabs unless the circuit breaker is open.
- k. The power circuit breaker ground connection shall be capable of carrying the short circuit rating of the circuit breaker for a minimum of two (2) seconds and must also be capable of withstanding the peak current value (or 2.7 times the rated short circuit current) of the circuit breaker.



- l. A grounded metal shutter system shall automatically cover the line and load stab connections when the circuit breaker unit is moved to the disconnected position. The shutter shall be pad-lockable in the closed position.
- m. Auxiliary contacts to provide circuit breaker element position indication (Truck Operated Cell switch or TOC) and to provide circuit breaker contact position (Mechanism Operated Cell switch or MOC) shall be available when specified. Both switch operator and switch shall be visible and accessible from the front of the low voltage compartment when the circuit breaker is in the fully connected position.
- n. The circuit breaker operating mechanism shall be completely trip free both mechanically and electrically. Mechanical tripping of a closed circuit breaker shall be possible with the front cubicle door closed.
- o. Control power and control circuit wiring shall be connected to the power circuit breaker by means of a sixteen (16) pin front connected umbilical cord and plug. This plug shall be mechanically interlocked. The plug shall not be removable while the circuit breaker is in the connected position. The circuit breaker shall not be inserted without the plug in place.
- p. For operator safety, the circuit breaker shall have provision for padlocking it in the disconnected position.
- q. Each circuit breaker shall have a mechanical operations counter.
- r. Each circuit breaker shall have an easily accessible means for contact wear indication.
- s. A steel interference plate shall be mounted in the bottom of each circuit breaker cell assembly which only allows a higher rated circuit breaker (voltage, current, interrupting rating) to be inserted into a lower rated cell assembly.
- t. Control power to be 125 volts d.c. trip, close, and spring charging motor

#### 8. Power Bus

- a. All bus bars shall be copper.
- b. The main power bus shall be silver plated along the entire length to a thickness between 0.0001 inches and 0.0005 inches.
- c. The entire bus, except for terminations, shall be completely isolated with metal barriers and insulated as required by ANSI Standards.
- d. The main power bus shall be supported on molded cycloaliphatic epoxy insulators and mechanically braced to withstand stresses resulting from current values equivalent to the close and latch rating of the largest circuit breaker in the assembly.
- e. Molded cycloaliphatic epoxy inserts are required whenever the bus passes through a barrier of any type on 15 kV applications.
- f. Bus joints shall be made with sufficient bolts and torqued to preserve initial contact pressure over the service life of the equipment. Bolts that are torqued to appropriate levels at the factory shall be identified with paint markings. Bolts shall be rated Grade 5 and plated for corrosion resistance.
- g. Power bus orientation shall be A-B-C top to bottom, front to back, and left to right when viewed from the front of the switchgear.

#### 9. Instrument Transformers

- a. Current Transformers (CT)
  - i. Current transformers shall be installed so that they can be easily maintained or replaced from the front of the switchgear without entering the power bus or cable termination compartments. Unless specified otherwise, the polarity marking shall be toward the circuit breaker.
  - ii. Each current transformer shall be rated to withstand the thermal and mechanical stresses imposed by the short circuit rating of the applied circuit breaker.
  - iii. The secondary termination of current transformers shall be on a shorting terminal block.

- iv. Current transformers shall have a rated five (5) ampere secondary current unless otherwise specified.
  - v. Metering and relaying accuracy classification shall be as specified in the data sheets and shall be suitable for the connected burden.
  - vi. Current transformers, when installed, shall be fully rated for the appropriate voltage class. Current transformers with 600 volt insulation levels may be used if installed with fully rated insulation barriers such as around primary disconnect bushing assemblies.
- b. Voltage Transformers (VT)
- i. Voltage transformers and associated fuse assemblies shall be installed in drawout assemblies so that they may be readily disengaged from the power bus.
  - ii. When moved to the withdrawn position, the transformer drawout unit shall automatically ground the transformer primary windings and the fuses. A visible indication of positive ground shall be required. The ground may be a momentary or sweeping action that occurs as the unit moved out of the connected position.
  - iii. Voltage transformers shall have 120 volt secondaries unless otherwise specified.
  - iv. Voltage transformers shall have an accuracy rating comparable to the metering equipment and a burden capacity equal to twice the initial load.
  - v. Current limiting fuse protection shall be provided on the primary side of each voltage transformer.
  - vi. Voltage transformers shall be designed to withstand the basic impulse level of the switchgear.
- c. Control Power Transformers (CPT)
- i. Control power transformers shall be fixed mounted for sizes above 15 kVA with the primary current limiting fuses mounted in a drawout unit.
  - ii. When moved to the withdrawn position, the fuse drawout unit shall automatically ground the fuses. A visible indication of positive ground shall be required. The ground may be a momentary or sweeping action that occurs as the unit moves out of the connected position.
  - iii. Each control power transformer shall have a secondary molded case circuit breaker interlocked with the drawout assembly so that the load is disconnected prior to drawout.
  - iv. All control power transformers shall be provided with two (2) 2.5% taps above and below rated voltage.
  - v. Secondary winding shall be 120/240Vac, single phase, 60Hz, 3 wire unless otherwise specified.

## 10. Control and Secondary Wiring

- a. Control wiring shall be SIS type #14 AWG, 41 strand extra flexible, stranded copper or larger.
- b. Current transformer secondary wiring shall be SIS type #12 AWG, 65 strand, extra flexible, stranded copper or larger.
- c. Current transformer secondary wiring shall terminate on shorting type terminal blocks.
- d. All control wiring shall be UL listed and shall have a VW-1 flame retardant rating.
- e. Exposed wiring shall be suitably protected against contact with sharp edges. Throughout the assembly it shall be neatly bundled and secured with nylon wire ties. Where control wiring passes from cubicle to door it shall be wrapped with suitable protection so as to prevent damage. Holes cut to allow control wires to pass from cubicle to cubicle shall have a grommet for protection.
- f. Splicing of control wire is not permitted. Control wiring must be a continuous length from terminal to terminal.
- g. Each control wire shall be marked at both terminations to agree with wiring diagrams. Plastic wire markers of either the slip on or heat shrink variety shall be provided.
- h. Control wires leaving the cubicle of origin shall first terminate on a terminal block. No control wire may leave a cubicle directly from any other device.

- i. Space heater circuits, if included, are an exception.
- i. Where possible, a minimum of ten percent (10%) spare terminals shall be provided in each cubicle.

#### 11. Meters, Switches, And Relays

- a. Indicating meters shall be one percent (1%) accuracy, four inch (4") square switchboard type, with taut band suspension unless otherwise specified.
- b. Control switches shall be rotary cam type with engraved face plates.
- c. Ammeter and voltmeter transfer switches shall have an off position and shall be provided with knurled knob handles.
- d. Selector type control switches (Auto-Manual or Hand-Off-Auto) shall have oval handles.
- e. Circuit breaker control switches shall have pistol grip handles.
- f. Protective relays shall be of the type, model, and manufacturer specified by UCB.
- g. Current and voltage test plugs for field monitoring and maintenance shall be provided when specified.
- h. Indicating lights shall be provided as shown on the control schemes. Lamps shall be replaceable from the front of the switchgear without opening the cubicle door. Lamps shall be of the LED type.

#### 12. Nameplates

- a. Laminated, plastic, engraved nameplates shall be provided and mounted by stainless steel screws or rivets.
- b. Identification nameplates shall be black with white letters, caution nameplates shall be yellow with black letters, and warning nameplates shall be red with white letters.
- c. Each externally visible device or component shall have an identification nameplate. Lettering shall be, at a minimum, 5/32 inches in height.
- d. Each internal device or component shall have an identification marking.

#### 13. Finishes

- a. All steel structure members shall be cleaned, rinsed, and phosphatized prior to painting.
- b. The coating process shall be an electrostatically applied polyester powder with a final baked on average thickness between 1.5 and 4.0 mils.
- c. Standard exterior finish shall be ANSI 61 light gray.
- d. Finish shall have a minimum pencil hardness of 2H as tested per ASTM 03363.
- e. Finish shall pass the ASTM 81 17 salt spray test for a minimum of 1000 hours.
- f. Finish shall pass impact testing per ASTM 02794 with minimum values of 160 in-lb. For direct impact and 120 in-lb. for reverse impact.
- g. Test reports for compliance with the above requirements shall be available upon request.

#### 14. Inspection And Testing

- a. Each circuit breaker shall be tested for proper adjustment and operation prior to shipment. The circuit breaker shall be given a minimum of one hundred (100) mechanical operations. Test reports shall be available upon request.
- b. Each vacuum interrupter shall receive a vacuum integrity test by means of the system AC high potential test prior to shipment.
- c. Each circuit breaker shall have a contact-timing and contact-motion velocity test.
- d. Each circuit breaker shall be identified with an individual serial number permanently mounted on the breaker by means of a metal nameplate.
- e. The Manufacturer shall maintain permanent records of each circuit breaker produced and the production test results.
- f. The component bill of material shall be checked for proper quantity, description, and part number.
- g. Physical dimensions shall be checked against approved drawings.

- h. Equipment shall be subjected to a primary current injection procedure to determine proper operation of all current sensitive components.
- i. Equipment shall be subjected to a primary voltage injection procedure to determine proper operation of all voltage sensitive components.
- j. Complete assembly shall have a low frequency withstand (an AC high potential) test performed to assure insulation system integrity.
- k. The Manufacturer shall have in place a system of recording, correcting, and verifying resolution of discrepancies discovered during the inspection and testing process. The manufacturer shall be ISO 9001 certified.
- l. Certified production test reports indicating satisfactory completion of all inspection and test procedures shall be available upon request.
- m. Upon request the equipment shall be made available for inspection prior to shipment.
- n. Production tests shall be performed in accordance with ANSI standards C37.20.2 and C37.09.
- o. Test reports for design tests shall be available upon request.

## 15. Documentation

### a. Drawings

- i. Prior to fabrication, the following drawings shall be submitted by the manufacturer for approval:
  - 1. Front elevation view.
  - 2. Single Line diagram.
  - 3. Base plan including mounting details, cable entry area, and door swing requirements.
  - 4. Cross section view of each different section.
  - 5. Three line diagram.
  - 6. Component bill of material indicating quantity, description, and part number.
  - 7. Control or schematic diagram for each different unit.
- ii. Following the return of approval drawings the manufacturer shall prepare and submit wiring diagrams indicating physical location of secondary control components and the appropriate wiring connections. Each control wire shall be labeled. Copies of these drawings shall be submitted to the Owner's Representative upon completion.
- iii. After the return of approval drawings or after any change made to previously approved drawings, the manufacturer shall submit a record copy of any and all drawings that contained revisions.
- iv. After completion of the inspection and testing procedures, the manufacturer shall submit a complete set of "As Built" drawings. These drawings shall function as a record of the final construction of the equipment at the time it left the factory.
- v. Drawings may be provided in any of the following forms as requested by UCB:
  - 1. Full size plotted reproducible drawings size as required. "D size" measuring approximately 34" x 22". "C size" measuring approximately 22" x 17", "B size" measuring approximately 17" x 11", or "A size" measuring approximately 11" x 8.5".
  - 2. Three (3) reduced photocopies of original plotted drawings.
  - 3. Digital files in AutoCAD 2009 (.dwg) or later format.
- vi. Each drawing prepared by the manufacturer shall show, at a minimum, the UC Berkeley Project Name, UC Berkeley Project Number, jobsite location, purchase order or contract number, and equipment identification number in addition to any information required by the manufacturer.

### b. Operating and Maintenance Manuals

- i. At time of shipment, the manufacturer shall provide six (6) copies of the operating and maintenance instructions for all major components contained in the switchgear assembly.
- ii. Manuals shall contain a table of contents to allow for easy reference.

- c. Spare Parts List
  - i. Upon completion of the engineering phase, a quotation for one (1) year's recommended spare parts shall be submitted.
- d. Spare fuses - medium voltage
  - i. Two sets of spare fuses shall be provided for each type of fuse included in each switchgear line-up provided. This would normally require six (6) P.T. fuses and four (4) control power transformer fuses.
- e. Accessories
  - i. Breaker Truck
  - ii. Breaker Test Panel
  - iii. Ground and Test Device with cables
  - iv. Breaker Racking Tools and Accessories

26 20 00      *Low-Voltage Electrical Distribution*

26 27 00      *Low Voltage Distribution Equipment*

26 27 16      *Electrical Cabinets and enclosures*

#### 1. Lighting And Receptacle Panel Boards

- a. Specify general purpose 20 AMP minimum bolt-on circuit breakers for 120/208 and 277/480 volt panel boards; Eaton, Siemens or Square D. Minimum interrupting capability shall be 10,000 amperes for 120/208 volts and 14,000 amperes for 277/480 volts. Confer with the Campus Electrical Engineer for available fault current levels.
- b. When more than one panel board is fed by the same feeder, provide a main circuit breaker in each panel board.
- c. Locate all busses in the rear of the panel board cabinet. Mount circuit breakers on suitable supporting members at the front of the cabinet and connected with suitable straps or lugs to the bussing in the rear of the cabinet. Individual circuit breakers shall be removable from the cabinet without disturbing the bussing in any way.
- d. Specify door-in-door arrangement. Adjustable trim clamps are not acceptable. Surface mounted panel boards shall have the front mounted on a piano hinge on the right side, with double locked doors.
- e. Specify all locks on panel boards in a single building so that all the outer locks of the door-in-door assembly are keyed alike and all the inner locks of the door-in-door assembly are keyed alike, but different from the outer locks.
- f. Detail the layout and dimensions of special-sized panel boards on the Drawings.
- g. Specify permanent, fade- and weatherproof plastic or vinyl labels for panel boards surfaces and components.
- h. Each panel board shall contain three 1-inch spare conduits from panel boards to accessible space above furred ceilings, to allow for use of spare circuits or spaces provided in the panel boards. Spare conduits shall be capped off in accessible space above furred ceilings.
- i. Percentage of spares and spaces in panel for future growth shall be thirty percent (30%). Provide hardware and bus taps for installation of future breakers in spaces provided in the panel board.
- j. Specify bolted copper bussing. No aluminum allowed.
- k. The Contractor shall balance phases during normal building operation.
- l. Panel boards shall contain a panel schedule located in a door mounted plastic pouch. The schedule shall contain the following information:
  - i. Panel type.
  - ii. Building in which panel board is located.
  - iii. Location of panel.

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- iv. Panel board manufacturer.
  - v. Panel bus bracing or interrupting capacity (KAIC).
  - vi. Panel board voltage rating.
  - vii. Panel board amp rating.
  - viii. Feeder wire size.
  - ix. Neutral size.
  - x. Ground size.
  - xi. Conduit size.
  - xii. Branch circuit interrupting capacity (KAIC).
  - xiii. Branch circuit breaker type.
  - xiv. Main breaker type, ampacity, and interrupting capacity (KAIC).
  - xv. Wire size, phase, and description of each circuit.
  - xvi. Special breaker types such as GFI shall be noted.
  - xvii. Identification of PNL and BRK feeding the new PNL.
- m. Please refer to Appendix A: Drawings for a sample Panel Board Schedule:

26 27 26      *Wiring Devices*

2. Corridor Receptacles

- b. In all new buildings and building remodels, provide in all new corridors dedicated 20-amp, 120-volt circuits to feed corridor 20-amp duplex receptacles only. Spacing shall be no more than fifty feet (50'-0"). The maximum distance from any end wall shall be twenty-five feet (25'-0"). The maximum number of outlets per 20-amp circuit shall be six (6).

3. Wiring Devices

- a. Wall (Local) Switches: Totally enclosed, AC rated, premium industrial specification grade, ivory, or match existing finish. 120/277V, 20 amps. Leviton (catalog numbers), Sierra, Hubbell, or equal.

Single Pole Switches	#1221-2 I	20 amps	277V
Two Pole Switches	#1222-2 I	20 amps	277V
Three Pole Switches	#1223-2 I	20 amps	277V

- b. Dimmers: Commercial grade, 120V, 2000 watt or 20 amps minimum rating. Lutron, or equal is campus standard for all dimming systems.
- c. Duplex Convenience Receptacles: premium industrial grade 3-wire grounded, nylon face, rated 20 amps, 125V. All receptacles connected to the emergency circuit shall have red colored outlets, and red metal cover plates. All receptacles incorporating an isolated grounding conductor connection shall be identified by an orange triangle located on the face of the receptacle. All other devices shall be ivory or match existing face.
- d. Ground Fault Circuit Interrupter (GFCI) receptacles: 3 wire grounded, ivory, or match existing finish, rated 20 amps, 125V, Hubbell, Leviton or equal. Provide waterproof lift cover for outdoor installation.
- e. Exterior lighting shall be on photocell control, used in conjunction with a non-latching lighting contactor. A bypass spring-wound timer with "hold" feature shall be installed to enable trouble-shooting.
- f. For exterior outlets in plazas or patios, electricity output shall be denied via a timer or switch between 10pm and 6am.

## 26 28 00 Low-Voltage Circuit Protective Devices

### 26 28 16.13/16 Enclosed Switches and Circuit Breakers

#### 1. Circuit Breakers

- a. Provide molded case circuit breakers conforming to Underwriters' Laboratories, Inc. (UL) 489:
  - i. Breaker shall be thermal-magnetic type or microprocessor based; Eaton, Siemens or Square D.
  - ii. Adjacent poles shall be connected to phases A,B,C, respectively.
  - iii. Minimum symmetrical interrupting current rating shall be as indicated on drawings.
  - iv. Connectors shall be designed for use with copper conductors.
  - v. Mounting shall be "bolt-on" type, removable without disturbing any other breaker.

#### 2. Safety Disconnect Switches

- a. Heavy duty type, 600v, HP rated for motors, standard enclosure indoors and weathertight outdoors; fused or non-fused as required; Eaton, Siemens or Square D.
- b. All disconnect switches shall be National Electrical Manufacturers Association (NEMA) Type HD; lockable in the "OFF" position. Switches shall have a dual cover interlock to prevent unauthorized opening of the switch door when the handle is in the "On" position, and to prevent closing of the switch mechanism with the door open. Provide defeater mechanism to bypass this mechanism.

## 26 29 00 Low-Voltage Controllers

### 26 29 13.13/16 Across-the-Line/Reduced-Voltage Motor Controllers

#### 1. General Requirements

- a. Gutter-mounted motor control centers consisting of starters and fused switches are not acceptable. Provide circuit protection in the form of circuit breakers mounted in suitable panels. Provide safety disconnect switches per code at all remote motor locations. Motor starting controls may be centralized in a single panel if a sufficient number is involved. Comply with requirements of the Energy Management Control System for wiring, fusing, and related work.
- b. For motor control centers serving loads at voltages above 120 volts, use 120 volt control circuit furnished by a control transformer within the motor control center and connected to the bus. Motor control centers shall be Allen-Bradley, Eaton, Siemens, or equal.
- c. In buildings with large equipment power demands, limit building restart load after power interruptions. Use three (3) wire protection on all large motors such as supply and exhaust fans and other equipment susceptible to damage from automatic restarts. Discuss which motors should have this type protection with Capital Projects (CP).
- d. Motor starters for critical applications require solid state overload relays with single-phase protection. Without single-phase protection, motors will burn out when source power loses a phase. The solid-state type overload relay provides both of these protections since it monitors the actual current the motor is drawing with built-in phase loss protection.
- e. Motor starters for non-critical applications may utilize thermal overload heater-type relays.

#### 2. Description

- a. Each individual mounted motor starter and starters mounted in Motor Control Centers shall be National Electrical Manufacturers Association (NEMA) or International Electrotechnical Commission (IEC) rated.

#### 3. Individual Mounted Starters

- a. Control Voltage shall be 120VAC. Individual mounted starters shall have control transformer within the enclosure unless motor voltage is 120VAC. Control circuits shall be disconnected when the disconnecting means is in the open position (Ref. 99 NEC 430-71 and 430-74), a minimum of two (2) control circuit disconnect contacts shall be provided; one for the starter and one for other circuits fed through the starter auxiliary contact. Common control circuits for multiple buckets and/or controllers are not acceptable.
- b. All three-phase motor starters shall be individually mounted and/or in MCCs.
- c. Auxiliary Contacts: Each starter to have a minimum of two (2) NO and two (2) NC auxiliary contacts with provision to add a minimum of two (2) more.
- d. Overload Relay: Electronic Solid State type, with phase loss protection, short circuit protection, and FLA adjustable trip over 2:1 range. Thermal overload, heater-type relays may be used as an alternative, with UC Berkeley Campus Electrical Engineer pre-approval.
- e. Start/Stop: Standard configuration shall be 3-wire start/stop mounted in cover. Refer to Division 25: Integrated Automation for more details. In special circumstances, H-O-A may be required. Consult with UCB Owner's Representative.
- f. Pilot Light: Provide with RED and GREEN pilot lights mounted in the cover. The pilot light lamp shall be LED type. RED means motor on and GREEN means motor off.
- g. All starters shall have disconnect switches.

#### 4. Manufacturer and Vendor

- a. Starters with Electronic Overload Relays:
  - i. Manufacturers:
    - 1. Siemens
    - 2. Eaton
    - 3. Allen Bradley
    - 4. Schneider/Square D
- b. Separately Mounted Starters:
  - i. Starters for fractional horsepower 120V motors shall be manual type unless shown otherwise, equipped with built-in overload protection and pilot light:
  - ii. Manufacturers:
    - 1. Siemens
    - 2. Eaton
    - 3. Allen Bradley
    - 4. Schneider/Square D
- c. Pilot Lamps, LED Type:
  - i. Manufacturer :
    - 1. Ledtronics, Inc., or equal.

### 26 29 23 *Variable-Frequency Motor Controllers*

#### 1. Scope Of Work

- a. These guidelines define the minimum performance requirements for Variable Frequency Drive (VFD) assemblies for use on a standard NEMA Design B induction motor.

#### 2. Coordinate with Section 23 05 00 *Common Work Results for HVAC*, Subsection 13, *Variable Frequency Drives Serving HVAC Equipment* for additional requirements of VFDs serving HVAC equipment.

#### 3. Information Required Of Bidders

- a. Bidding Documents shall require each bidder to provide names, addresses and phone numbers of not less than ten (10) existing installations in the immediate geographical area.



- b. Each bidder shall list any exceptions to these guidelines. If no departures are listed with the bid, the Contractor shall be bound by the Specifications.

#### 4. Warranty/Guarantee

- a. The VFD shall be warranted against defects in material and workmanship for at least one (1) year after Project acceptance.
- b. Additional warranty coverage shall be available in the form of an annual service agreement at an annual fee based on the capacity of the VFD.

#### 5. Quality Assurance

- a. Each VFD shall be designed and manufactured in accordance with the latest revisions of the following applicable codes and standards:
  - i. Institute of Electrical and Electronic Engineers (IEEE).
  - ii. IEEE Standard 519-1992, Guide for Harmonic Control and Reactive Compensation for Static Power Converters
  - iii. American National Standards Institute (ANSI)
  - iv. Underwriters Laboratory, Inc. (UL)
  - v. UL Standard 508, Electrical Industrial Control Equipment
  - vi. Canadian Standards Association (CSA)
  - vii. National Electrical Code (most current edition)
  - viii. National Electrical Manufacturer's Association (NEMA) ISC 6, Enclosures for Industrial Controls and Systems.
- b. The VFD shall be UL listed, as one (1) entire assembly, and bear the UL label.
- c. Circuit boards shall be completely tested and burned-in prior to assembly into the completed VFD.
- d. The VFD manufacturer shall have a failure analysis laboratory to evaluate the failure of any component.
- e. A site-specific preliminary harmonic analysis, showing total voltage harmonic distortion (THD) and total current harmonic distortion without additional external devices or external filters shall be submitted by the VFD manufacturer for approval by the Owner's Representative. Power quality shall be a key factor when reviewing a proposal. Preliminary analysis shall be accepted by UCB prior to drive purchase. Compliance shall be empirically verified by the VFD manufacturer with onsite field measurements of the harmonic distortion at the point of common coupling with and without VFD's operating. The building distribution transformer(s) shall be the point of common coupling. In the event that field measurements demonstrate that harmonic distortion exceeds the levels claimed by the VFD manufacturer, the VFD manufacturer shall provide and install (at no additional cost to the University) the equipment required to reduce harmonic distortion to acceptable levels.

#### 6. Manufacturers

- a. The following VFD manufacturers shall be considered to be of acceptable quality. Certain models by the following manufacturers may or may not meet the requirements of these specifications. Consult with UC Berkeley Electrical Engineer.
  - i. Asea Brown Boveri (ABB)
  - ii. T. B. Woods
  - iii. Toshiba
  - iv. Safetronics
  - v. Danfoss Graham

#### 7. General Requirements

- a. The VFD shall be of an advanced Pulse Width Modulation (PWM) type capable of achieving full motor performance with no derating of motor output due to current waveform distortion. The VFD

shall be capable of operating multiple motors in parallel with the ability to switch motors on and off independently via external contactors. In addition, the VFD shall include the following ratings, adjustments, and parameters:

- i. Power Unit Rating: one hundred percent (100%) continuous, one hundred ten percent (110%) intermittent for one (1) minute when previously operating at full load.
  - ii. Minimum Efficiency: ninety percent (90%) at maximum output; eighty-five percent (85%) at fifty percent (50%) output
  - iii. Rated Input Voltage: 480V, 3 phase, 60Hz and 208V 60Hz available.
  - iv. Output Voltage: 0-480V or 0-230V 60Hz.
  - v. Allowable Wire Length to Motor: 200 ft. (unless VFD schedule shows greater wire length)
- b. The VFD shall be capable of operating in the following service conditions:
- i. Ambient Temperature: 0 to 40 degrees C (32 to 104 degrees F)
  - ii. Relative Humidity: 0 to 95 percent, non-condensing.
  - iii. Elevation: 0 to 3300 feet (100 meters) above MSL.
  - iv. AC line Voltage Variation:
    1. 480 V: Minus 5 percent to plus 10 percent; 58-62 Hz.
    2. 208 V: Minus 5 percent to plus 10 percent; 58-62Hz.
  - v. Singularly, each VFD shall produce a maximum of three percent (3%) harmonic voltage distortion (THD) without additional external devices or external filters, and simultaneous operation of multiple VFD'S shall not add more than five percent (5%) total harmonic voltage distortion back to the bus when measured at the point of common coupling without additional external devices or external filters. The building distribution transformer(s) shall be the point of common coupling.

#### 8. Adjustments - Auto, Manual, Bypass

- a. The VFD shall operate in the AUTO or MANUAL modes and, at a minimum, shall include the following front panel mounted switches and indicators:
  - i. Local/Remote switch.
  - ii. Digital Indicator of Frequency, Current, Volts, Torque, Hp, kW, kWhrs.
  - iii. Manual allowing speed control.
  - iv. Run/Stop Switch.
  - v. Fwd/Rev Switch.
  - vi. Power on and run indicator.
  - vii. Fault indication including: current limit, overvoltage, undervoltage, overload, or thermal motor protection.
- b. The VFD shall have provisions to lock out unauthorized access to alter or reprogram the VFD's setpoints.

#### 9. Control Requirements

- a. The VFD shall be capable of operation with either a two-wire maintained contact motor control circuit or a three-wire start/stop momentary contact motor control circuit. In addition, the VFD must accept the inputs and provide the outputs listed below:
  - i. Communicator to DDC, interface with BACNET.
  - ii. Analog Input: 0-10Vdc, 0-20mA, 4-20mA, 20-0mA or 20-4mA. Linearity deviation between control signal and motor speed: Plus or minus one percent (1%) of rated motor speed.
  - iii. Digital Inputs: Four (4) each programmable for reset, start, stop, quick stop, change to preset speed, change parameter set, increase speed, decrease speed, current limit over ride.
  - iv. Analog Outputs: Four (4) each programmable to provide 0-20mA or 4-20mA proportional to frequency, torque, current or power (Kw.)

- v. Digital Outputs: Two (2) each programmable to indicate ready, run, trip, current above preset, frequency above preset, or electronic thermal overload.

#### 10. Manual By-Pass

- a. A manual bypass device shall be provided for all VFDs that control motors used in any of the following circumstances: 1) Ventilation in laboratories; 2) Ventilation in animal laboratories or rooms; and motors fed from wire size #8 and larger. In terms of horsepower, that means that 460 volt motors 25 hp or larger require a by-pass device. Similarly, 208 volt motors 15 hp or large require a by-pass device.
- b. Manual transfer to line power shall be via 3 contactors sized for applicable voltage and motor current. One contactor shall be between the VFD output and the motor. The second shall be between the by-pass power line and the motor, providing across-the-line starting. The third contactor shall be between the line voltage and VFD input. Transferring load via contactors shall disconnect VFD inputs from line voltage and outputs from the motor, thus providing the ability to safely trouble shoot and test the VFD while operating in the by-pass mode. A fused disconnect switch is required. By-pass and VFD output contactors shall be electrically and mechanically interlocked to prevent both being closed at the same time. Include motor thermal overload protection in by-pass and VFD modes.
- c. Door mounted status lights shall include power on, drive, and by-pass.
- d. Provide a terminal strip for connection of fire, smoke contacts, external start command, and VFD control signal. All external interlocks shall function in hand, auto, or by-pass. External start/stop signal shall be functional in auto and by-pass modes.
- e. 120VAC control power to be supplied by a fused transformer.
- f. Manual by-pass and accessories to be furnished and mounted by the VFD manufacturer.

#### 11. Automatic By-Pass With Magnetic Contactors

- a. In rare applications, such as critical service pumps with no secondary pump for backup, the VFD shall be specified with automatic bypass. The automatic bypass shall include all of the features specified in the manual bypass plus the following additional feature:
  - i. Output from the VFD run contact shall control the contactors so that a VFD failure shall automatically transfer the motor to across-the-line starting.

#### 12. Start-Up Commissioning

- a. The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. The commissioning personnel shall be the same personnel that will provide the factory service and warranty repairs at the Owner's site. Sales personnel and other agents who are not factory certified technicians for VFD field repair shall not be acceptable as commissioning agents.
- b. Start-up services shall include checking for proper operation and installation of the VFD, its options and its interface wiring to the building automation system. At a minimum, this service shall include:
  - i. Verification of wire terminations to the VFD and its optional circuitry.
  - ii. Up to one (1) hour per drive of operator training of operation and service diagnostics at the time of equipment commissioning.
  - iii. Measurement for verification of proper operation on each of the following items:
    - 1. Motor voltage and frequency. Verify proper motor operation.
    - 2. Control input for proper building automation system interface and control calibration.
    - 3. Calibration for the following set points (and adjust as necessary): minimum speed, maximum speed; acceleration and deceleration rates.
  - iv. Three hard copies and one electronic copy (PDF format) of all Operation and Maintenance Manuals shall be provided for each unit.

### 13. Shaft Grounding

- a. Shaft Grounding on all VFDs is required.
- b. Modern AC or DC variable speed motors have been shown to develop an electrical potential between the shaft and the frame of the motor. There are two different approaches to shaft grounding depending on whether the installation is new, or a retrofit. For new motor installations, a shaft grounding ring shall be factory installed. The ring is installed behind the end plate to keep it protected from the environment. An example of this installation is the Baldor Super-E motor.
- c. For retrofits of existing motors, the following shall be installed:
  - i. Product: Shaft Grounding Systems (Patent Pending).
  - ii. Manufacturer: Shaft Grounding Systems, Inc., or equal.
  - iii. Product Class: Shaft Grounding System (Patent Pending).
  - iv. Trade Name: Shaft Grounding System.
  - v. Manufacturer Code Identification: See specific model number.
  - vi. Materials: The products manufactured by Shaft Grounding Systems contain only stable materials commonly used within industry. These are not believed to constitute a hazardous material under Office of Safety and Health Act (OSHA) regulations.
  - vii. Brushes: Specifically developed proprietary carbon compounds are used in Shaft Grounding Systems to ensure sustained performance. At present, the brush wear life expectancy is from three (3) to five (5) years based upon data obtained from running these brushes for over two (2) years in continuous industrial applications.
  - viii. Seals: In systems designed for wet, or severe, environment applications, the brush contact area is sealed to keep contaminants from entering the Shaft Grounding System. The proper use of Shaft Grounding Systems will generate very small amounts of particulate wear products. In systems designed for Clean Room use, the wear products are contained within a special enclosure within the Shaft Grounding System. This makes the clean room systems suitable for use in all Clean Room air handling applications. The wear products are from the carbon based electrical brush and the bronze material upon which the brush makes contact.
  - ix. Performance: The Shaft Grounding System is designed to reduce shaft voltage levels to less than three (3) volts typically required for current to pass through bearings. Shaft voltages without Shaft Grounding Systems typically range from three (3) to thirty (30) volts, or higher.

26 30 00      Facility Electrical Power Generating and Storing Equipment

26 36 00      Transfer Switches

26 36 23      Automatic Transfer Switches

#### 1. Transfer Switch Shall:

- a. Have a full rated neutral with lugs for NORMAL, EMERGENCY and LOAD neutral conductors inside cabinet (4-pole with a switched neutral).
- b. Be equipped with direct acting linear operators for simple, reliable and fast acting during automatic operation.
- c. Be factory equipped with the programmed transition delay feature. This feature shall provide a field adjustable time delay during switching in both directions, during which time the load is isolated from both power sources, to allow residual voltage of motors or other inductive loads (such as transformers) to decay before completing the switching cycle. The programmed transition feature shall have an adjustable time of 0 to 7.5 seconds minimum.

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- d. Have signal before transfer contacts, adjustable from 0.1 to 10 seconds, to send a signal to elevators or other controls prior to transfer.
- e. Have a bypass/isolation feature to allow racking out of the ATS for inspection and service without interruption of electrical service. This requirement may be waived in smaller, non-critical and non-research facilities. Consult with Campus Electrical Engineer.
- f. Be equipped with an in-phase monitor. This will allow momentary paralleling with utility power when transferring from normal to emergency or from emergency to normal power.

## 2. Front Panel Devices

- a. Provide devices mounted on front of main cabinet door consisting of switch position indicator lights, white NORMAL, amber EMERGENCY, normal source available green, emergency source available red, and key operated switch to provide the following positions and functions.
  - i. TEST: Simulated normal power loss to control unit for testing of generator set, including transfer of load.
- b. Provide ammeter, voltmeter, and frequency meters.

## 3. Manufacturer

- a. Suggested Manufacturer: Cummins-Onan Power Generating Systems, ASCO, Russelectric, or equal.

## 26 50 00 Lighting

### 1. Lighting Luminance

- a. The Project shall meet the current requirements of the most recently adopted version of the California Electrical and California Energy Codes. The Contractor or subcontractor or commissioning agent retained for the project shall submit documentation of this compliance.
- b. General illumination levels shall be based on the latest standards published by the Illuminating Engineering Society of North America. Consult with Capital Projects (CP) for certain areas where lower illuminance is acceptable for energy savings. Lighting calculations shall be based on actual predicted reflectances in coordination with the architect and/or landscape architect. Where actual reflectances cannot be determined, use realistic maintained average values for ceiling, wall, and floor reflectances. The designer shall submit calculations and documentation of target luminance.
- c. Suggested values for maintained average illuminance readings in typical spaces are as follows:
  - i. Classrooms - 30 fc.
  - ii. Offices - 30 fc.
  - iii. Laboratories - 50 fc,
  - iv. Circulation Areas – 5-10 fc.
  - v. Pedestrian pathways and plazas - .5 fc
  - vi. Fire Marshal-designated building entries and entry paths – 1 fc
  - vii. Consult with the annual Campus Safety Guide prepared by UCPD concerning designated night time walking routes or with the Campus Architect.
- d. The Illuminating Engineering Society (IES) light levels recommended in its Lighting Handbook shall be used as a guide for campus outdoor lighting. Campuses shall also consider IES activity levels (high, medium, and low) in the design of lighting in open parking facilities. These activity levels reflect both vehicular and pedestrian activity. In open parking situations, the majority of a campus' activities are categorized as "low activity" ("Educational Facility Parking"). However, there may be some open parking situations that are classified as "Medium Activity" (residential complex parking or cultural, civic, or recreational events).
- e. Local blackboard lighting is normally undesirable. General lighting may be concentrated near blackboards for increased vertical illumination.

- f. Entire building lighting (or portion thereof) may be controlled by a Lighting Management System, Wattstopper or approved equal.
- g. Photocell shall be mounted at a workable height and location.

## 2. Green Building

- a. All new construction and major renovations must meet the current UC policy and procedure requirements included in the UC Sustainability Practices Policy: <http://ucop.edu/sustainability/policy-areas/index.html>. The UC Sustainability Practices Policy provides guidance on the required sustainable energy systems and on UC's USGBC LEED certification and credit requirements.

### 26 51 00 *Interior Lighting*

#### 1. Circulation Area Lighting:

- a. Stairwell fixtures shall be easily accessible for maintenance and shall provide illumination in accordance with current IES recommendations.
- b. Provide emergency egress lighting in each stairwell and corridor to meet minimum light level and duration requirements as required by the latest edition of the California Building Code.
- c. Locate light switches, vacancy and occupancy sensors for lobbies, corridors, stairwells and similar circulation areas to accommodate persons entering or leaving the building at night. Locate devices to turn on lights ahead and turn off lights behind as the person moves through the building. Provide controls at each elevator landing to control corridor lights to meet this requirement per elevator code requirements.
- d. Design corridor light circuits so that a small number can be left on for night service and for extended building shutdowns, such as the winter holiday/energy curtailment period. This typically requires an active fixture at each change of corridor direction. The non-active fixtures shall be circuited to be controlled by a Lighting Management System.
- e. Provide appropriate circuiting and either photoelectric or Lighting Management System switching for daylighted portions of circulation areas, so that fixtures in these areas will normally be off during the daytime.

### 26 51 13 *Interior Lighting Fixtures, Lamps and Ballasts*

#### 1. Lighting Fixtures:

- a. Pendant Fixtures shall be Finelite Series 12 LED, Prudential Wave2 Linear LED, or approved equal. Fixtures shall be clearly and permanently marked with the UL label and the manufacturer's name and model number. LEDs shall have a minimum rated lifespan of 100,000 hours, a color temperature of 4000k and a minimum CRI of 80 (90 is preferred).
- b. Troffer or acoustical ceiling fixtures shall be Finelite HPR-LED, Prudential Wing LED, or approved equal. Fixtures shall be clearly and permanently marked with the UL label and the manufacturer's name and model number. LEDs shall have a minimum rated lifespan of 100,000 hours, a color temperature of 4000k and a minimum CRI of 80 (90 is preferred).
- c. Special lighting fixtures chosen for architectural or decorative purposes must be owner-serviceable, with replaceable LEDs and Drivers and approved as a variance by the Campus Architect and the Campus Building Official. Fixtures without replaceable LEDs and Drivers will not be approved.
- d. In areas where egress lighting must be provided, provide circuiting to emergency power. Where emergency power is insufficient or unavailable, specify battery- or capacitor-assisted drivers to provide required egress lighting.
- e. Provide local lighting controls in all rooms except for special cases such as auditoriums, libraries, and theaters. Central lighting controls for such spaces shall comply with code requirements and

approved by the Facilities Services Energy Office and Facilities Services Electrical Shop. Programmed control of lighting must be accomplished by means of campus EMS, or by dedicated Lighting Management System by Wattstopper, or approved equal.

- f. To conserve energy, control areas separately, and provide convenient switches, vacancy and occupancy sensors, Lighting Management for areas with different use patterns as required by the latest edition of the California Electrical and Energy Codes. Provide vacancy or occupancy sensors for classrooms, circulation areas, lounges, and other spaces in which occupants do not feel ownership and are likely not to turn off the lights.
- g. Check and coordinate lighting fixtures with other ceiling elements including fire sprinkler layouts, mechanical diffusers, grilles, speakers, smoke detectors, clearances to structure, insulation, ductwork and piping with the architect and mechanical engineer. Obtain approval from the Campus Fire Marshal layouts of multiple systems.
- h. In remodel work that involves significant light fixture replacement, contractor shall provide the University with copies of fixture invoices, to facilitate any potential rebates from utility or state entities.
- i. Fixtures for special close work tasks shall illuminate the task area only.
- j. Support all lighting fixtures to resist both gravitational and seismic forces in compliance with code requirements. Additionally, comply with other seismic requirements in this Division as applicable.
- k. Do not mount fixtures against combustible surfaces without approved spacers as listed in the UFC, the NEC, and the CBC.

## 2. Lamps:

- a. Exceptions to the following standards shall be approved prior to the start of the design phase by Facilities Services Energy Office and Electrical Shop.
- b. Specify LED lamps unless otherwise approved.
- c. In new construction and renovation, the fixtures shall be Finelite Series 12 LED, Prudential Wave2 Linear, or approved equal. Finelite and Prudential provide replacement LED strips and drivers for these fixtures, and replacement of strips or drivers shall be performed by Facilities Services Electrical Shop or by contractors working in concert with them.
- d. In retrofit projects, lamps and drivers shall be of the General Electric LumenChoice Type C Tube and Driver system (no known equal).
  - a. Tubes are to be LEDT8/LC/G/4/840 or LEDT8/LC/G/2/840, 4000k Color Temperature,
  - b. Drivers shall be General Electric LumenChoice Model LED/DR/D2L/LW or LED/DR/D4L/LW for standard installations, or model LED/DR/D2L/HW or LED/DR/D4L/HW in installation where higher light output is necessary
    - i. These drivers allow for switched, fixed dimming where illumination may be too high in a given area. These options should be exercised by the project in consultation with Facilities Services Energy Office and Electrical Shop.
- e. All lamps shall be new and properly operating at the time of commissioning and acceptance of the electrical work.

## 26 52 00 [Emergency Lighting](#)

### 1. Emergency Lighting Systems

- a. In addition to code requirements, install emergency lighting systems where required for personnel safety. Provide central battery or engine generator type or separate battery-powered portable type depending on the application. Discuss with Capital Projects (CP).
- b. Exit Discharge must be illuminated, with emergency lighting, when building is without power or operating on emergency power.
- c. Areas directly outside of Exit Discharge must be illuminated similarly.



## 2. Emergency Exit Signs

- a. Signs shall be Light Emitting Diode (L.E.D.) exit sign by Hubbell Prescolite or equal.
- b. Visibility compliance
  - i. Routes must be marked every one hundred feet (100'-0") with illuminated exit signs.
  - ii. Minimum luminance must be fifty (50) lux on the face of the sign and 1 ft-candle (10 lux) at any point, .1 ft-candle at the floor level. Levels may decline by no more than 60% over the 1.5 hour minimum lighting period.
  - iii. Signs shall be no more than two hundred feet (200'-0") apart in a corridor.
  - iv. Signs shall be clearly visible along the exit route.
  - v. No other high visibility signs may be located in proximity the Exit signs.
  - vi. Signs may flash upon activation of Fire Alarm.
- c. Code applications
  - i. An Exit sign shall be at every exit door.
  - ii. Directional Exit signs are required at intersection of all corridors, exits to stair and exits to ramps.
  - iii. Signs shall be of Non-flammable material.
  - iv. Illuminated signs shall be UL924 listed.
  - v. All supplied exit signs shall include a self-test feature to auto run required monthly and annual system tests and provide visible indication (LED) that tests have run and are successful.

## 26 56 00 Exterior Lighting

### 1. General:

- a. Consult with the Campus Architect and Outdoor Lighting Master Plan on lighting design guidelines (e.g., foot candle/light trespass, illuminance, uniformity, glare and temperature) for different campus contexts (e.g., pathways, gathering spaces, ceremonial spaces, features/accents, transit stops, bike parking areas). In general, the campus goal for exterior lighting is to promote safety and create visibility by creating layers of light, as well as reducing light pollution and energy consumption.
- b. Integrally designed architectural lighting or free standing pedestrian lighting is preferred around structures. Wall pack lighting is not preferred, but where necessary they shall use LED lamps. Light fixtures shall generally include cut-off shields as needed to prevent light trespass into neighboring off-campus areas; however, some trespass may be allowable in lower-density areas, such as through glades and natural areas, where minimal light spill enhances safety.
- c. Per the Outdoor Lighting Master Plan, projects should provide adequate levels of egress lighting (0.5fc) to the primary and secondary campus pedestrian pathways.
- d. Type 4 lights throw light lengthwise and should be used for pathways. Type 5 square lights are best used at pathway intersections or open areas.
- e. Distance between lighting and vegetation shall not be less than five feet (5'-0"), unless lighting is being used as a landscape feature that creates additional light spill onto pathways or gathering spaces, as approved by the Campus Architect.
- f. For ornamental/architectural lighting and lights at fountains or other special features, consult with the Campus Architect.
- g. Pedestrian and bicycle parking area lighting shall be downlit.
- h. Lights for dumpster areas shall be operated by motion detectors.
- i. Subgrade installed uplights gradually develop moisture issues and are difficult to maintain. Uplights mounted above grade are preferred.
- j. Shoebox luminaries are acceptable at parking lots off of the central campus.



## 2. Circuiting

- a. For landscape development, include a conduit system to an exterior electric handhold and provide panel board circuits in the building for landscape lighting. Consult with Capital Projects (CP) for sizing and location.
- b. Outdoor lighting to be on emergency power wherever available.
- c. Street and path lighting shall be on staggered circuits to ensure that any two (2) adjacent fixtures will be on different circuits. All pole lights shall be individually fused.
- d. Lighting circuits shall be activated and deactivated by a photoelectric cell which controls a lighting contactor. A by-pass with spring wound, twelve (12) hour timer shall be installed to enable troubleshooting. Brand: Intermatic, Model: FF12HHC, Description: 12 Hour Time Limit with Hold. See Appendix A: Drawings for a typical schematic detail.
- e. Conduit size shall be 1-inch minimum. Materials shall be as follows.
  - i. Rigid conduit, wrapped or PVC coated.
  - ii. PVC, Sch 80 meeting proper depth requirements by NEC.
  - iii. High Density Polyethelene (HDPE)
- f. Minimum wire size shall be #8 AWG copper stranded wire between the source and the first pole and between poles.

## 3. Fixtures and Lamps:

- a. Pedestrian pathways in the classical core shall generally use Sentry Electric Corp Models SBP-NB-LEDV18C-0.7A-830-KHT4 or SBP-NB-LEDV18C-0.7A-830-KHT5SQ, with 26W, 3,000K, cast aluminum decorative luminaire, black finish, polycarbonate diffuser globe with integral 3,000K LED and 3" post top fitter or approved equivalent if allowed by Campus Architect.
- b. Posts shall be cast iron fluted poles, thirteen feet (13'-0") high, Sentry Electric Corp Model SCI-NY20-13'
- c. Cross arms for double-headed lights shall be Sentry Electric Corp decorative cross arm model: SAL-WB-2 Black, with standard plate.
- d. 3000K post top retrofit system shall be Philips Lighting or approved equivalent. Type 4 lights throw light lengthwise and should be used for pathways. Type 5 square lights are best used at pathway intersections or open areas. Designer shall specify the appropriate fixture depending on pole location.
- e. Pathways outside the classical core may use other fixtures as approved by the Campus Architect.

### 26 56 13 *Lighting Poles and Standards*

3. Cast iron fluted poles shall be thirteen feet (13'-0") high, catalog #SCI-NY20-13' as supplied by Sentry Electric LLC, Freeport, NY. This is a special casting for the University of California, Berkeley campus. Factory prime and paint on site to campus standards ("Elephant Breath"). Set concrete footings flush with grade in paved areas and two inches above finished grade in landscape areas. Footings shall be twenty-four inches (24") in diameter by fifty-four inches (54) deep. For double-headed lights, use Sentry decorative cross arm model SAL-WB-2 Black. Use of other materials as aluminum or polycarbonate may be allowed as approved by the Campus Architect.
4. Post spacing shall ensure sustainable, required application head to head foot-candle coverage, generally 0.5 foot-candles.
5. Hand holes are sufficient at each pole. In areas where the distance between poles exceeded one hundred feet (100'-0"), concrete pull boxes shall be installed.
6. Conduit runs to contain a proper sized grounding conductor. The grounding conductor shall be bare and bonded to each pole. Ground the circuit at the source panel.
7. Each pole shall have a water-tight in-line fuse.



27 00 00 Communications

27 00 00 Communications

The specifications for communication systems and its support infrastructure are detailed in the Information Services & Technology (IS&T) Telecommunication Standards. They can be found on the Design & Project Management page at: <https://technology.berkeley.edu/services/telecom-dpm>. Questions regarding their implementation should be directed to [cns-projects@berkeley.edu](mailto:cns-projects@berkeley.edu). For any work that affects telephone systems, consult the Campus Wired Phone Policy: <http://campuspol.berkeley.edu/policies/wiredphones.pdf> as well as <https://technology.berkeley.edu/voice>

28 00 00 Electronic Safety and Security

28 10 00 Electronic Access Control and Intrusion Detection

28 13 00 Access Control

1. General Information

- a. The following pages provide a general specification format for card access control systems being installed on the Berkeley campus. The Specification format provides areas for a user to insert appropriate details for the specific installation. Most of this detail will be provided through analysis of the UC Police Department Crime Prevention Security Survey of the area to be controlled.
- b. All card access control systems interconnected to the University of California Police Department (UCPD) must meet the technical requirements of this Specification to provide required stability, and compatibility required for interconnect to the Police Department's computer.
  - i. Description: Provide general description of project in this section.
  - ii. The Contractor shall be an authorized dealer for Software House hardware and Hughes Identification Devices, and be thoroughly familiar with all aspects of the access control hardware.
  - iii. Coordinate final devices with the architect's hardware consultant.
  - iv. The Contractor shall be thoroughly familiar with the operation of the CCURESystem 1 Plus access control software manufactured by Software Housing of Cambridge, MA.
  - v. Coordination with Management: All work on systems described herein shall be completed in coordination with building management and University of California Police Department Crime Prevention Bureau personnel to provide a consistent level of service. Coordinate closely with the University University's Representative to obtain latest system requirements, to develop scope of work, and to obtain list of pre-approved vendors.
  - vi. University of California Representatives and On-Site Inspections:
    1. Questions on content of this Specification, bid variance or other modifications, all required responses and submittals shall be directed to the University University's Representative.
    2. Arrangements for on-site inspections and for answers to technical questions related to equipment or specifications for installation, modification, or repair work to be performed as part of this contract shall be directed to the University University's Representative who will coordinate with the University of California Police Department.

2. Automated Access Control Equipment

- a. Description:
  - i. This chapter describes acceptable automated access control hardware for use where such hardware is referenced hereafter in this Specification.
  - ii. The system shall operate on a proximity principle where card insertion in a reading device is not required.
  - iii. All access devices are to be mounted in accordance with accessibility height requirements.

- b. Equipment Performance:
- i. The access controller shall be an intelligent access control and alarm monitoring microprocessor based unit. It shall accommodate the following functions at a minimum:
    1. Eight (8) external card reading sensors.
    2. Eight (8) supervised general purpose input points.
    3. Sixteen (16) supervised input points.
    4. Eight (8) programmable relay output points.
    5. Direct connect or dial-up communication mode.
    6. The approved panel shall be the Software House Istar Pro.
  - ii. Proximity Card Reading Sensors:
    1. The proximity card reading sensors shall be vandal-proof and weatherproof sealed solid state units having no slots or other openings.
    2. It shall read the ID credential when it is held within 4 - 5.5<sup>2</sup> (10 - 14 cm) of its surface and transmit this unique ID to the proximity card reader module.
    3. Readers to be installed per manufacturer's specifications; some readers cannot be mounted on metal.
    4. The sensors shall be designed to operate properly within the temperature range of -22 to 150 degrees F (-30 to 65 degrees C) and within a relative humidity range of 0 - 95% noncondensing. No special housing or treatment shall be required for outdoor use.
    5. Physical damage, including breaking open of the sensor housing, shall not allow a perpetrator access to any circuitry which would allow the system to be compromised.
    6. Transmission of any frequency (or set of frequencies) in the sensor at any power level shall not compromise the system.
    7. Presentation of an invalid set of frequencies (such as would occur if a perpetrator were attempting to pick the system) shall temporarily disable the sensor - thus eliminating the possibility of sweeping the system and finding a valid combination.
    8. The approved proximity card reader shall be HID R-class Multi-tech reader or Software House Multi-format proximity reader, whichever is most appropriate for the application.
  - iii. Elevator Controlled Units:
    1. The Contractor shall use self-supporting Software House approved elevator traveler cable.
    2. There shall be a totally functional elevator override system for Fire Department or service use.
    3. The elevator shall be installed to shut itself down during a fire alarm, with no instructions from the system computer.
    4. For non-secure buildings, the system shall be hard-wired into the fire system panel to automatically unlock doors during a fire alarm.
  - iv. Proximity Command Key:
    1. The ID credential shall be a credit card size passive component with the coding technique contained inside: i.e., not visible from the outside.
    2. It shall be warranted for at least fifteen (15) months under normal use conditions.
    3. Each key shall contain a number not shared with any other key in that system.
    4. Proximity card formats are 26-bit Wiegand and Corporate 1000, issued by the Cal-1 Card Office.

- v. Modems:
    - 1. Modems are not permitted. Card access panels shall communicate via IP addressing.
  - vi. Housing: All equipment shall be housed in a local door junction box, with a key lock
  - vii. Power Modules:
    - 1. The power modules shall provide for converting the available commercial power to the power required by the proximity card readers, as well as power on/off switching, fault protection, and power on indication. The wiring between the power module and the powered device(s) shall be integral and require only a plug in connection.
  - viii. Locking Hardware
    - 1. All locking hardware shall have rim mount strikes.
    - 2. Locking hardware shall accommodate a small format interchangeable (sfic) keyway.
    - 3. All locks shall default to fail secure, upon loss of electrical power.
  - c. Wiring Requirements:
    - i. All access control wiring of size 18 gauge or smaller shall be stranded copper or tinned copper wire to minimize risk of breakage from movement or impact by a foreign object. Wiring shall be of a sufficient size to carry maximum currents found in the associated circuit(s) and still maintain equipment voltages at a continuous operational level throughout the system.
    - ii. All wiring for door readers shall be of size 18 gauge.
    - iii. All exposed wiring runs shall be enclosed in conduit or wire mold; armored sheath must cover wiring between conduit/walls and associated access control panels, contacts, and sensors to prevent tampering with wiring.
    - iv. Wiring inside walls or ceilings will not be considered exposed wiring.
    - v. All wiring shall be clearly labeled at each termination point to show the origin and use of the wire (or pair of wires or cable); an identification scheme (numbers and/or letters for designation) may be used in conjunction with circuit diagrams referenced in Section 6 of this Specification.
    - vi. Any exception to provisions of this section must be approved in writing by the UC Police Department Crime Prevention Unit.
3. Approved Signaling Systems
- a. General Information: Access Control controller panels shall employ the following signaling system to communicate access information from the user premise to the University of California Police Department Computer Room.
  - b. Dedicated Communication Line:
    - i. Access control panels communicate with the Sproul Hall server via IP addressing on a restricted UCPD subnet. These network drops shall be ordered through campus IS&T. Only Crime Prevention Unit employees can request such drops.
    - ii. Coordinate closely with the University University's Representative on provision of:
      - 1. Communications lines.
      - 2. Communications conduit.
    - iii. This system is a partially supervised system. Loss of communication results in an internal computer alarm being received at the Police Department. This condition may or may not be noticed by the user department depending on the use of the auto unlock feature.
4. Standards and Guarantees

- a. Technical Standards: Equipment to be supplied shall conform, unless otherwise indicated, to the current applicable standards of the following organizations or documents:
  - i. American National Standards Institute (ANSI).
  - ii. Electronics Industries Association (EIA).
  - iii. Federal Communications Commission (FCC).
  - iv. National Electrical Code (NFPA-70).
  - v. National Electrical Manufacturers Association (NEMA).
  - vi. Underwriter's Laboratories (UL).
  - vii. US Occupational Safety and Health Administration (OSHA).
- b. Contractor's Provisions, Equipment and Hardware:
  - i. The term Contractor, as used in the remainder of this section, refers to the Contractor or original equipment manufacturer if manufacturer's original equipment warranty and repair service is applicable.
  - ii. The Contractor shall provide the following services that will repair or exchange, in the times indicated, all defective parts and assemblies returned by the University for repair:
    - 1. Emergency no-charge warranty service within five (5) calendar days, excluding shipping time, for defective items returned within the appropriate guarantee time specified herein.
    - 2. Non-emergency no-charge warranty service within twenty (20) calendar days, excluding shipping time, for defective items returned within an appropriate guarantee period specified herein.
    - 3. Emergency full-charge non-warranty service within five (5) calendar days, excluding shipping time, for defective items returned after expiration of the guarantee period specified herein.
  - iii. For a period up to one (1) year after Substantial Completion, and upon order placement, the Contractor shall supply to the University exact replacement plug-in modules, printed circuit board assemblies, and specialized parts for use in the equipment delivered in accordance with this Specification. Coordinate with Division 1 contract guarantee requirements.
- c. Minimum Guarantees, Equipment and Hardware:
  - i. All parts and materials employed in delivered equipment which normally require installation shall be guaranteed by the Contractor against mechanical, electrical and workmanship defects for one (1) year from date of system acceptance.
  - ii. All parts and materials employed in delivered equipment requiring no installation shall be guaranteed by the Contractor against mechanical, electrical and workmanship defects for a period of one (1) year from the date of delivery.
  - iii. A manufacturer's shop drawing defect, for the purpose of this standard, shall be defined as identical failures occurring within one (1) year after delivery in at least five or five percent (5%) of total, whichever is larger, of identical assemblies, subassemblies, or parts, supplied on the same contract.
  - iv. Delivered items shall be guaranteed by the Contractor against manufacturer's shop drawing defects for one (1) year from the date of system final acceptance. Upon written notification and confirmation by the Contractor of shop drawing defects evidenced within the one (1) year guarantee period, the Contractor shall take corrective action at the equipment site within five (5) calendar days at no cost to the University.
  - v. Whenever it is necessary for the Contractor to take corrective action for shop drawing defects in a delivered item, the Contractor shall take the same corrective action in all identical equipment delivered on the same purchase order.

- vi. All parts and materials used in corrective action for shop drawing defects shall be guaranteed by the Contractor against mechanical, electrical, and workmanship defects for one year from date of such corrective action.
  - vii. Guarantee, other than for shop drawing defects, shall include parts and materials during appropriate guarantee period specified herein and on-site labor guarantee period of one (1) year after Final Acceptance for equipment installation or after equipment delivery if installation is not applicable.
  - viii. If the Contractor has not completed on-site guarantee repairs within five (5) calendar days after notification of malfunction, the University may complete such repairs and bill the Contractor for material and labor costs at the current Government Technician hourly rate.
  - d. Minimum Guarantees, Material and Workmanship:
    - i. Workmanship and materials provided by the Contractor in performance of any initial installation or modification work required in compliance with this Specification shall be guaranteed for a period of one year after date of system acceptance. Workmanship or materials found to be defective during this period shall be corrected by the Contractor within five (5) calendar days at his expense.
    - ii. Workmanship and materials provided by the Contractor in performance of any maintenance work required in compliance with this Specification shall be guaranteed for a period of one (1) year after maintenance work is completed. Workmanship or materials found to be defective during this period shall be corrected by the Contractor within five (5) calendar days at his expense.
5. Detailed System Specifications
- a. This section is reserved for a detailed description of the proposed system. It should follow the same format as the remainder of this specification.
  - b. The Police Department Crime Prevention Bureau's Security Survey of the facility which will use the automated access control system will usually provide sufficient detail for a designer to complete this specification.
  - c. The Crime Prevention Bureau maintains Specifications from other projects which may be used as a guideline in preparing this Chapter.
6. System documentation
- a. The contractor shall supply complete installation and operation manuals for each system component or sub-assembly.
  - b. The contractor shall supply applicable Federal Communications Commission (FCC) type acceptance number for new systems or modifications where changes are made to equipment interconnected to the public telephone network.
  - c. The contractor shall supply as-built wiring diagrams which show location(s) of all equipment and wiring for the access control system. For installations where wiring is identical for several systems, the Contractor need only supply one set of diagrams referencing all applicable locations. Wiring diagrams include:
    - i. Block diagram of system showing major components, junction blocks, panels, and their locations.
    - ii. Detailed wiring diagrams, to include any Contractor identification numbers applied to wiring or cables.
    - iii. Layout diagrams for Contractor supplied terminals, interconnect strips or junction panels in the systems.
7. Testing, Inspection and Acceptance
- a. Systems Testing:



- i. All components of new installations or modifications shall be tested by the Contractor to ensure each is operating properly following installation. This testing shall be conducted in conjunction with the UCPD Crime Prevention Unit.
  - ii. The system shall be connected to the Police Access Control computer in coordination with the Crime Prevention Unit to ensure proper interface.
- b. Inspection:
  - i. Following testing, the Contractor shall notify the University of California Police Crime Prevention Unit and Capital Projects (CP) inspectors to arrange for inspection of the completed system. Inspection shall be requested as stated in the particular contract, but in no case less than twenty-four (24) hours in advance of the requested inspection. Inspection will require the Contractor to demonstrate that all requirements of the contract are met and that all parts of the access control system(s) are operational.
- c. System Acceptance:
  - i. Acceptance of installed access control systems and modifications shall be made only after they are operational for a period of thirty (30) continuous days with less than one percent (1%) downtime attributable to failure of equipment, material, and/or workmanship.
  - ii. Should the system require adjustment or replacement of parts, another thirty (30) day acceptance period shall begin on the day the adjustment or replacement is made.
  - iii. A system will be accepted only after it operates for a full thirty (30) days in compliance with the requirements above, unless otherwise approved in writing by the Police and Purchasing Departments.
  - iv. Acceptance of installed access control systems and modifications shall be made only after successful completion of the inspection as outlined above.

## 28 16 00 Intrusion Detection

### 1. General Information

- a. Description: Provide general description of the project in this section
- b. Coordination with Management:
  - i. All work on systems described herein shall be completed in coordination with the building management and University of California Police Department Crime Prevention Unit personnel to provide a consistent level of service. Coordinate closely with the University University's Representative to obtain latest system requirements to develop scope of work, and to obtain list of pre-approved vendors.
  - ii. Only prequalified University vendors may install security alarm work.
  - iii. Accessible mounting heights shall be observed.
  - iv. Coordinate final alarm devices with the architect's hardware consultant.
  - v. Submit intrusion detection system for approval by the University's Representative and UCPD prior to bidding.

### 2. Alarm Equipment and Wiring

- a. Description: This chapter describes acceptable alarm hardware for use where such hardware is referenced hereafter in this Specification and describes wiring requirements.
- b. Equipment Approval:
  - i. Fire alarm equipment shall not be installed under this security alarm contract. See 28 30 00: Electronic Detection and Alarm of this document for coverage of these systems.

- ii. Emergency, hold-up, and intrusion alarm equipment protecting high hazard or security facilities shall be Underwriter's Laboratory (UL) approved/listed for use in the type of application being proposed. Emergency, hold-up, and intrusion equipment includes:
    - 1. Dual technology motion detectors.
    - 2. Door and window switches/contacts:
      - a. Magnetic reed contacts.
      - b. Mechanical switches.
      - c. Vibration contracts.
    - 3. Glass-breakage detectors (window foil shall not be used).
    - 4. Shunt and reset switches.
    - 5. Control instruments or panels.
    - 6. Power supplies, batteries, and wiring.
    - 7. Horns, bells and sirens are not allowed except with written permission of the Crime Prevention Unit.
  - iii. All alarm systems must be equipped with a battery operated stand-by power supply capable of continuously operating the alarm system (including any associated signal circuit to the UCPD) for a period of eight (8) continuous hours in case of the loss of commercial power. Switchover to or from battery power, must not activate associated alarm equipment, nor send any alarm to the Police Department. Digital communicator panels may send a low battery signal to the Police Department at the time that battery voltage reaches a preset low level.
    - 1. Standby battery, as referenced in this Specification, is a gelled electrolyte rechargeable battery with a minimum two (2) ampere-hour capacity, unless otherwise approved by the Crime Prevention Unit.
  - iv. It is desirable to have a battery system that is continuously float charged from commercial power to maintain batteries at full charge during periods of non-battery operation and to automatically recharge them when commercial power is restored following battery powered operation.
- c. Wiring Requirements:
- i. All alarm wiring of size 18 gauge or smaller shall be stranded copper or tinned copper wire to minimize the risk of breakage from movement or impact by a foreign object. Wiring shall be of a sufficient size to carry maximum currents found in the associated circuit(s) and still maintain equipment voltages at a continuous operational level throughout the system.
    - 1. Use of any wire smaller than 24 gauge other than inside of an alarm panel is prohibited.
    - 2. Any cable containing wire of size 22 gauge or smaller which has more than six (6) conductors (3 pairs) shall have, at a minimum, two (2) additional wires (1 pair) for use in future expansion or breakage repair. An extra two (2) wires (1 pair) shall be allowed for each multiple of twelve wires (6 pairs) thereafter in the same cable.
  - ii. All exposed wiring runs shall be enclosed in conduit or wire mold; armored sheath must cover wiring between conduit/walls and associated alarm panels, contacts, and sensors to prevent tampering with wiring.
    - 1. Wiring inside walls or ceilings shall not be considered exposed wiring.
3. Approved Signaling systems
- a. General Information
    - i. Alarm panels shall communicate alarm information from the user premise to the University of California Police Department Communications Center.

1. Alarm signaling methods and user account numbers shall be supplied by the Alarm and Access Control Unit.
- ii. Coordinate with the University's Representative regarding which contracts will provide:
  1. Telephone lines (Centrex only).
  2. Conduit for telephone lines.
- b. Digital Communicator (Non-supervised)
  - i. Bosch GV Series alarm panels shall be required. Comparable panels, capable of using Bosch PRS remote programming software for dialing into the UCPD alarm receiver may be acceptable.
  - ii. Alarm receiver telephone number and zone information shall be provided by the UCPD Crime Prevention Unit for each system.

#### 4. Standards and Guarantees

- a. Technical Standards: Equipment to be supplied shall conform, unless otherwise indicated, to the current applicable standards of the following organizations or documents:
  - i. American National Standards Institute (ANSI).
  - ii. Electronics Industries Association (EIA).
  - iii. Federal Communications Commission (FCC).
  - iv. National Electrical Code (NFPA-70).
  - v. National Electrical Manufacturers Association (NEMA).
  - vi. Underwriter's Laboratories (UL).
  - vii. US Occupational Safety and Health Administration (OSHA).
- b. Contractor's Provisions, Equipment and Hardware:
  - i. The term Contractor, as used in the remainder of this Chapter, refers to the Contractor or original equipment manufacturer if manufacturer's original equipment warranty and repair service is available.
  - ii. The Contractor shall provide the following services that will repair or exchange, in the times indicated, all defective parts and assemblies returned by the University for repair:
    1. Emergency no-charge warranty service within five (5) calendar days, excluding shipping time, for defective items returned within the appropriate guarantee time specified herein.
    2. Non-emergency no-charge warranty service within twenty (20) calendar days, excluding shipping time, for defective items returned within appropriate guarantee period specified herein.
    3. Emergency full-charge non-warranty service within five (5) calendar days, excluding shipping time, for defective items returned after expiration of the guarantee period specified herein.
  - iii. Whenever it is necessary for the Contractor to take corrective action for design defects in a delivered item, the Contractor shall take the same corrective action in all identical equipment delivered on the same purchase order.
  - iv. All parts and materials used in corrective action for design defects shall be guaranteed by the Contractor against mechanical, electrical, and workmanship defects for one year from date of such corrective action.
  - v. Guarantee, other than for design defects, shall include parts and materials during appropriate guarantee period specified herein and on-site labor guarantee period of ninety (90) calendar days after equipment installation or after equipment delivery if installation is not applicable.
  - vi. If the Contractor has not completed on-site guarantee repairs within five calendar days after notification of a malfunction, the University may make such repairs and bill the

Contractor for material and labor costs at the current Government Technician hourly rate.

- c. Minimum Guarantees, Material and Workmanship:
  - i. Workmanship and materials provided by the Contractor in performance of any initial installation or modification work required in compliance with this Specification shall be guaranteed for a period of one (1) year after date of system acceptance. Workmanship or materials found to be defective during this period shall be corrected by the Contractor within five (5) calendar days at its expense.
  - ii. Workmanship and materials provided by the Contractor in performance of any maintenance work required in compliance with this Specification shall be guaranteed for a period of one (1) year after maintenance work is completed. Workmanship or materials found to be defective during this period shall be corrected by the Contractor within five (5) calendar days at its expense.
  - iii. Coordinate with Division 1 for contract guarantee requirements.

## 5. Documentation

- a. The Contractor shall supply complete installation and operation manuals for each system component or subassembly in hard copy and PDF formats.
- b. The Contractor shall supply applicable Federal Communications Commission (FCC) type acceptance numbers for new systems or modifications where changes are made to equipment interconnected to the public telephone network.
- c. The Contractor shall supply as-built wiring diagrams which show location(s) of all equipment and wiring for alarm system. For installations where wiring is identical for several systems, the Contractor need only supply one (1) set of diagrams referencing all applicable locations. Wiring diagrams include:
  - i. Block diagram of system showing major components, junction blocks, panels, and their locations.
  - ii. Detailed wiring diagrams, to include any Contractor identification numbers applied to wiring or cables.
  - iii. Layout diagrams for Contractor supplied terminals, interconnect strips or junction panels in the systems.
  - iv. The fee for services for initial inspection and one re-inspection (if needed) will be paid by user. Any subsequent inspection charges for re-inspection(s) resulting from Contractor failure to meet requirements of the contract will be assessed against the contract.
  - v. Wiring diagrams shall be submitted in hard copy and PDF formats.
- d. Number, length and scheduling of demonstration and training sessions shall be determined by the Police Department in cooperation with the Contractor and user.

## 6. Systems Acceptance

- a. Acceptance of installed alarm systems and modifications shall be made only after they are operational for a period of thirty (30) continuous days with less than one percent (1%) downtime attributable to failure of equipment, material, and/or workmanship.
- b. Should the system require adjustment or replacement of parts, another thirty (30) day acceptance period shall begin on the day the adjustment or replacement is made.
- c. A system will be accepted only after it operates for a full thirty (30) days in compliance with requirements outlined in this section; unless otherwise approved in writing by the Police and Purchasing Departments.
- d. Acceptance of installed alarm and/or video surveillance systems and modifications will be made only after successful completion of inspection as outlined above.

## 28 20 00 Electronic Surveillance

### 28 23 00 Video Surveillance

1. Cameras and equipment for video monitoring shall be reviewed by UCPD Crime Prevention Unit prior to any proposed installations and must meet the approval of UCPD.
2. Standard video monitoring solutions shall include:
  - a. Server: Supermicro SSG-6027R-E1R12T 2U rackmount server or equivalent (must be approved by UCPD)
    - i. CPU: Intel Xeon E5-2620 Sandy Bridge EP 2.0 GHz 15MB L3 Cach LGA 2011 95W Server Processor or equivalent (must be approved by UCPD)
    - ii. Operating System hard drives: 2 Samsung 256 Pro SATA III Internal solid state drives–RAID 1 or equivalent (must be approved by UCPD)
    - iii. Operating System: Windows Server 2012
    - iv. Memory: 2 x 8 GB 240 pin DDR3 Crucial Ballistix Sport (16 GB) SDRAM 1600 (PC3 12800) low profile memory
    - v. Storage Attached Units: Attached storage units will utilize serial attached SCSI interface
    - vi. Storage hard drives: Western Digital “Purple” or better (or equivalent), minimum 3TB each (drives must be approved by UCPD)
    - vii. Video Management Platform: Genetec
  - b. Network related installations and equipment must meet the specifications and approval of UC Berkeley IS&T: Switches, routers, network cable must be installed and approved by IS&T.
  - c. Network Connectivity shall be provided by IS&T for all video monitoring in university-owned buildings and environs.

Camera Cabling: Must conform to IST standards for testing and labeling.

## 28 30 00 Electronic Detection and Alarm

### 28 31 00 Fire Detection and Alarm

#### General

##### 1. Codes and Standards

- a. Comply with the most current edition of the following applicable codes and standards: California Fire Code, and California Building Code, California Electrical Code, National Fire Protection Association (NFPA) 72, 90A, and 90B.
- b. This standard is a supplement to legal code requirements. The provisions of this document address how code required systems are configured and installed.

##### 2. Structures

- a. When more than one structure is served by a single fire alarm control panel, an alarm initiated in one structure shall cause the audible devices to sound only in that structure. The silencing of the audible devices in one or more structures shall not prevent the sounding of subsequent alarms in another structure.

##### 3. Wire Types And Sizes

- a. All circuit runs shall be continuous between devices, without splices, wherever feasible. Where a continuous run is not feasible, connections shall be made in a UL listed metal electrical box. Wire nuts shall be permitted only in nominal four-inch (4”) metal outlet or junction boxes in conformance with Section 370-16 and limited by Table 370-16(a). All other connections shall be via terminal

blocks or wire nuts (no but-splice or crimp connections) in metal enclosures conforming to the requirements of the California Electrical Code. Conductors connected together shall have the same color insulation. All connections shall be accessible for inspection and servicing and shall be clearly identified on the contractor record drawings.

- b. Wire and cable shall be sized, twisted and shielded as required by the fire alarm system manufacturer, and shall meet the requirements of the California Electrical Code.
- c. When a signaling line circuit is within the same conduit raceway as a notification appliance circuit for speakers or a firefighter's telephone system, the signaling line circuit or the notification appliance circuit/firefighter's telephone circuit shall shield both.
- d. Stranded wire is not to be used on any part of the fire alarm system. The single exception shall be factory provided internal wiring harnesses with factory provided termination. Stranded wire when not tinned produce ground faults and shorts when installed in electronic terminal strips.
- e. Fire alarm shop drawings will provide specific wiring direction for fire alarm systems. Wire type and gauge is not interchangeable and subject to strict Designated Campus Fire Marshal approval for rating and voltage drop calculations.
- f. Two solid conductors of dissimilar size shall not be placed under the same terminal. Sample: Electronic resistors must be "pig-tailed" to a #14 solid wire if they are connected with a #14 solid wire under a terminal screw. Mechanical connections between dissimilar wires may become loose and become a chronic maintenance issue. All terminations shall be installed so as to guarantee continuous connection.
- g. All fire alarm cable shall be labeled at each termination. All electrical circuits shall be numerically identified at both ends with wire taped numbers.
- h. Tie in to existing systems using the following wire types, sizes and colors unless countermanded by considerations of distance, amperage, voltage drop or manufacturer's requirements.
  - i. Siemens MXL/XLS based addressable alarm systems alarm signaling circuits (Siemens ALD circuits) shall use twisted shielded cable #16 red and black solid. Siemens XLS circuits shall use **NON-shielded** cable #16 red and black solid.
  - ii. Conventional alarm systems initiating zones (manual pull stations, smoke detectors, heat detectors) shall use # 18 AWG Solid Cu. TFN, red positive, blue negative.
  - iii. Audible signal circuits (horns and horns with strobes) shall use # 14 AWG Solid THHN, orange positive, yellow negative (polarity referenced to supervisory condition).
  - iv. Strobe only circuits (strobes, strobes in tandem with speakers); #14 AWG Solid THHN, gray positive, violet negative
  - v. Flow and Tamper Switches zones (conventional alarm systems); #18 AWG Solid TFN both wires black.
  - vi. Door holder circuits, 24 volt DC shall use #18-#16 AWG Solid TFN, white positive, black negative.
  - vii. Wires connecting remote annunciator panels and remote trouble annunciators (conventional systems); # 18 AWG Solid TFN, Switch legs: black, common yellow, with wire number labels on both ends.

#### 4. Risers and Terminal Cans.

- a. All vertical risers shall have terminal cans mounted at each floor. Each floor's fire alarm conductors shall branch from the floor riser terminal can. This facilitates isolation of branch circuits.
  - i. All splices in the riser terminal cans shall be via terminal strips.
  - ii. All terminals in the riser junction cans shall be labeled with permanent labels. The label shall identify wire circuit number and destination. Sample: ALD 6- 2nd floor.
- b. Access to fire alarm system components shall not be impeded by system wiring that passes over or around the component so as to restrict service access. Fire alarm components shall not be mounted in wire troughs, or J-Boxes and J-Cans of insufficient size to provide safe access to energized circuits.

- c. Vertical riser wiring will be in conduit, sized to allow for twenty-five percent (25%) additional expansion.

## 5. Conduits and Raceways

- a. All fire alarm system wiring must be installed in raceways separate from those used by other electrical systems.
- b. Power-limited fire alarm (PLFA) cable, where used, not installed in UL listed metal conduit or raceway shall be mechanically protected by building construction features:
- c. Installation shall be in areas not subjected to mechanical injury.
- d. Fire alarm circuits shall be supported by the building structure. Cable shall be attached by straps to the building structure at intervals not greater than 10 feet. Wiring installed above drop ceilings shall not be laid on ceiling tiles. Wire shall not be fastened in such a manner that puts tension on the cable.
- e. Cable shall be types FPLP, FPLR or FPL, or permitted substitutions, selected for the installation application as required by the California Electrical Code.
- f. Minimum size of raceway for all fire alarm systems shall be 3/4" trade size raceway unless approved by Capital Projects (CP).
- g. All fire alarm system wiring shall be installed in raceways separate from those used by other electrical systems. Sample 1: 120 VAC feed from distribution panel (circuit Breaker) to fire alarm control panel shall be in a separate conduit. Sample 2: Control switch leg from a 120 VAC Fire Smoke Damper to a programmable fire alarm relay (Siemens TRI-R) must be in a separate conduit from the fire alarm signal (Siemens ALD) wiring to that relay (Siemens TRI-R). Sample 3: Elevator control wire switch leg 24 VAC to a programmable fire alarm relay (Siemens TRI-R), used for elevator recall, and shall be in a separate conduit from the fire alarm signal (Siemens ALD) wiring to that relay (Siemens TRI-R). The inclusion of AC wiring in the same raceway or non-separated J-box with fire alarm wiring may induce inductance voltages that corrupt data transmission.
- h. Flexible metal or seal-tight conduit may be used to connect individual fire alarm devices to the conduit system. Sample 1: Seal-Tight (trade name) may be used to connect a Water Flow switch to a programmable monitoring point (Siemens TRI). Sample 2: Flexible metal conduit may be used to connect a smoke detector mounted on a 4sq electrical box in a drop-ceiling tile to the 4sq junction box in the fire alarm EMT conduit system.
- i. All electrical enclosures, raceways and conduits shall contain only those electrical circuits associated with the fire alarm system and shall not contain any circuits that are unrelated to the system.
- j. All cable which is not enclosed by conduit shall be supported and anchored with nylon straps or clamps. The use of staples is prohibited.
- k. Cables and conductors having scrapes, nicks, and gouges or crushed insulation shall not be used.
- l. All electrical circuits shall be labeled.
- m. All fire alarm conduit systems shall be installed so as to have a continuous ground bond reference. Sample: EMT conduit with approved fitting providing a complete and common ground reference through the system. Sample: EMT conduit system with ground reference wire bonding the complete conduit system providing a complete and common ground reference through the system.

## 6. Supervision

- a. The following circuits shall be supervised to detect the presence of open circuits, short circuits, or ground on either wire:
  - i. Initiating zones (manual pull station, heat detector, smoke detector, flow switch, other)
  - ii. Audible/visual signal zones
  - iii. Battery circuit
  - iv. Alarm annunciator circuits

- b. All connections to initiating devices or audible devices shall be made directly to the device (i.e., no pig-tail connections), in such a way that the disconnecting of any one or more wires from the device will interrupt the continuity of the zone and cause a trouble condition on the fire alarm control panel.

## 7. Auxiliary Relays

- a. There shall be provided, as required, within the control panel Siemens Programmable Supplementary Relay Modules, type CRM-4 (MXL/XLS) and CRC-6 (XLS). Each contains programmable independently actuated relays, fitted with form “C” contacts, rated at 120 VAC, 2 amps inductive.
- b. There shall be provided, as required, Intelligent Initiating Devices Interface Modules with programmable relays, type Siemens TRI-60R or HTRI-R, with one (1) form “C” relay contact, rated at 120 VAC, 2 amps.
- c. There shall be provided, as required, Auxiliary Relays in the bases of the Addressable Smoke Detectors. These relays shall be set by software to be controlled by the logic of the Fire Alarm System (CSG) not activated by default with the associated smoke detector independent of software conditions. Smoke detectors with built-in relays shall be used only when programmable remote relays (Siemens TRI-r type or subsequent model) are not available. Smoke detectors with relay bases shall only be installed with a back-box of sufficient size and accessibility to allow maintenance and repair without the hazard of electrical shock or ground fault.
- d. There shall be provided auxiliary relays with the air sampling tube type duct smoke detector assemblies when required, these relays are integrated within duct detector housing and fully controlled by the system software logic (CSGM or Zeus).
- e. All remote relays shall be installed in a location and manner that they may be accessible for easy maintenance. Each addressable device shall have its address and usage prominently marked for maintenance purposes.
- f. All relays in an addressable fire alarm system shall be controlled by the custom software logic (Siemens CSGM or Zeus software). This will allow the full control of auxiliary relays from the menu driven fire alarm control panel. The use of default relays is not allowed.
- g. Auxiliary relays and monitoring TRI and HTRI devices shall be mounted in weather-proof cans when installed in locations where high moisture content is possible.

## 8. Zoning

- a. Each sprinkler flow switch shall have its own zone.
- b. Each air duct smoke detector shall have its own zone.
- c. Each fire extinguishing system (e.g., Halon, dry chemical, pre-action sprinkler or carbon dioxide) shall have its own zone.
- d. Each smoke detector that is part of an elevator recall system shall announce its particular floor at both the fire alarm control panel and at all alarm annunciator panels. It is permissible to connect an elevator recall smoke detector on the same initiating zone as other devices on its particular floor; however, an alarm triggered by any of these other devices shall not cause the elevator to be recalled.
- e. Vertical zoning shall not be allowed (i.e., no zone shall include more than one floor).

## 9. Living/Sleeping Areas

- a. Each living unit (dormitory room or apartment) shall be provided with at least one 120-volt smoke alarm. This smoke alarm shall not activate the building fire alarm system. It shall automatically reset itself when the smoke clears.
- b. Each living unit (dormitory room or apartment) shall also be provided with at least one thermal detector. This thermal detector shall activate the building fire alarm system. The thermal detector may be housed in the same case as the smoke detector, as part of a combination smoke/heat detector. The thermal detector shall be rated 118°F to 135°F fixed temperature; a rate-of-rise action may be included.



- c. The requirement for a thermal detector in living units is waived if all rooms are served by an automatic sprinkler system.

#### 10. Labeling

- a. All fire alarm systems shall have the fire alarm terminations and sub-modules completely labeled (as appropriate) with professional-type labels. This includes control panels, annunciator panels, and terminal panels. Hand lettering and dyno-type label are not acceptable. Label shall identify wire circuit number and destination. Sample: ALD 6- 2nd floor, NAC Module 004.
- b. All junction boxes shall be provided with red covers on which the letters "FA" appear in white one inch (1") high lettering. Fire Alarm conduit shall be red. AHJ requirement, this facilitates trouble shooting, inspection, and provides a visual indicator of a vital infrastructure.
- c. All alarm systems devices shall be labeled with a professional (Brother P-Touch- type) label with three-eighths to one-half inch (3/8"-1/2") black lettering. This includes all initiating, notification and control devices. The label shall be visible from the floor, giving the address of each device in the same manner as the FACU display screen. This aids fire department rapid response, required maintenance testing, accurate and cost effective trouble shooting.
- d. Sample: "003-034", located on the mounting base of smoke and heat detectors, on the cover of TRI, on the upper activation lever of MPS, and on the cover of flow and tamper switches. All monitoring devices (TRI type alarm and status devices) shall have a label describing usage. Example: A TRI-D for sprinkler water flow and valve tamper alarm shall stay "010-010 Water Flow 3rd floor, 010-011 Tamper 3rd Floor" NAC (horn/strobes) shall have each circuit and device address labeled. Example: A22-3/V57-14.

11. All devices, such as smoke detectors, air duct detectors, flow switches, and sprinkler valves, which are installed above ceilings, below floors or in other locations not readily visible from the common access floor shall have one of the following:
- a. A remote indicating lamp visible from the floor to indicate when that device is in alarm condition.
  - b. Professional signage, adjacent to the alarm devices or remote indicating lamp (LED), so that the fire response personnel and maintenance personnel may easily locate them. Example: "smoke detector 002-032 above ceiling".

12. Each device shall have its address marked on the back of the plug-in unit and base.

13. All terminals in the riser junction cans shall be labeled with permanent labels. The label shall identify wire circuit number and destination. Sample: ALD 6- 2nd floor.

- a. All junction boxes shall be provided with red covers on which the letters FA appear in white one-inch (1") lettering

#### 14. Access Door in Air Ducts

- a. Whenever duct smoke detectors are used, access doors shall be provided in the duct work of sufficient size and location to allow viewing, cleaning and replacement of smoke detector sampling tubes.

#### 15. Roll-Down Fire Doors/Shutters

- a. See Division 08 00 00: Openings.

#### 16. Wet Locations

- a. Fire alarm devices or other equipment to be installed in wet or damp locations shall be listed for weather-proof application. Wet locations shall include but not be limited to outdoor installations,

machine rooms subject to high humidity, damp shower rooms, laboratory wash down areas and locations subject to the presence of steam and steam condensate.

- b. FA wiring to outdoor locations (PIV monitoring) shall have a zone isolation module. Isolation modules protect the system from cascading ground fault in monitored wiring.

#### 17. Project record Documents

- a. The installer shall provide as-built three (3) hard copy and one (1) electronic copy of documents as follows:
  - i. Provide as-built plans showing the physical routing of wires to devices.
  - ii. Provide as-built riser diagram showing the zoning of initiating devices and audible signal devices.
  - iii. Provide as-built panel wiring diagram of the fire alarm control panel.
  - iv. Provide, for addressable systems, an address list showing, for each device, the address, device type, location, and message.
  - v. Provide, for software-driven systems, a copy (on disc) of the software used to program the system. This software should be fully functional so that qualified University personnel can make future modifications and repairs to the programming.
  - vi. Provide, for software-driven systems, a hard copy printout showing the programmable options and how each option is implemented in this system.
  - vii. As-built drawings shall show at minimum, but not be limited to, the items required by NFPA 72 and the California Fire Code.
  - viii. Shop drawings shall include but not be limited to, the items required by NFPA 72 and the California Fire Code. (clearly identify design parameter i.e., hydraulic or pipe schedule).
  - ix. Shop drawings submitted for approval to the AHJ shall include the general notes:
    - 1. The automatic sprinkler system shall conform to the requirements of NFPA 13 adopted by the State of California
    - 2. Penetrations of rated assemblies shall be fire-stopped. Fire-stopping shall be an approved material as described in State Fire Marshal Standard 12-43.1
    - 3. Installation of the sprinkler system shall not be started until completed plans and specifications (including water supply information and capacity of existing sprinkler system, if any) have been approved by the AHJ.
    - 4. Approved plans and specifications shall be kept on the job site and made available upon request.
    - 5. At various stages and upon completion, the system shall be tested in the presence of the University Fire Prevention Services and/or Campus Fire Marshal
    - 6. Submittals having inaccurate hydraulic calculations, content, which are illegible, incomplete or unclear, shall be returned without review or approval
  - x. Drawings/Documentation boxes must be mounted near the FACU.

#### 18. Prior To Acceptance Testing

- a. Prior to acceptance testing, the installer shall pre-test all equipment to ensure a successful demonstration.
- b. At the time of acceptance testing provide two (2) copies of record drawings and files and software to Facilities Services for maintenance usage in addition to documentation required by UCB project management.
- c. Prior to acceptance testing the installer is to, provide a hard copy printout showing the fire alarm system programming for review, show all system configuration, alarm logic, and custom programming. Prior to acceptance testing the installer shall to provide at the job site a stamped set of

fire alarm shop drawings and a set of drawings showing approved changes in device location or addressing.

- d. Installers shall provide documentation that all design and manufacturers requirements to wire size, color, type, and installation have been met.
- e. Manufactures of fire alarm equipment shall certify that the equipment has been installed per documentation and in accordance with the manufacture's written requirements.
- f. The installer shall test for grounds, induction, and continuity. A high-potential test shall be performed and documented by the installer before electronic alarm components are connected to the wiring system.

## 19. Execution

- a. Contractor Qualifications
  - i. Work performed on University of California Berkeley fire alarm systems, shall be performed only by certified personnel who must have a valid California State Fire Alarm Certification Card.
- b. Pre-Work Orientation Training.
  - i. Installers, contractors and others working on University fire alarm systems shall meet with representatives of the equipment manufacture and Facilities Services staff to prior to commencement of work for an orientation on the equipment and installation standards.
- c. Testing and Demonstration
  - i. During acceptance, the Contractor shall perform a complete demonstration of the fire alarm system. The demonstration shall include the following:
    1. Activation of every initiating device.
    2. Testing of all appropriate circuits for open-circuit supervision, short-circuit supervision, and ground-fault supervision.
    3. Observation of the functioning of all other components of the fire alarm system.
  - ii. The above demonstration shall be in the presence of the State Fire Marshal or designee. Prior to that demonstration, the Contractor shall pre-test all equipment to ensure a successful demonstration.
- d. Limitations On Contractor Access
  - i. No outside contractor shall access an existing fire alarm control panel or any other part of an existing fire alarm system unless the system has first been appropriately shut down or secured by the University. When the Contractor is finished, the system shall be re-energized or reconnected by the University.
  - ii. When a new fire alarm system is completed, the final connection to the campus-wide fire alarm signaling system shall be performed by the University. Final connection shall be interpreted to mean the physical connecting of wires or similar action, and not the installation of equipment or wires.
- e. Maintaining Alarm Services In A Building
  - i. Installers are responsible for installation of equipment and/or wiring per UCB standard, NEC, NFPA, CSFC and manufactures instructions.
  - ii. When construction occurs in an occupied or partially occupied campus building, the installer and Contractor is responsible for maintaining the fire and life safety fire alarm system within the occupied portion of the building. This shall apply to construction that is "phased" and construction with a limited scope of impact with in a building.
  - iii. When a contractor or installer has an existing fire alarm system within an occupied campus building turned over to them for work via a shut-down by Facilities Services that contractor is responsible for the fire life safety of the occupants during the duration of the shut-down.
- f. Acceptance Testing

- i. The acceptance test shall be in the presence of the Authority Having Jurisdiction (Designated Campus Fire Marshal [DCFM]) and in the presence of Facilities Services fire alarm personnel.
- ii. During the acceptance, the installer shall perform a complete demonstration of the fire alarm system. The acceptance test shall include but not be limited to the following:
  1. Activation of every initiating device.
  2. Activation of every sprinkler control and monitoring device, with test of time delay features as outlined in this Division.
  3. Activation and check of every notification appliance, audible/visual device.
  4. Activation of all fire alarm system controlled components, these shall include but not be limited to all door closures, and all automated fire door functions, all air pressurization features, and all auxiliary signaling features.
  5. Activation of all fan and air handler controls, with air handlers and fans in full operation.
  6. Activation of Campus signaling to the University of California Police Department.
  7. Activation of all fire alarm control features (i.e., by-pass software functions in addressable alarm systems).
  8. Testing of all appropriate circuits for open-circuit supervision, short-circuit supervision, and ground fault supervision.
  9. Proof of completion of loop resistance testing, megger testing of wire insulation, air velocity and flow tests of duct detection.
- iii. If the fire alarm installation or remodel is in “phased” stages, or if there are substantial corrections and additions to the scope of the Project, the installer shall assume responsibility for subsequent testing and retesting of the fire alarm installation.
- iv. If an existing fire alarm signal, notification, control circuit, or the system software logic has to be disrupted then the installer is responsible for retesting the existing system to the extent deemed acceptable to the authority having jurisdiction (UCB, Designated Campus Fire Marshal [DCFM]).
- v. At final testing, the Contractor or fire alarm supplier shall submit for review a copy of the final alarm programming (Siemens MXL/XLS systems, CSGM). The program shall include all system logic functions, custom messaging, and network configurations.

20. State Fire Marshal Approval

- a. All fire alarm equipment and devices shall be California State Fire Marshal listed

21. Approval By Designated Campus Fire Marshal and Fire Protection Engineer

- a. All drawings and specifications for fire alarm installations shall be approved by the Designated Campus Fire Marshal and a fire protection engineer licensed in the State of California. Drawings and specifications shall be approved by Facilities Services after receiving the Designated Campus Fire Marshal and fire protection engineer's stamp of approval, including signature and date.

*28 31 13 Fire Detection and Alarm Control, GUI and Logic Systems*

1. Fire Alarm Control Panels

- a. The campus standard, identified by thorough, earlier bid processes, for fire alarm equipment is Siemens brand.
- b. This is a proprietary item. No substitutions allowed.
- c. Match existing system for device additions only.
  - i. In existing systems where a limited scope of work does not require a new /upgraded fire alarm, match existing listed alarm components.

- ii. When existing FA system cannot support code required elements, a total system upgrade shall be required.
- d. New fire alarm control systems shall be fully addressable using Siemens MXL/XLS, XLS and Desigo series fire alarm systems. To expand existing systems use a Siemens MXL/XLS, Siemens MXL/XLSV (voice alarm) to match existing panels. These systems shall be referred to as addressable systems.
- e. In small buildings an addressable Siemens Desigo series fire alarm system may be used. Approval for this application must be obtained in advance from the Authorities Having Jurisdiction (Designated Campus Fire Marshal [DCFM] and Facilities Services Fire Prevention Unit).
- f. If any type of fire alarm control panel other than the above Siemens models is specified, it shall be reviewed for approval in advance by Capital Projects (CP).
- g. Addressable fire alarm control systems that are installed in pre-existing buildings or during building renovations shall replace all pre-existing fire alarm control panels and sub-panels. The functions of these panels will be included in the design of the new addressable alarm system. This may include but not be limited to fire suppression systems, smoke control systems, and power shutdown systems. Pre-existing panels shall not be used as subpanels of the new alarm system.
- h. One building per fire alarm system, one system per building
  - i. Each building shall have one dedicated fire alarm system. The designated main panel and select remote control/annunciator stations (Sample: Siemens RCC) shall control all of the fire alarm functions within that building. No building shall have more than one (1) fire alarm control system. Self-contained engineered suppression systems will be configured as a monitored sub-system of the building fire alarm system. All alarm initiating devices shall be controlled via the main FACP.
  - ii. New administrative and/or occupancy areas shall not constitute a new building.
  - iii. Each building shall have a distinct dedicated signal to the campus alarm monitoring facility (UC Police Department).
  - iv. When a building is defined as having more than one (1) structure (with approved fire separation) and is served by single fire alarm control panel, an alarm initiated in one structure shall cause the audible/visual devices to sound only in that structure. The silencing of the audible devices in one or more structure shall not prevent the sounding of subsequent alarms in other structures that constituted that building's system.
- i. All addressable fire alarm control systems shall include in the main fire alarm control panel a LCD alphanumeric display and the required key-pad switches or interactive touch screen, for full control of the fire alarm system. These controls will constitute the sole means of access and control for the fire department. For Siemens XLS "Fire Finder" the integrated video screen and keys shall constitute the control and display functions.
- j. All fire alarm control panels shall be mounted in locations that are accessible to routine maintenance, and protected from environmental hazards. Remote panels and fire alarm control panels mounted in custodial spaces, storage closets, above ceiling and damp or dusty locations shall not be allowed. This shall include all remote subpanels, power supply panels, notification power adder panels, and engineered sub-systems. Sample: Siemens MXL/XLSR, MXL/XLSRV, XLSR, PS-35, PAD-3 series NAC panels, auxiliary power or amplifier panels, and engineered sub systems such as VESDA or suppression systems.
- k. All fire alarm panels (including remote panels, power panels, and engineered sub-system panels) shall require adequate permanent lighting to safely illuminate the interior of the panel, and a 110v AC receptacle within 4 feet of the panel.
- l. The master fire alarm control panel or control function remote annunciator shall be located indoors, immediately adjacent to the main firefighter's point of entry. The fire alarm control panel shall be located at the Berkeley Fire Department's point for primary response. This location is to be determined by the Authority Having Jurisdiction (AHJ) (i.e. the Designated Campus Fire Marshal

[DCFM]). The master or main fire alarm control panel shall contain all the fireman controls necessary for full control of alarm annunciation, alarm acknowledge, audible silence, and alarm reset.

- m. All addressable fire alarm control systems Siemens XLS, MXL/XLS, Siemens MXL/XLSV (voice alarm) and Siemens Desigo shall have a panel-mounted printer (Siemens TSP-40, thermal strip printer). This printer shall be on the main fire alarm control panel. When control panels require a remote printer, type and location of the remote printer shall have approval, obtained in advance, from the University of California, Berkeley AHJs (Designated Campus Fire Marshal [DCFM] and Facilities Services Fire Prevention Unit)
- n. Fire Alarm Panel Configurations: The main Fire Alarm Control Panel (FACP) shall include:
  - i. A “RESET” switch in the main fire alarm control panel or remote annunciation/control panel shall reset the fire alarm system, including alarm initiating devices (smoke detectors and duct smoke detectors), and alarm notification devices (audible/visual horn/strobes). The exception to this is specific engineered panels. No additional switch shall be needed to reset smoke detectors, or sub-panels.
  - ii. A single switch, located in the main fire alarm control panel, shall silence all fire alarm system audible alarm indicating appliances. Strobes shall flash until panel is reset.
  - iii. All addressable fire alarm systems shall be software configured for self-restoring trouble conditions.
  - iv. Addressable fire alarm systems shall have keypad or touch screen activated, software controlled, by-pass functions. All by-pass functions shall be supervised and produce a monitored system "trouble" condition.
    - 1. All supervised bypass switches shall be programmed to “survive reset” and to toggle on/off.
    - 2. The by-pass switch software functions shall “by-pass” the inputs of alarm and supervisory devices, and the outputs of the notification and other control functions.
    - 3. These by-pass switches shall be assigned to perform logic functions, one switch per function, per the current UCB, Facilities Services alarm programming guide for Siemens alarm systems. AHJ and UCB, FA Engineer pre-approval of function assignments shall be required. The functions for by-pass shall include but not be limited to:
      - a. U.C Police Department by-pass (monitoring).
      - b. Audible/visual alarm by-pass.
      - c. Auto sprinkler flow alarm and tamper switch by-pass.
      - d. Elevator recall by-pass.
      - e. Smoke control by-pass (fan and damper controls).
      - f. Door closure by-pass.
      - g. Alarm input by-pass (device grouping by pre-approval only).
      - h. Suppression system activation by-pass.
- o. Within any building, all locked fire alarm equipment, such as control panels, sub-panels, power supply panels, battery cans, fan control panels, manual pull stations, terminal cans and key switches, shall have one common key.
- p. All alarm indication and notification devices shall be connected to the fire alarm system.
  - i. All alarm-initiating devices shall be wired so as to trigger the building central fire alarm system in the advent of an alarm. This includes (but is not limited to) elevator-recall smoke detectors, duct smoke detectors and devices which are part of engineered fire-extinguishing systems such as inter gas, range-hood, and dry-sprinkler systems. All notification appliances, evacuation alarms including voice speaker, horn, chime and visual strobe lights shall be connected to and controlled via the building fire alarm system.
- q. Fire Alarm Sub-Panels

- i. The use of any third party add-on or stand-alone controls or control panels other than engineered detection and suppression assemblies is not acceptable. All fire alarm panels, sub-panels and appliances shall be of the same manufacturer, and product line (MXL/XLS, XLS or Desigo) and listed for its application.
  - 1. Sample: XLS and XLSR panels, Siemens Pad-3 series NAC extender panel, Siemens PS-35 power supply.
  - 2. Sample exceptions: Engineered suppression and special detection systems. FM-200 chemical suppression system, VESDA high sensitivity smoke detection (HSSD) or Gas leak detection systems.
- r. All doors and other front-covers on fire alarm control panels shall swing on factory-installed hinges. Front-covers which need to be lifted off and removed from the panel to gain access to the wiring terminals shall not be allowed.
- s. Capacity For Expansion:
  - i. All new fire alarm systems shall have capacity for future expansion. The control panels, and component modules, shall have sufficient, node address, electrical capability and enclosure space to handle the following:
    - 1. In addressable fire alarm systems (Siemens MXL/XLS and XLS ) each Signaling Line Circuit (SLC) shall have 25% spare capacity in the number of addresses assigned.
    - 2. A 25% increase in the number of visual alarm indicating appliances (NAC) or proportional increase in the candela rating of visual devices in each zone.
    - 3. A 25% increase in the number of audible alarm indicating appliances (NACs) or proportional increase in the wattage rating of voice speaker devices in each circuit.
    - 4. A 25% increase in the number of Initiating Device Circuits.
    - 5. Graphic displays including smoke control fan status and elevator status displays, if approved , must include at least 25% more lamps and directory space than required, with wires for the additional lamps installed to the fire alarm control panel.
- t. Connection To The Campus-Wide Monitoring System.
  - i. All building fire alarm systems shall automatically transmit all required alarm signals to the University of California Police Department Communications Center. A digital alarm communicator transmitter (DACT) compatible with Cerberus alarms systems and the receiving equipment at the University of California Police Department Communications Center shall be provided. The digital dialer shall transmit the code required "alarm", "supervisory", "trouble" signals and other monitored signals required by the AHJ.
  - ii. The University of California specifies the use of a Digital Alarm Communicator Transmitter (DACT). It shall be a Silent Knight model 5128.
    - 1. A remote keypad, Model 5230 shall be mounted adjacent to the DACT enclosure.
    - 2. By-pass of the DACT activation shall be by impairment of the alarm panel monitoring contacts. This function shall be part of the required "fire department by-pass" feature of the fire alarm system and be supervised by the FACP.
    - 3. The alarm system on the DACT must be activated by supervised, switched contacts, normally open/ closes on activation.
    - 4. Alarm, Trouble, and Supervision conditions shall be transmitted to the DACT via programmable relay contacts. In XLS, XLSV, MXL/XLS and MXL/XLSV systems use a CRC-6 or CRM (convention relay) module. . Use of the non-programmable, default relay contacts shall have the pre-approval by the UCB FA Engineer.
    - 5. The Silent Knight model 5128/29 zones shall be assigned and wired as follows:
      - a. Zone 1 - Alarm
      - b. Zone 2 - Trouble, connected to FACP trouble condition contacts
      - c. Zone 3 - Supervision including Fire Sprinkler valves

- d. Zone 4 – User defined
  - 6. All penetrations of the DACT enclosure must be made in a manner approved by the NEC.
  - 7. Signals shall be sent via SK 4/2 format.
  - 8. The DACT shall require two (2) voice analog POTs telephone lines, dedicated to the use of the fire alarm signaling system.
  - 9. The DACT enclosure shall include a terminal strip connecting the alarm zone input harness and the FACP control relays. Wire nuts and butt splicing is not acceptable.
- iii. When alarm and supervisory functions other than fire alarms are monitored by UCB via UCPD, each function shall have a dedicated and distinct Digital Dialer zone assignment. Multiple Dialers with dedicated account and zone assignment may be required for additional alarm monitoring zones with pre-approval of AHJ and UCB FA Engineering.
- iv. Campus wide Mass Notification is under design consideration. New Fire Alarm Systems and System up-grades will pre-plan for Mass Notification.
- u. One Floor Per Signaling Line Circuit And Initiating Device Circuit:
  - i. Design the SLC and IDC circuits so that each circuit shall provide alarm detection and communication for only one (1) floor (or wing off a large floor) per circuit. No SLC or IDC shall serve more than one (1) floor. The intent is to prevent more than one geographic area within the building from having a loss of alarm detection if an SLC or IDC circuit. is impaired for any reason, and to facilitate shut-downs, expansion and maintenance operations.
  - ii. When more than one initiating circuit is required per floor than the circuits shall not be overlapping on the floor plan. Each circuit shall cover a distinct geographic or functional area only. Exception: Cross-Zoned areas using overlapping SLC or IDC circuits.
  - iii. When two (2) or more distinctly different occupancies or functions are on the same floor than a separate SLC or IDC shall be assigned to that geographic area and circuits shall not be overlapping. Sample: A building divided between a laboratory wing and a general classroom wing.

### *28 31 53.13 Fire Alarm Pull Stations*

#### 1. Manual Pull Stations

- a. Manual pull stations shall be required in all buildings, including those equipped throughout with an automatic sprinkler system installed in accordance with California Building Code or California Fire Code Section 903.3.1.1
- b. For new addressable installations, manual pull stations shall be Siemens MSI-10.
- c. Manual pull stations shall be addressable and intrinsic to the alarm system. The use of an intelligent interface device between a conventional (non-addressable) manual pull station and an addressable control panel shall not be allowed, except where ambient conditions preclude electronic components
- d. For new hard-wired installations, manual pull stations shall be Siemens MS-57 or equivalent. The two (2) poles of the switch shall be wired in parallel for backup purposes.
- e. For additions to existing installations, manual pull stations shall be of the same brand and model as existing ones, if available.
- f. When manual pull stations are surface-mounted (as opposed to flush-mounted), proper back-boxes specifically manufactured for the device shall be used. Ordinary electrical junction boxes shall not be acceptable as back-boxes.
- g. All manual pull stations shall be mounted at a height of no more than forty-eight inches (48") above the finished floor.
- h. In areas where a security device is required to prevent nuisance alarms a Safety Technology International Inc. "Stopper II" type pull station cover shall be installed.



- i. Manual pull stations shall not be mounted in outdoor applications. Example: MPS shall not be mounted to security fences or patio gates.

### *23 31 43/46 Fire/Smoke Detection Sensors*

#### 1. Automatic Fire Detectors

- a. Automatic fire detectors shall be selected, located and spaced according to the guidelines contained in NFPA 72 and its appendices.
- b. Smoke detectors for the initiation of addressable building-wide alarms shall be: Siemens FP-11, HFP-11(environment compensations type) or subsequent model. The location and software configuration of the individual smoke detectors shall be determined by the application, including but not limited to consideration of dust, gas, air velocity, fumes, temperature and ambient electromagnetic fields.
- c. Smoke detectors with integrated heat sensing that cannot be software suppressed (Siemens FP-11) shall not be used in areas subject to high ambient temperature (sun light or steam release). Smoke detectors shall be photoelectric/ non heat sampling type in these applications.
- d. Smoke Detectors for the initiation of conventional (non-addressable) building-wide alarms shall be listed for the fire alarm system. Sample: Siemens PE-11, or subsequent model. The type of smoke detector shall be determined by the individual application, including but not limited to consideration of dust, gas, and air velocity, fumes and ambient electromagnetic fields.
- e. All smoke detectors shall be connected to the building fire alarm system, and shall initiate a fire alarm condition when in alarm.

#### 2. Placement

- a. Smoke or heat detectors shall be placed in locations that are readily accessible for routine maintenance and testing. Detector placement that has obstructed access due to layered building systems (cable trays, HVAC duct work) is not acceptable. Detectors shall be accessible in construction areas, without undue obstruction.
  - i. Spot-type smoke detectors shall be ceiling mounted.
  - ii. Sidewall mounting of spot-type smoke detectors shall be accepted only with Facilities Services (FS) and Designated Campus Fire Marshal (DCFM) pre-approval. Sidewall mounting increases maintenance and induces false alarms due to dust accumulation.
  - iii. Spot-type smoke detectors shall be placed no closer than three feet to air-supply or air-return registers.
  - iv. For high-ceiling applications and for atriums, stair wells and large area applications photoelectric beam-type smoke detectors and air sampling detection shall be used in place of spot-type smoke detectors. The potential for smoke stratification and inaccessibility of spot type detectors shall be considered.
  - v. For high-value applications and for high-air-flow applications, air-sampling-type smoke detectors are preferable to spot-type smoke detectors.
  - vi. Heat detectors shall not be used in areas protected by a wet fire sprinkler system unless called for by the Authority Having Jurisdiction (Designated Campus Fire Marshal [DCFM]). Exceptions may include head detectors used to anticipate automatic sprinkler system activation (elevator shunt-trip configurations).
  - vii. Rate-of-rise-type thermal detectors, detectors which utilize air passing through an orifice for their operation, shall not be used in areas where high humidity is anticipated.
  - viii. Smoke detectors powered solely by batteries shall not be permitted except for battery-powered smoke detectors installed on a temporary basis to provide for coverage while the permanent smoke detectors or fire alarm system are under repair or otherwise not functioning.

- ix. For high-value applications and for high-air-flow applications, air-sampling-type smoke detectors are preferable to spot-type smoke detectors. Brand and model shall be submitted to Capital Projects (CP) for approval.
- b. Air Duct Smoke Detectors
- i. Air-duct smoke detection shall be accomplished by one of three methods, the use of in-duct mounted or plenum mounted spot-type detector, sampling tube type duct detectors or full-air detection in accordance to National and State Fire Codes.
  - ii. In low air flow or static air ducts use an in-duct mounted smoke detector.
  - iii. In-duct mounted smoke detectors shall be Siemens HFP-11, FP-11 or subsequent model, listed for the anticipated air velocity and temperature conditions.
  - iv. In-duct smoke detectors shall be mounted “pendant style” to inside top of the duct. Detector shall be mounted to a listed electrical conduit box.
  - v. Do not use relay bases on in-duct mounted smoke detectors. Use a programmable remote relay (Siemens TRI-R, HTRI-R type or subsequent model), mounted outside of the duct, for relay functions. Relay base and wiring are virtually inaccessible for maintenance after construction and constitute a shock hazard. This restriction applies to all similar installations.
  - vi. A remote alarm indicating light (LED) shall be required, located so that it is readily visible from the floor by emergency responders and service personnel. The LED shall be clearly labeled to indicate the detector that is in alarm, and located as close as possible to the in-duct detector.
    - 1. Lamp shall be clearly visible from a common access floor space.
    - 2. Lamp shall be clearly labeled for this purpose. Sample; “In-Duct Smoke Detector 002-027 in alarm. Detector in duct above”.
  - vii. An access hatch within the duct shall be provided to inspect and clean the smoke , and access hatches through any sub-ceilings or structural features shall be provided.
- c. For high-ceiling applications and for atriums, stair wells and large area applications photoelectric beam-type smoke detectors and air sampling detection shall be used in place of spot-type smoke detectors. For high-ceiling applications the possibility of smoke stratification shall be considered in the design of the smoke detection system. Duct detectors mounted outside the duct and using air-sampling tubes shall include the following:
- i. All smoke sampling tubes shall extend beyond the duct and penetrate the far wall of the duct. The tube end shall be sealed in an approved manner. Exception: Where the outer duct wall is against a structural wall the sampling tube may be sealed and secured to the inside duct wall, inspection hatches must be provided for routine inspection of the sampling tube seal.
  - ii. Duct detectors mounted 10’ above the floor or concealed, either within a ceiling or obscured by any building feature, shall have a remote alarm indicating light (LED). The remote light shall be located so that it may be readily visible from the floor by emergency responders and service personnel. The LED shall be clearly labeled to indicate the detector that is in alarm, and located as close as possible to the duct detector.
  - iii. An access hatch in the duct shall be provided to inspect and clean the outside of the sampling tubes within the duct and access hatches through any sub-ceilings or structural features shall be provided.
  - iv. All air-duct smoke detectors shall activate the building fire alarm system in addition to controlling the heating, ventilating, smoke damper and air conditioning equipment. These duct detectors shall be either Siemens addressable or Siemens conventional system duct detectors equipped with relays for auxiliary control contacts.
  - v. Air-duct detectors that are by a different manufacture than the building fire alarm system or that are supplied, as part of an integrated air-handler system shall not be used.

- vi. Air-duct smoke detectors shall not be used as a substitute for other types of automatic fire detection. Air-duct smoke detectors shall not serve as the sole method of automatic fire detection.
- vii. Air-duct smoke detectors shall be used only when required by the Fire Marshal for the control of smoke within heating, ventilating, damper control and air conditionings equipment. If an alternative technique for controlling the heating, ventilating, damper control and air conditioning equipment is available (e.g., 100% coverage of the affected area by spot-type smoke detectors), the alternative technique of area detection is to be preferred.
- viii. Plenum-type high air velocity smoke detectors shall be used in plenum spaces whenever possible, instead of duct smoke detectors using an extended air sampling tube. In duct smoke detection application subject to high heat or extreme ambient heat variations do not use smoke detectors with a fixed thermal element (Siemens FP-11). Samples of high heat environments: Duct detectors in weatherproof outdoor roof enclosures, subject to sun light heat. In-duct detection in ducts used to mix hot and cold air near the detector; and plenums near heat exchanger coils.
- ix. All duct, in-duct and plenum detectors shall be tested when the air handling systems are fully operational and air-balancing is complete. The installing agency is required to prove that air flow through and around the detector is within the Manufacturer's specified tolerances. The test is to be conducted via AHJ approved metering devices.
- x. Duct Detectors on air handling systems utilizing a Variable Frequency Drive (VFD) or an Energy Management System that changes or cycles air flow rates shall have all duct detectors listed for static air flow.
- xi. The requirements for periodic testing, cleaning, and calibration of fire detectors shall be kept in mind when locating detectors. Access for maintenance crews shall be as convenient as possible.

### 3. Air Sampling Engineered Systems

- a. All air sampling systems shall be engineered by a qualified firm, shop drawings, calculations and design pre submitted to UCB AHJs for pre-approval.
- b. All sampling pipe connections to control units shall be via a pipe union assembly. This is to allow cleaning, testing and replacement of the units as required.
- c. Each sampling pipe run shall require a test point (at end-cap) located no higher than five feet, six inches (5'-6") from the floor grade for periodic testing.
- d. Connection to the building fire alarm system for alarm, trouble and supervisory monitoring shall be supervised for open wiring per NFPA 72, plug in terminal strips shall be configured to supervise placement integrity.
- e. The power supply, if not integrated into the sampling control unit, shall be supervised independently of the air sampling unit. A distinct trouble address shall be assigned to power supply and the air sampling systems.

### 4. Sprinkler Flow Switches and Control Valve Tamper Switches will be connected to and monitored by the fire alarm system.

- a. All sprinkler flow switches shall be capable of a routine water flow test using an inspector's test valve. The Inspector's test valves shall be provided wherever necessary to accomplish this, preferably as far downstream from the flow switch as possible.
- b. Each wet sprinkler system shall have a main flow switch.
- c. Sectional flow switches are encouraged.
- d. A non-silenceable water flow alarm, if required, shall be a component of the fire alarm system and software configured.

- e. All sprinkler inspector's test valves and drain valves will be piped into a plumbing drain of sufficient capacity to accept the full volume of water in that sprinkler section without overflow or flooding. Inspector's tests and drains that empty into a sink or require the installation of a test hose are not accepted.
- f. Pre-Action Sprinkler systems shall be monitored and controlled by the building fire alarm system.
- g. All flooding (filling with water) of a dry-sprinkler or pre-action sprinkler systems shall initiate a full alarm condition in the building fire alarm system. Sprinkler flooding shall initiate an alarm both during an engineered alarm triggered flood (e.g., a cross-zoned smoke detector condition) and the flooding of the sprinkler via a manual lever.
- h. All dry-sprinkler and pre-action sprinkler systems shall monitor the status of the piping integrity (low supervisory air pressure) at the building fire alarm control panel. Low air status shall report as a "supervisory" condition.
- i. Each fire sprinkler shut off valve shall be provided with a tamper switch to supervise it electrically against undetected closure. Valve tamper switches including PIV switches shall induce a "Supervisory" condition.
- j. On existing hard-wired conventional systems, each tamper switch shall be wired to a dedicated tamper-switch zone in the fire alarm control panel. There shall be one (1) such zone for each tamper switch. Tamper switches shall not be connected to flow switch initiating alarm zones.
- k. On addressable alarm systems each tamper switch shall have a dedicated address. The grouping of more than one (1) valve tamper switch to activate an alarm-monitoring device is not acceptable.

### *28 31 63 Fire Alarm Integrated Audio Visual Evacuation Systems*

1. Audible/Visual Signaling (Notification Appliances)
  - a. One (1) Floor Per Notification Appliance Circuit (NAC)
  - b. No notification circuit (fire alarm audible/visual devices) shall serve more than one (1) floor.
  - c. When more than one (1) circuit is required per floor than the circuits shall not overlap on the floor plan.
  - d. No alarm notification impairment on a single circuit/floor shall prevent any other floor performing alarm activation.
  - e. When two (2) or more distinctly different occupancies or functions are on the same floor, separate NACs shall be assigned to each occupancy. Circuits shall not be overlapping. Sample: A building divided between a laboratory wing and a general classroom wing shall have one NAC for each wing.
  - f. All fire alarm systems shall include audible/visual notification appliances. Systems using silent alarms shall not be permitted.
  
2. Audible/Visual Alarm Shall Be Seen And Heard In All Areas
  - a. Sufficient audible/visual indicating appliances shall be provided so that fire alarms can be heard and seen in all areas of the building. The sound and visual alarm shall conform to the requirement of California Fire Code (NFPA 72).
  - b. This level of notification shall be provided in all occupied areas, including those areas only occasionally occupied by service staff, such as mechanical equipment rooms. All final sound measurements shall be performed while the space is completely occupied by its assigned tenants and while normal activities are in progress. All audible levels are determined in field tests by the Designated Campus Fire Marshal (DCFM).
  - c. All building remodeling projects in existing buildings shall provide for additional fire alarm notification appliances if the remodeling would otherwise result in areas where the fire signals are not sufficient.
  
3. Audible/Visual Alarm Characteristics

- a. Audible signaling devices shall be of the same manufacture within a building. All equipment shall be compatible with the building fire alarm.
- b. Notification appliances shall be electronic Fire Horns, Horn/Strobes, Speakers, Speaker/Strobes, and Strobe Lights.
- c. Wall mounted notification strobe lights and combination horn/strobes and speaker/strobes shall be at eighty inches (80") above finished floor to bottom of lens, or six inches (6") from ceiling to bottom of lens if ceiling is less than eighty-six inches (86") from floor. Code required mounting locations (accessible for hearing impairment) take precedence. Exceptions to mounting location require pre-approval by the University of California, Berkeley Authorities Having Jurisdiction.
- d. Listed ceiling mounted notification appliances are to be used in open area floor plans and locations where sight lines to visual devices may be routinely obscured.
- e. Audible and Visual notification appliances shall be fully synchronized. Audible pulse rate and strobe flash shall be synchronized throughout the building alarm system. Exceptions allowing Synchronization by-floor requires pre-approval by the University of California, Berkeley Authorities Having Jurisdiction
- f. At least one notification appliance shall be located so that its signal can be heard and seen at the fire alarm control panel, with any door(s) to the control panel room closed. No audible indicating appliance shall be located within twenty feet (20'-0") of a fire alarm control panel or sub-panel, unless it is in a separate room with a door in between.
- g. All audible-signaling devices shall sound with uniform alarm code (3 beats, pause, and 3 beats). Voice messages shall incorporate this code.
- h. Audible/visual fire alarm devices shall be red in color. White devices with red lettering will require pre-approval by the University of California, Berkeley Authorities Having Jurisdiction. All non-fire evacuation notification devices shall be a different color and visual devices shall have a distinct lens color different than that used on the fire alarm. All NAC device colors shall be consistent within a building.
- i. Surface mounted notification appliances (horns, strobes, and speakers) shall have back boxes provided by the manufacture for that use only. Flush mounted notification appliances shall use "deep" mounting boxes.

#### 4. Notification Device Controls

- a. Notification Appliance Circuits (NACs) shall be controlled by the main fire alarm control panel, and through integrated remote control panels.
- b. Notification Appliance Circuits (NACs) may be controlled by control modules mounted in the fire alarm control panel and remote panels. For non-voice systems use the Siemens CSM-4 (Conventional Signal Module) or subsequent model. In a Siemens MXL/XLSV system use Siemens Zone Control Modules (for example, ZC2-8B)
- c. Notification Appliance Circuits (NACs) may be controlled via remote control panels. Control panels (PAD-3) that use the alarm signaling circuit (Siemens MXL/XLS ALD loop) to supply control activation are not accepted, except in limited circumstances as NAC extenders. Consult with Facilities Services Fire Protection Engineer. Sample; in the Siemens MXL/XLS, Intelligent Control Points (ICPs) or Siemens TRI-R monitoring modules for notification control are not accepted.
  - i. NAC extender panels may be used in upgrading existing fire alarm systems that are incapable of having the existing notification circuits expanded or upgraded to match current code requirements.
  - ii. NAC extender panels may be used when the building design precludes the practical use of a central NAC panel. Sample: When voltage loss in NAC conductors is excessive due to linear distance (buildings with extended wings) or extensive audible sound baffling (buildings with many small rooms and suites within suites).

- d. Audible/visual indicating appliances shall be designed to continue signaling until manually silenced by the fire department. No automatic time-out circuitry shall be used to silence the indicating appliances.
- e. A single alarm silence switch shall be provided inside the fire alarm control panel so that the alarm indicating appliances may be silenced without resetting the fire alarm system. If this switch is of the maintained-contact type, its position shall be supervised so that it cannot unknowingly be left in the silenced position. New alarm systems will be designed to accommodate subsequent alarms (alarms initiated after the alarm silence switch has been operated) by sounding and flashing the indicating appliances.
- f. In laboratories where the level of sound provided by corridor notification appliances is not adequate and because of the need to avoid startling laboratory occupants who may be engaged in potentially hazardous activities the following may be installed with Fire Marshal pre-approval:
  - i. Addressable voice systems allowing speaker volume and sound levels to be adjustable inside laboratory applications.
  - ii. A strobe light only may be used with AHJ pre-approval.
- g. In residential occupancies fire alarm system (general building alarm) notification appliances shall be located to provide required sound levels in all rooms (this applies to audible/visual devices located in corridors and inside living spaces). Each living space shall have a building fire alarm system notification appliance within apartment, suite or stand-alone dorm room. The device may be an audible base on a system smoke detector. This will insure the required evacuation alarm sound level.

## 5. Battery Backup

- a. Battery backup shall be provided to power the fire alarm system in the event of AC power failure.
- b. Battery capacity shall be determined in accordance with appropriate codes and industry practice.
- c. Batteries shall be of the lead acid gel or deep cycle type unless otherwise approved by the University.
- d. Manufacture date must be within one (1) month of system acceptance.
- e. An automatic battery charger, integral to the fire alarm control panel, shall be provided.
- f. Batteries shall be supervised to detect open circuits, short circuits, grounds, and low battery voltage.
- g. Meters shall be provided as part of the fire alarm control panel to indicate charging voltage and charging current.
- h. Provide 24-hour battery back-up test to check for adequate voltage and drop.

## *28 31 33.16 Fire Detection and Alarm Interfaces to Access Control Hardware*

### 1. Door Releases

- a. Alarm-controlled door releases shall be of the simple electromagnetic type as opposed to the integrated hydraulic closer type of door release.
- b. Door releases shall have an operating voltage of 24 VDC.
- c. Each door release circuit shall be independently fused at the fire alarm control panel. The fuse shall be chosen to open the circuit at 125% of normal current.
- d. Electromagnetic door hold opens shall be wired so as to be de-powered during AC power failure; alternatively, electromagnetic door holders shall be included in the battery stand-by calculations.
- e. Fire Alarm Signals shall take precedence over security signals.

### 2. Automatic Fire Doors

- a. Where possible a horizontal accordion fire door shall be used rather than a coiling roll-down door.
- b. All self-closing fire doors shall incorporate the following features:

- i. Provide battery back-up or emergency AC panel circuits for the power supply for the fire door system. When operating on battery power the door should operate, in every respect, as when on normal power.
- ii. An uninterruptible power supply (UPS) is required with the use of generator emergency power. The power supply transfer time must be less than the time required to release the fire door fire release mechanism. This will prevent door closure during the transfer period from normal power to stand-by power.
- iii. Standby power for the door controls shall not be provided by the fire alarm system.
- iv. Provide an audible (voice) and visual local alarm on all fire closures (including motorized and gravity drop closures).
- v. Provide adequate and safe access to control and mechanical elements of the door (access panels shall be of a size and placement so that service personnel may work safely with both hands, without inordinate leaning, stretching or reaching). An application requiring the removal of hoods, shrouds, and architectural elements such as soffits to reset door systems does not provide an acceptable access.
- vi. Provide a motorized closure and a motorized reset of the door system during normal fire conditions.
- vii. Provide, on roll-down, doors access for drum and curtain repair and replacement. If door curtains cannot be repaired the assembly must be removed from the wall.
- viii. The door control smoke detector (s) shall send an alarm signal via the alarm system control software to the associated programmable relay that shall operate the fire doors or accordion partition. The door control fire alarm relay shall be located near the door system and accessible for maintenance and repair without having to raise the door to normal position. Door assemblies that require maintenance or emergency response personnel to enter via a temporary unsecured secured door present a safety hazard.

### 3. Annunciator Panels

- a. An annunciator panel is not required if:
  - i. The fire alarm control panel is located immediately inside the fire department's entry door, or;
  - ii. The fire alarm control panel is located within a room whose entrance is immediately inside the fire department's entry door.
    - 1. The fire department's entry door shall be selected by the Campus Fire Marshal, in consultation with the Berkeley Fire Department.
    - 2. The requirements for a remote annunciator and location of the annunciator shall be determined by the Authority Having Jurisdiction (Designated Campus Fire Marshal [DCFM]).
- b. Annunciators shall not be mounted in outdoor locations. The only exceptions shall be mounting within approved listed weatherproof enclosures located in non-weather or sun exposed locations (i.e. covered porches).
- c. For addressable alarm systems the annunciator shall be a Siemens RCC-1 or subsequent model. This uses an alphanumeric display that is a one-to-one match with the display at the main fire alarm control panel. Use of the remote annunciator for system control shall require pre-approval by the University of California, Berkeley Authorities Having Jurisdiction.

### *28 31 33.26 Fire Detection and Alarm Interfaces to Intrusion Detection*

#### 1. Connection To Security Alarm Systems

- a. Connection to building security systems shall be by programmable remote relays Siemens type TRI-R or subsequent model.

- b. The interface between a fire alarm system and building security system shall be determined by consultation between the Designated Campus Fire Marshal (DCFM), UC Police Department Crime Prevention Unit and Facilities Services.
  - c. Control relays connecting the fire alarm system and a building security system shall have a secure (key operated) by-pass switch. This shall be provided and configured so that an impairment of the fire alarm system shall not impair the building security operation. Power loss and or shifting to stand-by power on the fire alarm system shall be considered as impairment.
  - d. Panels using LED lights shall not be acceptable. Panel shall be LCD Digital Remote Enunciator RCC Series Display or equal.
    - i. Graphic displays for smoke control fan status and elevator status displays may be approved by the Authority Having Jurisdiction and must include at least twenty-five (25%) more lamps and directory space than required, with wires for the additional lamps installed to the fire alarm control panel.
2. Single Reset Switch
- a. The main Reset in a fire alarm control panel shall reset all smoke detectors (including air duct smoke detectors) connected to that panel. No additional switching action shall be needed to reset any smoke detector. Exception: Engineer detection and suppression systems (Vesda HSSD).
3. Single Alarm Silence Switch
- a. A single switch, located in the main fire alarm control panel, shall silence all audible alarm devices. The main fire alarm control panel is the panel which either trips the DACT, as described in this division.
4. Bypass Switches
- a. The fire alarm control panel shall include supervised bypass or disconnect switches for each of the following functions:
    - i. municipal tie (central station signaling)
    - ii. audible signaling devices (one [1] bypass switch for all devices)
    - iii. door holders (one [1] bypass switch for all door holders)
    - iv. sprinkler flow switches (one [1] bypass switch for each flow switch)
    - v. extinguishing systems which initiate a fire alarm condition on the fire alarm control panel, e.g., range hood extinguishing system, (one [1] bypass switch for each extinguishing system.)
    - vi. equipment shutdown or turn-on circuits, e.g., building fan shutdown circuits, fan turn-on circuits, door opener circuits, etc., (one [1] bypass switch for each circuit.)
    - vii. lobby recall circuits (one [1] bypass switch for each elevator bank)
    - viii. extinguishing devices that are controlled by the fire alarm control panel, e.g., Halon systems or pre-action sprinkler systems (one [1] bypass switch for each device.)
5. Single Circuit Breaker - Dedicated Circuit
- a. No other (non-fire-alarm) equipment shall be fed by this circuit breaker.
6. Single Key Connection To Security Alarm Systems
- a. All fire alarm systems shall be totally separate from security alarm systems. No common wiring, raceways, batteries, control panels or signal transmission systems shall be used.
  - b. Connection to building security systems shall be by programmable remote relays Siemens type TRI-R , HTRI-R or subsequent model.
  - c. The interface between a fire alarm system and building security system shall be determined by consultation between the Designated Campus Fire Marshal (DCFM), UC Police Department-Alarms and Access, and Facilities.



- d. Control relays connecting the fire alarm system and a building security system shall have a secure (key operated) by-pass switch. This shall be provided and configured so that an impairment of the fire alarm system shall not impair the building security operation. Power loss and/or shifting to stand-by power on the fire alarm system shall be considered as impairment.

## 28 35 00 Refrigerant Detection and Alarm

1. Refrigerant Detection and Alarm systems shall be designed and constructed to comply with the most recent adopted versions of the California Fire Code and the California Mechanical Code
2. The panel must be located outside of the chiller room adjacent to the door.
  - a. If the chiller room has multiple doors, remote display panels are required.
3. Provide multiple alarm levels:
  - a. Low level alarm shall transmit signal to BAS - The low level alarm shall NOT activate the refrigerant leak detection system horns/strobes.
  - b. High level alarm shall transmit a Fire Alarm signal to FACU resulting in the activation of the fire alarm system and building evacuation. The high level alarm shall activate the refrigerant leak detection system horns/strobes.
4. The digital alarm communicator transmitter (DACT) must include a dedicated contact for the refrigerant leak detection system alarm to UCPD. It shall be identified as "Refrigerant Leak Alarm".
5. Sensing tubing must be either:
  - a. Plastic tubing in conduit (the type of plastic is to be per the panel manufacturer's requirements, or
  - b. Copper tubing
6. The detection panel is to display the refrigerant gas concentration at each sampling point.
7. Sampling points are to be provided at locations where the refrigerant gas will collect and where the sampling ports can detect the gas.
8. Each sampling point is to be identified by a number. The number must be identified on the tubing where it connects to the detector (i.e., identified at both ends of the tubing).
9. Horn strobes shall be provided in the chiller room so that the strobes are visible to all locations in the room. The horn shall have a sound pressure level of 15dB above the ambient level when chillers, pumps and all equipment in the chiller room are operating.
10. Strobes shall be yellow. The spacing of the strobes shall be based on the candela rating of the strobe.
11. Horns shall sound a continuous sound which is not similar to the fire alarm system horns.
12. The panel shall include a switch to silence the horn/strobes. This switch shall be a momentary contact type and not require the use of a key.
13. Signs shall be posted at the entry door(s) to the chiller room stating:
  - a. "IF REFRIGERANT LEAK ALARMS ARE SOUNDING/FLASHING, DO NOT ENTER"

14. Signs shall be posted in the chiller room stating:
  - a. "IF REFRIGERANT LEAK ALARMS ARE SOUNDING/FLASHING, LEAVE THE ROOM IMMEDIATELY"
  
15. Signs shall be posted at each horn/strobe stating:
  - a. "REFRIGERANT LEAK ALARM. IF HORN/STROBES HAVE ACTIVATED, LEAVE THE ROOM IMMEDIATELY"
  
16. Refrigerant leak detection panels shall not be located outside unless approved by the DCFM. Panels located outside shall be weather protected. Panels using plastics that will degrade or discolor when exposed to UV radiation shall not be used. Panels shall be located such that the temperature within the panel enclosure does not exceed the temperature rating of the equipment.

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## 31 00 00 Earthwork

### 31 06 00 Schedules for Earthwork

#### 31 06 20.16 Backfill Material Schedule

1. Backfill material shall be selected in accordance with the recommendations of the Geotechnical Engineer, as stated in the project's written geotechnical report.
2. Soils containing clay clods, cobble larger than six inches (6") in any dimension, organic matter, debris of any type, and soils classified as expansive are defined as unsuitable and shall not be used as backfill.
3. Rubble shall not be placed in structural backfill or trench backfill. Rubble may be placed within engineered fill areas only with the written approval of the Engineer and must be placed in a manner that enables full compaction of the placed soils around it without voids or soft spots to the minimum relative compaction required by the contract documents.
4. Pipe bedding material for pipe diameters less than or equal to twelve inches (12") in diameter shall consist of coarse, poorly graded sand.
5. Pipe bedding material for pipe diameters greater than twelve inches (12") in diameter shall consist of 3/8-inch pea gravel.
6. Pipe may be laid on undisturbed native soils only with express written approval from the Engineer.
7. Pipe zone backfill material shall consist of the same material used for bedding.
8. Trench zone backfill material shall consist of clean, granular suitable soil material.
9. Structural backfill material shall consist of clean, granular non-expansive soil free of clay or clods larger than four inches (4") in any dimension and acceptable to the Geotechnical Engineer. Where suitable material is not available on site, the Contractor shall import suitable soil from a local supplier after approval of the source and material by the University's Representative.
10. Every truckload of imported material shall be accompanied by certification from the supplier stating the material properties, classification, source and volume. The Contractor shall keep these documents on site and make them available for inspection by the Owner's Representative at any time.

### 31 10 00 Site Clearing

1. Soil Management Requirements
  - a. All soil must be evaluated by UC Berkeley standards for environmental contamination with laboratory analysis before export to any off-site location. UC Berkeley soil cannot be taken to K-12 schools, residential developments or other sensitive receptor sites.
  - b. Soil, Landscaping and Fill Material cannot be removed, transported or reused without full environmental screening as approved by UC Berkeley's Office of Environment, Health and Safety.
  - c. Non-Hazardous Soil must have Bills of Lading (BOL) or other shipping documents for transportation to acceptance site signed by UC representatives.
  - d. Hazardous materials disposal manifests may only be signed by EH&S Campus Staff with DOT training. All soil shipping documents (BOLs and manifests) must be sent to EH&S for final record retention.

### 31 23 00 Excavation and Fill

1. Excavation for utility trenches and minor structures
  - a. Utility trenches shall be excavated into native soil or engineered fill to the line and depth indicated in the Contract documents.
  - b. Where utilities are to be installed in fill areas, the fill shall be placed and compacted per the Geotechnical Engineer's direction, to a minimum depth to allow trenching depth to achieve

installation of the pipe with bedding and trench zone backfill at least three feet (3 ft.) above the top of the pipe.

- c. The trench or excavation for vaults and manholes shall be excavated to a sufficient depth to provide bedding, foundation and pipe wall such that the pipe invert will rest at design grade. The trench/excavation bottom shall be smooth undisturbed native soil, free of protrusions, roots, rock outcrops, debris, and unsuitable soils.
- d. Bell holes and other divots for joining, valves and other protuberances shall be made in the trench bottom or bedding material, such that the full length of the pipe is supported by the bedding.
- e. Where soils at the bottom of the excavation are not suitable, over-excavation shall be required to remove unsuitable soils. If the volume of excavation required to expose suitable native soil is so large as to make removal impractical in the opinion of the Geotechnical Engineer, the Contractor shall follow the recommendation of the Geotechnical Engineer to remove sufficient soil to be replaced with drain rock, foundation rock or other material as required by the Geotechnical Engineer to provide a suitable foundation upon which the Work can be constructed. This foundation shall be built up and compacted to the requirements in the Contract documents, as recommended by the Geotechnical Engineer, or to a minimum relative density of 95% if no requirement is stated in the Contract documents. Payment for over-excavation and backfill shall be as negotiated with the Owner.
- f. Where hard rock is encountered during excavation activities, the Contractor shall bring this condition to the attention of the University's Representative at the time it is encountered and prior to proceeding with hard rock excavation. No payment for extra effort for hard rock excavation will be made without first negotiating the terms for such payment and timely notification to the University's Representative at each such encounter.
- g. Utility trench width for pipelines up to 6 inches in diameter shall be a minimum of 8 inches and a maximum of 12 inches clear on each side of the pipe. Trench shall maintain vertical sides at least throughout the pipe zone to the maximum extent practical. Where soil or other existing conditions prevent meeting the trench width requirements, recommendations of the geotechnical engineer as to how to best support the pipe and provide adequate compaction during backfill shall be followed.
- h. Utilities shall not be installed in a common trench. Where alignments are parallel, the deepest utility shall be installed first to allow adequate backfill and compaction before cutting the trench for the subsequent utility into compacted soils.
- i. An accepted Safety Plan shall be in place prior to any trenching or structural excavation activities. Such Plan shall include means to protect unauthorized workers and the public from entering or falling into an excavation. Trenches that must remain open at the end of the day shall have sufficient barricades to prevent intruders from entering the trench.
- j. Blasting is prohibited.

## 2. Dewatering

- a. The Contractor shall take groundwater and the possibility of surface water entering excavations into consideration when developing his/her bid for the Work. It is the Contractor's responsibility to perform all dewatering activities as necessary and in accordance with all local and state laws and regulations, as water is encountered during the entire project duration.
- b. Water shall not be allowed to accumulate in an excavation. Soil moisture condition shall meet the recommendations of the Geotechnical Engineer at the time materials are installed and until the time that backfilling has been completed. Filling a ponding excavation with gravel or rock as a substitute for dewatering is not allowed.
- c. The Dewatering Plan shall include monitoring of drawdown impacts to adjacent structures, activities, landscape elements and water courses. Long-term detrimental impact to heritage trees, watercourses or built facilities will not be allowed. If such impacts become apparent

during construction, the University will require corrective action, including stopping work until alternative methods can be implemented.

- d. Disposal of water from dewatering activities shall be in accordance with all state and local regulations. Plans, means and equipment required for dewatering and disposal of water shall be included in the Contractor's Dewatering Plan and consistent with the Contractor's Stormwater Management Pollution Prevention Plan.
- e. Where groundwater or weather conditions present a volume of water that could not have reasonably been anticipated, the Contractor may propose renegotiation of the activities. Similarly, where the Contractor included dewater costs into the project price but less or no such expenses were incurred, the Contractor shall credit the University for costs not incurred.

### 3. Backfilling

- a. Backfilling shall be conducted with materials indicated in the Contract documents and to the depths indicated in the drawings. Recommendations of the Geotechnical Engineer with respect to materials specifications, lift thickness, minimum compaction, or any other recommendation shall be adhered to. Where a conflict exists between the drawings, the Specifications, and the Geotechnical Report, the Geotechnical Report shall govern. Any variance from this requires specific written acceptance from the Geotechnical Engineer.
- b. Prior to backfilling of minor structures, the Engineer of Record shall ensure that the structure is built to Specifications, including adequate drainage and sealing of joints.
- c. Prior to backfilling of utility trenches, the verify that the pipe has been installed to line and grade indicated on the drawings, without dips or sags, that the pipe has been installed in accordance with the manufacturers recommendations and include means of verification in the daily report.
- d. Backfilling shall be perform in lifts not to exceed eight inches (8") and soil shall be placed uniformly around the structure and across the pipe trench. If the Geotechnical Engineer recommends thinner lifts, then the stricter lift thickness shall govern.
- e. Backfill material shall be within the range of moisture content specified at the time of placement. Material that is too dry shall be dampened prior to backfill. Material that is too wet shall be mixed with dry soil that is of the same type such that the mixed soil meets specification requirements for that particular backfill material.
- f. Soil shall be carefully placed in a trench or other excavation and shall not be dumped directly on a pipe or structure. Place soil evenly on both sides of the pipe and tamp the soil firmly under the haunch of the pipe, filling voids. Avoid displacement of the structure or pipe during placement of the backfill material and compaction.
- g. Each lift shall be compacted to the density required by the Geotechnical Engineer. Only hand equipment shall be used within the pipe zone. Wheeled compaction methods shall not be used over pipe trenches until backfill depth reaches at least three feet (3 ft.) above the top of pipe.
- h. Jetting shall not be allowed.
- i. Where minimum depth of fill cannot be accomplished, the Engineer shall direct the Contractor to perform other means to protect the pipe which may include: Controlled Density Fill (CDF), concrete encasement, bridging of the trench, pipe casing or other means, depending on site conditions and service requirements. While the Contractor may propose a method he/she prefers, the Contractor shall not initiate a shallow installation without written direction from the Engineer.

### 31 41 00 Shoring

- 1. Wherever state local or federal regulations require shoring, the Contractor shall prepare a Shoring and Sheeting Plan, signed and stamped by a California registered civil engineer with a shoring specialty.
- 2. The Shoring and Sheeting Plan shall be submitted to the University's Representative prior to excavation activities that will require shoring and/or sheeting.

3. The Contractor shall strictly adhere to the requirements of the Shoring and Sheeting Plan, at a minimum safety precaution.
4. Excavations shall avoid to the maximum extent possible excavation under pavements, walkways and roadways. Where such excavation is unavoidable, barricades shall be installed that will prevent workers, the general public and vehicles of all types from traversing areas near the area.
5. Excavations will be backfilled at the earliest possible time. Where work cannot be completed within one work day, the open excavation shall be completely covered in such a manner that intruders cannot enter or fall into the excavation.
6. It is solely the Contractor's responsibility to maintain safety on the worksite.

## 32 00 00 Exterior Improvements

### 32 10 00 Bases, Ballasts, and Paving

#### 32 12/13 00 Flexible/Rigid Paving

1. Materials
  - a. Use asphalt or concrete with broom or salt finish of natural color.
2. Joints
  - a. Determine expansion requirements before specifying.
3. Installation
  - a. Specify standard installation methods: base depths, reinforcement (concrete) and weak surface depth depend on load requirements and thus vary.
4. Styles, Colors, Finishes
  - a. Darker materials preferred, as they are usually easier to match in the future.
5. Contractor Additional Requirements
  - a. Identify manufacturer's source for replacement for paving types of individual pieces, i.e., tiles, bricks, slate.
  - b. Stamped concrete installations shall require turn-over of tamp template pattern to the University.

#### 32 14 00 Unit Paving

##### *32 14 13 Precast Concrete Unit Paving*

Campus standard impervious concrete unit paving for shared pedestrian and vehicular walkways and plazas shall be a Mission Style 6" x 12" x either 60mm or 80mm Gray Charcoal blend, from Cal Stone, 426 East Grant Line Road, Tracy, CA 95376; (209) 833-7366 or approved equal.

##### *32 14 13.19 Porous Precast Concrete Unit Paving*

Campus standard pervious concrete unit paving for shared pedestrian and vehicular walkways and plazas shall be a 6" x 12" x either 60mm or 80mm Gray Charcoal blend, from Pacific Interlock Pavingstone (408) 257-3645 or approved equal.

##### *32 14 40 Stone Paving*

Avoid flagstone pavers as they tend to come loose from base material, crack and can be difficult to match at later dates

#### 32 15 00 Aggregate Surfacing

##### *32 15 40 Crushed Stone Surfacing*

Standard campus crushed stone surfacing stabilizer shall be Soilshield-LS polyvinyl acrylic copolymer, tan in color, from Soil-Loc, Inc. Scottsdale, Arizona; (888) 828-7300, or approved equal. Install per manufacturer's instructions.

#### 32 16 00 Curbs, Gutters, Sidewalks, and Driveways

All new concrete flatwork shall include a glare-reducing admixture. This shall be either be one (1) pound of lampblack per cubic yard or an equivalent liquid measurement.



## 32 17 00 Paving Specialties

### 32 17 13.19 Precast Concrete Parking Bumpers

Parking blocks shall be precast reinforced concrete, 10" wide x 6" high x 3' long, with minimum of two (2) anchor pin holes. Provide 1/2" diameter x 24" length hot dipped galvanized steel anchor pins for securing parking blocks

### 32 17 26 Tactile Warning Surfacing

Curbs and ramps shall follow state access code requirements, UC Berkeley standard detectable warning shall be yellow reinforced "CASTinTACT 3" concrete tiles either mortar or wet set supplied by Masco Masons Supply ([http://www.masco.net/pdf/catalogs/castintact3/CASTinTACT3\\_Catalog.pdf](http://www.masco.net/pdf/catalogs/castintact3/CASTinTACT3_Catalog.pdf)) (No known equal). Overall dimensions shall comply with all applicable state and federal access codes.

## 32 30 00 Site Improvements

### 32 31 00 Fences and Gates

See [Landscape Heritage Plan](#) Section 4, *Pedestrian Barriers and Traffic Controls* for various approved campus fence designs. The campus standard two (2) rail wood fence shall be used near natural areas or steep drop offs. Project and site-specific fences and gates shall be developed in concert with the Campus Architect.

### 33 33 13 Site Bicycle Racks

1. New buildings and buildings undergoing major renovation should provide bicycle parking/storage for both long-term and short-term users depending on building program and occupant load.
2. The site should provide a mixture of secure/indoor bicycle parking (long-term parking) and outdoor bicycle racks (short-term parking) for no less than 15% of the average peak daily occupancy of the building. In some cases, providing more bike parking may be advisable, particularly for residential buildings and for buildings that house a substantial number of faculty, staff or researchers (e.g., office buildings, laboratories, clinics, special event spaces such as the stadium or athletic fields). To determine this, discuss with Physical & Environmental Planning during the design process.
  - a. Short-term bike parking (bicycle racks) should be highly-visible, well-lit and located within 50' of major/primary building entrances. Outdoor bicycle racks should be securely surface mounted or cast in place.
  - b. Bicycle racks shall use inverted u style racks of galvanized or stainless steel pipe, or similar. The rack shall securely accommodate a bicycle six feet (6'-0") long with its frame supported at two locations so that the bicycle cannot be pushed or fall in a manner that will damage wheels or components.
  - c. Bicycle racks should be placed so that bicycles do not disrupt the path of travel or intrude into the street. On sidewalks less than fifteen feet (15'-0"), racks may be parallel to the curb with at least twenty-four (24") from the curb.
  - d. Each bicycle parking space shall be accessible without moving another bicycle. Racks perpendicular (side-by-side) to the curb shall be no less than thirty-six inches (36") apart (forty-eight inches [48"] preferred). Racks parallel (end-to-end) to the curb should be no less than forty eight inches (48") apart (seventy-two inches [72"] preferred).
  - e. The area devoted to bicycle parking should be hard surfaced: concrete, asphalt, decomposed granite or equivalent at the discretion of the campus architect.

- f. Racks shall be at least five feet (5'-0") from fire hydrants and four feet (4'-0") from bus stops, loading zones, blue (accessible) zones, curb ramps, and crosswalks. Racks should not conflict with utility boxes or access.

### 32 33 14 Site Bicycle Lockers

#### Long-Term Bike Parking

1. Discuss bicycle planning requirements with the UCB project planner to determine the appropriate bike parking accommodations. New buildings and buildings undergoing major renovation should provide bicycle parking/storage per the campus' Bicycle Master Plan. New buildings and major renovations should incorporate secure bicycle parking areas, either interior bike storage rooms or exterior, secure bike cages/shelters, when the building program includes staff or faculty offices, labs or other spaces where occupants spend considerable amount of time during the day.
2. Indoor bike storage areas may consist of indoor bike rooms, secure bicycle cages, bicycle lockers, or other structures accessible only by those issued keys for use. Indoor bike parking/storage locations should be indicated with signage directing people to these spaces. It is recommended that indoor bike rooms also include storage units for bicycle commuter personal effects and space for bicycle repair equipment such as air pump, tire level, etc.
3. Indoor secure bicycle parking may use hanging wall racks, inverted U racks, bike lockers, or two-tiered racks depending on which style maximizes use of the space. Each space must be accessible without moving another bicycle and must accommodate a path of travel to allow people to access the bicycle parking.

### 32 33 00 Site Furnishings

#### 32 33 23 Site Trash and Litter Receptacles

1. The campus standard for outdoor receptacles is solar compacting units that compact materials following the three material streams: landfill, cans and bottles, and compost. Big Belly units are purchased through Waxie Sanitary Supply located at 901 N Canyons Parkway, Livermore, Ca 94550, (925)454-2900. Each station will have at least one cans & bottles, one compost, and one landfill unit. The entire station will measure 49.8" tall x 75" wide and 26.8" deep. For more additional information, please contact Cal Zero Waste (<http://zerowaste.berkeley.edu>) for details. In cases where an alternative is proposed, please contact Cal Zero Waste, Facilities Services for review and approval.
2. For indoor receptacles, see Section 12 46 33 *Waste Receptacles*.

#### 32 33 43.13 Site Seating

1. The campus standard outdoor or memorial bench in the public realm shall be an unfinished, teak wood bench either 6' or 8' long "Parkside" bench, available from Gardenside International Limited at 808 Anthony St, Berkeley, CA 94710, (415) 455-4500, or approved equal. All benches shall be blind anchored into concrete. See Appendix A: Drawings for typical Installation details. Wherever possible, benches shall have center armrest to discourage unlawful lodging. Plaques or engravings shall undergo campus approval process.

### Trash and Recycling Enclosure

1. All projects that include Trash and Recycling Enclosures, whether new or modification to existing, require review and approval, including Designated Campus Fire Marshal (DCFM) and Campus Architect approval.
  - a. Enclosures that house fewer than six plastic 64 gallon wheeled carts and no dumpsters, bailers or compactors may be enclosed with a simple fence. See Section 32 31 00 *Fences and Gates*, above.
2. Drainage
  - a. Provide a three inch (3") minimum drain line inside the enclosure routed to the sanitary sewer; with a trap-type catch basin or a cleanout to grade in combination with a p-trap.
3. Doors
  - a. Install sturdy, wide, and positive closing doors (not to exceed 15lbf for opening).
  - b. Doors shall have a mechanism with sufficient tolerance to remain closed with ½ inch of door misalignment.
  - c. Design door opening width to extend a minimum of two feet (2'-0") past width of bins on both sides to allow ease of bin movement.
4. Paving
  - a. Pave enclosure pad and front entry concrete apron with an impermeable material.
  - b. Reinforced six inch (6") thick concrete is recommended at a minimum.
5. Grading
  - a. If the enclosure is open to rainfall, the inside of the enclosure shall be graded to drain to a dual sanitary sewer - storm drain. A valve shall be installed to enable switching from storm to sanitary drain for cleaning or spills.
  - b. Grade the apron away from the enclosure pad to keep storm water out.
  - c. Grades shall not exceed five percent (5%), nor be less than one percent (1%).
  - d. Create positive surface run off around enclosure and swale in front of doors, if site grades require it.
6. Walls/Screening
  - a. Include an interior curb, with strike plate or bumper guard to prevent damage to walls.
  - b. Walls/screening shall screen the contents inside the enclosure.
7. Lighting
  - a. Provide motion sensor controlled lighting in the enclosure.
  - b. Lighting shall be designed to provide a minimum of 0.5 foot-candles inside and along the access route to the enclosure.
  - c. Use long life LED fixtures compatible with surrounding pedestrian lighting.
8. Water Supply
  - a. Provide a lockable hose bib source inside the enclosure.
9. Access
  - a. The top of the dumpsters cannot exceed thirty-six inches (36") from the finished grade or use of mechanical assisted or automated system must be provided
  - b. The dumpsters must be accessible to the street level for servicing
  - c. The path from the service elevator to an indoor enclosure shall be within a building. No impediments shall exist in the path of travel to any enclosures. Impediments include: stairs, textured surfaces, bumps, drains, slopes/grades greater than two percent (2%).
  - d. Distance from Enclosure to Truck Access
    - i. Locate the enclosure no more than five feet (5'-0") away from truck access. Pathway and parking grades shall not exceed two percent (2%).

- ii. If needed for protection, traffic control bollards shall be placed to allow pedestrian access to the enclosure and spaced eighty inches (80") on center to allow bins to roll through them.
10. Equipment in enclosure to accommodate compactor, baler, dumpsters and carts for the different material streams.
- a. Size of enclosure and number of dumpsters, carts, compactors and balers will be determined by size of building, occupancy, and building use. Please contact Cal Zero Waste for proper sizing of the enclosure. Typical campus installations may include the following (with dimensions of each):
    - i. Plastic 64 gallon wheeled carts are 44" tall x 30" wide x 30" deep
    - ii. Two cubic yard bins are 54" tall X 80" wide x 52" deep
    - iii. Nedland NSC200-20 yd. compactors are 102" tall x 101" wide x 18'4" deep
    - iv. Harmony M60MD Balers are 95.75" tall x 78" wide x 37" deep; Required operating area: 39.5 sq. ft.
  - b. Each waste stream collected shall have designated containers, signage, and space at enclosures for collections:
    - i. Dumpsters/Baler (dependent on building size and generation) for cardboard.
    - ii. 64-gallon black plastic wheeled carts for landfill.
    - iii. Compactors or 64-gallon green plastic wheeled carts for compost.
    - iv. 64-gallon blue plastic wheeled carts for cans and bottles.
    - v. 64-gallon blue plastic wheeled carts mixed paper.
    - vi. Designated location and space for reusable items, salvage, and pallets.

### 32 39 00      **Manufactured Site Specialties**

- 1. For bollards and barrier-poles, consult with the UCPD Crime Prevention Unit (510-642-3722) for device type and dimensions, as well as campus padlocks and anchoring mechanisms to the ground.

### 32 80 00      **Irrigation**

#### 1. General

##### a. Pre-Project Planning

- i. Consult with Facilities Services Grounds Shop Irrigation Lead prior to project design (at least 6 months if possible) to determine infrastructure (wiring and existing piping), appropriate point of connection and available existing controllers (best communication path, line of sight and radio and/or signal strength). This is necessary to best utilize existing systems and avoid destruction of and incorrect placement of or incorrect equipment choice.

##### 1. Mainlines

- a. Consult with the Irrigation Lead prior to design when adding new systems to establish Mainline supply and point of connection. This will avoid problems with the looped Campus system and confirming an independent point of connection.

##### 2. Controllers

- a. Consult with Irrigation Lead prior to New irrigation system installs to determine whether a new controller is the best option OR adding to an existing controller. If it's deemed adding to an existing controller is the best option then the project needs to accommodate funding to expand the hardware in the controller and provide for added labor costs.

##### b. General Design Type and Irrigation Equipment Selection

- i. Irrigation Design—Low precipitation stream shrub spray head nozzles (e.g. Rainbird 1800 SAM-PRS with MP Rotator Stream Nozzles). Basis of design shall be Rainbird Model 1812 SAM-PRS with 12” pop-up height unless low growing ground cover is selected.
      - ii. No drip or subterranean emitter piping shall be used in campus landscape irrigation.
      - iii. Large scale bubbler-type emitters shall be used only for isolated trees and shrubs, not in large plant zone irrigation, ground covers or multiple shrub mass planting areas.
      - iv. Controllers shall be battery operated only where a physical necessity or installation of appropriate power infrastructure is cost prohibitive.
        - 1. Consult prior to use--If battery operated controllers are unavoidable, they shall be Rainbird TBOS II Controllers and appropriate TBOS DC Solenoids, with installation locations noted on laminated zone maps.
- c. General Layout
  - i. For PVC schedule 40 lateral distribution lines lay all TEE & ST ELL fittings in a vertical orientation (threaded connection pointing up) to facilitate improved irrigation head placement – this will require the use of one more swing joint ST ELL than is typically required
  - ii. Contractors to perform system pressure testing, pipe depth and general inspection criteria for all work (including small scale work)
- d. Quality Assurance
  - i. Underwriters Laboratories: Electrical wiring, controls, motors and devices must be U. L. listed, and so labeled.
  - ii. Installer Qualifications for solvent joints: Employ personnel trained by the manufacturer's representative in techniques for making correct joints prior to performing work on the site.
- e. Delivery, Storage and Handling
  - i. Storage: Store material in an orderly manner. Avoid interference with other construction activities.
  - ii. Protection: Protect all materials to prevent intrusion of dirt and moisture. Protect the installed work and materials of other trades. Cover and protect from sunlight.
- f. Site Conditions
  - i. Perform irrigation installations when weather and soil conditions are suitable as determined by the Owner's Representative.
  - ii. Coordinate with the work of others, particularly with respect to utilities and underground systems.
  - iii. If underground construction, obstructions, or unforeseen utilities are encountered, notify the Owner's Representative.
  - iv. Examine the drawings and the site and be aware of connections required and existing improvements to remain and those to be protected.
  - v. Survey existing irrigation and wiring.

2. Submittals:

- a. Operating and Maintenance Tools:
  - i. Deliver the following items to the Owner when work is completed prior to final acceptance.
    - 1. Two keys for each automatic controller cabinet.
    - 2. Four quick coupler and matching hose swivels with globe valves.
    - 3. Two keys for opening valve boxes.
    - 4. Two laminated color-keyed zone diagrams for the area covered by each controller.
- b. Product data: Prior to installation of any work, prepare a list of each material proposed for use and submit to the Owner's Representative for review.
- c. Record Drawings: Submit record drawings showing dimensioned locations and depths for each of the following:

- i. Point of connection: Sprinkler pressure line routing. Provide dimensions for each one hundred lineal feet (100'-0"), maximum along each routing, and for each change in direction. Gate valves; sprinkler control valves (buried only); quick coupling valves; control wire routing; other related items as may be directed.
  - ii. Provide point of connection pressure and flow readings to ensure they meet the design criteria and allow for existing demand.
  - iii. Record all changes that are made from the drawings, including changes in pressure and non-pressure lines. "As-Built" drawings must be provided
  - iv. Locate all dimensions from two permanent reference points such as buildings, monuments, sidewalks, curbs, or pavements.
  - v. Record all changes that are made from the drawings, including changes in pressure and non-pressure lines.
  - vi. Final review will not commence without prior receipt of record drawings.
- d. Controller Charts:
- i. Do not prepare charts until record drawing have been reviewed by the Owner's Representative.
  - ii. Provide one controller chart for each automatic controller installed. Chart shall be a reproduction of the Record Drawing, fitting the controller door. Photo reduction prints are required, keeping reduction to maximum size possible to retain full legibility. The chart shall show the area covered by that controller.
  - iii. Identify the area of coverage of each remote control valve.
  - iv. Following acceptance of charts hermetically seal between two layers of thirty-millimeter (30 mil.) thick plastic sheet.
- e. Operating and Maintenance Manuals: Provide descriptions of all installed materials and systems in sufficient detail to permit maintenance personnel to understand, operate and maintain the equipment.
- i. Include one laminated, color-keyed zone diagram for the area covered by each controller in the manuals.
  - ii. Submit both hard and electronic (PDF) copies of all Operations and Maintenance Manuals.

### 3. Warranties/Guarantees

- a. In addition to the manufacturer's guarantees or warranties, warrant all work for one year from the date of final acceptance against defects. Cover repair of damage to any portion of the site or adjacent areas resulting from leaks or defects in materials and workmanship. Submit warranty in writing to the Owner's Representative.

## 32 81 00 Irrigation Components

1. General piping: Main line: Schedule 40 PVC with schedule 40 solvent weld fittings. Lateral Line: Schedule 40 PVC with schedule 40 solvent weld fittings; size as shown on drawings. Pressure test supply line from point of connection through backflow prevention unit. Pressure test supply lines downstream of backflow prevention units and non-pressure lines.
- a. Brass Pipe and Fittings: 85% red brass, American National Standard Institute (ANSI), schedule 40 threaded 125 pound class. Fittings: medium brass threaded 125-pound class.
  - b. Plastic Pipe and Fittings:
    - i. Pipe shall be identified with the following markings:
      - 1. Manufacturer's name
      - 2. Nominal pipe size
      - 3. Schedule of class
      - 4. Pressure rating psi
      - 5. NSF (National Sanitation Foundation) seal of approval

6. Date of extrusion

- ii. All connections shall be solvent welded, unless seismic activity or other considerations dictate that ring-tight piping will provide better joint strength. Designer to consult Facilities Services Grounds Shop Irrigation Lead in such instances.
- iii. Fittings: Standard weight, Schedule 40, injection molded PVC. Comply with ASTM - D17854, cell classification 1345B. Threads, where required, injection molded type. Tees and elbows: side gated.
- iv. Threaded nipples: Standard weight, Schedule 80 with molded threads.
- v. Joint Cement and Joint Primer: Type as recommended by manufacturer of pipe and fittings.

2. Components:

- a. Tracer wire: 12 gauge unshielded copper wire shall be installed with all main lines.
- b. Gate valves: Nibco, Stockham or equal with brass handle. Non-rising stems. For three inch (3") pipe or larger, use a square head valve.
- c. Chloramine Resistant Backflow Preventer: 975 XL Y Wilkins. Install in painted metal cage on a concrete pad. Color TBD by Owner's Representative
  - i. Pressure Regulator valve (PRC) or Watts N55BDU-MI Wilkins 500 series.
  - ii. Turbine Meter Class 2 – Brass construction by Master Meter Neptune-Trident with dry contact leads.
- d. Remote Control Valves: Install Rainbird PESB plastic remote control valve (or approved equal) for all sizes one and one half inch (1.5") and below. Install Rainbird EFBCP brass remote control valve (or approved equal) for all sizes above one and one half inch (1.5"). Install Rainbird PESB remote control valve (or approved equal) for low-flow installations (e.g. drip and/or bubbler zones). Install ball valve before remote control valve and union on lateral side, label with Christy ID tags.
- e. Valve Boxes: Carson 910 ten inch (10") series for isolation valves and/or Brooks splice boxes 1419 to 1200. Use Christie "B" series concrete in high traffic areas.
- f. Quick Couplers: Rainbird 33DRC yellow with locking covers or equal. Install in fourteen inch (14") square concrete sprinkler blocks in high traffic areas. Schedule 80 fittings. No premade swing joint assemblies allowed.
- g. Sprinkler Heads – Lawns:
  - i. Rotary Type: Hunter Stainless I-20, I-25, I-40, I-44 or equal.
  - ii. Spray Type: Rainbird 1800 SAM PRS Series, six inch (6") with MP Rotator nozzles by Walla Walla (or equal) for low water use
  - iii. Sprinkler Heads – Shrub Areas:
    - 1. Spray heads: Rainbird 1800 SAM PRS series 6" – 12" or equal.
    - 2. Bubblers: Hydro Rain 610 Flood Bubbler or Rainbird Bubbler or equal.
- h. Controllers: Campus Vendor for Motorola systems is Central Control Systems Ltd. (530) 662-6841. Before specifying, consult with Facilities Services Grounds Irrigation Lead Nick Cole (nickcole@berkeley.edu or (510) 812-0908) regarding the desired controller configuration at this site in coordination with the campus network.
  - i. Cabinets: Use Strongbox stainless steel enclosure on a concrete pad for exterior installations or a wall-mount Type 1 electrical enclosure for interiors.
  - ii. Controllers shall be mounted:
    - 1. In a Strongbox Stainless Steel Enclosure with Pedestal mounted on concrete pad for all exterior installations
    - 2. In a Type 1 Wall-Mount for all interior installations
  - iii. Controller modules shall be one of the following:
    - 1. Motorola IRRInet-ACE with the following features:
      - a. Choice of: 8, 16, 24, 32, 40, 48, 56, 64, 72, 80, 96, 104, 112, 120, or 128 Stations

- b. 8 Programmable Inputs
  - c. UHF Radio Kit
  - d. Foster 100VA 24VAC Transformer
  - e. 110V Surge Protector
  - f. GFI/Outlet Power Switch Assembly
  - g. 8 Station/2 Input Valve Switchboards
  - h. Phoenix PLC-RSC Relay Mod 6A 12VDC
  - i. Installation Terminals & Hardware
  - j. UHF L0-Profile Antenna Kit
  - k. 2-Wire Decoder Module where Needed
2. Motorola IRRInet-M with the following features:
    - a. Choice of: 12, 24, 36, or 48 Stations
    - b. 4 or 8 Programmable Inputs
    - c. UHF Radio Kit
    - d. MW 12 Volt DC Power Supply
    - e. Foster 100VA 24VAC Transformer
    - f. Back-up Battery
    - g. 110V Surge Protector
    - h. GFI/Outlet Power Switch Assembly
    - i. 8 Station/2 Input Valve Switchboards
    - j. Phoenix PLC-RSC Relay Mod 6A 12VDC
  3. Motorola Solar Powered DC IRRInet-M with the following features:
    - a. Choice of: 12, 24, 36, or 48 Stations
    - b. 4 or 8 Programmable Inputs
    - c. UHF Radio Kit
    - d. Sun Saver Charge Regulator
    - e. EP26-12 Storage Battery
    - f. Installation Terminals & Hardware
    - g. UHF LO-Profile Antenna Kit
    - h. Panel PV-MOD, 20W, 12V w/ Mounting Hardware
    - i. Mast plus Weatherhead and Hardware
  4. Solar Powered Piccolo-XR, with the following options
    - a. 2 or 4 outputs/2 or 4 inputs
    - b. Moultrie 6v Solar Panel
- iv. Electrical Wiring and Service:
1. 120V High voltage: In conformance with drawings. Provide hookup to controller.
    - a. Note: All Installations Must Include a 5/8", 8' Grounding Rod With Accessories
  2. Low voltage: Connections between controller and remote control valves. Make direct burial AWG – UF, 600 volt wire. Make water proof splices, where permitted, use # MNO DBLY splice kit with copper crimp-type connectors, or equal. Size wire according to manufacturer’s recommendations, in no case less than NO 14. Ground wires: white in color.
  3. Two spare control wires of different colors shall be looped through every valve on the system
- v. Flow Meters:
1. Specify ARAD, Ltd model by line size (1.5", 2", 3", 6", 8") 2 BMU-CIR (for 2" line) Hydrometer, master valve /flow meter with potted 24v AC solenoid, manual on/off auto valve with copper tubing and drain plug., 10 gallons/pulse. Meter cable from controller to the meter to be installed with dry contacts. For All 'Low Flow'



applications (less than 6gpm) use appropriately sized Arad that will capture these lower flows. At the same time system design flows need to be maintained.

### 3. Execution

- a. Examine site conditions prior to commencement of work. Note the extent and type of work to be done and after verification of quantity, location and condition of all existing systems and/or components to remain and how they will integrate with new improvements. Should there be discrepancies between the contract documents and the actual site conditions, do not proceed with the installation without notifying the Owner's Representative. Proceeding without notification, the Contractor assumes full responsibility for all revisions and related costs.
- b. Preparation.
  1. Exercise care in excavation and working near existing utilities. Check existing utility locations.
  2. Do not proceed with work until unacceptable site conditions are corrected or existing utilities are located and/or marked out in field.
- c. Protection:
  1. Provide barricades, coverings, warning signs, lights and other protection required by local code or OSHA to prevent damage to existing improvements to remain and protect the public.
  2. Protect improvements on adjoining areas as well as those on the project site.
  3. Restore any improvements damaged by this work to original condition, as acceptable to the Owner's Representative. Installer shall notify Owner's Representative of any and all damaged infrastructure - pipe, fittings, irrigation heads, wiring, etc. Remediation shall be reviewed as it happens prior to repair and then tested after repairs are complete.
  4. Protect existing trees and other vegetation to remain against damage. Do not stockpile construction or excavated materials within drip lines without protection.
- d. Trenching.
  1. Trench Depths: Main line 24", Control Wires 24", Lateral Lines 14" - 18" (2" pipe), sleeves beneath pavement 24".
  2. Line Clearances: Provide 3" - 4" (36" top of pipe) of clearance between each line and not less than 12" of clearance between lines of other trades.
  3. Trenching depths which require variation due to site conditions shall be reviewed by Owner's Representative and Facilities Services Grounds Shop Irrigation Lead.
- e. Backfilling
  1. Initial backfill over lateral lines to be clean, fine granular material as reviewed and accepted by the Owner's Representative.
  2. Initial backfill over all pressure lines to be clean sand.
  3. Compact native soil backfill to a dry density equal to adjacent undisturbed soil. Restore to adjacent grade, free from depressions, humps, or other irregularities.
    - i. Backfill: Free of rocks over 2 inches, metal and trash.
    - ii. Sand bedding for pressured pipe: Not less than 6 inches below and above pipe. Note: Avoid introduction of dissimilar materials which may result in a galvanic reaction.
- f. Installation
  1. Install plastic pipe and fittings in compliance with manufacturer's instructions for same. Install RCV manifold with schedule 80 threaded nipples and "L" couplers. Each RCV shall have a line size Tru-Union ball valve and union. 'Tru-union' (ball valve/union combination-'Iplex' by USP preferable) before the RCV and sch 80 union after the RCV all threaded joints.
  2. Install any back flow assembly in area shown at minimum height permitted by local code. Install pressure line from point of connection to backflow unit per local code. Chlorinate all extensions of domestic water lines to the backflow assembly. Install with unions at both upstream and downstream connections. Install in order: meter; PRV; backflow device. Use all brass or copper fittings under and above ground from supply line. A buried isolation valve at backflow and meter

station shall be placed on the supply line to isolate the backflow station. The first fitting of copper or brass downstream leg of the backflow will be a female to male PVC SCH 80 fitting.

3. The Owner's Representative shall approve the location of all specified assemblies.
4. Brass pipe and fittings: Assemble using Teflon tape applied to male threads only.
5. Plastic pipe and threaded fittings: Assemble using Teflon tape applied to male threads only. Make threaded connections from main line to RCV.
6. Tape all open ends of pipe during installation to prevent entry of any foreign matter into the system.
7. Install copper tracer wire to all PVC pressured lines, taped every fifteen feet (15'-0"). Stub tracer wire up at backflow unit, isolation valves and/or irrigation controller.
8. Quick Coupling Valves: Unless otherwise indicated, locate valves 12 inches maximum from hardscape. Install with steel rod clamped by two stainless steel clamps. Assemble with triple swing joint utilizing SCH 40 nipples and SCH 80 90 degree elbows.
9. Sprinkler Heads: Adjust locations indicated on drawings to achieve full and uniform coverage, preferred PSI range and prevent overspray. Do not exceed the maximum or minimum spacing indicated by manufacturer – All heads to be equipped with nozzles of matching precipitation rates for any one RCV circuit.
10. All sprinkler heads to be assembled with triple swing joints utilizing SCH 40 nipples and SCH 80 90 degree elbows – Prefabricated joint assemblies not allowed.
11. Existing Pavement:
  - i. Piping under existing pavement may be installed by jacking, boring or by hydraulic driving except as otherwise specified or directed. Use existing sleeves where applicable.
  - ii. Using Type L Copper piping if no sleeve is installed.
  - iii. All construction projects shall install minimum 4" sleeves any time there is an opportunity to install a sleeve under existing or new paving and/or hardscape
12. New Pavement:
  - i. Coordinate installation of piping and wires under paved areas with the Contractor. Use sleeves under pavement. Provide four inch (4") sleeves where possible.
  - ii. If wires under paved areas cannot be continuous, enclose all splices in an acceptable splice box.
  - iii. All construction projects shall install minimum 4" sleeves any time there is an opportunity to install a sleeve under existing or new paving and/or hardscape
13. Valves and Valve Boxes:
  - i. Provide at all locations indicated. Install only one (1) valve per box, minimum six inches (6") clearance from bottom of valve to soil level. Valve must be fully enclosed within box allowing space for maximum opening of flow control.
  - ii. Fill area under box at each corner with supporting brick. Add welded wire under box to prevent pest intrusion.
  - iii. Add 3" layer of pea gravel at base of box
  - iv. All remote control valves to be installed with SCH 80 threaded fittings, with ball valve and two unions. To be threaded from main and the second union immediately after the valve.
  - v. Always use threaded elbows before and after the valve manifold for each valve
  - vi. Identification:
    1. Identify valves with Christie ID tags.
    2. Burn valve number in box lids Burn "MSTR" in master valve lid
  - vii. For low flow (less than 6gpm) use only Rainbird PEB commercial plastic valves
  - viii. All remote control valves to be installed with SCH 80 threaded fittings, with "tru-union" ball valve and union. To be threaded from main.
14. Fittings:

- i. For PVC schedule 40 lateral distribution lines lay all TEE & ST ELL fittings in a vertical orientation (threaded connection pointing up) to facilitate improved irrigation head placement – this will require the use of one more swing joint ST ELL than is typically required.

15. Identifications:

- i. Identify valves with Christie ID tags.
- ii. Burn valve number in box lids.
- iii. Burn MSTR in master valve lid.

16. Low Voltage Wiring:

- i. Place wiring in the same trench and routing as pressure supply lines.
- ii. Install wiring under main line, minimum six-inches (6”) sand cover between control wires and pipe and top of pipe.
- iii. When more than one wire is placed in a trench, tape wires together at a maximum of ten foot (10’-0”) intervals.
- iv. Provide a twenty-four inch (24”) expansion loop at each connection and directional change.
- v. Use a continuous wire between controller and remote control valves.
- vi. Except as otherwise approved, do not splice wire at any point.
- vii. Anywhere a splice is made as a result of cut wire, splice must be in a dedicated splice box and brought to the surface so it is serviceable.
- viii. At locations where splicing is allowed, make splices within an acceptable splice box.
- ix. Provide each controller with a separate ground wire.
- x. Two spare control wire of different colors shall be looped through every valve on the system.

17. Connections:

- i. Make connections to the existing water line at the location indicated on drawings. Make any minor changes in the location as may be necessary due to actual site conditions.
- ii. Make connections to electrical service for full operation. Make minor changes in location as may be necessary due to site conditions.

g. Field Quality Control

1. System Flushing:

- i. After sprinkler pipe lines and risers are in place and connected, and prior to installation of sprinkler heads, thoroughly flush all lines with a full head of water.
- ii. Do not install sprinkler heads until lines have been flushed and reviewed by Inspector.

2. Pressure Tests:

- i. Provide all equipment necessary to test systems, including pump.
- ii. Perform all hydrostatic tests in the presence of the Project Inspector and the Owner’s Representative.
- iii. Test all pressure supply lines under hydrostatic pressure of 125 PSI for a period of two (2) hours unless another test is accepted to show lines free of leaks and defects.
- iv. If the only piping installed is less than twenty feet (20’-0”) long, pressure testing shall be required for that section at the time of installation.
- v. Upon the completion of the piping installation, the entire system shall be tested with the Owner’s Representative present.
- vi. Do not backfill over any line more than is necessary until it has been inspected and tested. Leave all joints uncovered.
- vii. Do not connect remote control valves, quick couplers or any other valve assembly until testing is satisfactorily complete.

3. Coverage Tests:

- i. Perform coverage tests in the presence of the Owner’s Representative and Facilities Services Grounds Shop Irrigation Lead after sprinkler system is completed, but prior to any planting. Test the system to assure that all areas are irrigated completely and uniformly.
- ii. Do not spray onto pavement or structures. Install adjustable arc nozzles as needed to provide full coverage without over spray.
- iii. Adjusting and Cleaning:
  - 1. System adjustment
    - a. Valves: Adjust flow for proper operation.
    - b. Heads: Adjust for alignment and coverage.
    - c. If it is determined that coverage can be improved by a nozzle change, make such changes or arrange with the manufacturer to have changes made as part of the Work.
  - iv. Make changes and adjust the system prior to any planting.
  - v. Perform final cleaning of all risers, heads, and equipment for proper operation. Demonstrate operation and uniform coverage in the presence of the Owner’s Representative prior to start of maintenance period and again before final acceptance.
- 4. Programming:
  - i. Assign the master valve to the last valve control position in the controller.
  - ii. Set the master valve to “auto-operate”
  - iii. Coordinate controller program with the product vendor, Facilities Services Grounds Irrigation staff, and the Owner’s Representative.
  - iv. Prepare laminated diagram of circuit system for installation in the controller cabinet.
  - v. Submit a written schedule of circuits and programs to the Owner’s Representative for the maintenance period and recommendations for post establishment period.
  - vi. At final inspection, demonstrate operation of the controller and coverage for all spray and drip systems. Turn over charts and specified materials to the Owner’s Representative.
- 5. Clean-up:
  - i. Upon completion of the work, restore ground surfaces to required elevations and remove excess materials, debris and equipment from the site. Keep soil out of storm water lines. Thoroughly remove soils via vacuuming or dry sweeping.

*32 91 13.16 Mulching*

1. Where called for, the Contractor shall furnish and install three inch (3”) depth of clean, natural wood chip “Walk-On” top-dressing mulch in areas designated on plan. Mulch shall be an interlocking mix of wood particles in varying sizes from two-inches and smaller derived from tree and shrub trimmings aged for several weeks. No Eucalyptus sources are permitted. The mulch supplier shall be a member of the U.S. Composting Council that adheres to the standards of the Seal of Testing Assurance Program (STA). For slopes over 5-percent use ‘Gorilla Hair’ (shredded Redwood bark) in place of 2-inch and smaller chips. Dyed mulches are prohibited.
2. Mulch can harbor ants, and as such should not be used in close proximity to buildings, refuse areas or outdoor eating areas.

32 90 00 Planting

32 92 00 Turf and Grasses

32 92 23 Sodding

32 00 00 Exterior Improvements

Adopted February 25, 2020

1. Campus mowed turf lawns for general use are commercial improved tall dwarf fescue blends with 5-10% bluegrass. This may be installed as seed with ninety (90) day Contractor's maintenance period until a uniform density is achieved with at least two mowings and a top dress fertilizer application. It may be installed as sod with a forty-five (45) day maintenance period with at least two mowings and a top dress fertilizer application. Sod shall feature tight joints, be rolled smooth and be fully rooted by the end of the maintenance period. See guidelines on protecting new lawn in 32 92 00: Turf and Grasses and 32 93 00: Plants Maintenance sections.
  - a. Some approved options include:
    - i. Medallion Plus by Pacific Sod, (800) 692-8690
    - ii. A-G Elite+ by A-G Sod Farms, Inc., (800) 588-6882
    - iii. 90-10 or 90-5 by Delta Bluegrass Company, (800) 637-8873
2. Sod Planting
  - a. Areas to be planted shall be free of weeds, rocks, debris and heavy construction traffic. Shaping and finish grading shall have been accomplished and approved prior to any sod placement. Finished surfaces shall be smooth, true to slopes and grades. Finish grades shall be one (1) inch lower than top of curbs, pavements and headers to receive sod.
  - b. Scarify planting area and completely break up soil to a depth of six (6) inches.
  - c. Unless indicated otherwise in the soil analysis results (Item 1.4 D), spread soil amendment at the rate of 6-cubic yards per 1000 square feet (2-inch layer) and commercial fertilizer at the rates indicated in Section 2.0 - Products. Mix uniformly into the top six-inches of soil. Rake to a smooth, even surface. Finished surfaces shall be smooth, true to slopes and grades.
  - d. Rake all areas to remove rock one (1) inch or larger in size, sticks and debris and grade to a smooth, even surface. Grade to form all swales; pitch to catch basins, street, curbs, etc, to insure proper surface drainage.
  - e. Lightly roll and reshape surface to level humps and hollows. After mixing, foot tamp soil, water and let settle. Add additional soil as necessary to create a rounded surface over the utility trench so that water does not settle along the utility trench.
  - f. Sod slabs shall be laid promptly after delivery to job site.
  - g. In hot, dry or windy weather, the stacked sod at job site shall be lightly sprinkled with water to prevent slab edges from excessive drying.
  - h. Sod slab ends and sides must be butted together for a close fit without overlapping; stagger the slabs for better appearance. Any gaps between sod slabs that are greater than one-inch will require that slabs be reset closer together or that the gaps be filled with appropriate quality sand.
  - i. Sodded areas shall be lightly rolled after a light initial watering, then irrigated heavily to assure water penetration in the soil to a depth of eight (8) inches.
  - j. In hot, dry or windy weather, the initial watering shall be carried out on conveniently large areas, before entire area is sodded, to prevent newly installed sod from excessive drying.
  - k. Protect sod areas by erecting fences, barriers, signs, etc. as necessary to prevent trespassing.

## 32 93 00 Planting

### Part 1 - General

1. Scope
  - a. Furnish all labor, equipment and materials necessary for import soil sampling and testing, soil placement, soil preparation, planting and maintenance period as shown and specified.
2. Applicable Documents:

- a. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this Specification to the extent indicated by the references thereto:
  - i. American National Standards Institute (ANSI) Publications:
    1. ANSI Z60.1 - 1973, Nursery Stock
    2. ANSI Z133.1 - 1972, Safety Requirements for Tree Pruning, Trimming, Repairing or Removal
  - ii. American Joint Committee on Horticultural Nomenclature Publications: Second Edition 1972, Standardized Plant Names
3. Work Specified Under Other Sections
  - a. Consult all other sections to determine extent and character of work specified elsewhere but related to that included in this section. Work specified herein shall be properly coordinated with that specified.
4. Submittals
  - a. Submit the following samples for approval together with information from the supplier that describes the material sources, break-down by particle size and fertility information (where applicable):
    - i. Import soil, if necessary: 0.5 cubic foot bag.
    - ii. Soil Amendment: 0.5 cubic foot bag and Compost Lab Analysis.
    - iii. Mulch: 0.5 cubic foot bag.
5. Substitutions
  - a. Any substitutions of materials for any reason shall have prior approval from Landscape Architect.
6. Storage
  - a. Plants not installed on the day of arrival at the site shall be stored and protected as follows:
    - i. Outside storage shall be shaded and protected from the sun and wind.
    - ii. Plants stored on the project shall be protected from drying out at all times by covering the balls or roots with moist sawdust, wood chips, shredded bark, peat moss or other similar mulching material.
    - iii. Plants, including those in containers, shall be kept in a moist condition until planted, by watering.
    - iv. Lime and fertilizer shall not be stored with any landscape materials.
  - b. Storage of materials shall be only in areas designated or as approved by the Owner.
  - c. Handling - Care shall be taken to avoid damaging plants being moved from the nursery or storage area to the planting site. Plants shall be protected from drying out. Plants shall not be handled by the trunk or stem. Plants shall be protected from freezing or drying out by a covering of burlap, tarpaulin, mulching material during transportation from the heeling-in bed to the planting site. Damaged plants shall be rejected and shall be removed from the site.
7. Environmental Conditions
  - a. Planting of trees, shrubs, vines and groundcovers shall be done only during periods which are normal for such work as determined by the season, weather conditions and accepted practices.
8. Grading
  - a. Contractor shall be responsible for maintaining finish grades in all planting areas and for executing any fine grading as may be necessary or incidental to all planting operations.
9. Quality Standards
  - a. All work to be in accordance with the latest Safety Orders of the Division of Industrial Safety, O.S.H.A., and applicable State and local laws or regulations.
10. Timely Order Of Plant Materials

- a. In order to receive plant materials in a timely fashion, Contractor shall order plant materials within ten days of the Notice to Proceed. Any potential delays in delivery or requests for substitution shall be brought to the attention of the Owner's Representative immediately.

## Part 2 - Products

### 1. Import Soil

- a. In the event that import soil is required for trench backfill in plant areas, conform to the following requirements. The import soil shall sustain healthy plant life, without admixture of subsoil, free from rocks larger than 1 inch size, sticks and other foreign matter. Imported soil shall be USDA classification of sandy loam, sandy clay loam or loam with maximum gravel content no more than 15 percent, rock content no more than 5 percent and maximum organic content no more than 15 percent.
- b. The soil chemistry suitability considerations:
  - i. Salinity: Saturation Extract Conductivity (ECe) less than 3.0 ds/m @ 25° C
  - ii. Sodium: Sodium Adsorption Ratio (SAR) less than 6.0
  - iii. Boron: Saturation Extract Concentration less than 1.0 ppm
  - iv. Reaction: PH of Saturated Paste: 5.5-7.5 without high lime content
- c. Submittal of import soil sample shall include a soil fertility test and amendment/fertilizer recommendations as specified in Section 1.4-D.

### 2. Fertilizer

- a. Fertilizers shall be non-synthetic as submitted by the Contractor and approved by the Owner's representative.. Synthetic, quick-release fertilizers shall not be permitted. Fertilizers prohibited in the Generic Materials List by the Organic materials Review Institute (OMRI) are prohibited in the project.

### 3. Soil Amendment

- a. Soil amendment shall be organic yard compost. Compost shall be well decomposed, stable and weed free. It shall be derived from one or more locally sourced organic materials such as: food waste or urban plant debris, agricultural crop residue or herbivore animal manures with a preference for urban plant debris and food waste. It shall not contain mixed solid waste. The product shall contain no substances toxic to plants, will possess no objectionable odors and shall not resemble the feedstock (the original material from which it was derived). Compost shall be tested through the US Composting Councils USCC Seal of Testing Assurance Program (STA). A lab analysis shall be performed by a STA certified laboratory using the test methods used in the Seal of Testing Assurance program found in the Test Methods for Examination of Compost and Composting Manual (TMECC). Verifying current participation in the STA program can be confirmed by logging onto the USCC website at [www.compostingcouncil.com](http://www.compostingcouncil.com). The compost lab analysis shall be submitted as part of the "Compost Technical Data Sheet" before delivery of compost. Physical properties of compost shall meet the following characteristics:
  - i. Physical properties of compost:
    1. Particle size: A minimum of 90% of the material by dry weight shall pass through a 1/2-inch screen or smaller.
    2. Color: Dark brown to black.
    3. Odor: No odor, soil-like, musty, and moldy are acceptable. Sour, ammonia-like, or putrid is unacceptable.
    4. Particle characterization: Identifiable wood pieces are acceptable, but the balance of material should be soil-like without recognizable grass or leaves.
  - ii. Organic matter content: 35% minimum based on dry weight and determined by ash method. Minimum 250 lbs organic matter per cubic yard of compost.

- iii. Carbon to Nitrogen ratio: Maximum 35:1 if material is claimed to be nitrogen stabilized.
- iv. pH shall be in the range of 6.5 to 8.5.
- v. Soluble salt concentration may vary but must be reported: 2.5 dS (mmhos/cm) or less is the preferred salt content.
- vi. Moisture contents shall be between 35% and 60%.
- vii. Contaminants: The compost shall be free of contaminants such as glass, metal and visible plastic.
- viii. Stability: Based on Carbon Dioxide evolution rate, it should be less than 8 Mg CO<sub>2</sub>-C/g OM per day.
- ix. Maturity indicator: Must pass maturity tests or demonstrate its ability to enhance plant growth.

4. Mulch

- a. Mulch shall be an interlocking mix of wood particles in varying sizes from two-inches and smaller derived from tree and shrub trimmings aged for several weeks. No Eucalyptus sources are permitted. The mulch supplier shall be a member of the U.S. Composting Council that adheres to the standards of the Seal of Testing Assurance Program (STA). For slopes over 5-percent use 'Gorilla Hair' (shredded Redwood bark) in place of 2-inch and smaller chips.

5. Header Boards

- a. Where noted on the drawings, headers for enclosure of crushed rock paving and/or asphalt paving shall be minimum 3/16-inch by 4-inch, black anodized aluminum edging with stakes as manufactured by the Sure-Loc Edging, 494 E. 64th Street, Holland, MI 49423, 1 (800) 787-3562, info@surelocedging.com, or equal as submitted and approved by the Owner in writing.

6. Plant Materials

- a. Quality and size shall conform to best nursery practice. Nursery grown stock only shall be used. Secure approval of Owner's Representative for quality and size of all plant materials.
- b. Measurements shall be as shown; where not shown shall be of uniform and standard size -- neither over-grown and root bound nor too recently canned so that the root system is not thoroughly established throughout the can. Pruning shall not be done prior to delivery except by approval.
- c. Contractor shall be responsible for inspection of plant materials required by the Owner, County or State at any time before and during progress of the work. Rejected plants shall be removed from the site immediately.
- d. Contractor shall adequately protect plants from sun and wind, on site and in transit.
- e. Plant label shall identify each species and variety. Substitutions are not desired; requests for substitution shall be made at least 30 days prior to planting.
- f. Quantities necessary to complete the work as shown on the Drawings shall be furnished. Quantities shown on Plant List are approximate only and shown for convenience of the Contractor.
- g. Turf sod shall be improved tall dwarf fescue with bluegrass by Delta Bluegrass 90-10 or Pacific Medallion Plus, or equal. See section 32 92 00 for additional information on sod requirements.

7. Selection of Plants and Pest Management

- a. The following plant species harbor roof rats in the bay area and shall be avoided:
  - i. Algerian ivy (*Hedera canariensis*)
  - ii. Arborvitae (*Thuja orientalis*)
  - iii. Bamboo (*Bambusa spp.*)
  - iv. Himalayan blackberries (*Rubus procerus [discolor]*)
  - v. Honeysuckle (*Lonicera caprifolium*)
  - vi. Italian cypress (*Cupressus sempervirens*)
  - vii. Lombardy poplar (*Populus nigra "Italica"*)
  - viii. Juniper tams (*Juniperus Sabina "Tamariscifolia"*)



- ix. Palm trees (date) (*Phoenix dactylifera*)
- x. Pampas grass (*Cortaderia selloana*)
- xi. Star jasmine (*Trachelospermum jasminoides*)
- b. Acceptable Ground Cover Substitutes for Algerian Ivy Include:
  - i. African Daisy (*Arctotis acaulis*)
  - ii. African Daisy (*Arctotheca calendulacea*)
  - iii. African Daisy (*Osteospermum fruiticosum*)
  - iv. Trailing African Daisy (*Gazania*)
  - v. Creeping Thyme (*Thymus sepyllum*)
  - vi. Dichondra
  - vii. Goldmoss stonecrop (*Sedum acre*)
  - viii. Ground ivy (*Nepeta hederacea*)
  - ix. Needle point ivy
  - x. Hahns Ivy
  - xi. Climbing Fig (*Ficus repens*)
  - xii. Fescue (*Festuca rubia iliahae*)
  - xiii. False Strawberry
  - xiv. Sand Strawberry (*Fragaria chiloensis*)
  - xv. Spring cinquefoil (*Potentilla verva*)
  - xvi. Creeping Speedwell (*Veronica repens*)
  - xvii. Mondo grass (*Ophoprogon japonicas*)
  - xviii. Snow-in-summer (*Cerastium tomentosum*)
  - xix. Wooley Yarrow (*Achillea tomentosa*)
  - xx. Bronze Ajuga (*Ajuga crispa*)
  - xxi. Chamomile (*Anthemis nobilis*)
  - xxii. Germander (*Teucrium chamaedrys*)
  - xxiii. Japanese Spurge (*Pachysandra terminalis*)
  - xxiv. Wintercreeper (*Evonymus fortunei*)

### Part 3 - Execution

#### 1. Import Soil Placement

- a. Following completion of rough grading, when planting areas are free from weeds and the heavy traffic associated with the construction of building and pavements, Contractor shall:
  - i. Rip and scarify subgrade in all planting areas to a depth of (six) 6 inches. Extreme care shall be taken to work around planting marked to be saved.
  - ii. Remove from soil surface all miscellaneous debris, including items from construction such as gravel, wire, stucco etc., and rocks over two (2) inches in size.
  - iii. Import soil shall be spread in all planting areas as noted on the plans in sufficient depth that when broken down, leveled, and settled, the resultant thickness shall not be less than six (6) inches. Finished surfaces shall be smooth, true to slopes and grades. Import soil and level of planting areas shall be one (1) inch below top of headerboards, pavements, walks and curbs. Particular attention shall be given to the installation of surface drainage swales.

#### 2. Shrub Planting

- a. Finished surfaces in planting areas shall be smooth, true to slopes and grades. Areas to be planted shall be free of weeds, rocks, debris and heavy construction traffic.
- b. Place shrubs in designated locations and secure approval of Owner's Representative before excavating pits, making such adjustments as may be required.

- c. Dig pits circular in outline with vertical sides as detailed on Drawings. After pits are dug, break sides to open wall of pit for root penetration.
  - d. Backfill in planting holes shall be a mixture of loose soil in a finely divided condition free from rocks, clods or lumpy material, thoroughly mixed with an equal volume of soil amendment.
  - e. Fertilize Shrubs with Agriform tablets at the rates specified in Section 2 - Products of these Specifications.
  - f. Plants shall be set in backfill mixture, in flat bottom holes, to such depth that the top of the plant ball will be two (2) inches above finish grade.
  - g. Backfill shall be watered until the backfill is saturated to the full depth of the hole.
  - h. Build basins around plants. Basins shall be formed with level bottoms and walls as detailed.
  - i. Mulch basins with wood chips, depth as specified in Drawings, and thoroughly water.
  - j. For all trees in lawn areas, cut and remove turf in a circular pattern around the tree so that trunks and stakes do not interfere with mowing operations.
  - k. Place three (3) inch mulch in all shrub areas between plants.
3. Groundcover Planting
- a. All Planting Areas - Areas to be planted shall be free of weeds, any rocks over 2-inches in diameter, debris and heavy construction traffic. After completion of finish grading, disc or rototill a minimum of twelve (12) inches in depth and cultivate to a loose friable condition the top layer of soil to a minimum of six (6) inches, free of clods.
  - b. Unless indicated otherwise in the soil analysis results (Item 1.4 D), spread soil amendment at the rate of 6-cubic yards per 1000 square feet (2-inch layer) and commercial fertilizer at the rates indicated in Section 2.0 - Products. Mix uniformly into the top six-inches of soil. After mixing, foot tamp soil, water and let settle. Add additional soil as necessary to create a rounded surface over the utility trench so that water does not settle along the utility trench. . Rake to a smooth, even surface. Finished surfaces shall be smooth, true to slopes and grades.
  - c. Plant groundcover plants in evenly spaced rows with staggered plant spacing. Water immediately after planting and in sufficient quantity to wet the soil around the plants to a depth of eight (8) inches.
  - d. Place three (3) inch mulch in all groundcover and shrub areas between plants.
  - e. Fertilize at the rate specified in Section 2.0 - Products.
  - f. After the plants have been thoroughly watered, allow the soil to adequately dry to provide a workable surface. Rake the area to provide a uniform, even surface.
4. Preliminary Inspection And Approval
- a. Contractor shall request a preliminary inspection of planting work upon completion of all planting. Inspection and approval of the completed work shall establish the beginning of the maintenance period. No partial approvals will be given.
5. Maintenance
- a. Maintenance shall be as specified below; shall immediately follow, coincide with and be continuous with and during the planting operations; and shall continue for 60 calendar days after all planting is complete and accepted.
    - i. Shrubs:
      - 1. Maintain as specified after acceptance in a vigorous, thriving condition by watering, pruning, cultivating, spraying and other necessary operations.
      - 2. Protect from damage by erosion or trespass and provide proper safeguards.
      - 3. Replace unhealthy, damaged or dead shrubs promptly with material as specified.
    - ii. Groundcover and Turf:
      - 1. Maintain constant moisture to a depth of eight (8) inches.

2. Keep areas free of undesirable weeds and grasses by application of suitable weed killers or hand pulling. Maintain by watering, weeding, replanting, reseeding, mowing, fertilizing, rolling and top dressing, and other necessary operations to establish an even, thick and vigorous stand of grass and groundcover.
  3. Fertilize groundcover areas with commercial fertilizer at the rate specified in Section 2.0 - Products. Water thoroughly into soil.
  4. Maintain turf through second cutting or for 60 days, whichever is longer.
  5. Fertilize turf areas with commercial fertilizer at the rate noted in Section 2.0 - Products after planting, after second cutting or at the end of 45 days, as coordinated with the Landscape Architect. Water thoroughly into soil.
  6. After second cutting or at the end of 45 days, as coordinated with the Landscape Architect. top dress turf areas with a mix of 50% washed sand and 50% soil amendment, average 1/4- inch depth, to even field grades.
  7. Protect areas against all damage, including erosion and trespass, and provide safeguards.
  8. Replant damaged areas and plants promptly as specified.
6. Clean-Up And Final Inspection
    - a. Final inspection for approval and acceptance shall be made at the conclusion of the maintenance period. Written notice requesting such inspection shall be submitted at least ten (10) days before anticipated date.
    - b. Prior to being considered ready for inspection, Contractor shall have made all corrections and repairs and have the job cleared of all weeds and debris and presented in a neat, orderly fashion.
7. Guarantee And Replacement
    - a. Guarantee all shrubs and ground cover in a healthy, thriving condition until the end of the maintenance period or until active growth is evident.
    - b. Replace all dead plants and plants not in a vigorous condition as soon as directed by Landscape Architect. Plants used for replacement must be of the same kind and size as specified, planted and maintained as outlined above. All replacement of plants shall be done before the final acceptance.
    - c. All replacement of plants shall be at the sole expense of the Contractor.

33 00 00 Utilities

33 01 00 Operation and Maintenance of Utilities

33 01 10.58 *Disinfection of Water Utility Piping Systems*

1. Standard Disinfection Procedure For Domestic Water System

- a. Witnessing and Testing: Perform entire disinfection procedure while a representative of Environment, Health and Safety (EH&S) is in attendance. Provide five (5) days' notice to schedule procedure.
- b. Contractor's Responsibility: Furnish a copy of the California Department of Pesticide Regulation (DPR) Qualified Applicator License, equipment, materials and transportation to disinfect domestic hot and cold water systems and fire lines directly connected thereto, in conformity with procedures and standards described herein.
- c. Disinfecting Agent: An aqueous solution of sodium hypochlorite (minimum 5.25% available chlorine). The use of powdered hypochlorite and chlorine gas are prohibited unless specifically approved by Environment, Health and Safety (EH&S).
- d. Preliminary Preparations:
  - i. Service Cock: Provide within three feet (3'-0") of the entrance of the supply main to the building, a three-quarter inch (3/4") service cock, or valve, for the purpose of introducing the disinfecting agent
  - ii. Flushing: After final pressure tests and before draining for disinfection, open each fixture or outlet until the water flow is clear.
- e. Disinfection Procedure:
  - i. Drain entire domestic water system including fire line.
  - ii. Post suitable warning signs at each outlet: Warning - Do Not Use - Water System Being Chlorinated.
  - iii. Inject disinfectant solution into the system through the service cock by means of a pump, or other pressure device, at a slow continuous rate, simultaneous with a reduced flow from the water main, until the Ortho-Tolidin test for residual chlorine at each outlet shows a concentration of at least 50 ppm, but not more than 100 ppm.
  - iv. Close all outlets and valves, including the service valve at the main and the injection cock. Retain the chlorinated water in the system for 24 hours.
  - v. After the 24 hour holding period, the residual chlorine concentration shall be not less than 50 ppm as shown by the Ortho-Tolidin test.
  - vi. Drain and flush entire domestic water system until Ortho-Tolidin tests show background residual chlorine concentration at any and all outlets.
  - vii. Environment, Health and Safety (EH&S) shall determine whether samples of water must be collected and analyzed for the determination of bacteriological quality.
- f. Standards Necessary for Approval:
  - i. The water system shall have been uniformly chlorinated with a witness from Environment, Health and Safety (EH&S) as outlined above.
  - ii. The results of water sample analysis shall be negative for the Coliform organisms.
  - iii. If the test for the bacteriological quality of the water in the system does not meet the standards, repeat the disinfection procedure until the specified standards are met.
  - iv. Final Approval: Environment, Health and Safety (EH&S) shall give written approval to the University for acceptance and use of the water system after the above procedures have been successfully completed and the standards met.

1. Design Requirements:

- a. Use the following criteria in determining pipe sizes:
  - i. Existing known or estimated demands or flows. Obtain design loads from the Facilities Services Utilities Shop.
  - ii. Future known or estimated demands or flows due to expansion of the area served, new buildings or building additions.
  - iii. Steam distribution and condensate return piping and electric cable sizing shall be based on existing sizes and campus requirements. Discuss these with Capital Projects (CP).
- b. Show or note the following on the plans:
  - i. Existing and future surface grades where there is to be a change.
  - ii. Invert elevation of sewer and drainage structures and pipe.
  - iii. Specify equipment such as lift stations.
  - iv. Rim elevation of manholes and drainage grates.
  - v. Percent of slope where drainage and velocities are a factor.
  - vi. Any intersecting or closely parallel utilities or obstructions, new or existing, that may cause interference.
  - vii. Provide a profile to determine clearances and show the above required information.
  - viii. Coordinates of manholes and catch basins from the University grid.

2. Pipe testing:

- a. Pipe testing requirements vary depending upon the type of pipe. The Designer shall specify testing requirements for all installed pipe systems according to the type and service of the pipe and taking into consideration the manufacturer's recommendations for the particular installation. Testing shall follow generally accepted and published standard testing methods (such as hydrostatic testing methods as described in ANSI/AWWA C-600. It is critical that the Specifier be clear about the test method to be followed and that it is appropriately matched to the pipe material and the particular installation. Standardized leak testing is required for all water, sewer, storm drain, gas, steam and condensate pipelines, manholes and other hydraulic structures, valves, hydrants and all associated appurtenances. Specify what (if any) leakage shall be acceptable, and detail the procedures to be followed in the event of a failed test. Specify what must be left exposed until the pipe/appurtenance testing is completed. The Owner's Representative shall be notified not less than 72 hours prior to any test and the Contractor shall make all reasonable provision to facilitate the Owner's Representative to witness the testing procedures.

3. Base all elevations on Berkeley campus datum. Do not use City of Berkeley or United States Geological Studies (USGS) datum unless outside of the campus property. Indicate datum used on the drawings.

4. Utility Connections:

- a. Identify all utility connections required for the Project. The University owns and operates much of its own systems and requires that coordination be conducted with the Facilities Services Utilities Engineering Office to assist in identifying the appropriate Point of Connection (POC) for each utility. In the event that the Project will connect directly to public utility systems or City of Berkeley systems, coordination with that/those entity(s) shall be arranged by the University's Representative. The Designer shall collect data necessary to assess the available capacity of the system(s) that the Project will connect to and perform due diligence to estimate early in the project design stage whether the available POC can provide adequate capacity to accept the proposed Project. In the event that the available capacity of the existing system appears to be

inadequate, the Design team shall negotiate with the University's Representative, in coordination with the Facilities Services Utilities Engineering Office (for University owned facilities) or appropriate public utilities personnel.

- b. Clearly identify who pays for construction utilities. On major University-administered projects, the University of California shall pay for water but the Contractor shall pay for electrical power, meters, transformers and connections and is responsible for their installation.
5. Thrust Restraint: All pressurized transmission services shall be provided with thrust restraint which shall be indicated on the drawings. Where concrete thrust blocks are utilized, mass, size and installation shall conform to Appendix A, Detail FS08/FS08A.
  6. Groundwater: The Designer shall estimate potential high groundwater levels and provide designs compatible to prevent floatation of buried utilities pipes, manholes and vaults.
  7. Installation Schedule: Site work shall be performed without blocking campus walks or roads. When the Work cannot be completed without blocking walkways and/or roads, schedule the work to be completed during academic break periods to the maximum extent possible. Provide temporary access routes—particularly for pedestrians and cyclists—including clear wayfinding provisions for all obstructed paths walkways and roads. Provide a project schedule showing bid dates, construction time and anticipated completion date and submit to Capital Projects (CP) for approval. Update this schedule on a monthly basis throughout the project implementation until completion and handover.
  8. Utilities Metering: For new construction and major renovations, building main utility meters with local totalizer indicator connected to data acquisition server are required. These shall be installed following these standards.
    - a. Electric Meters:
      - i. There are two cases that need to be considered when specifying and installing meters:
        1. Case 1: Metering at the main breaker for all buildings with existing or planned Solar PV systems or those with potential for future Solar PV systems.
          - a. Acceptable meters for these installations are:
            - i. Eaton IQ 250/260\*
            - ii. ElectroIndustries/Gaugetech Shark 100/200\*
          2. Case 2: Metering at the main breaker for only those buildings that have no existing or planned Solar PV systems, and where there is no potential for future Solar PV systems.
            - a. Acceptable meters for these installations are:
              - i. Eaton IQ 250/260\*
              - ii. ElectroIndustries/Gaugetech Shark 100/200\*
              - iii. Square D ION 6200\*
              - iv. Siemens 9200\*
              - v. Veris H 8163 meter with H 8163-CB communications card\*\*
      - ii. Manufacturers
      - iii. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features, and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in

compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Campus Electrical Engineer ten (10) business days prior to bid date.

b. Microprocessor-Based Metering Equipment

i. General:

1. Where indicated on the drawings, provide a microprocessor-based line of multifunction, power, and energy meters, designated device equal to meters identified in paragraph 1. The meter shall be UL Listed. All meters shall have the following ratings, features, and functions in the following paragraphs, unless a specific meter is designated.
2. The meter shall be designated Multifunctional Electrical measurement on 3 phase, 4 wire power systems. The Meter shall support 3 Element Wye, 2.5 Element Wye, 2 Element Delta, and 4 wire Delta systems.
3. Meter dielectric shall meet or exceed 3000 VAC RMS for one (1) minute.
4. All inputs and outputs shall be galvanically isolated to 1500 Volts AC.
5. The meter shall have an accuracy of +/-0.5% or better for volts, amps, power, and energy functions. The meter shall meet the accuracy requirement of IEC60687 class 0.5 and ANSI 12.20 class 0.5.
6. The meter shall provide true RMS measurements of voltage - phase to neutral and phase to phase; current - per phase and neutral.
7. The meter shall provide sampling at 64+ samples per cycle on all channels.
8. The meter shall provide volts - phase to phase and phase to neutral, Amps - each phase, total kW, kVAR, PF, kVA, Frequency, kWh, kVAh, kVARh, and 1 KYZ pulse output. Measured quantities shall be available on display and via MODBUS registers.
9. The meter shall provide total % THD (Total Harmonic Distortion) monitoring for voltage and current per phase.
10. The meter shall include a three-line, bright red, 0.56" LED display or larger.
11. The meter shall fit in both DIN 92mm and ANSI C39.1 round cut-outs.
12. The meter shall be capable of operating on a power supply of 90 to 265 Volts AC.
13. The meter shall provide update rate of 1 second.
14. The meter shall be programmable from front faceplate.

ii. Voltage Inputs

1. The meter shall be user programmable for voltage range to any standard PT ratio up to and including 1,000:1 (120 kV:120 V).
2. The meter shall accept a direct voltage input range of up to 400 Volts Line to Neutral and a range of up to 690 Volts Line to Line.

iii. Current Inputs

1. The meter current circuits shall have a burden not to exceed 0.05 VA at five (5) amps RMS.
2. The meter shall accept a current input of up to ten (10) amps continuous. Start-up current for a five (5) amp input shall be no greater than 0.005 amps.
3. Fault Current Withstand shall be 120 Amps for one (1) second, non-recurring.
4. The meter shall be programmable for current to standard CT ratio up to and including 5,000:5.
5. The meter shall accept current inputs of Class 10 (0 to 10A), five (5) amp nominal.

iv. Communications

1. The communications portion of the meter shall be capable of Modbus communication via RS485 port and be able to communicate to Obvius data acquisition server.
  2. Baud rates shall be selectable between 9600 baud and 19,200 baud.
- v. Outputs
1. The meter shall include 1 set of KYZ terminals on the back for connection to building Energy Management System (EMS) for kW load monitoring.
- vi. Environment
1. The power meter shall be able to be stored and operate in the range of -20 to +70 degrees Celsius.
- c. Water Meters:
- i. Disc or turbine water meters shall be capable of providing a pulse output signal to connect to Obvius data acquisition server. Meter dry-contact pulse output can utilize 24VDC power available from the server.
  - ii. Maximum pulse rate is 10hz and the minimum pulse width is 50ms.
  - iii. Acceptable meter pulse output signals are:
    1. 1, 10 or 100 gallons per pulse
    2. 1 or 10 cubic feet per pulse
    3. Maximum of 600 pulses per unit volume (gallon or cubic feet) with maximum continuous operation not to exceed a rate of 100 gallons per minute for disc meters and 600 gallons per minute for turbine meters. Use the design or expected flow rate in the meter selection.
  - iv. Where meters with single pulse output shall be connected to both the building Energy Management System (EMS) and the Obvius data acquisition server, provide and install pulse-splitter solid-state isolation relay like the TransData IB6 or approved equal.
  - v. For meters that only provide analog output (e.g. 4 to 20mA signals), provide and install a precision integrator/relay output converter like the Flex-Core VFC-070 or approved equal, to convert analog output to pulse signal required for the Obvius data acquisition server.
  - vi. Installation standards for parallel connections, bypass and isolation valves shall be as described in separate sections under Divisions 21, 22 and corresponding Appendix.
  - vii. Suggested manufacturers, meter models and required electronic transmitters:
    1. Neptune Technology Group - T8/T10 Disc, Trident Turbine (TT), High Performance Turbine (HPT) and Tru/Flow Compound meter models with Tricon/E digital pulse output, 3- terminal, 24VDC electronic transmitter.
    2. Badger Meter – Recordall Disc or Turbo Series models with RTR 2-terminal, dry-contact pulse output, electronic transmitter register.
    3. Sensus Meter – Omni Compound C2 or Turbo T2 models with Omni electronic register that provides programmable pulse outputs.
- d. Condensate Meters:
- i. Building steam condensate return shall be measured with a condensate meter designed to work with a condensate receiver to measure varying flow for intermittent and multi-pump applications. The unit shall have a local flow and flow rate display and remote pulse output for flow rate.
  - ii. Flow meter using electromagnetic induction designed to measure volumetric flow rate of fluid. Meter shall not be affected by electrostatic or electromagnetic interference.



- iii. Meter size shall be one inch (1”) with measurement range of 0 – 1.0 ft/s to 0 – 32.8 ft/s flow velocity shall be installed to the discharge side or condensate return pipe to the steam plant.
  - iv. Provide individual meter calibration documentation indicating accuracy and current output.
  - v. Provide dry-contact pulse output signal with flow rate (gallons per minute) to connect to the Obvius data acquisition server. Pulse multiplier shall be 1 gallon per pulse.
  - vi. Where meters with single pulse output will be connected to both the building Energy Management System (EMS) and the Obvius data acquisition server, provide and install pulse-splitter solid-state isolation relay like the TransData IB6 or approved equal.
  - vii. Accepted manufacturer and meter model. No substitution allowed:
    - 1. Central Station Steam Company Cadillac CMAG-RC electromagnetic flow detector with remote converter/flow computer.
  - viii. Follow manufacturer’s installation requirements.
- e. BTUH Meters:
- i. For systems where the heating hot water system is shared across two (2) isolated buildings, a BTUH (British thermal unit hour) meter shall be installed to measure quantity of thermal energy of heating hot water of the receiving building.
  - ii. Follow the manufacturer’s installation requirements.
- f. Steam Meters:
- i. Steam use shall be measured with a steam metering system consisting of a vortex shedding flow meter and except in condensate returns, with pressure and temperature sensors connected to a flow computer. Flow computer shall have a local display to read mass flow (pounds) and mass flow rate (pounds per hour).
  - ii. The system shall be set up at the main service entrance to the building before the building steam pressure reducing station. The meter to be flanged-type designed for service at nominal steam pressure of 125 psi.
  - iii. The flow computer shall provide a contact pulse output signal to communicate mass flow rate in pounds per hour to the Obvius data acquisition server.
  - iv. Where meters with single pulse output will be connected to both the building Energy Management System (EMS) and the Obvius data acquisition server, provide and install pulse-splitter solid-state isolation relay like the TransData IB6, or approved equal.
  - v. For meters that only provide analog output (e.g. 4 to 20mA signal), provide and install a precision integrator/relay output converter like the Flex-Core VFC-070, or approved equal that will convert analog output to pulse signal required for the Obvius data acquisition server.
  - vi. Installation standards such as parallel connections, bypass and isolation valves are covered in separate sections under Division 23 and corresponding Appendix.
  - vii. Suggested manufacturers and meter models:
    - 1. Yokogawa – Vortex flow meter with flow converter model DigitalYewflo DY/DYA.
    - 2. Endress and Hauser – Flow meter model Proline 72F vortex flow meter with RMS621 remote flow computer and Cerabar PMC 131 pressure transmitter.
    - 3. Emerson Rosemount – Vortex Flow Meter 8800D series with remote display
  - viii. Follow the manufacturer’s installation requirements.
- g. Data Acquisition Server
- i. The data acquisition server shall be a server appliance, not a PC.

- ii. The data acquisition server shall be able to receive and store data from metering devices in 15- minute intervals. The server shall be able to upload data from every data log using the comma separated value (CSV) format. Users shall be able to access data through a web-browser.
- iii. The data acquisition server shall be capable of ModBus RTU communications supporting a minimum of 32 external devices and be expandable. A minimum of eight (8) flexible inputs, three (3) terminals (+24VDC, Input signal and Ground) with expansion capability are required. Servers shall have a minimum of thirty-two megabytes (32MB) of random access memory (RAM) and at least a sixteen megabyte (16MB) flash drive with RJ45 10/100 Ethernet network connection that will allow connection to the campus local area network.
- iv. For remote meter locations that do not allow direct 2 or 3-wire communication hard-wiring to the data server, a wireless Modbus/pulse transceiver shall be installed to send meter signal to the server.
- v. Provide expansion modules to increase the capacity of either ModBus or pulse input from external metering devices as needed.
- vi. Accepted manufacturer and model numbers. No substitution allowed except for the latest model as approved by UCB.
  - 1. Data acquisition server shall be from Obvius. Use Obvius AcquiSuite model A8812-1.
  - 2. Wireless Modbus/pulse transmitter shall be Obvius Modhopper model R9120-5
  - 3. Expansion modules shall either be Obvius Flex I/O Module model A8332-8F2D or the High Density Pulse Module model A8911-23
  - 4. See [www.obvius.com](http://www.obvius.com) for additional information.
- vii. Install data acquisition server in twenty-four inch tall by twenty inch wide by six inch deep (24”h x 20” w x 6” d) or larger enclosure panel. Provide two (2) 120-volt power outlets and one (1) Ethernet data connection port inside panel.

h. Gas Meters

- i. The main campus gas service is most often used for research and laboratory applications like Bunsen burners, and is not normally metered in individual buildings but rather by the utility company. Heat is provided from the central steam distribution system.
- ii. For off-campus buildings where gas service is used for both heat and research and laboratory applications, work with the utility company to install a compatible metering system that provides a dry-contact pulse output signal to the Obvius data acquisition server.
- iii. Where meters with single pulse output shall be connected to both the building Energy Management System and the Obvius data acquisition server, provide and install pulse-splitter solid-state isolation relay like the TransData IB6, or approved equal.
- iv. For meters that only provide analog output (e.g. 4 to 20mA signal), provide and install a precision integrator/relay output converter like the Flex-Core VFC-070, or approved equal that will convert analog output to pulse signal required for Obvius data acquisition server.

9. Earthwork for Utilities—General:

- a. Refer to Section 31 06 20.16, *Backfill Material Schedule* for utility backfill material requirements.
- b. Refer to Section 31 23 00, *Excavation And Fill* for utility trench and utility structure excavation and backfill requirements.
- c. All utilities shall be installed to the line and grade shown on the Construction Drawings. Where existing conditions conflict with line and/or grade alignment shown, the Contractor shall obtain

written direction from the University's Representative to adjust any utility alignment. Any realignment of gravity systems shall maintain a minimum positive slope in all pipe segments not less than one percent (1%).

- d. Utility installations that deviate from the coverages required by this section require written approval from Capital Projects (CP) and may require concrete cover, encasement or other engineered means of containment and/or protection where vehicular traffic or other conditions so require. Where existing conditions conflict with the contract documents, notify Capital Projects (CP) immediately for written direction.
- e. When two (2) or more services are installed in a parallel alignment, stagger their placement at least one foot (1'-0") vertically and one foot horizontally (1'-0") to allow side connections without interference. Separation greater than one foot may be required to meet water utility separation requirements. Where separation requirements in the Contract Documents conflict with Federal, State or local authority requirements, the more stringent requirements shall govern. Separation requirements will not be waived.
- f. Maintain sufficient clearance between parallel piping to permit repair or new taps.
- g. Provide underground warning tape placed one foot (1 ft.) above the pipe for all underground utility installations. The tape shall be detectable for all non-ferrous conduits.
  - i. Detectable warning tape shall be minimum 5 mil thick with minimum 3 mil detectable core with tensile strength meeting ASTM D882, permanently printed in black with the utility service, minimum three inches (3") wide for tape buried less than 22 ft deep and six inches (6") for tape buried deeper than 22 ft.
  - ii. Non-detectable warning tape shall be min. 5 mil thick solid color organic polyethylene film min three inches (3") wide, permanently printed in black with the utility service.
  - iii. Warning tape shall be color coded per APWA standard colors as follows:
    1. Blue Water
    2. Green Sanitary Sewer
    3. Light Green Storm Drain
    4. Orange Communications (Identify type on tape)
    5. Purple Reclaimed Water
    6. Red Electric
    7. Yellow Gas
  - iv. Where warning tape and tracer wire are shown on the drawings, placement shall be as indicated.
- h. Where services are in municipal streets, comply with City requirements for installation, coverage, backfill, and compaction in lieu of University requirements.
- i. Applicable Standards: The Designer shall incorporate into the Contract Documents by reference all applicable standards, including but not limited to specific standards and methods produced by the following: Reference the date of publication of any particular standard to which the Contractor shall be held responsible.
  - i. ASTM International
  - ii. American Public Works Association (APWA)
  - iii. American Water Works Association (AWWA)
  - iv. American National Standards Institute (ANSI)
  - v. National Fire Protection Association (NFPA)
  - vi. American Society of Mechanical Engineers (ASME)
  - vii. California Department of Transportation (Caltrans Standard Specifications)
  - viii. Standard Specifications for Public Works Construction (Greenbook)
  - ix. These Design Standards
  - x. Any other relevant published standard

- j. Submittals: Prior to commencement of site work activities, the Contractor shall provide the following documents complete and acceptable to the Owner:
  - i. Shoring and Sheeting Plan: Before starting work on a project which triggers state, federal and/or local regulations for shoring, sheeting or slope protection, the Contractor shall submit a shoring and sheeting plan signed and stamped by a licensed civil engineer. The Contractor shall submit the Shoring and Sheeting Plan to the Geotechnical Engineer for review and comment prior to submitting to University's Representative.
  - ii. Dewatering Plan: Before starting work on a project where ground or surface water may impact earthwork and/or construction activities, the Contractor shall submit a dewatering plan describing the basic components of the dewatering system proposed and its planned method of operations and drawdown monitoring. Submit the dewatering performance records weekly.
  - iii. Product submittals are required as specified under each section. Refer to Section 01 33 00, *Submittal Procedures*
    - i. Per CBP CUL-4, if the project is likely to affect a known cultural resource, mitigation shall be required by avoiding or reducing ground disturbance.
    - ii. Do not place soils or other materials on top of vaults, valves, manholes or other utility appurtenances. Where grade changes are required, existing underground appurtenances shall be accommodated with the addition of grade rings, raising vault access ways, raising valve boxes to finished grade. Leaving any appurtenance without adequate access, including valve stems or vault covers or deposition of soils inside valve boxes is unacceptable. New utilities' rim elevations will set as indicated on the drawings, at or above grade as appropriate.

33 10 00      *Water Utilities*

33 11 00      *Water Utility Distribution Piping*

1. General:

- a. Refer to Appendix A: Standard Details
- b. Refer to Division 21—FIRE SUPPRESSION and Appendix D: Fire Service Main Specifications. Campus systems that are dedicated for the supply of fire protection system shall comply with the referenced standards. Campus systems that provide both domestic water service and fire suppression service shall meet the requirements of this Section as well.
- c. Buried water pipelines shall be provided with a minimum three feet (3 ft.) cover. Where site conditions prevent installation of pipeline with specified cover, alternate protection shall be provided, subject to written approval of the University's Representative.
- d. Submittals: The Contractor shall provide detailed submittals for all products proposed under this section. For pipelines larger than two inches (2") in diameter, the submittal shall include a layout diagram in plan and profile indicating all joints, appurtenances, special fittings and thrust restraint.
- e. Codes and Standards: The design and installation of underground water piping shall conform to the following codes and standards except as specifically noted in these standards.
  - i. Latest edition of the California Plumbing Code (CPC)
  - ii. Latest edition of the California Fire Code
  - iii. Latest edition of the California Building Code
  - iv. Latest adopted edition of the National Fire Protection Association (NFPA) 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances
  - v. American Water Work Association (AWWA) standards and manuals as appropriate for installation and materials including, but not limited to:

- vi. C-104 (2013): Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
- vii. C-105 (2010): Polyethylene Encasement for Ductile-Iron Pipe Systems
- viii. C-150 (2008): Thickness Design of Ductile-Iron Pipe
- ix. C-151 (2009): Ductile-Iron Pipe, Centrifugally Cast for Water
- x. C-503 (2014): Wet-Barrel Fire Hydrants
- xi. C-504 (2010): Rubber-Seated Butterfly Valves
- xii. C-600 (2010): Installation of Ductile-Iron Water Mains and Their Appurtenances
- xiii. C-605 (2013): Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for water
- xiv. C-651 (2014): Disinfecting Water Mains
- xv. C-900 (2007): Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in. (100 mm Through 300 mm), for Water Transmission and Distribution
- xvi. M-11 (2004): A Guide for Steel Pipe Design and Installation, 4th Ed.
- xvii. M-14 (2014): Recommended Practice for Backflow Prevention & Cross-Connection Control, 4th Ed.
- xviii. M-17 (2006): Installation, Field Testing and Maintenance of Fire Hydrants, 4th Ed.
- xix. M-23 (2002): PVC Pipe - Design and Installation, 2nd Ed.
- xx. M-27 (2013): External Corrosion: Introduction to Chemistry and Control, 2nd Ed.
- xxi. M-41 (2009): Ductile-Iron Pipe and Fittings, 3rd Ed.
- xxii. M-55 (2006): PE Pipe—Design and Installation, 2nd Ed.

## 2. Products and Materials

### a. General:

- i. Refer to the latest edition of the California Building Code. Materials and systems must be based on a comprehensive review of the project design requirements. Use of non-standard materials requires the express written consent of the Campus Building Official during the design phase of any project.

### b. Pipe:

- i. Polyvinyl Chloride Pipe (PVC) when consistent with the project's sustainability goals and acceptable to the University's Representative. Material to be in conformance with AWWA C-900 DR-14 (Class 305); or
- ii. High-Density Polyethylene Pipe (HDPE) if specifically approved by Facilities Services and the Designated Campus Fire Marshal; or
- iii. Cement-lined ductile-iron pipe (DIP) may be used only in underground fire service mains supplying building fire protection systems, which shall use cement-lined ductile-iron pipe from five feet (5'-0") outside of the foundation wall through the foundation wall to the inside of the building and be fitted with a Link Seal (or equal) device to prevent transfer of water through the wall.

### c. Joints & Fittings:

- i. Fittings shall conform to type and pressure rating of piping in which they are used.
- ii. Water pipes shall be constructed with welded or constrained joints.
- iii. Flexible couplings shall be installed within three feet (3 ft.) of any structure wall that the pipe penetrates, including vaults, buildings and manholes. Flexible couplings shall be placed, installed and selected to maintain the sufficient pipe restraint to prevent displacement caused by thrust.
- iv. Pipe larger than three inches (3") in diameter and subject to hydraulic pressure (such as groundwater) shall utilize Link-Seal type pipe seals at wall penetrations through building, vault and manhole walls.

- v. Pipe seals at wall penetrations not normally subject to hydraulic pressures and small diameter pipes (less than 3” dia.) may utilize rubber sleeve and lip type seals where acceptable to the Campus Building Department.
- d. Valves:
  - i. Campus water system valves for buried service shall be rubber-seated butterfly valves designed and manufactured specifically for buried service.
  - ii. The product shall comply with AWWA C504 (Rubber-Seated Butterfly Valves, 3 In. through 72 In.)
  - iii. Minimum pressure class 150
  - iv. Manufactured with flanged ends unless specific written authorization is provided by the University’s Representative for alternate means of connection. Mechanical Joints shall not be permitted to connect a valve to a twelve inch (12”) or larger PVC or HDPE pipe..
    - v. All buried valves shall be provided with 2” square AWWA compliant operating nut.
    - vi. Valves shall open when turned counter-clockwise.
    - vii. Provide one tee handle operating wrench with length to suit maximum valve depth.
    - viii. All above grade valves shall be provided with a lockable operating handle or wheel in such a configuration that it can be easily operated to fully open and fully closed position.
    - ix. Manufacturer & Model: Pratt Groundhog Butterfly Valve or approved equal.
- e. Indicator Valves:
  - i. Refer to Section 21 13 00, *Fire Sprinkler Systems*
- f. Meters: Refer to Section 33 05 00, Subsection 6, *Water Meters*
- g. Backflow Prevention Assemblies: Refer to Section 33 12 13.13, *Water Supply Backflow Preventer Assemblies*
- h. Air, Air/Vacuum Release and Combination Valves:
  - i. Air release, air/vacuum release and valves shall be selected according the hydraulic requirements of the Project by the Designer.
  - ii. Selected products shall be manufactured by Val-Matic Valve & Manufacturing Corp., or approved equal.
- i. Valve boxes:
  - i. All buried valves shall be provided with risers and cast iron covers
  - ii. Box shall be concrete, with a steel frame, manufactured to withstand HL-93 loading
  - iii. Riser/Extension to grade shall be HDPE or Cast Iron soil pipe. Refer to Appendix A, drawing FS06 or FS07.
  - iv. Lid shall be Cast Iron with the word “WATER” cast into the lid.
  - v. Box shall be Christy G05 or approved equal.

### 3. Execution

- a. Water System Design
  - i. Water demands for new facilities shall include consideration of current and future uses a minimum of 20 years into the future or as clarified by project design criteria as accepted by the University’s Representative.
  - ii. After demands are determined, size water lines on the basis of friction loss. Do not exceed ten percent (10%) of the initial pressure at full demand or 7.5 feet per second velocity with a minimum pressure of 60 psi for building services.
  - iii. Provide valves at all services from mains and at other points to minimize disruption of building operations. Valves shall be located at the building exterior where mains enter the building. Where critical services and research are conducted, particular attention to redundancy and isolation configurations shall be incorporated into the design. A minimum of two (2) valves shall be installed at each Tee.

- iv. Use separate domestic and fire water supply feed to a building where it is drawn from the University system.
  - v. Use two pressure zones where the pressure at the lowest point of use will exceed 80 psi to maintain 35 psi at the highest point of use.
  - vi. Provide a thrust block table on the drawings. See Appendix A: Drawings for standard thrust block details.
  - vii. Campus water mains shall be designed to minimize dead ends and facilitate looped network configurations.
  - viii. Air, vacuum and combination release valves shall be provided where hydraulically necessary. It is the design engineer's responsibility to identify location and type of valve required and the appropriate size of the valve.
  - ix. Fire protection service. (Refer to Division 21, Fire Suppression)
    - 1. From campus water supply system: Provide separate fire and domestic feeds to building from campus water system.
    - 2. Off campus buildings:
      - a. Provide separate fire service supply from public mains for fire hydrants for buildings served by the utility company (off campus).
      - b. Provide separate fire sprinkler supply drawn after the water meter to buildings that are directly connected to the public water source.
      - c. The University will arrange for and pay for domestic and fire protection water service to off-campus buildings served by the utility company. Furnish size and pressure requirements to Capital Projects (CP).
- b. Pipe system installation
- i. Trench excavation, bedding and backfill operations shall be conducted as described in Section 31 23 00, *Excavation And Fill* and Section 33 05 00, *Common Work Results For Utilities*.
  - ii. Pipelines shall be installed as indicated on the Construction Drawings and in accordance with manufacturer's recommendations.
  - iii. All buried valves shall be installed in concrete valve boxes set at grade and flush with pavement. Where the valve is not located in a paved area, the valve box may be set above grade to an extent appropriate to the location, provided it does not present a tripping or other hazard.
  - iv. A concrete pad shall be placed under all valves.
  - v. Hot tapping and use of saddles are not permitted unless approved in advance by the Campus Building Official.
  - vi. Air release, vacuum release or combination valves shall be installed above grade. A lockable protective cage or cover, as approved by the University's Representative, shall be installed over the valve.
  - vii. Thrust restrain shall be provided either by mechanical means or by use of engineered concrete thrust blocks. Where concrete thrust blocks are used, the Designer shall calculate the mass and dimensions required per UCB Detail FS08/FS08A.
  - viii. Corrosion Protection: Buried ferrous pipe and appurtenances shall be thoroughly coated with an approved bituminous mastic coating and wrapped in a minimum of one layer of 10 mil polyethylene film per AWWA C105 (Polyethylene Encasement for Ductile Iron Pipe Systems).
- c. Pipe system cleaning, flushing, testing and disinfection
- i. All reasonable measures shall be taken during construction to prevent dirt and debris from entering the pipeline and appurtenances, including maintaining protective end caps until installation of the pipe and covering all pipe system openings when not performing direct work on the system.

- ii. The water supply system shall be cleaned and thoroughly flushed with potable water prior to testing to remove all grit and foreign matter. Flushing shall continue until the discharge runs clean. Disposal of flushing water shall be discharged to the sewer or as directed by the University Inspector.
- iii. System testing shall occur before the pipe zone backfill operation is completed to facilitate identification of location of potential leaks. Only sufficient backfill to assure the stability of all pipe and appurtenances during flushing and testing operations shall be performed prior to system testing acceptance.
- iv. The Contractor shall provide a minimum of five (5) days notification to the Campus Inspector and EH&S prior to commencement of the system testing operations.
- v. Testing of the system or any components therein shall be performed according to the testing procedures detailed in the Contract Documents.
- vi. Following successful testing of the system, the Contractor shall disinfect the water system piping and appurtenances according to Section 33 01 10.58—DISINFECTION OF WATER UTILITY PIPING SYSTEMS.

33 11 05 Fire Service Main

1. General:

- a. The design and installation of UCB Campus water mains that are dedicated for the supply of fire protection systems shall comply with this section. The design and installation of UCB Campus water mains that supply both fire protection systems and domestic water systems shall comply with both this section and the section 33 10 00 Water Utilities.
- b. Acronyms and Definitions
  - i. ACI – American Concrete Institute
  - ii. A.F.F. – Above Finished Floor level
  - iii. AHJ – Authority Having Jurisdiction – Campus Fire Marshal
  - iv. AWWA – American Water Works Association
  - v. CBC – California Building Code (2013) (including amendments in Chapter 35)
  - vi. CCR – California Code of Regulations
  - vii. CEC – California Electrical Code
  - viii. CFC – California Fire Code (2013) (including amendments in Chapter 880)
  - ix. CFM – UCB Campus Fire Marshal or UCB Deputy Fire Marshal
  - x. CMC – California Mechanical Code
  - xi. EBMUD – East Bay Municipal Utility District
  - xii. EH&S – Office of Environment, Health & Safety
  - xiii. FS – Facilities Services
  - xiv. FDC – Fire Department Connection
  - xv. FM – Factory Mutual (FM Global)
  - xvi. NFPA – National Fire Protection Association
  - xvii. UC – University of California at Berkeley
  - xviii. University – University of California at Berkeley
  - xix. Approved – Acceptable to the CFM and FS
  - xx. Control Valve – A valve that controls the supply of water to the fire sprinklers and/or standpipe hose valves and if closed will prevent water from supplying the fire sprinkler system and/or standpipe system. It does not include drain valves, inspector test valves, trim valves on backflow preventers, or system valve trim valves.
- c. The design and installation of underground fire service mains shall conform to the following codes and standards except as specifically noted in this section:
  - i. 2013 Edition of the California Building Code



- ii. 2013 Edition of the California Fire Code
- iii. 2013 Edition of NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances,
- iv. American Water Works Association (AWWA) standards and manuals as appropriate for the installation and materials
  - 1. C-104 (2013): Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
  - 2. C-105 (2010): Polyethylene Encasement for Ductile-Iron Pipe Systems
  - 3. C-150 (2008): Thickness Design of Ductile-Iron Pipe
  - 4. C-151 (2009): Ductile-Iron Pipe, Centrifugally Cast for Water
  - 5. C-503 (2014): Wet-Barrel Fire Hydrants
  - 6. C-504 (2015): Rubber-Seated Butterfly Valves
  - 7. C-600 (2010): Installation of Ductile-Iron Water Mains and Their Appurtenances
  - 8. C-605 (2013): Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for water
  - 9. C-651 (2014): Disinfecting Water Mains
  - 10. C-900 (2007): Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in. (100 mm Through 300 mm), for Water Transmission and Distribution
  - 11. M-11 (2004): A Guide for Steel Pipe Design and Installation, 4th Ed.
  - 12. M-14 (2014): Recommended Practice for Backflow Prevention & Cross-Connection Control, 3rd Ed.
  - 13. M-17 (2006): Installation, Field Testing and Maintenance of Fire Hydrants, 4th Ed.
  - 14. M-23 (2002): PVC Pipe - Design and Installation, 2nd Ed.
  - 15. M-27 (2013): External Corrosion: Introduction to Chemistry and Control,
  - 16. M-41 (2009): Ductile-Iron Pipe and Fittings, 3rd Ed.
  - 17. M-55 (2006): PE Pipe—Design and Installation, 2nd Ed.
- v. University of California - Berkeley Construction and Design Standards for Underground Water Mains.

Where conflicting requirements are encountered, the more stringent requirements shall be used and enforced as determined by the Campus Fire Marshal.

- d. Fire Service Mains shall be installed in accordance with NFPA 24 and AWWA Standards.
- e. Domestic and irrigation water mains shall be installed in accordance with the CPC and AWWA standards.
- f. The requirements detailed below are intended for both fire service mains and domestic/irrigation piping unless the requirement specifically refers to a specific type of service.

## 2. Pipe and Fittings:

- a. All piping is to be either
  - i. PVC AWWA C-900 DR-14 (Class 305), or
  - ii. HDPE, if specifically approved by Facilities Services and the Designated Campus Fire Marshal or
  - iii. Cement lined ductile iron pipe (DIP) may be used in accordance with Item 2(b) or with specific approval from Facilities Services.

Unlined cast iron and asbestos cement pipe shall not be installed.

- b. Underground fire service mains supplying building fire protection systems shall use cement lined ductile iron pipe or listed stainless steel pipe from 5 feet outside of the foundation wall to the flange above grade at the exterior wall of the building.

- c. HDPE pipe shall be joined by fusion welding per the manufacturer’s instructions. Saddle taps are not permitted for new installations. Saddle taps for existing HDPE pipe must be specifically approved by FACILITIES SERVICES.
- d. Pipe shall not be deflected along the length of the pipe. Deflection shall be at the pipe-to-pipe joints or pipe-to-fitting joints. The maximum joint deflection shall not exceed 2 degrees.
- e. PVC Pipe and fittings shall not be stored in direct sunlight. Pipe shall be stored in such a manner as to prevent sagging or bending.
- f. Piping shall be installed with the AWWA C-900, pressure rating, and pipe diameter markings on the top of the pipe.
- g. Square cuts shall be beveled with an insertion line marked at the appropriate distance from the end of the pipe. Gaskets, grooves and spigots shall be clean and free of foreign materials prior to assembly. Do not bevel pipe used with MJ fittings or valves.
- h. Corrosion Protection:
  - i. All ferrous materials, restrainers, “T” Head bolts, clamps, joint restraint clamps, washers, tie bolts and nuts shall have one full coat of a protective coating (bituminous mastic) of an approved type before backfilling. The minimum thickness shall be 18 mills dry film thickness. The mastic shall be applied after successful completion of the hydrostatic test and after torque testing of all bolts.
  - ii. All restrainers and ductile iron fittings shall be wrapped with one layer of 10 mil plastic. Use the sleeve type of plastic encasement for straight runs of pipe. The edges of each layer of the plastic wrap shall be sealed with tape.
  - iii. All ductile iron pipe shall be wrapped with one layer of 10 mil plastic. Use the sleeve type of plastic encasement for straight runs of pipe. The edges of the plastic wrap shall be sealed with tape.
- i. Hot tapping and use of saddles is not permitted.
- j. Water service laterals shall originate from a butterfly valve connected directly to the main pipe (using a flange by flange connection) through a minimum 3” diameter pipe and butterfly valve.
- k. Stainless steel rods and dilly lugs may be used in lieu of JCM 610 restrainers, when the distance between the faces of retainer glands on the joint to be restrained is less than 3” feet.
- l. The distance between different services shall be as follows:
  - i. Potable water piping and steam piping (PVC/HDPE): 5 feet
  - ii. Potable water piping and steam piping Ductile Iron: 3 feet
  - iii. Potable water piping and sanitary sewer piping: 5 feet (Unless otherwise approved by Facilities Services)
  - iv. Potable water piping and storm drain piping: 1 foot
  - v. Potable water piping and electrical buss ducts:1 foot

3. Valves:

- a. Valves shall conform to AWWA C504. Valves shall be a Pratt or Mueller Butterfly Valves Triton HP#250. Valves shall open when turned counterclockwise.
- b. All valves 3 inch and larger used when Campus water main pressure is 150 psi or less shall be Pratt or Mueller 150lb flanged Butterfly valves. MJ valves may only be used with specific approval of FACILITIES SERVICES.
- c. MJ valves are not permitted to be installed 12” PVC Pipe. Valves shall open when turned counterclockwise.
- d. The pressure rating for all valves shall be as follows:

<u>Pressure Zone</u>	<u>Hydrostatic Test Pressure</u> (PSI)	<u>Rated Working Pressure</u> (PSI)
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<u>High</u>	<u>300</u>	<u>200</u>
<u>Medium</u>	<u>200</u>	<u>150</u>
<u>Low</u>	<u>200</u>	<u>150</u>

ALL valves shall include a name plate permanently attached to the valve indicating the above pressures. In addition written documentation shall be provided indicating the Hydrostatic test Pressure and the Working Pressure.

- e. Square cuts shall be beveled with an insertion line marked on the pipe at the required distance from the end of the pipe as required by the manufacturer. Gaskets, grooves and spigots shall be clean and free of foreign materials prior to assembly. Do not bevel pipe used with MJ fittings or valves.
- f. Valves shall be connected directly to Tee's using a flange-by-flange connection. Valves at other locations shall be at the discretion and approval of the Campus Fire Marshal and Facilities Services.
- g. A concrete pad shall be placed under all valves.

4. Backflow Preventers:

- a. Backflow preventers shall be installed in accordance with the following:

Backflow Preventer	Fire service mains supplying buildings	Domestic services to buildings	Irrigation systems Greater than 2" Diameter	Irrigation systems 2" Diameter or less
Wilkins 350 XL Wilkins 350 AXL	YES	NO	NO	NO
Wilkins 450 XL Wilkins 450 AXL	YES	NO	NO	NO
Wilkins 375 XL Wilkins 375 XL	NO	YES	YES	NO
Wilkins 475 XL Wilkins 475 XL	NO	YES	YES	NO
Wilkins 975 XL2	NO	NO	NO	YES

- b. Backflow preventers shall be installed in accordance with details in Appendix A.
- c. Backflow preventers shall be installed such that the vertical pipes from the underground water mains are plumb.
- d. A 4" outlet with bolted flange shall be provided downstream of the backflow preventer for testing purposes.
- e. A 1/4" diameter female pipe thread connection with plug shall be provided on both sides of backflow preventer supplying fire protection systems.
- f. All test openings in the backflow preventer shall be plugged.
- g. Bollards shall be provided where the backflow preventer is subject to vehicular damage as determined by the CFM and Facilities Services. Bollards shall be designed and installed in accordance with the CFC.

5. Thrust Restraint:

- a. Thrust block and joint restraint clamps shall be installed at all crosses, tees, wyes, caps, plugs, bends, valves and hydrants. The bearing area of the thrust block shall be in accordance with NFPA 24.
- b. Thrust blocks shall be formed. Concrete shall not encase the pipe, fittings, flanges, valves, restraints, or bolts. The thrust block shall be poured only against one side of the pipe or one side of the fitting (elbow or tee).
- c. Where piping includes a vertical offset, pipe-to-fitting joints shall be joined by either:
  - i. Flange by flange connections, or
  - ii. Mechanical joints with gravity thrust blocks. Tie rods shall be used to secure the pipe fitting against the gravity thrust block. The weight of the gravity thrust block shall be sufficient to counter the hydrostatic forces in the pipe. A pressure of 200 psi shall be used as the minimum pressure used to calculate the force on the fitting. Tie rods shall extend into the gravity block at least 12” and have a 2” return bend at the end of the rod. Either the anchor bolt shall be wrapped over the pipe or a steel clamp shall be used to secure the pipe to the gravity thrust block.

Anchor Bolt Sizing for Gravity Thrust Blocks		
<i>Pipe Diameter</i>	<i>Anchor Bolt</i>	<i>Steel Clamp</i>
6”	5/8”	3” X ¼”
8”	3/4”	3-1/4” X ¼”
10” +	1-1/8”	4” X ½”

- d. Joint restraint shall be installed at all pipe-to-pipe and pipe-to-fitting connections. Joint restraint clamps shall be either:
  - i. JCM Industries 600 series, #610 for MJ joints at pipe-to-fitting connections and #620 for Bell Joints at pipe-to-pipe connections, or
  - ii. EBAA 1500 TD, or
  - iii. US Pipe Field Lok Gasket restraints.
 No equal.
- e. A concrete pier block shall be installed below each valve. The pier block shall support the entire valve and be a minimum 4 inches thick.

6. Trench

- a. The trench shall have a minimum width of 24 inches plus the outside diameter of the pipe. 12 inches shall be provided on each side of the pipe to facilitate compaction.
- b. Where the depth of the trench is greater than 5 feet, the sides of the trench shall be shored.
- c. Warning tape marked “Caution Water Line Buried Below” shall be installed 12” below finished grade.
- d. Tracer wire shall be provided as follows:
  - i. Nonmetallic pipes shall be fitted with a tracer wire which shall be attached to the top of the pipe at a maximum of 10 ft intervals.
  - ii. Tracer wire shall be AWG #8 insulated solid copper wire.
  - iii. Tracer wire shall be continuous, and wire on any laterals shall be spliced into wire on main lines. Splices shall be covered with water resistant heat-shrink tubing. Wire nuts or electrical tape will not be acceptable.
  - iv. Tracer wire shall be brought up to the ground surface at valves, buildings, hydrants, or any point where the pipe rises above grade. At valves, bring tracer wire up to on the outside of the PVC (or C.I., soil pipe) valve access riser.

- v. The wire shall terminate with a three foot length exposed inside valve boxes, where the pipe extends above grade, and at hydrants to provide attachment points for pipe locating equipment.
- e. Bedding material under the pipe shall consist of 6 inches washed sand from the bottom of the pipe to the bottom of the trench. Bell holes shall be provided at each pipe joint. Pipe shall be uniformly supported along its entire length.
- f. Haunching material shall consist of washed sand from the bottom of the pipe to the springline of the pipe.
- g. Initial backfill shall consist of washed sand from the springline of the pipe to 12 inches above the top of the pipe.
- h. Final backfill shall consist of native soil to finished grade or Class 2 AB aggregate.
- i. Bedding, haunching, and initial backfill material shall be compacted to 90% Proctor Density.
- j. Final backfill shall be compacted to 90% Proctor Density in non-traffic areas and 95% Proctor Density in traffic areas.
- k. If there is less than 3'-0" of cover over water main in traffic areas, provide an 8" thick concrete cap twice as wide as trench width with #6 rebar in each direction. Place rebar mat 3" from bottom. The spacing between rebar shall be 18 inches o.c.

## 7. Pressure Reducing Valves

- a. See Appendix C: Fire Sprinkler System and Standpipe System Specifications

## 8. Fire Hydrants

- a. All fire hydrants shall be Clow Model #865, or equivalent. All hydrants shall have two (2) 4-1/2" outlets and one (1) 2-1/2" outlet.
- b. A dedicated control valve shall be installed for each fire hydrant. The control valve shall be an underground butterfly valve (See Item 3 above) connected directly to the Tee fitting on the water main using a flange-by-flange connection.
- c. A 4" thick concrete pad shall be placed under the hydrant bury per Appendix A: Drawings for typical installation details. The pad shall be installed before the hydrant bury is set in place.
- d. All fire hydrants shall include a breakaway riser connected directly to the base of the hydrant.
- e. All fire hydrants shall include a breakaway check valve connected directly to the breakaway flange. A concrete pad shall be poured at the breakaway check valve from 2 inches above the bottom flange of the check valve to 2 inches below the top flange of the breakaway check valve. The concrete pad shall extend laterally to undisturbed earth or two feet (2'-0") from all sides of the fire hydrant, whichever is less. The concrete shall not be poured in such a way that any bolt is obstructed or impairs the removal of the bolt in any way.
- f. Break away bolts shall not be used at flanges.
- g. The two 4 1/2" outlets of the fire hydrant shall face the street.
- h. All hydrants shall be rated for a minimum working pressure of 200 psi.
- i. Fire Hydrant blue reflective markers shall be provided. The reflective marker shall be located on the street approximately 2 feet from the centerline of the street on the side where the hydrant is located.
- j. Bollards shall be provided where the fire hydrant is subject to vehicular damage as determined by the CFM and Facilities Services.

## 9. Fire Department Connections (FDC):

FDC's shall be provided at a location approved by the Campus Fire Marshal. The FDC shall consist of:

- a. One 5" Storz connection with a screen and a cap. The Storz connection shall be oriented at a 30° angle downward, and

- b. At least two 2½” FDC inlets using female swivel connections with plugs or caps shall be provided. The number of 2½” inlets shall be based on one 2½” inlet for each 250 gpm system demand, and
- c. The 5” Storz connection and the 2½” inlets shall each include a check valve, and either a cap or plug. Each check valve shall be independent from one another.
- d. Where more than two 2½” inlets are used, each inlet shall have an individual clapper or check valve, and
- e. An automatic ball drip valve shall be provided between the 5” Storz inlet and its associated check valve.
- f. An automatic ball drip valve shall be installed between the 2½” inlet and its associated check valve when a 2½” plug is used in the inlet or drill a 1/8” hole in the plug.
- g. A ½” threaded plug shall be provided on the downstream side of the FDC check valve located on the bottom of the pipe to facilitate drainage of the pipe during required maintenance.
- h. Where a fire protection system includes a pressure regulating device, the FDC piping shall be piped to a point downstream of the FDC. A check valve shall be located between the FDC piping and the pressure regulating device (including pressure relief valves).
- i. Bollards shall be provided where the fire hydrant is subject to vehicular damage as determined by the CFM and Facilities Services.

10. Fire Service entrance to buildings

- a. Underground fire service mains shall not be installed under the building slab or foundation wall.
- b. Piping supplying fire protection systems shall enter the building at a point no more than 12 inches above finished grade.
- c. Subject to the approval of the Campus fire Marshal, where the fire service cannot enter the building above finished grade, an alternate location must be provided. Piping is not permitted to be installed under the foundation or the building floor slab.
- d. Flexible couplings shall be provided within 12 inches of the wall on both sides of the wall penetration.

11. Plan Submittal:

- a. For review and approval prior to the start of work, plans shall be submitted to:
  - i. Facilities Services, and
  - ii. Inspection Services, and
  - iii. UCB Campus Fire Marshal
- b. Plans shall include the above information and details. Plans shall comply with all UCB Campus Standards and NFPA 24.

12. Inspections:

All piping installations shall be inspected by Capital Projects Inspection Services and the UCB Campus Fire Marshal. Provide a minimum 72 hour notice for inspections. A pre-installation inspection is required by the CFM to inspect all of the materials intended to be used. Construction inspections shall be conducted for the following:

- a. Trench inspection including bedding material.
- b. Piping, fittings, valves, tracer wire inspection.
  - i. The inspection shall include inspection of the bituminous mastic on bolts and restraints. The bituminous mastic shall not be applied prior to torque testing (see Section 12.c(iii) below)
- c. Thrust restraint inspection.
  - i. Thrust blocks

- ii. Retainer glands
- iii. Torque testing of retainer gland bolts, thrust restrain bolts, and flange by flange bolts.
- d. Fire hydrant, breakaway flange, and breakaway check valve inspection.
- e. Backfill including warning tape
- f. Compaction

13. Acceptance Testing for Fire Service Mains:

All tests of piping shall be by Capital Projects Campus Inspection Services and the UCB Campus Fire Marshal. Provide a minimum 72 hour notice for tests.

- a. Hydrostatic test.
  - i. All piping, fittings, valves, hydrants, etc. shall be pressure tested to 200 psi or 50 psi + maximum static pressure, whichever is greater for a minimum of 2 hours.
  - ii. Maximum static pressure shall include the maximum system pressure fluctuation.
  - iii. The test pressure shall not drop during the test period.
  - iv. Leakage is permitted in accordance with NFPA 24 Section 10.10.2.2.4.
  - v. Gauges shall be either:
    - 1. A digital gauge having a 0.1 psi resolution and a 1% full scale accuracy or
    - 2. An analog gauge having a 3½ inch diameter face and a 1% full scale accuracy.
 The test pressure shall not exceed 75% of the analog gauge full scale. Gradations shall be in 1 psi increments
- b. Flushing.
  - i. All piping shall be flushed at 10 ft/sec or system demand, whichever is greater, for piping systems that do not supply a fire pump.
  - ii. All piping shall be flushed at 15 ft/sec or system demand, whichever is greater, for piping systems that supply a fire pump.
  - iii. The discharge from the flushing shall pass through a double layered burlap bag. If debris is collected, the flush shall be repeated.
  - iv. The flush shall continue until the discharge is clean and free of debris.
  - v. The duration of the flush shall continue for a time period as determined by the Campus Fire Marshal for water piping supplying fire protection systems and fire hydrants.
  - vi. The duration of the flush shall continue for a time period as determined by Capital Projects Campus Inspection Services for water piping dedicated to supplying domestic systems.
  - vii. Flushing shall be conducted after the hydrostatic test.
  - viii. The contractor shall be responsible for the safe discharge of the water so as not to damage buildings and landscaping as well as not polluting the environment.
- c. Valve operation – Valves shall be fully opened and closed under system pressure.
- d. Fire hydrants – Fire hydrants shall be fully opened and closed under system pressure.
- e. Disinfection shall be in accordance with Section 33 01 10.58, *Disinfection of Water Utility Piping Systems*. This standard applies to domestic, irrigation, and fire protection water piping.
- f. The contractor shall comply with the UCB Campus policy regarding the water discharge from flushing.
  - i. [Guidelines for Discharge of Automatic Fire Sprinkler Water \(PDF-60K\)](#)
  - ii. [Section 01572 - Storm Water Pollution Prevention \(PDF-320K\)](#)
- g. Backflow preventer
  - i. A flow test at system demand shall be conducted to verify proper operation and pressure drop

1. General

- a. The University of California at Berkeley adheres to State requirements (California Code of Regulations Title 17: Group 4) and adopts the standards and recommendations set forth by the University of Southern California: Foundation for Cross-Connection Control and Hydraulic Research - Manual of Cross-Connection Control (9th edition, August 1993 or subsequent revisions). The proper design, selection, installation and maintenance of cross-connection control devices is imperative, particularly in a university/mixed-use environment, for the protection of potable drinking water and distribution systems. Appropriate backflow prevention assemblies shall be selected from the most current USC-FCCCHR List of Approved Backflow Prevention Assemblies and shall be inspected and periodically tested as specified by the manufacturer by a certified tester.
- b. Provide backflow protection at any building water system where there are connections, actual or potential, to a contaminating liquid. Examples include laboratory hose cocks and connections from domestic system to HHW makeup and cooling towers.
- c. Backflow shall be prevented by installing a backflow prevention device at each individual point of possible contamination, where devices such as vacuum breakers or air gaps may be employed, or at a single point where an industrial water piping system takes off from the domestic water piping. Industrial water used in labs for experiments is assumed to be non-contaminated. The industrial system must be protected from heating hot water, cooling towers, etc., by additional pressure-reducing devices.
- d. Select the type of backflow prevention system appropriate to each individual case. Generally, a separate industrial water system will be justified in buildings having numerous outlets that are susceptible to contamination. A chemistry or laboratory building is a good candidate for a separate industrial system.
- e. Coordinate the requirements for backflow prevention for any building located off-campus with Capital Projects (CP) and the utility company and comply with agency and University requirements.

2. Backflow Prevention Assembly

- a. See Appendix A: Drawings for typical details.
- b. Backflow preventers shall be installed in accordance with the following:

Table 2				
Backflow Prevention Assembly	Fire Service Mains Supply Building?	Domestic Services to Building?	Irrigation Systems greater than 2" Diameter present?	Irrigation Systems 2" or less in diameter present?
Wilkins 350 AST (2) Wilkins 350 ASTR (2)	Yes	No	No	No
Wilkins 375 AST (2) Wilkins 375 ASTR (2)	No (1)	Yes	Yes	No
Wilkins 975 XL2 (2)	No	No	No	Yes
(1) Required where the fire sprinkler system uses antifreeze or where there is a water storage tank for fire protection systems				
(2) All models: Or Equivalent (Designated Campus Fire Marshal approval required)				

- c. A four inch (4") outlet with bolted flange shall be provided downstream of the backflow preventer for testing purposes.
- d. All test openings in the backflow preventer shall be plugged.



- e. Bollards shall be provided where the fire hydrant, fire department connection or backflow preventer is subject to vehicular damage, as determined by the Designated Campus Fire Marshal or Facilities Services. Bollards shall comply with CFC Section 312.
- f. Select appropriate backflow prevention devices for the intended service. The following devices are listed in approximate decreasing order of effectiveness and reliability.
- g. Air-Gap Separations (a physical break between the supply pipe and a receiving vessel): The air gap shall be at least twice the diameter of the supply pipe, measured vertically above the overflow rim of the vessel with a minimum clearance of one inch (1"). This provides the maximum degree of protection and should be used wherever a non-pressurized supply is acceptable. It shall be used where sewage or toxic substances are involved.
- h. Reduced-Pressure Backflow Preventers: Use for protection of all direct or indirect connections where the device may be subject to back pressure and for isolating industrial water systems from the domestic water system. Locate in an accessible location. Where spillage is unacceptable, discharge with an air gap into a floor drain. Install backflow preventer at least 12" above floor or ground. Test cocks must be accessible.
- i. Pressure-Type Vacuum Breaker: Use only as protection for direct or indirect water connections to all types of polluted or contaminated liquids where the vacuum breakers are not subject to back pressures. These units may be installed under continuous line pressure. Install in an accessible location. Where spilling into room is objectionable, it shall be specified as modified with drain connection and waste.
- j. Anti-Siphon Ballcocks: Use for tank-type water closets and urinals. The outlet of the backflow preventer shall be at least one inch (1") above the opening of the overflow pipe.
- k. Vacuum Breakers for Flush Valves: Occurs at toilets or urinals. Specify installation at least four inches (4") above the overflow rim.
- l. Double Check Valve Assemblies: Use to protect direct or indirect water connections where contaminants entering the system would not constitute a health hazard. Examples include steam, air, foods and beverages.

### 33 30 00 Sanitary Sewerage Utilities

#### 1. Products and Materials:

- a. Pipe:
  - i. High-Density Polyethylene Pipe (HDPE) conforming to AWWA C901/906
  - ii. Alternative pipe material will be allowed only with specific written approval of the University's Representative.
- b. Joints & Fittings:
  - i. Fusion welded joints between pipe sections
  - ii. Welded flanges shall be used to join valves and appurtenances.
- c. Manholes:
  - i. Precast concrete sections with eccentric cone
  - ii. Minimum 36-inch (36") diameter, or larger where the number or size of connecting pipelines requires.
  - iii. Provide ladder rungs if directed by the Facilities Services Utilities Engineering
  - iv. Provide a reinforced concrete base with smooth flow channel of a depth not less than 80% of the diameter of the pipe. Where two or more pipes provide inflow, these channels shall be shaped to form a wye to the discharge outlet.
  - v. Manhole sections shall be sealed to be water tight with a gasket or other suitable sealant recommended by the manufacturer for sealing buried concrete sewer manhole sections to water tight.

- vi. Frame and Cover: Cast Iron frame and cover with SEWER cast into the cover, not less than thirty inches (30”) in diameter.
- d. Bar Screens, Grinders, Pumps and Force Mains:
  - i. For any installation that would include pumped sewerage, project shall consult with Facilities Services Utilities Engineering. Such installations are only approved when absolutely necessary, and are considered on a case by case basis.

2. Design and Installation:

- a. After sewer flows are estimated, size sewer lines on quantity of flow and slope of line to result in minimum velocity of one and one-half feet per second (1.5 fps) when flowing at any percentage of full flow.
- b. Cleanouts: cleanouts shall be provided at each location where a sanitary waste line exits a building to join a lateral.
- c. Horizontal and vertical alignment shall be in straight lines between manholes. Provide a manhole at each change in direction or slope.
- d. Provide manholes in straight runs not exceeding three hundred feet (300'-0”) distances between manholes.
- e. Buried Sanitary Sewer pipelines shall be installed with a minimum three feet (3 ft.) of cover. Where site conditions prevent installation of pipeline with specified cover, alternate protection shall be provided, subject to written approval of the University’s Representative.
- f. Consider future connections at new manholes and provide stub out with plugged end hub.
- g. The Designer shall set the rim elevation flush with finish grade in paved areas and two inches (2”) above finished grade in landscape areas where mulch or shrubbery will be placed. Rim elevation in lawn areas shall be subject to the discretion of the Landscape Architect. Rim elevation in areas prone to flooding shall be set to the height necessary to avoid overtopping as determined by the flood analysis.

3. Applicable Standards and Tests:

- a. Main pipeline/lateral must be inspected and televised using National Association of Sewer System Companies (NASSCO) rating system upon completion.
- b. Pipeline/lateral must be pass an air or water test.
- c. EH&S shall receive expenditure/asset data regarding sewer portion per regulatory reporting requirement.
- d. Manhole must be inspected using NASSCO Manhole Assessment and Certification Program (MACP) requirements.

33 40 00 Storm Drainage Utilities

1. Stormwater Management

- a. All proposed storm drainage facilities and/or design shall comply with the current version of the Alameda County Clean Water Program C.3 Stormwater Technical Guidance.

2. Products and Materials:

- a. Pipe:
  - i. High-Density Polyethylene Pipe (HDPE) conforming to AWWA C901/906
  - ii. Precast reinforced concrete pipe (RCP) conforming to ASTM C76—Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
  - iii. Corrugated Metal Pipe (CMP) is not permissible
- b. Joints & Fittings: Joints and fitting to be water tight as compatible with the type of pipe installed.
  - i. For HDPE pipe, fusion welded joints and welded flange fittings.

- ii. For RCP, bell and spigot joints with rubber gaskets conforming to ASTM C443—Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets, or preformed flexible joint sealants, conforming to ASTM C990—Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Performed Flexible Joint Sealants.
    - c. Cleanouts: cleanouts shall be provided wherever a roof leader or other stormwater drain joins a stormdrain lateral at the perimeter of a building and provision of a storm drain manhole is impractical.
    - e. Manholes:
      - i. Precast concrete sections with eccentric cone
      - ii. Minimum 36-inch (36”) diameter, or larger where the number or size of connecting pipelines requires.
      - iii. Provide ladder rungs if directed by the Facilities Services Utilities Engineering
      - iv. Provide a reinforced concrete base with smooth flow channel of a depth not less than 80% of the diameter of the pipe. Where two or more pipes provide inflow, these channels shall be shaped to form a wye to the discharge outlet.
      - v. Manhole sections shall be sealed to be water tight with a gasket or other suitable sealant recommended by the manufacturer for sealing buried concrete manhole sections to water tight.
      - vi. Frame and Cover: Cast Iron frame and cover with STORM cast into the cover, not less than thirty inches (30”) in diameter
    - f. Headwalls, Endwalls and Energy Dissipation Structures:
      - i. All structures constructed in any creek or other open channel, or discharging to such, shall comply with all relevant regulations and permits. The Designer shall coordinate with the University’s Representative and the Utilities Engineering Office of Facilities Services in the design and specification of any such structure.
3. Design and Execution:
- a. After loads are estimated, base storm drain pipe size on the quantity of flow and slope of line to yield a minimum velocity of three feet (3’-0”) per second when flowing full.
  - b. Provide manholes at all changes in horizontal alignment or slope and not exceeding three hundred feet (300’-0”) distance between manholes.
  - c. Buried Storm Drain pipelines shall be installed with a minimum three feet (3 ft.) of cover. Where site conditions prevent installation of pipeline with specified cover, alternate protection shall be provided, subject to written approval of the University’s Representative.
  - d. All inlet structures, such as catch basins, curb inlets, headwalls, etc., may be reinforced concrete or suitable precast concrete with galvanized steel or cast iron grating.
  - e. Install storm sewer manholes similar to sanitary sewer manhole installation. Storm sewer manholes shall be precast or cast-in-place reinforced concrete with cast iron rim and open-grate cover and galvanized steps. Provide steps in any inlet structure with depth greater than three feet (3’-0”). Cover shall be round and have STORM cast in.
  - f. Install manholes on reinforced concrete bases, with flow lines smoothly grouted in, steps installed and rim and cover grouted in place.
  - g. Low Impact Development (LID) Best Management Practices (BMPs) shall be utilized in preference to conventional piped stormwater solutions or end-of-pipe solutions. The Designer is encouraged to coordinate closely with the Facilities Services Office of Utilities Engineering in the development of the Stormwater Management Plan.

33 46 00 Subdrainage

33 46 13 Foundation Drainage

1. Coordinate with the geotechnical consultant, the structural consultant and the civil consultant. Keep surface drainage away from the building.
2. In addition to waterproofing requirements, floor levels which are below finished grade shall have a foundation drainage system where possible. Drainage pipes shall be smooth perforated drain pipe in a gravel drainage bed, protected with filter fabric. Filter fabrics and mats shall be specified and shown. Provide gravel backfill or drainage mats. Show and detail drainage and backfill system in wall section. Locate drainage pipe invert elevation below bottom of concrete floor slab elevation
3. Additional drainage pipes will usually be required near the top of the below-grade wall at a point five to ten feet (5'-0" - 10'-0") away from the wall. Direct roof water or subsurface water to drainage pipes using membranes and/or clay caps sloped away from the building to the drainage pipe. Water diversion membranes shall be detailed with fold (slack) for possible settlement.
4. Eliminate hydrostatic head wherever possible. Where a water table is present, install additional drainage pipes as may be required to draw down water table at wall, below floor, and through footing in coordination with the geotechnical, civil, and structural consultants.
5. Where drainage depends on mechanical pumping, provide emergency power as well as structural provisions for buoyancy and lateral pressure.
6. Slab-on-grade construction (where below-slab waterproofing is not required) shall include a four inch (4") minimum gravel layer for capillary break, an 8 mil polyethylene moisture barrier (or equivalent) and a two inch (2") minimum layer of sand over the polyethylene.
7. Show and specify drainage backfill, drainage pipe and damp-proofing (or waterproofing) at retaining walls.

33 50 00 Fuel Distribution Utilities

33 51 00 Natural Gas Distribution

1. Size gas piping for estimated maximum demand flow in CFH (using 1000 BTU per cubic foot) per code requirements.
2. Show valves at all services from main and at other points to allow isolation of portions of main without interference to other building services.
3. Metallic gas piping below grade or within six feet (6'-0") of finish grade shall have a minimum wrap equal to Pabco D-13-20-246M or extruded polyethylene coating. Joints shall receive equivalent coating after tests.
4. Jeep test all pipe coatings and joints.
5. Buried gas lines shall be installed with a minimum three feet (3') of cover. Where site conditions prevent installation of pipeline with specified cover, alternate protection shall be provided, subject to written approval of the University's Representative.

33 60 00 Hydronic and Steam Energy Utilities

33 63 00 Steam Energy Distribution

1. Steam Piping shall be buried with a minimum thirty inches (30") of cover unless pipe manufacturer specifies additional cover, in which case the deeper cover shall be provided. Where site conditions prevent installation of pipeline with specified cover, alternate protection shall be provided, subject to written approval of the University's Representative.
2. Valves for high-pressure steam distribution (125 psi system) shall be 300 psi minimum steam rated flanged gate valves with rising stem (outside screw and yoke) and bypass/warm-up valve. Valves three inches (3") and smaller shall have a screwed union bonnet.

3. Condensate Piping: Valves for steam condensate return shall be 150 psi minimum steam rated flanged gate valves with rising stem (outside screw and yoke). Valves three inches (3") and smaller shall have a screwed union bonnet. Use only Brigit Lead-free Solder.
4. See also 22 35 00: Domestic Water Heat Exchangers
5. Size an individual building service on the estimated building demand, with velocities not exceeding 5,000 feet per minute. Discuss estimated building demand with Capital Projects (CP).
6. Size pumped building condensate piping for velocities not exceeding five feet (5'-0") per second and gravity condensate piping for estimated quantity at available slope.
7. Install prefabricated steam and condensate piping complete with insulation suitable for direct burial. Discuss type of prefabricated steam and condensate piping with Capital Projects (CP) before starting design. Perma-Pipe or "pop-together" pipe is not acceptable.
8. Access Hatches:
  - a. Refer to 05 00 00: Metals for requirements of metal fabrication, finishes and fasteners
  - b. Access Hatches shall be in accordance with the latest adopted standards of the National Association of Architectural Metal Manufacturers (NAAMM), American Welding Society (AWS) and ASTM International.
  - c. Products include:
    - i. Single Leaf: Bilco Model J-AL or equal
    - ii. Double Leaf: Bilco Model JD-AL or equal
  - d. Door leaves shall be at least one quarter inch (1/4") thick aluminum with stiffeners as required to demand live load of three hundred pounds (300lbs) per square foot and AASHTO HS20 loading, including a slip resistant finish (Slipnot, or equal).
  - e. Frame shall be at least one quarter inch (1/4") thick aluminum channel with anchor flange only along sides that are to be embedded in concrete. Provide channel to collect and drain water and provide a one and one-half inch (1 1/2") drainage coupling for connection to drainlines.
    - i. Provide Isolation coating between aluminum frame in contact with steel and concrete as required by 05 00 00: Metals
    - ii. All aluminum shall be mill finished with bituminous coating applied to the exterior portion of the frame that will be concealed after installation.
  - f. Doors shall be equipped with heavy forged brass hinges, stainless steel pins, spring operators and automatic hold-open arms with a positive automatic latch that will secure the door in the open position until the release handle is activated. Submit details of latch for review. Provide snaplock with removable handle, aluminum recessed hasp to door and frame where required for padlock. Doors shall not deflect more than one quarter inch (1/4") under a three hundred pound (300lb) point load either up or down, especially at the perimeter.
  - g. Channel support shelf for stiffeners shall be trimmed as shown in drawings.
  - h. Stainless steel fasteners:
    - i. For bolting hatch frame through flange of steel beam supports, see Appendix A: Drawings
    - ii. See Section 05 00 00: Metals for stainless steel bolt, nut and washer requirements.
    - iii. Provide isolation coating between dissimilar metals in contact with one another, in accordance with Section 05 00 00: Metals
  - i. All hardware shall be stainless steel throughout.
  - j. Provide stainless steel hold-open pin through holes in hold-open arms to ensure against accidental hatch closure. Attach pin to hatch with short stainless steel chain to prevent misplacement.
  - k. Provide stainless steel safety chain between double leaf doors at opposite end from latch.
  - l. Provide a ten inch by twelve inch (10" x 12") minimum size sign permanently attached to the underside of the hatch doors reading: "Danger: make sure hold-open latch is positively engaged before using. Insert pin in holes in hold-open arms to hold."
  - m. Coordinate dimensions and installation of access hatches with the dimensions and installation of alternating tread stairs and ladders. The alternating tread stairs and ladders shall not interfere with

the operation of the hatch and personnel access through the hatch. The top of the alternating tread stairs and ladders shall not interfere with the stiffener beams beneath the hatch doors, thus allowing the hatch doors to close flush with the top of the hatch frame.

- n. Coordinate connection of drainage coupling to plumbing drain line prior to concrete placement.
- o. Set frame level and true to plane at all four corners and flush with the adjacent finished surfaces prior to concrete placement. Doors, when closed, shall be flush with frames and flush with each other.
- p. Submittals: Submit product data, including full description of items proposed for use, and shop drawings, showing dimensions, attachments, inserts and relationships to adjoining construction.
- q. Guarantee: Provide a written guarantee effective for a period of twenty five (25) years from date of final acceptance of the project that floor hatches will not leak and will be free of defects in materials and workmanship

### 33 70 00 Electrical Utilities

#### 1. Electric Power Transmission

- a. Sizing of distribution ducts and cable is based on campus requirements. Obtain from Capital Projects (CP).
- b. Engineered ducts shall be provided for all buried transmission cable in either red concrete or duct trenches specifically designed for power transmission. All such ducts must be approved by the Owner's Agent.

### 33 80 00 Communications Utilities

2. See Divisions 26 and 27 for combined power and communication in duct banks.

#### 3. Fire Alarm

- a. Number and size of conduits are based on campus requirements. Obtain from Capital Projects.
- b. See Division 28 31 00: Fire Detection and Alarm.

Division 34 — Transportation

Division 35 — Waterway and Marine

Divisions 36-39 — RESERVED FOR FUTURE EXPANSION

Division 40 — Process Integration

Division 41 — Material Processing and Handling Equipment

Division 42 — Process Heating, Cooling, and Drying Equipment

Division 43 — Process Gas and Liquid Handling, Purification and Storage Equipment

Division 44 — Pollution and Waste Control Equipment

Division 45 — Industry-Specific Manufacturing Equipment

Division 46 — Water and Wastewater Equipment

Division 47 — RESERVED FOR FUTURE EXPANSION

Division 48 — Electrical Power Generation

Division 49 — RESERVED FOR FUTURE EXPANSION





## Appendix A: Drawings

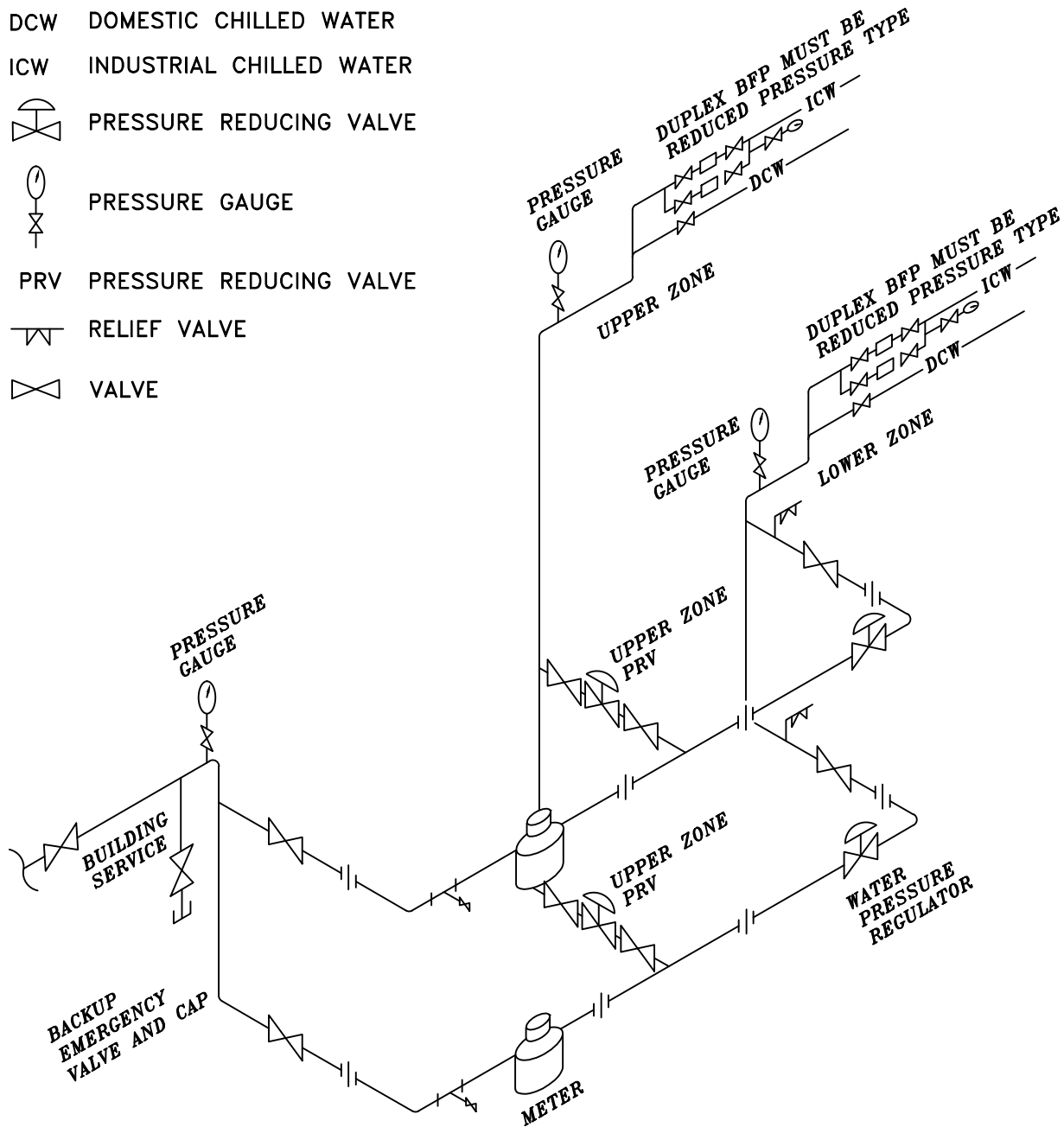
The following are typical installation details for the specified application. Consult Capital Projects (CP) for clarification or specific project requirements.

- FS01: Typical Water Service and Piping System
- FS02: Typical Water Station
- FS03: Backflow Preventer - Wilkins Model 350 AST
- FS04: Reduced Pressure Backflow Preventer – Model 825Y
- FS05: Reduced Pressure Principle Assembly - Wilkins Model 375 AST
- FS06: Reduced Pressure Principle Assembly – Wilkins Model 975 XL
- FS07: Reduced Pressure Backflow – Model 880
- FS08: Method #1 Flanged Valve or Tee with Adapters
- FS09: Method #2 Mechanical Joints Tie-In Using 12-inch Long Sleeve
- FS10: Concrete Thrust Block
- FS10A: Thrust Block Table
- FS11: Fire Hydrant Installation Detail
- FS12: Trench Backfill & Resurfacing in Paved Areas
- FS13: Trench Backfill in Landscaped Areas
- FS14: Concrete Encased 6-Way Duct Bank
- FS15: Warm-Up Valve
- FS16: Typical Steam Pressure Reducing Station
- FS17: Steam Vault – Typical (Elevation View)
- FS18: Manhole Structure
- FS19: Steam Manhole Cover Framing Plan – Manhole Hatch
- FS20: UCB “House” Vacuum System Design Layout and Schematic
- FS21: Post and Rail Fence
- FS22: Teak Bench Installation
- FS23: Site Lighting Control Schematic
- FS24: Typical Layout, Arrangement, Metering for Photo Voltaic System



## DUAL\_ZONE

- BFP BACKFLOW PREVENTER
- DCW DOMESTIC CHILLED WATER
- ICW INDUSTRIAL CHILLED WATER
-  PRESSURE REDUCING VALVE
-  PRESSURE GAUGE
- PRV PRESSURE REDUCING VALVE
-  RELIEF VALVE
-  VALVE



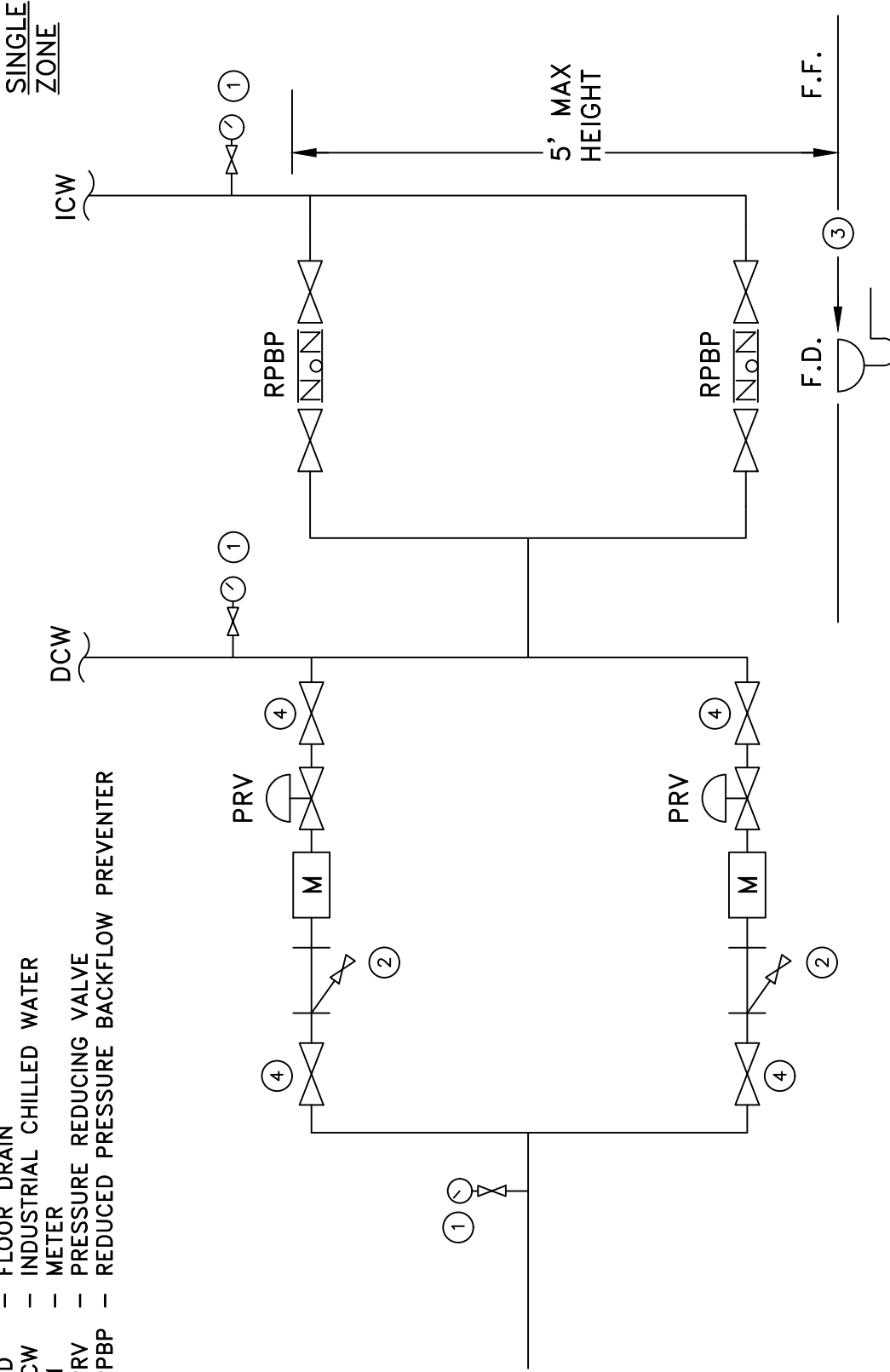
UC Berkeley  
Facilities Services  
GIS, Mapping & Drawing

Scale: NTS      Rev. Date: 01/06/20

TYPICAL WATER SERVICE  
AND PIPING SYSTEM

FS01

DCW - DOMESTIC CHILLED WATER  
 FF - FINISHED FLOOR  
 FD - FLOOR DRAIN  
 ICW - INDUSTRIAL CHILLED WATER  
 M - METER  
 PRV - PRESSURE REDUCING VALVE  
 RPBP - REDUCED PRESSURE BACKFLOW PREVENTER



1. GAUGE WITH VALVE
2. BALL VALVE FOR BLOW DOWN ON WYE STRAINER
3. FLOOR DRAIN LARGE ENOUGH TO HANDLE DISCHARGE
4. FULL PORT LEAD FREE VALVE



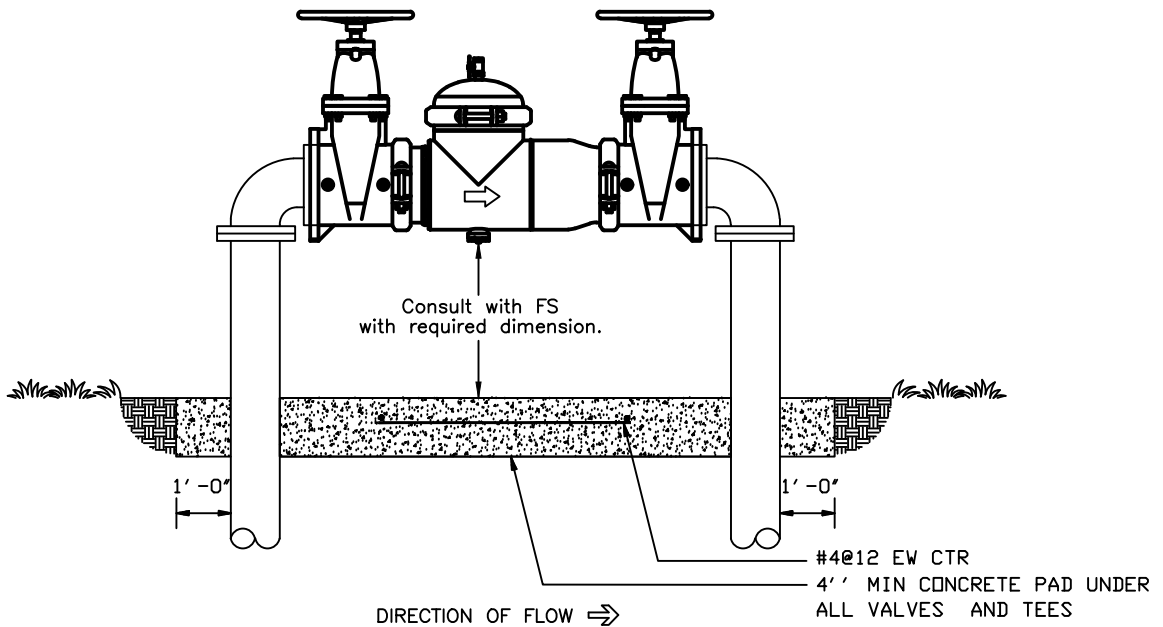
UC Berkeley  
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TYPICAL WATER STATION

FS02



WILKINS MODEL 350 AST  
BACKFLOW PREVENTER  
OUTDOOR HORIZONTAL INSTALLATION 10"  
 NO SCALE

NOTE: FOR FIRE SERVICE, INDICATING  
 TYPE VALVE IS REQUIRED.

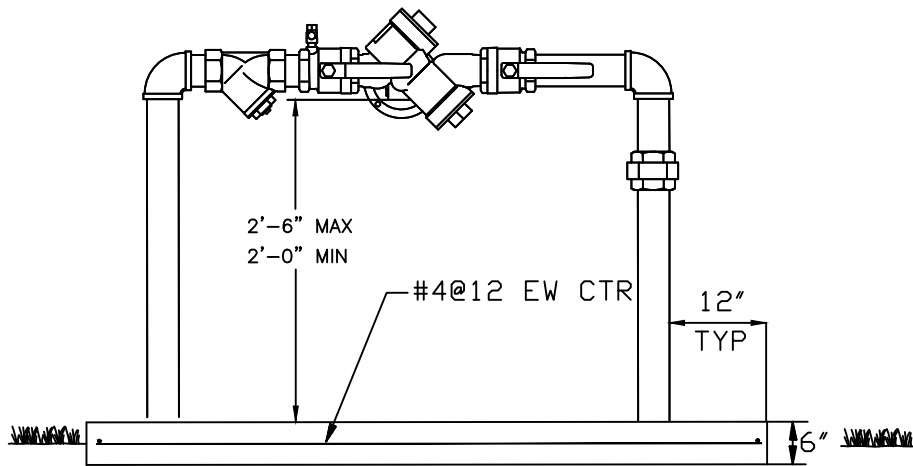


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BACKFLOW PREVENTER -  
 WILKINS MODEL 350 AST

FS03



MODEL 825Y REDUCED PRESSURE  
BACKFLOW PREVENTOR ASSEMBLY FOR  
LINE SIZES 2' AND LESS

NO SCALE

NOTE: FOR FIRE SERVICE, INDICATING  
TYPE VALVE IS REQUIRED.



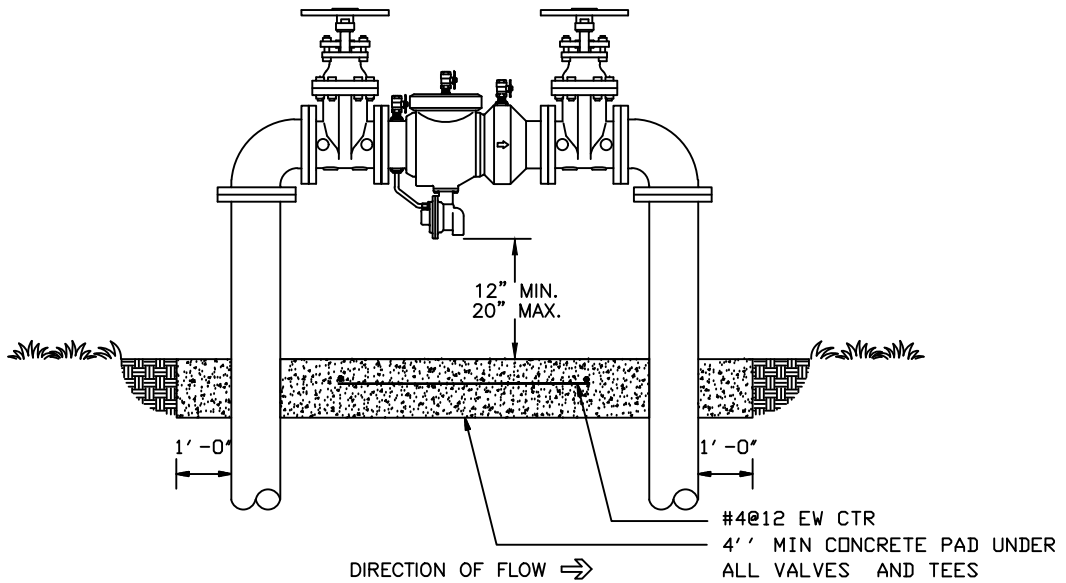
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REDUCED PRESSURE  
 BACKFLOW PREVENTER -  
 MODEL 825Y

FS04



WILKINS MODEL 375 AST  
REDUCED PRESSURE PRINCIPLE ASSEMBLY  
OUTDOOR HORIZONTAL INSTALLATION 2½ AND 10"  
(NOTE: MODEL 350 FOR FIRE SERVICE)

NO SCALE

NOTE: FOR FIRE SERVICE, INDICATING  
 TYPE VALVE IS REQUIRED.



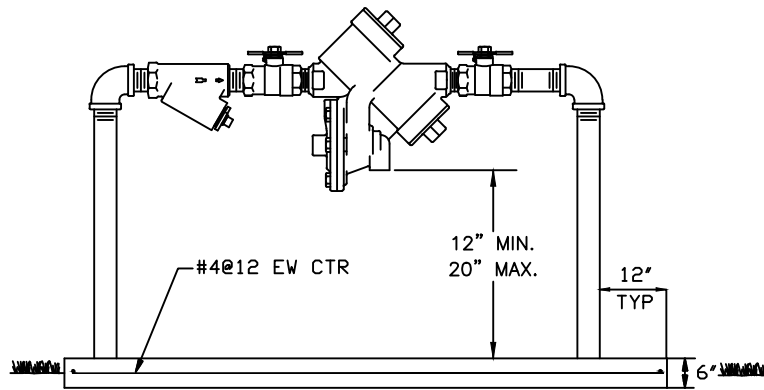
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Rev. Date: 01/23/15

REDUCED PRESSURE  
 PRINCIPLE  
 ASSEMBLY - WILKINS  
 MODEL 375 AST

FS05



DIRECTION OF FLOW ⇒

WILKINS MODEL 975XL  
REDUCED PRESSURE PRINCIPLE ASSEMBLY  
OUTDOOR HORIZONTAL INSTALLATION  
LINE SIZES 2" AND LESS

NO SCALE

NOTE: FOR FIRE SERVICE, INDICATING  
 TYPE VALVE IS REQUIRED.



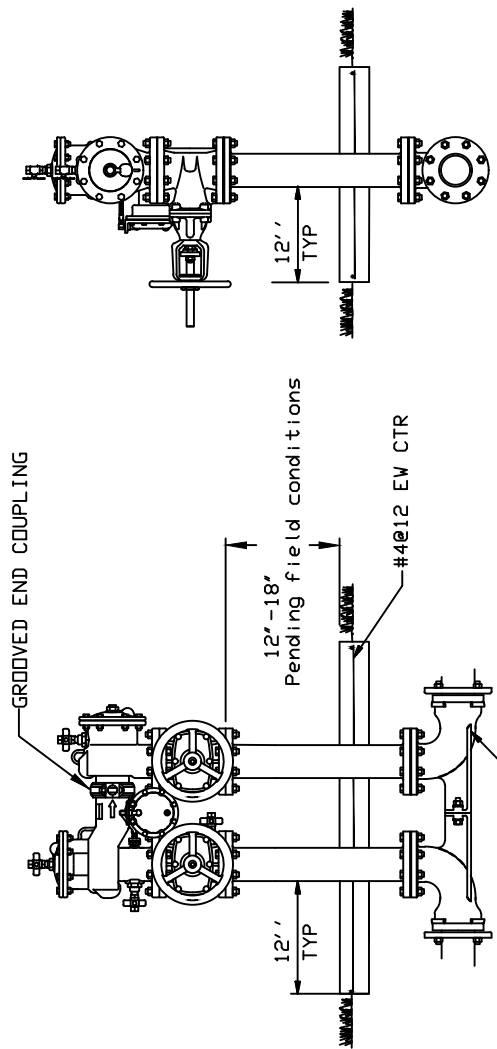
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REDUCED PRESSURE  
 PRINCIPLE ASSEMBLY -  
 WILKINS MODEL 975XL

FS06



FL X MJ VALVE SETTER  
 MODEL 880 REDUCED PRESSURE BACKFLOW ASSEMBLY  
 WITH DS&Y GATE VALVES FOR LINE SIZES

2 1/2" AND ABOVE  
 NO SCALE

NOTE: FOR FIRE SERVICE, INDICATING  
 TYPE VALVE IS REQUIRED.



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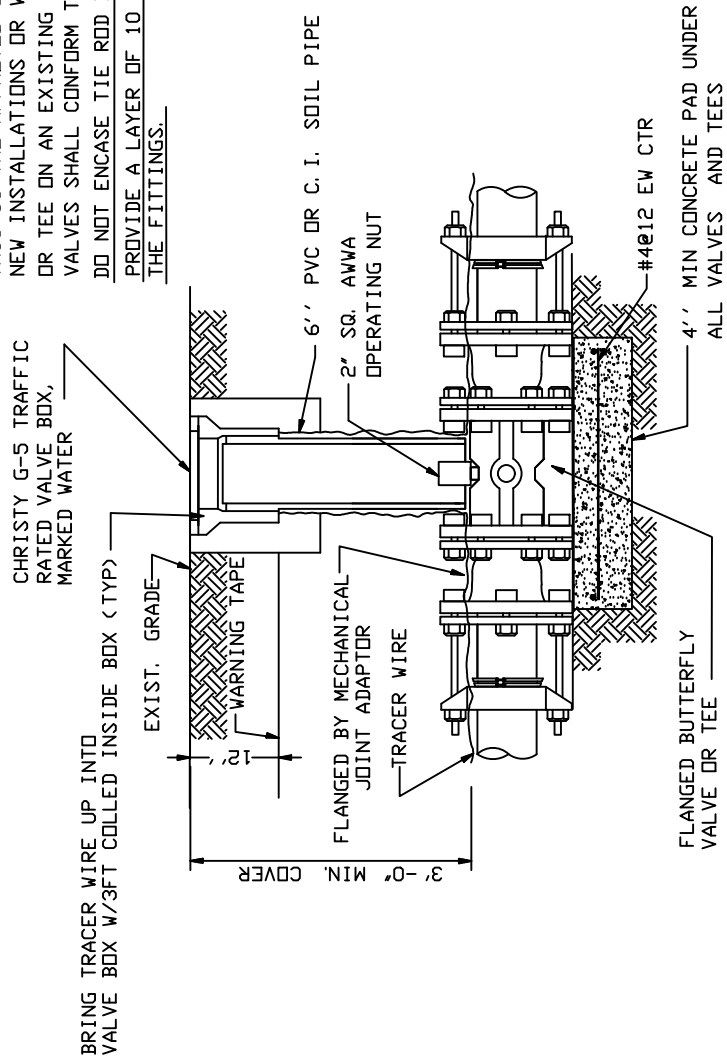
Scale: NTS

Rev. Date: 01/23/15

REDUCED PRESSURE BACKFLOW  
 MODEL 880

FS07

THIS IS THE APPROVED STANDARD. USE THIS DETAIL FOR NEW INSTALLATIONS OR WHEN CUTTING IN A VALVE OR TEE ON AN EXISTING LINE. VALVES SHALL CONFORM TO AWWA C504. DO NOT ENCASE TIE ROD BOLTS IN CONCRETE. PROVIDE A LAYER OF 10 MIL PLASTIC AROUND THE FITTINGS.



#1 METHOD  
 FLANGED VALVE OR TEE WITH ADAPTERS

NO SCALE



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METHOD#1 FLNAGED VALVE  
 OR TEE WITH ADAPTERS

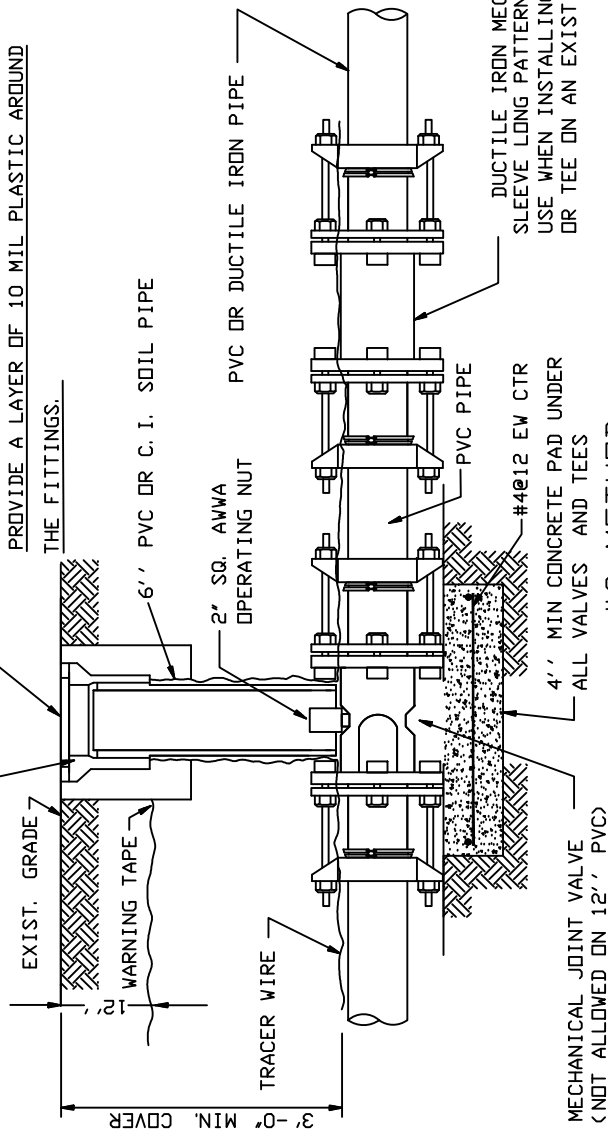
FS08



THIS IS THE ALTERNATIVE METHOD TO D-1 WITH APPROVAL OF PP-CS.  
 USE THIS DETAIL FOR CUTTING-IN TEES AND VALVES.  
 ON EXISTING PIPE. USE A SOLID D. I. SLEEVE WHERE APPROPRIATE.  
 VALVES SHALL CONFORM TO AWWA C504.  
 DO NOT ENCASE TIE ROD BOLTS IN CONCRETE.  
 PROVIDE A LAYER OF 10 MIL PLASTIC AROUND  
 THE FITTINGS.

CHRISTY G-5 TRAFFIC  
 RATED VALVE BOX,  
 MARKED WATER

BRING TRACER WIRE UP INTO VALVE  
 BOX W/3FT COILED INSIDE BOX (TYP)



DUCTILE IRON MECHANICAL JOINT SOLID  
 SLEEVE LONG PATTERN (12' LONG).  
 USE WHEN INSTALLING A NEW VALVE  
 OR TEE ON AN EXISTING LINE.

PVC OR DUCTILE IRON PIPE

MECHANICAL JOINT VALVE  
 (NOT ALLOWED ON 12" PVC)

#2 METHOD

MECHANICAL JOINTS TIE-IN USING 12" LONG SLEEVE

NO SCALE



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METHOD #2 MECHANICAL JOINTS  
 TIE-IN USING 12-INCH LONG SLEEVE

FS09



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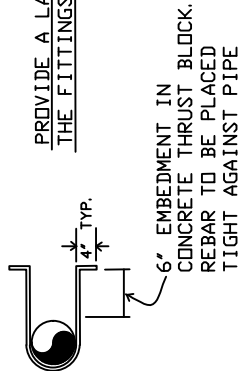
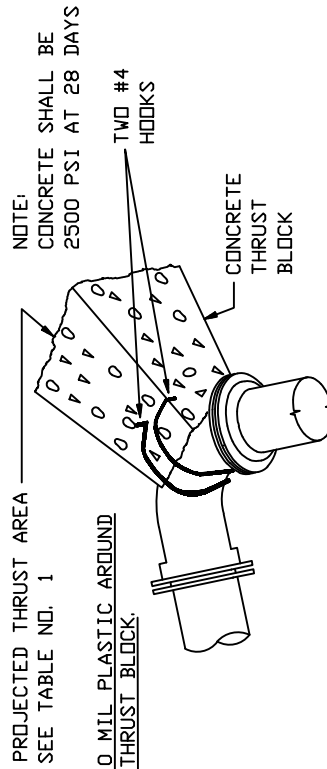
Scale: NTS

Rev. Date: 01/23/15

THRUST BLOCK TABLE

FS10

NOTE:  
THE SIDES (ONLY) OF ALL THRUST  
BLOCKS SHALL BE ACCURATELY  
FORMED WITH WOOD AND FIRMLY  
BRACED. THRUST AREA AND  
BOTTOM OF BLOCK SHALL BE  
PLACED AGAINST UNDISTURBED  
EARTH. PIPE, FITTING, JOINTS  
AND BOLTING SHALL BE KEPT  
FREE OF CONCRETE.



CONCRETE THRUST BLOCK

NO SCALE

SEE TABLE 1 (THRUST BLOCK TABLE) ON FS10A FOR DETAILS

**Thrust Block Design**  
 NFPA 24 (2013)  
 Standard for the Installation of Private Fire Service Mains and Their Appurtenances

Safety Factor	1.5	
Test Pressure	200	psi
Soil Bearing Capacity	2000	psf

Pipe Diameter		Thrust (lbf)				
		Fitting				
Nominal Diameter	Outside Diameter	90°	45°	22½°	11¼°	Dead End TEE
4	4.8	5,118	2,770	1,412	709	3,619
6	6.9	10,576	5,724	2,918	1,466	7,479
8	9.05	18,194	9,847	5,020	2,522	12,865
10	11.1	27,370	14,813	7,551	3,794	19,354
12	13.2	38,706	20,948	10,679	5,365	27,370

Pipe Diameter		Bearing Area (Ft <sup>2</sup> )				
		Fitting				
Nominal Diameter	Outside Diameter	90°	45°	22½°	11¼°	Dead End TEE
4	4.8	3.8	2.1	1.1	0.5	2.7
6	6.9	7.9	4.3	2.2	1.1	5.6
8	9.05	13.6	7.4	3.8	1.9	9.6
10	11.1	20.5	11.1	5.7	2.8	14.5
12	13.2	29.0	15.7	8.0	4.0	20.5

For hydrostatic test pressures greater than 200 psi, provide a correction based on the ratio of the test pressure to 200 psi.

Example: 8" Main 90° Elbow - Hydrostatic test pressure = 225 psi

$$\frac{225 \text{ psi}}{200 \text{ psi}} = 1.125$$

$$\text{Thrust} = 1.125 \times 18,194 \text{ lbf} = 20,468 \text{ lbf}$$

$$\text{Bearing Area} = 1.125 \times 13.6 \text{ Ft}^2 = 15.3 \text{ Ft}^2$$



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THRUST BLOCK TABLE

FS10A

NOTES:

1. BLUE REFLECTIVE PAVEMENT MARKERS SHOULD BE PLACED 12 INCHES FROM THE CENTERLINE STRIPE, OR APPROXIMATE CENTER STRIPE, AT THE POINT OF THE HYDRANT. THE STRIPE NEAREST THE FIRE HYDRANT.

CHRISTY G-5 TRAFFIC RATED VALVE BOX, MARKED WATER

BRINE TRACER WIRE UP INTO VALVE BOX 17/2FT COILED INSIDE BOX (TYP)

RAISED BLUE REFLECTIVE PAVEMENT MARKER (SEE NOTE 1)

FLANGED BOLTS SHALL BE SET ABOVE FINISHED GRADE TO ENABLE BOLT AND NUT REMOVAL. SEE ABOVE SCREWS MARKED 6" BE A MIN. FURTHER ABOVE TOP OF PAD.

CLDW MODEL 865. THE 4-1/2" OUTLETS MUST FACE THE STREET.

CONCRETE SIDEWALK

BREAK-OFF RISER

CONCRETE BLOCK TO BE POURED TO BREAK-OFF RISER. SHALL EXTEND 2' BELOW TOP FLANGE AND SHALL EXTEND TO UNDISTURBED GROUND AS SHOWN OR 2'-0" ON ALL SIDES.

HYDRANT BREAK-AWAY CHECK VALVE

USE FLANGE SPACERS OR EXTENSIONS TO ADJUST HYDRANT HEIGHT. DO NOT EXCEED 18" FROM THE CHECK VALVE OR FIRE HYDRANT.

CAST IRON HYDRANT BURY

TRACER WIRE

36" MIN.

6" P.V.C. or D.I. pipe

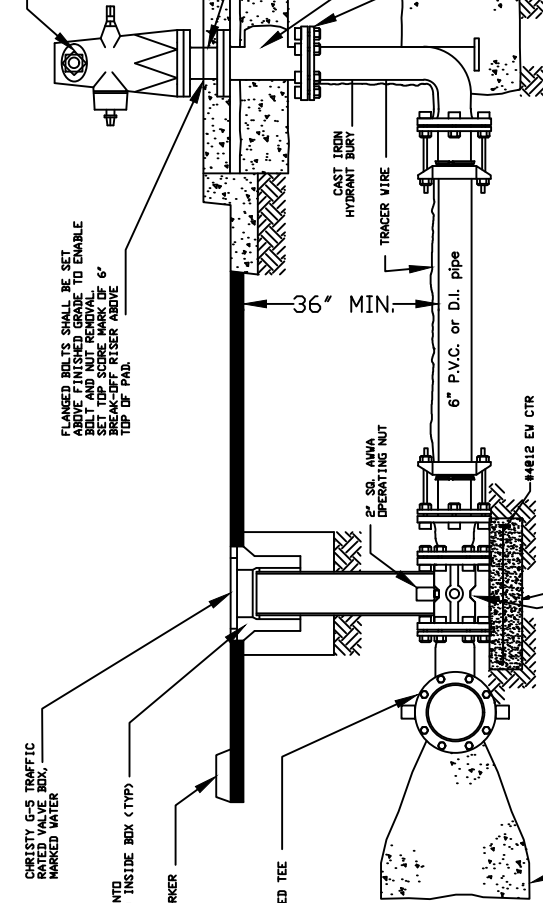
2" SQ. ANVA OPERATING NUT

4#12 EN CTR

4" MIN CONCRETE PAD UNDER ALL VALVES AND TEES

FLANGED BUTTERFLY VALVE

CONCRETE THRUST BLOCK



FIRE HYDRANT INSTALLATION DETAIL

NO SCALE



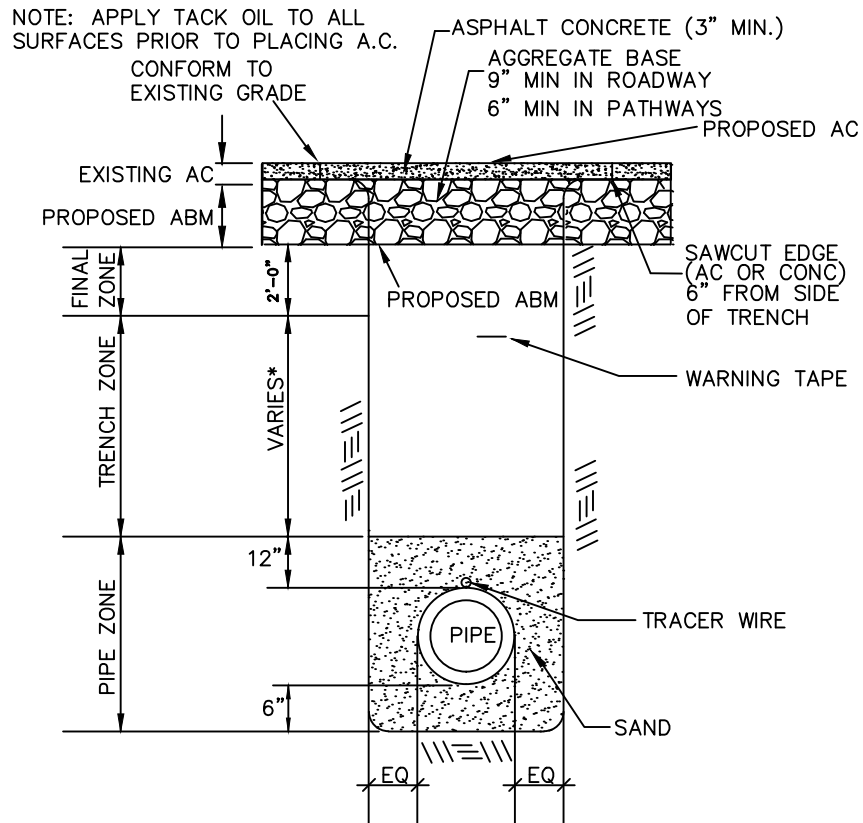
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FIRE HYDRANT  
INSTALLATION DETAIL

FS11



NOTE: WHERE AC IS AT EDGE OF PATHWAY  
INSTALL METAL HEADER BOARD

**TRENCH BACKFILL & RESURFACING  
IN PAVED AREAS**

NO SCALE

\*FOR FIRE SERVICE, A MINIMUM OF  
THIRTY SIX INCHES (36").

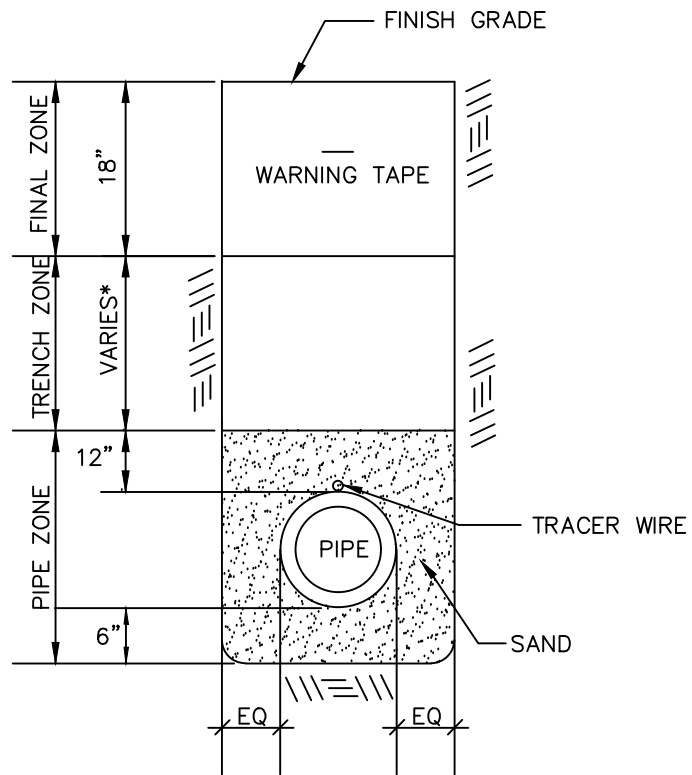


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TRENCH BACKFILL & RESURFACING  
IN PAVED AREAS

FS12



TRENCH BACKFILL  
IN LANDSCAPED AREAS

NO SCALE

\*FOR FIRE SERVICE, A MINIMUM OF THIRTY INCHES (30").



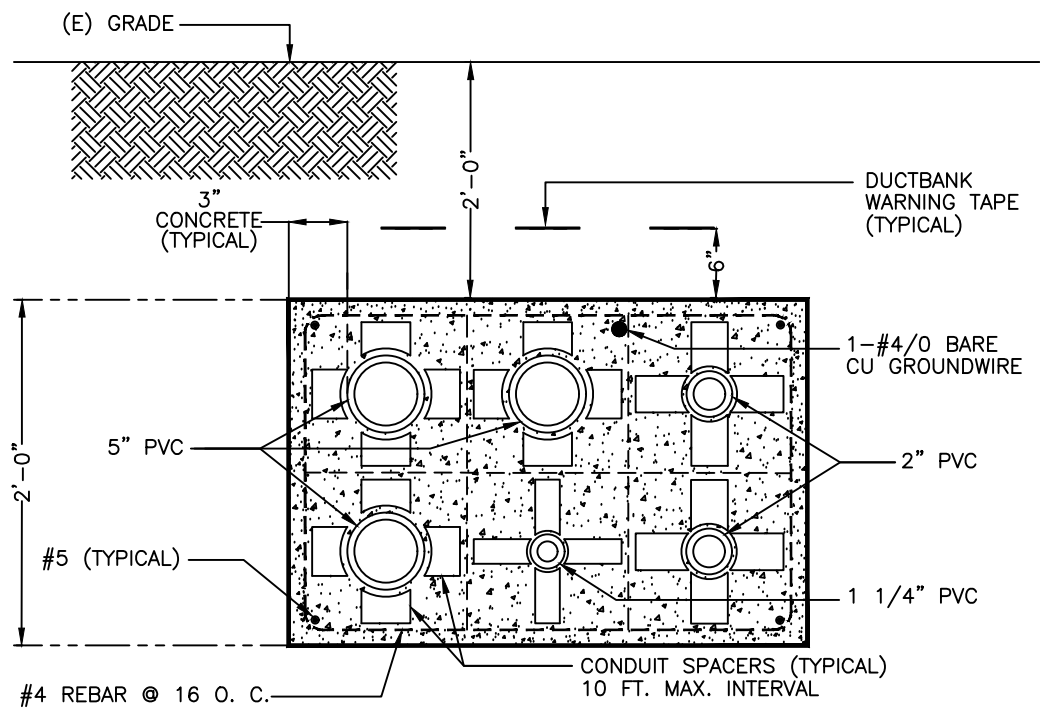
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TRENCH BACKFILL  
IN LANDSCAPED AREAS

FS13



NOTES:  
PVC IS SCHEDULE 40.  
RED CONCRETE FOR  
12KV ONLY.

CONCRETE ENCASED 6-WAY DUCTBANK  
CROSS-SECTION

NO SCALE



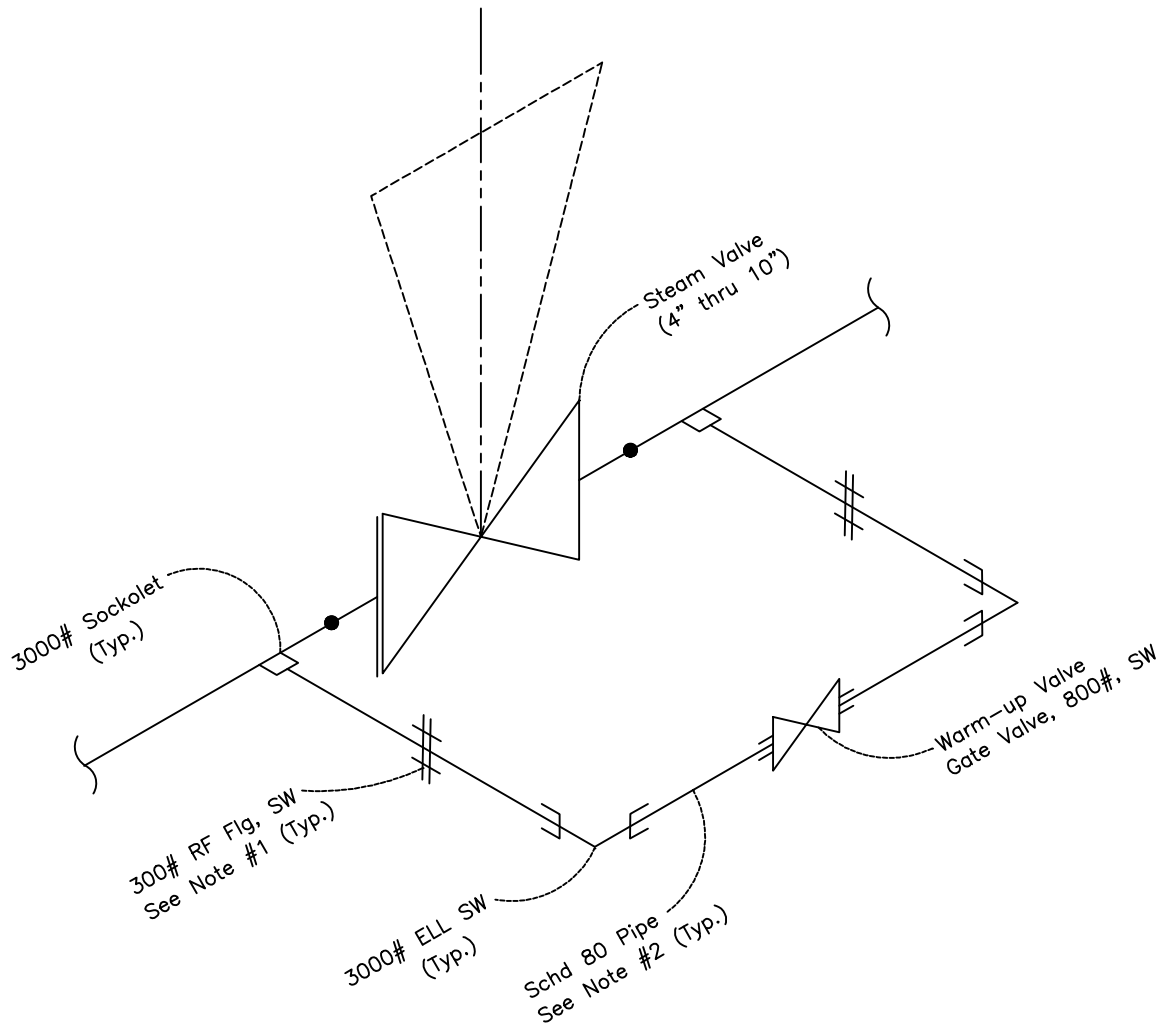
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CONCRETE ENCASED  
6-WAY DUCT BANK

FS14



WARM-UP VALVE

NO SCALE

Steam Valve Size	Bypass Size	Notes
5" x 6"	1 1/4"	Bypass Break-Out Flanges. Must provide adequate clearance for removal of Steam Valve.
8" x 10"	1 1/2"	Bypass piping shall be self_draining. No low points.



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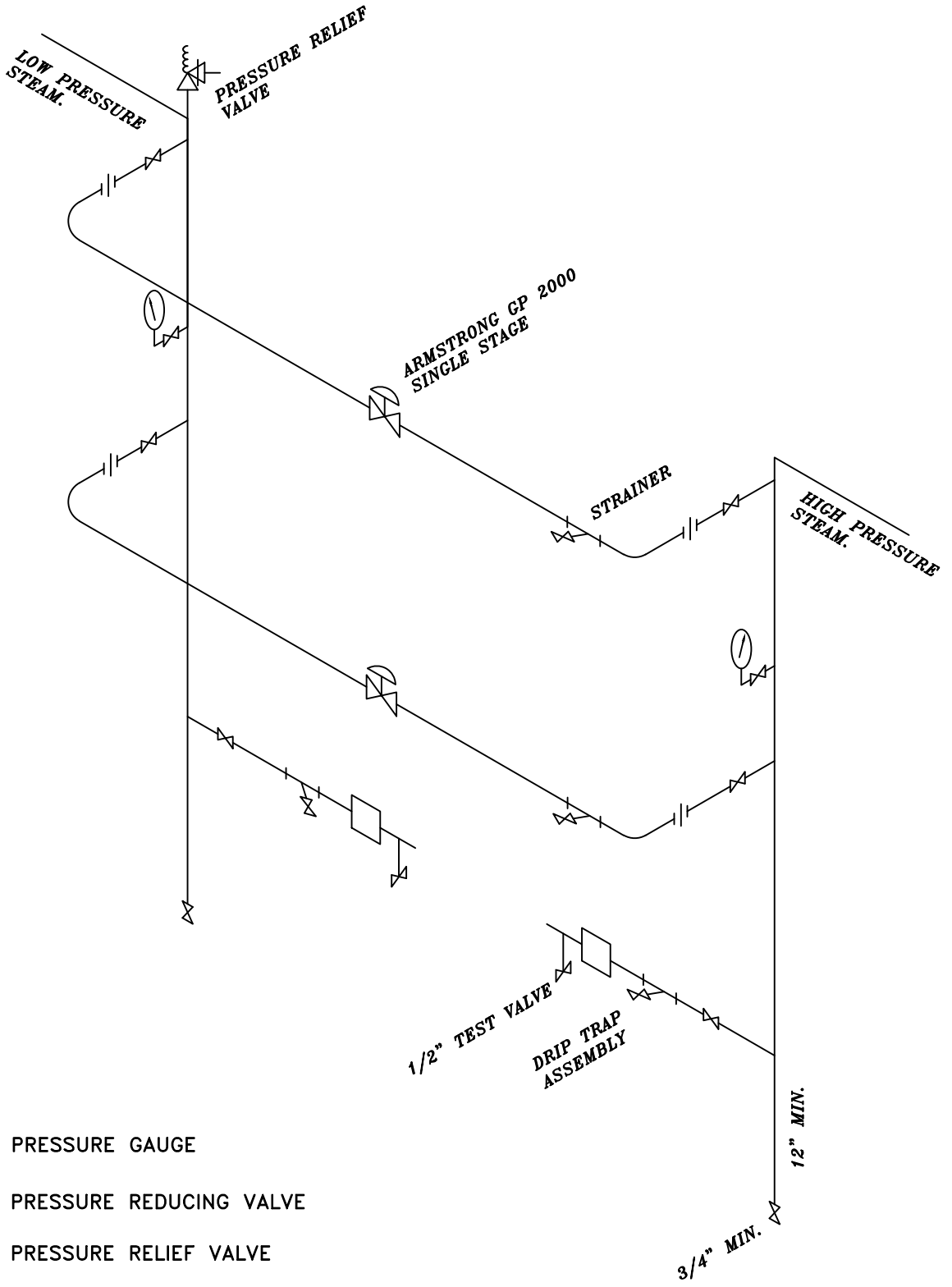
Scale: NTS





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WARM-UP VALVE

FS15





-  PRESSURE GAUGE
-  PRESSURE REDUCING VALVE
-  PRESSURE RELIEF VALVE
-  VALVE

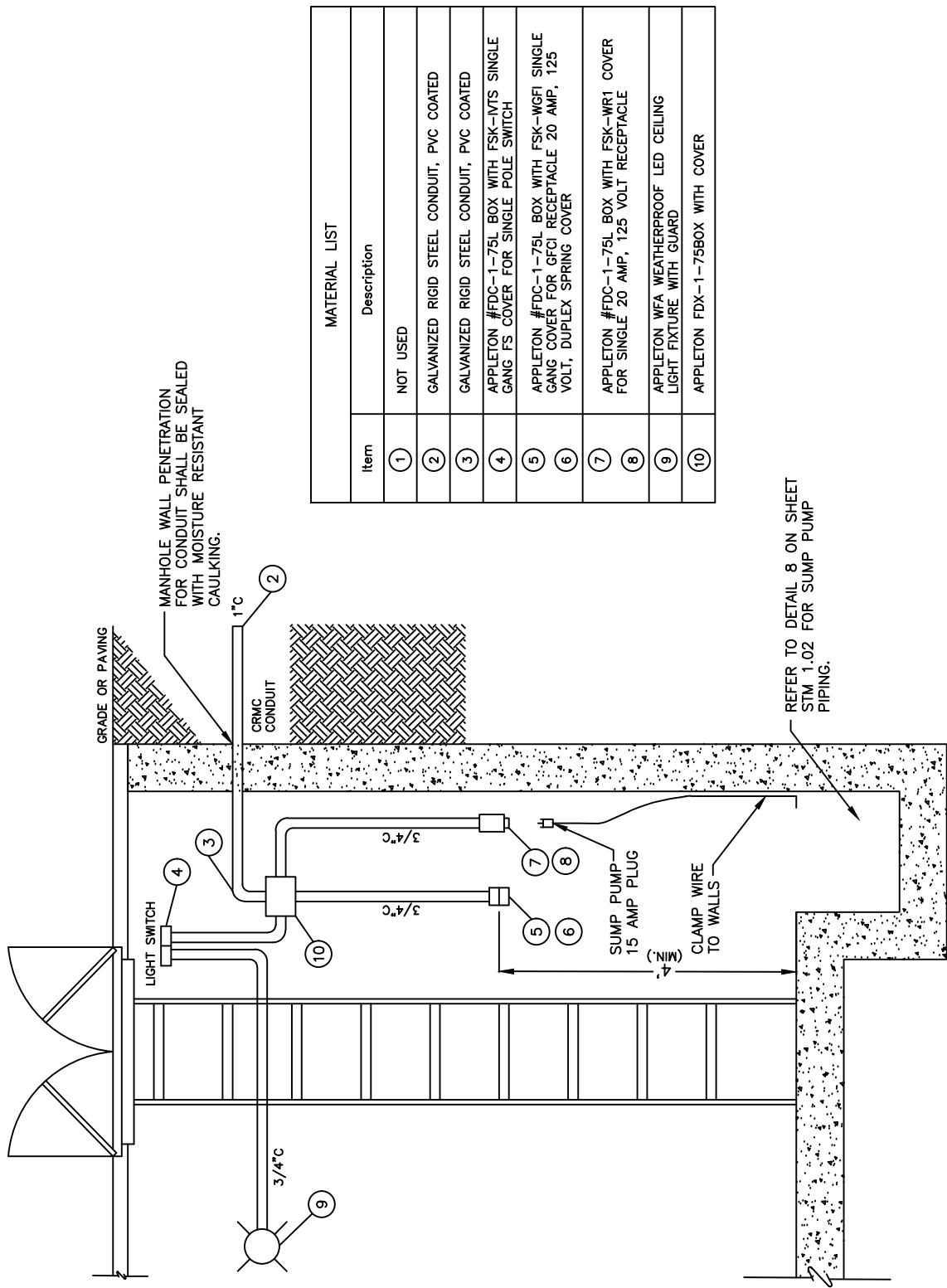


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TYPICAL STEAM PRESSURE  
 REDUCING STATION

FS16



MATERIAL LIST	
Item	Description
①	NOT USED
②	GALVANIZED RIGID STEEL CONDUIT, PVC COATED
③	GALVANIZED RIGID STEEL CONDUIT, PVC COATED
④	APPLETON #FDC-1-75L BOX WITH FSK-IVTS SINGLE GANG FS COVER FOR SINGLE POLE SWITCH
⑤	APPLETON #FDC-1-75L BOX WITH FSK-WGFI SINGLE GANG COVER FOR GFCI RECEPTACLE 20 AMP, 125 VOLT, DUPLEX SPRING COVER
⑦	APPLETON #FDC-1-75L BOX WITH FSK-WR1 COVER FOR SINGLE 20 AMP, 125 VOLT RECEPTACLE
⑨	APPLETON WFA WEATHERPROOF LED CEILING LIGHT FIXTURE WITH GUARD
⑩	APPLETON FDX-1-75BOX WITH COVER

STEAM VAULT - TYPICAL  
ELEVATION VIEW  
NO SCALE

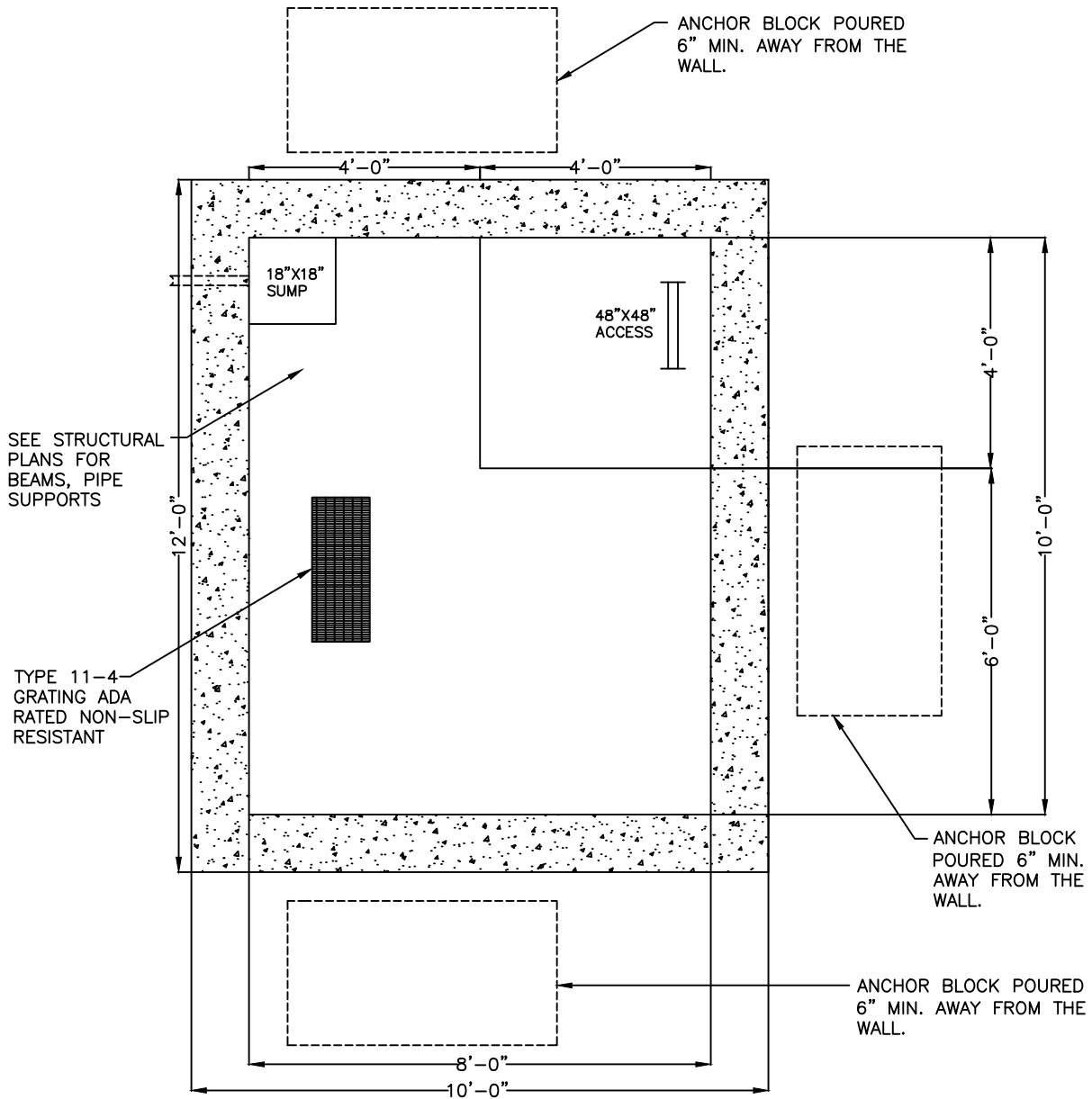


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STEAM VAULT  
TYPICAL (ELEVATION VIEW)

FS17



MANHOLE STRUCTURE

NO SCALE



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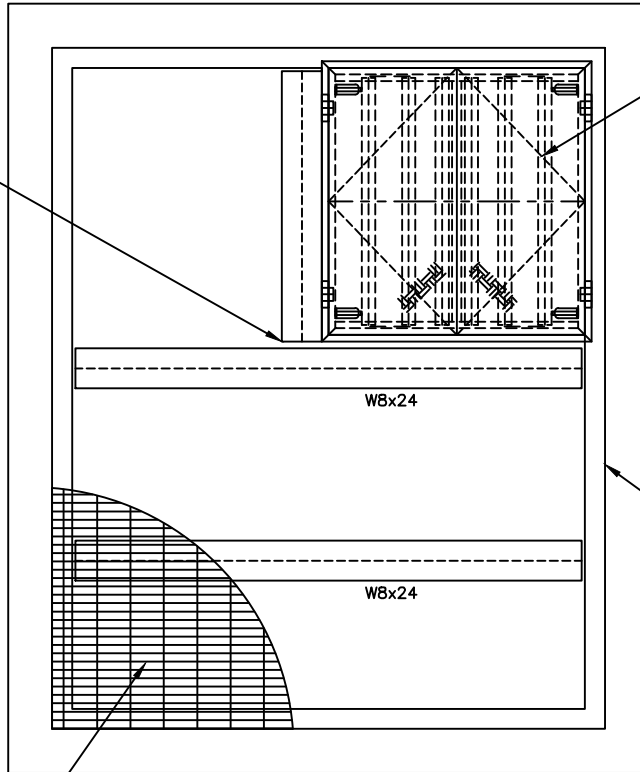
Scale: XXXX

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MANHOLE STRUCTURE

FS18

SEE PROJECT  
SPECS. FOR BEAM  
CONNECTION



"BILCO" TYPE JD-2ALH20  
DOUBLE LEAF ACCESS  
DOOR OR EQUAL

L 3 1/2" X 2 1/2" X 1/4" LLH.  
FRAME AROUND MANHOLE,  
TYP. EXCEPT AT HATCH

PACIFIC - 2 1/4" X 3/16"  
7-2 STEEL GRATING  
OR EQUAL

STEAM MANHOLE COVER FRAMING PLAN  
BILCO TYPE MANHOLE HATCH

NO SCALE



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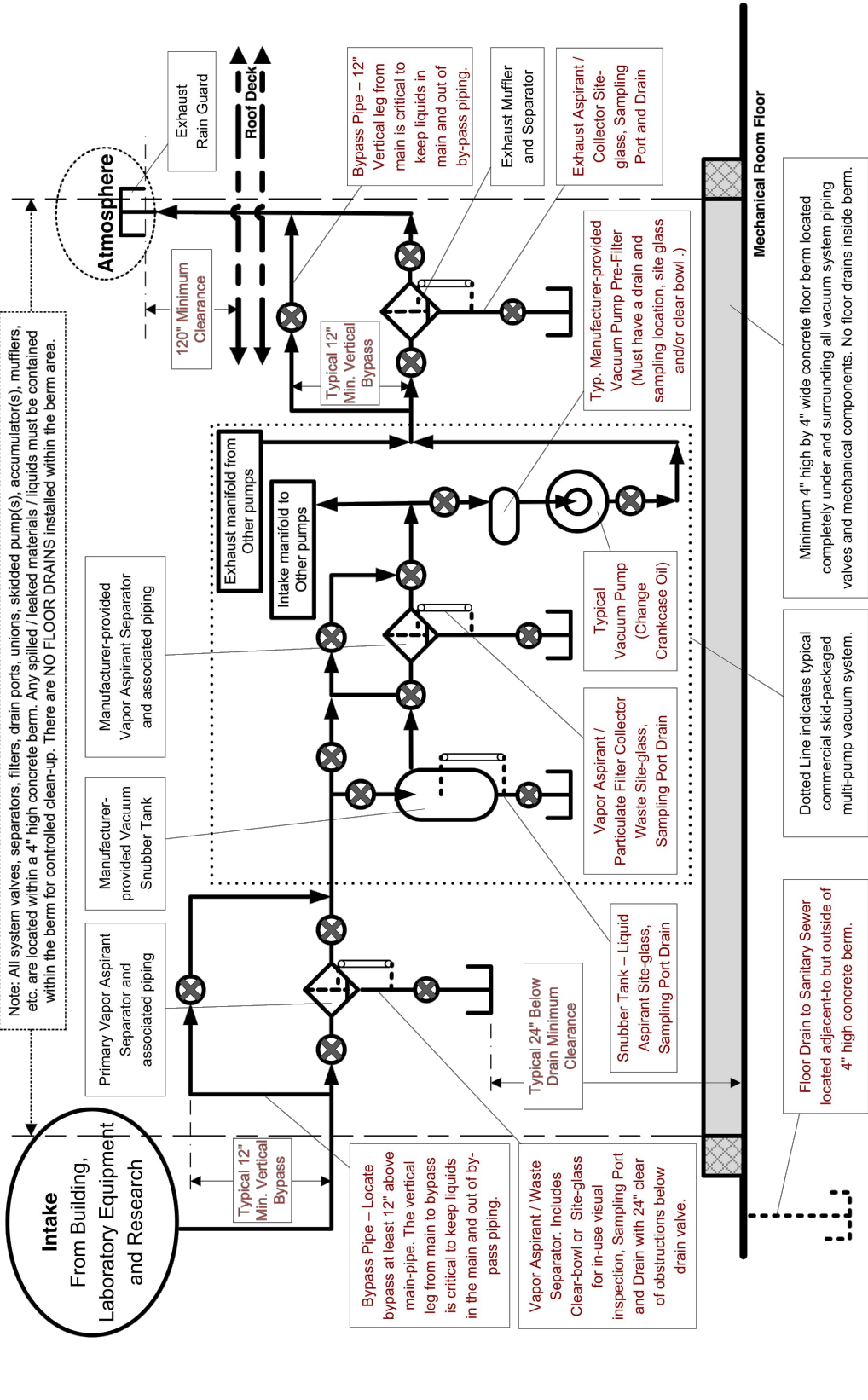
STEAM MANHOLE COVER  
FRAMING PLAN - MANHOLE HATCH

FS19

# UCB "HOUSE" VACUUM SYSTEM DESIGN LAYOUT & SCHEMATIC FOR A DRY (NO WATER) COMMERCIAL SYSTEM

Note: All system valves not shown, and cross piping to parallel pumps / vacuum systems not shown.

Note: All system valves, separators, filters, drain ports, unions, skidded pump(s), accumulator(s), mufflers, etc. are located within a 4" high concrete berm. Any spilled / leaked materials / liquids must be contained within the berm for controlled clean-up. There are NO FLOOR DRAINS installed within the berm area.



File: UCB House Vacuum Component Schematic - Specification 01-07-15

Questions - Please contact UCB EH&S Safety Engineering at 510-642-3073

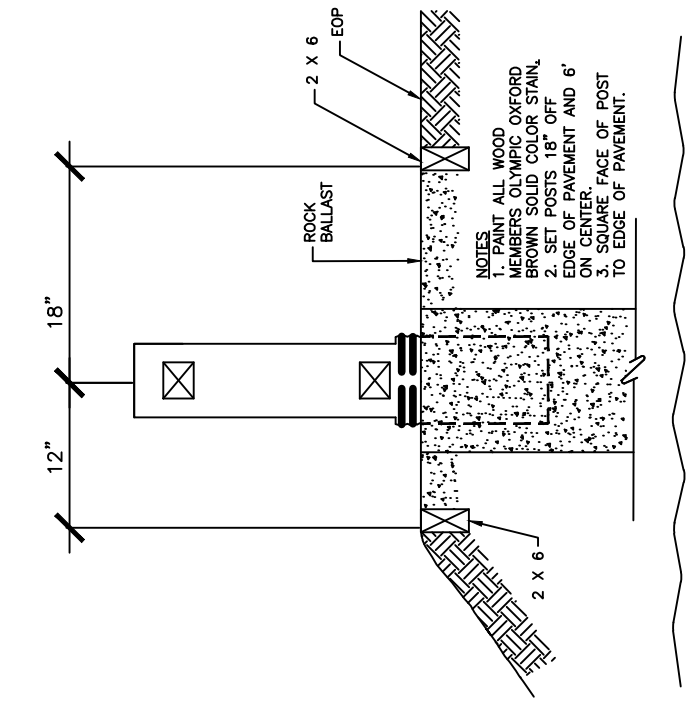


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Facilities Services  
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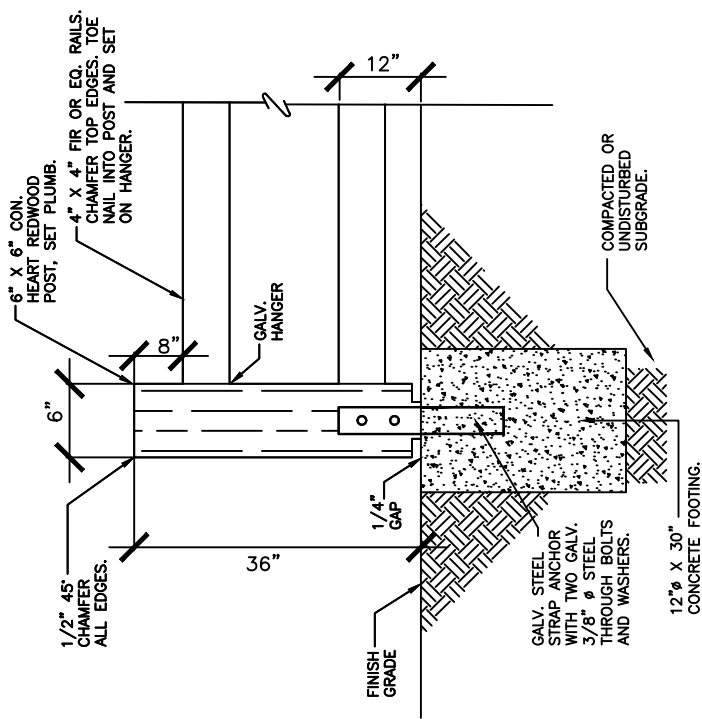
Scale: NTS Rev. Date: 01/23/15

UCB "HOUSE" VACUUM SYSTEM  
DESIGN LAYOUT & SCHEMATIC

FS20



POST AND RAIL FENCE  
CROSS SECTION  
ND SCALE



POST AND RAIL FENCE  
SECTION ELEVATION  
ND SCALE

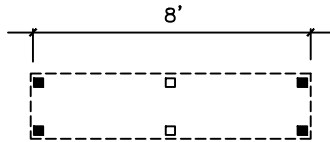


UC Berkeley  
Facilities Services  
GIS, Mapping & Drawing

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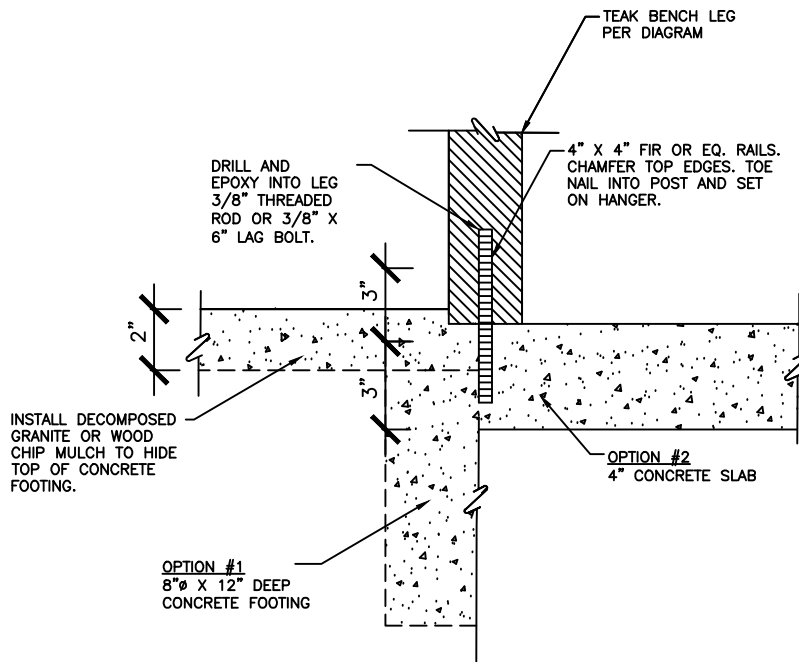
POST AND RAIL FENCE

FS21



ANCHOR LEGS DIAGRAM

NO SCALE



TEAK BENCH INSTALLATION  
BLIND ANCHORS

ANCHORING SECTION FOR VARIOUS CONDITIONS

NO SCALE



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Facilities Services  
GIS, Mapping & Drawing

Scale: NTS

Rev. Date: 1/23/2015

TEAK BENCH  
INSTALLATION

FS22

LIGHTING CIRCUIT  
LINE WIRES

LIGHTING CIRCUIT  
LOAD WIRES

LIGHTING CONTACTOR  
(NON-LATCHING)

COIL

INTERMATIC 12 HOUR  
SPRINGWOUND TIMER  
WITH HOLD-IT FEATURE

RED

WHITE

PHOTO-CELL

BLACK

WHITE

120V

LINE

NEUTRAL



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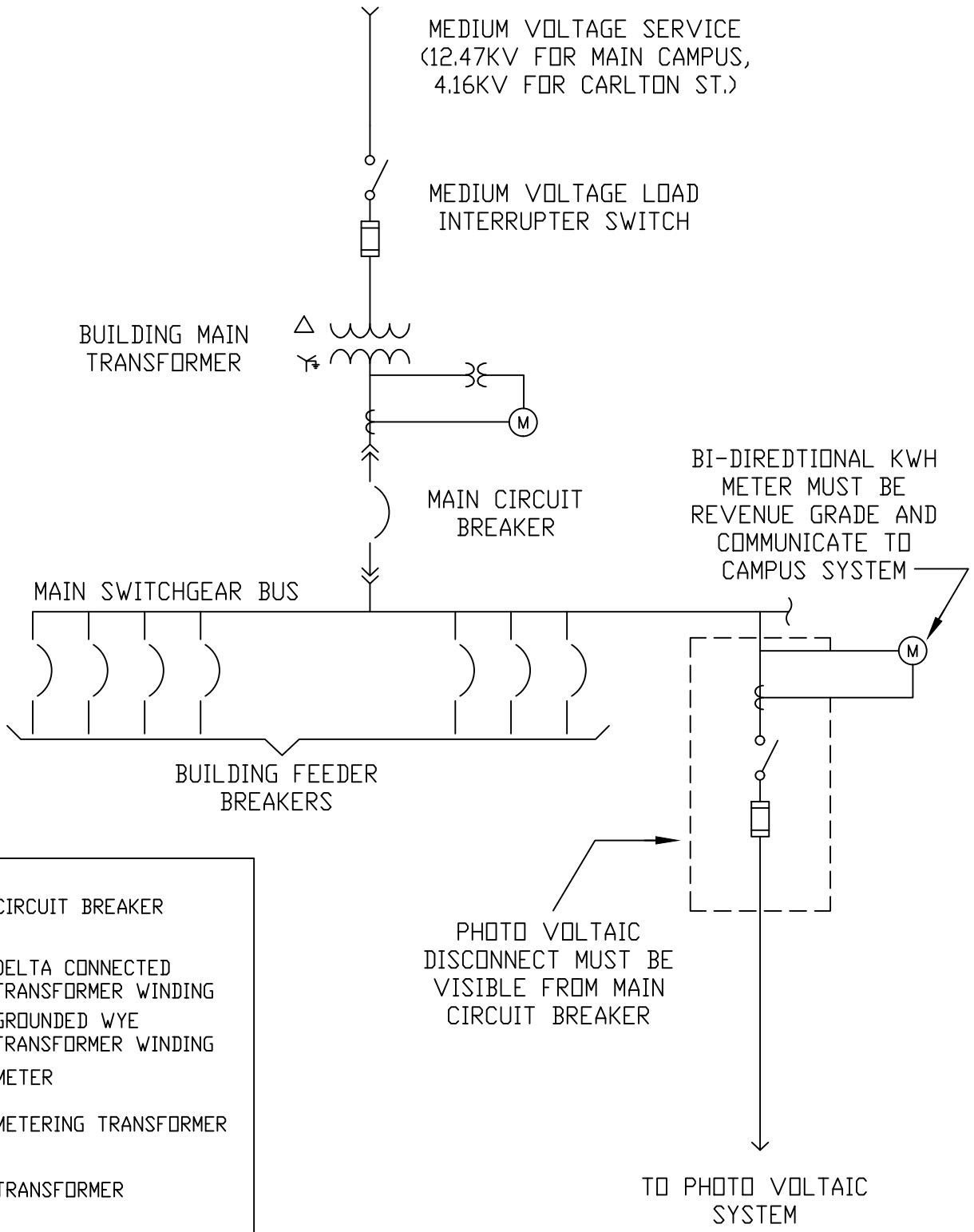
Scale: NTS

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SITE LIGHTING  
CONTROL SCHEMATIC

FS23





	CIRCUIT BREAKER
	DELTA CONNECTED TRANSFORMER WINDING
	GROUNDING WYE TRANSFORMER WINDING
	METER
	METERING TRANSFORMER
	TRANSFORMER
	FUSED SWITCH



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Facilities Services  
GIS, Mapping & Drawing

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TYPICAL LAYOUT, ARRANGEMENT,  
METERING FOR P.V. SYSTEM

FS24

## Appendix B: Guarantee Form

See form next page.

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GUARANTEE

Project Name: \_\_\_\_\_ Date: \_\_\_\_\_

Project Location: \_\_\_\_\_

Project Number: \_\_\_\_\_

Guarantee For: \_\_\_\_\_  
(Specification SECTION and Contract No.)

(the "Contract"), between The Regents of the University of California ("Owner") and \_\_\_\_\_  
("Contractor").

\_\_\_\_\_  
(Name of Contractor, Subcontractor, or Supplier as Applicable)  
hereby guarantees to Owner that the portion of the Work described as follows:

\_\_\_\_\_

\_\_\_\_\_ which it has provided for the above referenced Project, is of good quality; free from defects; free from any liens, claims, and security interests; and has been completed in accordance with Specification Section \_\_\_\_\_ and the other requirements of the Contract.

The undersigned further agrees that, if at any time within \_\_\_\_\_ months after the date of the guarantee the undersigned receives notice from Owner that the aforesaid portion of the Work is unsatisfactory, faulty, deficient, incomplete, or not in conformance with the requirements of the Contract, the undersigned will, within ten (10) calendar days after receipt of such notice, correct, repair, or replace such portion of the Work, together with any other parts of the Work and any other property which is damaged or destroyed as a result of such defective portion of the Work or the correction, repair, or replacement thereof; and that it shall diligently and continuously prosecute such correction, repair, or replacement to completion.

In the event the undersigned fails to commence such correction, repair, or replacement within ten (10) calendar days after such notice, or to diligently and continuously prosecute the same to completion, the undersigned, collectively and separately, do hereby authorize Owner to undertake such correction, repair, or replacement at the expense of the undersigned; and Contractor will pay to Owner promptly upon demand all costs and expenses incurred by Owner in connection therewith.

SUBCONTRACTOR OR SUPPLIER (If Applicable)

Signed: \_\_\_\_\_ Title: \_\_\_\_\_

Typed Name: \_\_\_\_\_

Name of Firm: \_\_\_\_\_

Contractor License Classification and License Number: \_\_\_\_\_

Address: \_\_\_\_\_

Telephone Number: \_\_\_\_\_

CONTRACTOR

Signed: \_\_\_\_\_ Title: \_\_\_\_\_

Typed Name: \_\_\_\_\_

Name of Firm: \_\_\_\_\_



# Campus Sign Standards

## Introduction

The Campus Sign Standards are the basis of design for signage in campus buildings. They are intended to provide consistency and visual familiarity to members of the campus community and campus visitors alike. These standards are to aid design professionals and campus departments in the implementation of a successful sign program that meets the requirements of the University.

It is the intent that these standards will:

- Provide design standards for campus signage.
- Classify signs and designate their appropriate use.
- Aid the developing of sign packages for specific areas or facilities.
- Assist in the application and placement of signs.

The Campus Sign Standards are an addendum to the Campus Design Standards, administered by the Campus Building Department. They were written by subject matter experts from departments across campus and represent UC Berkeley's commitment to lasting, high-quality additions to the campus built environment.

New signage that comports with these standards will be required for projects as follows:

1. The space or area being renovated for projects under \$1,000,000 total value,
2. The affected floor and path of travel for any projects valued between \$1,000,000 and \$4,999,999
3. The affected building for any projects over \$5,000,000.

The Campus Sign Standards are administered jointly by the Campus Building Department (CBD), Planning and Environmental Policy (PEP), The University of California Police Department (UCPD), Designated Campus Fire Marshal (DCFM), Facilities Services, Disability Access & Compliance and Public Affairs.

It is recognized that the campus is made up of buildings and areas of development which span a range of architectural styles. Some level of variation of interpretation may be considered if deemed appropriate by Planning and Environmental Policy (PEP) and the Campus Building Department

(CBD). Questions or requests for variances to the standards should be directed to the Campus Architect.

Exterior signage, including, but not limited to building identification and naming, addressing, departmental, unit or tenant identifications, directional and wayfinding signage are subject to separate guidelines that address use, design and placement. Questions about exterior signage or the review and approval process should be directed to the Campus Architect

## General Information For All Signs

### Sign Placement

Signs shall be located to present the necessary information at the point of first exposure to the viewer and meet all current applicable code requirements for accessibility, legibility and construction. These standards are intended to support applicable current codes. It is the responsibility of the organization or individual requesting signs to evaluate these codes to ensure that the proposed sign conforms to their requirements. In the event of conflict between these standards and applicable code, the applicable code shall govern.

Prior to locating a sign, consideration should be given to existing signage or other posted materials. In areas requiring multiple posted signs or other materials, signs should be coordinated and consolidated to aid in effective messaging. This may entail replacing existing signage when a new sign is proposed to ensure consistent design. In selecting the location of an exterior building sign, consideration shall be given to the surrounding area, including approach, elevation, pedestrian traffic and likely viewing angles of those approaching the building's exterior.

### Color

The University-approved colors for signs are Berkeley Blue (Hex 003262, CMYK 100|71|10|47, Pantone 282) with white lettering (Hex FFFFFFFF, CMYK 0|0|0|0) in raised relief where required by code or function. Other colors may be allowed if that choice would enhance or support a particular interior or architectural design. Such uses shall comply with the Primary and Secondary Palettes as established by Public Affairs (<https://brand.berkeley.edu/colors>). Requests for use of alternate colors shall be made in writing, with supporting documentation, to the Campus Architect. Such requests will be evaluated on a case-by-case basis by Planning and Environmental Policy (PEP) and Public Affairs.

### Sign Size

The main consideration in determining sign size is the distance from which it must be read, the relative importance of the message, and the length of the message. Applicable code requirements should be referenced for raised and/or visible text height and braille requirements.

### Visual Elements

Pictograms, icons and other visual elements shall match those published in the most recent version of the California Building Code (Section 11B). Where pictograms are not listed in the California Building Code, those listed in the most recent version of the California Manual on Uniform Traffic Control Devices (CAMUTCD) shall be used. Where pictograms, icons and other visual elements are not listed in the California Building Code or CAMUTCD, every effort shall be made to emulate similar, listed pictograms, icons or other visual elements so as to present a unified design. AIGA and DOT pictograms may also be used. Pictograms shall be selected to match those used in existing signage in the building or surrounding area provided they are compliant with current code.

## Typography

The University-approved typeface, Freight, includes Sans, Text and Micro fonts. The Freight family shall be used for all signage, with Freight Sans being the preferred typeface for most signs in public spaces. More information regarding typography may be found in the Public Affairs Brand Guidelines (<https://brand.berkeley.edu/typography/>). Freight Family fonts may be licensed from Public Affairs and contain “normal numerals” (i.e. those that do not drop below the line). These are found under “Lining Figures” in Glyphs in any Type and Table section of Adobe Products. Other typefaces may be allowed in limited circumstances, where matching a particular, historic interior or architectural design is important or when producing equipment identification signage in non-public areas. Such uses shall be evaluated on a case-by-case basis and shall only be considered when the request is made in writing, with supporting documentation, to the Campus Architect.

## Typography Examples



## Sign Materials

Interior signs shall be built up of 1/8-inch thick backer material chosen to meet the architectural style of the project, and any code requirements. For raised copy and braille, etched polymer should be adhered to the header with flush edges. Adhered characters are not acceptable. The face of any insert panel should be clear, non-glare acrylic glued flush to the face of the header and footer. The back panel should be 1/4-inch thick material the same or complimentary to the backer material. Pursuant to the University’s commitment to waste-reduction and reduced environmental footprint, signs with permanent lettering shall be used in areas where changes are not expected in the long term. Signs that incorporate easily-changeable (i.e. paper) inserts shall be used in areas where changes in room assignment or programmatic use occurs with any regular frequency. Where inserts are used, departments or other users shall use black text on white paper.

## Sign Design and Manufacture

In construction and renovations projects, the designer or sign fabricator shall produce a sign schedule, design development drawings and working or shop drawings. These drawings shall be submitted during plan review, and shall comport with the standard details below and include signs outlined in the checklist below. More specific construction details provided by a licensed design professional may be required. Designers shall be prepared to share digital artwork with signage contractor.

## Sign Checklist

New construction and renovation projects must provide a sign plan, schedule and sign details sheet, including but not limited to the signs outlined below. Existing non-compliant and or non-standard signage in renovation projects shall be updated to this current standard.

### Exterior

- Exterior Building Mounted Signage/Address Signage (consult Campus Architect)
- Smoke and Tobacco Free Signage
- Limited or Restricted Access (where applicable)
- Video Security (where applicable)
- Regulatory Signage
- Specify accessible entrance and directional signage towards alternative accessible entrance

### Interior: Code Required

- Building Directory and Map
- Room Identification Sign
- Room Number and/or Name Identification Sign
- Room Number and Identification Sign
- Restroom Door and Wall Signage
- Accessible Restroom Door Signage
- Accessible Restroom Location
- Stairway Identification Sign
- Tactile Floor Identification
- Alternate Path of Egress
- Accessible Exit Sign
- Accessible Exit Ramp
- Accessible Exit Route
- Accessible Exit Stair
- Accessible Area of Refuge
- Emergency Evacuation Signage (Coordinate with Campus Fire Marshal)
- Fire Riser Inside
- FACP Inside
- Occupancy Sign
- Assisted Listening Device
- No Roof Access
- OEM Hazard Signage
- Designated Waiting Area (DWA)

#### Interior: Wayfinding

- Directional Signage
- Informational Signage/Department or Program Signage
- Inclusive Restroom Door Signage
- Inclusive Restroom Location

#### Interior: Specialty

- Electronic Display(s)
- Caution Placard(s) (cont'd)
- Limited or Restricted Access (where applicable)
- Video Security (where applicable)
- Regulatory Signage

### Gender-Inclusive Restroom Facilities

In accordance with the University's nondiscrimination policies, UC Berkeley enforces the guidelines published by the University of California Office of the President which seek to create an inclusive facilities and provide direction on the implementation of gender inclusive facilities in UC-owned buildings. See the UCOP policy here: <https://www.ucop.edu/construction-services/facilities-manual/resource-directories-rds/rd4-project-programmatic-guidelines/rd-4-1.html>. Adopted standard signs are included in detail CS09 of the standard details at the end of this appendix.

### Electronic Displays

The use of electronic displays as interior informational signage is a recent innovation that allows for inexpensive customization and easy updating of information. These elements, however, consume energy and shall be Energy Star-certified models and should be limited to main building lobbies, elevator lobbies and other shared lobby or circulation routes where such signage would be appropriate. Consult the Facilities Services Energy Office should you have questions regarding appropriate uses of Electronic Displays.

Electronic displays must adhere to the same accessibility requirements of other building elements, as outlined in Chapter 11B of the *California Building Code*, especially with regard to viewability, placement and obstruction of paths of travel.

- Electronic displays shall comply with visual character requirements of *CBC 11B-703.5*, including *Table 11B-703.5.5*.
- Wall mounted electronic displays shall not protrude more than 4 inches from the wall, in compliance with *CBC 11B-307.1*.
- Touch-enabled electronic displays shall comply with *CBC 11B-301* "Reach ranges" and *CBC 11B-309* "Operable parts".

### Regulatory Signage

Exterior or interior regulatory signage shall be approved by UCPD so that the district attorney may be consulted and applicable enforcement codes can be confirmed. Laminated interior signage by building managers or others is no longer permitted. Changes by site special conditions and intrusion alarm systems shall be reviewed with UCPD by emailing [police@berkeley.edu](mailto:police@berkeley.edu).

### Emergency Signage

Consult with UCPD and Office of Emergency Management at [oem@berkeley.edu](mailto:oem@berkeley.edu) for emergency signage, such as campus hazard and evacuation information signage.



## Designated Waiting Area Signage

Consult with UCPD and Office of Emergency Management at [oem@berkeley.edu](mailto:oem@berkeley.edu) for Designated Waiting Area signage.

## Appendix D: Room Numbering Guidelines

### 1. General Information

- a. The primary function of room numbering is to serve as a wayfinding tool for building users. A building's room numbers are often the only "road map" available to new students, faculty and staff, as well as outside delivery persons, service providers, and emergency personnel; therefore, room numbering schemes should be comprehensible to first-time users.
- b. Additionally, room numbers serve as unique identifiers in campus databases and as a means to identify spaces for operational purposes such as planning and scheduling. Room numbers are utilized in the identification of mechanical assets, fire alarms, smoke detectors, electric panels, breakers, and more.
- c. For new buildings, room numbering should adhere to the following guidelines as closely as possible. For renovations or additions, the building's existing room numbering scheme may either be extended or replaced with the campus standard. This determination will privilege ease of wayfinding above other considerations.
- d. All room numbering and/or renumbering will be coordinated through the University's Representative/Asset Manager with final approval by the Campus Fire Marshal.

### 2. Approval Process

- a. Room numbers must be incorporated in Design Development (DD) documents for all projects. Prior to the development and/or submission of DD documents, the Designer must submit proposed room numbers in floor plan format along with a room schedule for campus approval per the following example:

Floor Number	Floor Name	Room Number	Room Type	Area (ft <sup>2</sup> )	Occupant Load
B2	Basement Level 2	B201	Electrical	56	1
B1	Basement Level 1	B110	Telecom	22	1
1	1 <sup>st</sup> Floor	100	Lobby	225	32
2	2 <sup>nd</sup> Floor	245	Office	150	2
3	3 <sup>rd</sup> Floor	370	Classroom	1075	54
RF1	1 <sup>st</sup> Roof	RF101	Machine	57	1

### 3. Floor Numbering

- a. Floors from the first to the 99th will be numbered 1-99.
- b. First floors are at or above grade and should include the building's main entry.
- c. Floors below grade or below the first floor are considered basement or sub-basement floors, and should begin with floor B1 and continue downward as B2, B3, etc.
- d. Mezzanines are partial floors between two main levels. Mezzanines should be numbered with an M prefix followed by the number of the floor that is directly below it. (E.g. a mezzanine between the third and fourth floors of a building would be designated floor M3.)
- e. Roofs will be numbered RF01, RF02, RF03, etc. advancing upward from the lowest roof (RF01) to the highest.

#### 4. Room Numbering

- a. To facilitate horizontal and vertical movement through a building, the numbering scheme needs to be sensible, transparent and consistent. Allowing for differences in floor plan and building design, the following are the principle conventions used on the campus:
- b. Each room or area is assigned a number or a number and letter(s).
- c. Each room has only one number, regardless of the number of doors entering into it.
- d. Each room number within a building must be unique.
- e. Rooms are generally numbered using a standard three digit scheme. Four digit room numbers should only be used in buildings that are more than nine floors or large buildings with many rooms on each floor for which the standard three digit numbering scheme will not allow for a flexible, non-consecutive plan.
- f. First floors are assigned room numbers 100-199 or 1000-1999, second floors are assigned numbers 200-299 or 2000-2999, etc. Below-grade basement floors are assigned room numbers B100-B199 or B1000-B1999; subbasements are assigned numbers B200-B299 or B2000-B2999, etc.
- g. Rooms on mezzanine floors are numbered with the same number as the room that is stacked below or the room that it is contained within, with the letter “M” prefixed to the room number (e.g. a mezzanine room directly above room 310 should be numbered M310).
- h. With the exception of basements, mezzanines, and roofs, rooms are not assigned alpha prefixes or leading zeroes.
- i. In buildings with one main corridor, room numbers start at the main entrance and advance progressively, such that lower numbers are on one side of the building and higher numbers are on the other. This may require initiating room numbers at a side entrance or end of a hallway in a building whose main entry is in the middle of a single corridor.
- j. In buildings with multiple corridors, room numbers should start at the building’s main entrance and proceed clockwise in an ascending order (or counterclockwise if necessitated by the building design).
- k. Even and odd numbers are assigned to opposite sides of the hallway.
- l. Room numbers on one side of a corridor should maintain sequence with room numbers on the opposite side of the corridor as much as possible (e.g. room 101 is across the corridor from room 102). This may require skipping room numbers.
- m. To the greatest extent possible, rooms in similar locations on different floors will have similar room numbers such that they are vertically coordinated or “stacked” (e.g. rooms 110, 210 and 310 occur in the same vertical stack).
- n. While room numbers advance progressively, they should not necessarily be consecutive. A greater level of flexibility is achieved when a consecutive scheme is avoided. Sufficient numbers should be skipped to provide a reserve of available room numbers for future renovations, particularly around larger rooms that might easily be subdivided. When considering skipping room numbers, use structural features such as windows and columns to gauge possible renovations and renumbering requirements. Alternatively, consider skipping one number per every 10 foot length of wall along a corridor.

#### 5. Nested Rooms / Suites

- a. Nested rooms, or rooms that can only be accessed through another room (e.g. office suites), are assigned an alpha suffix preceded by the number of the outer room (e.g. 101A, 101B, 101C, etc.).
- b. Suffix letters are assigned in the same clockwise direction as the overall building numbering scheme, beginning from the main entry and advancing sequentially.
- c. A nested room within another nested room should be assigned a second alpha suffix (e.g. 101AA, 101AB, etc.).
- d. Alpha characters “I” and “O” should be avoided, since they are easily confused with numbers.

- e. **Cubicles and laboratory benches (for internal campus use only):** Designers are only required to assign room numbers to individual rooms; however, departments can create their own internal numbering scheme for cubicles, lab benches and other open-plan seating arrangements. These should be labeled with the number of the room followed by a dash and then the cubicle or bench number. Example: 101-1, 101-2, 101-3, etc. Please note that these numbering schemes will not be recorded in central campus databases.
6. Non-Assignable / Miscellaneous /Exterior Spaces
- a. All “rooms” will receive a room number whether or not they are assignable, including restrooms, janitorial closets, and mechanical and electrical rooms. These rooms should follow the standard numbering scheme and be consistent with the rest of the floor plan.
  - b. All other non-assignable spaces, including corridors, vestibules, enclosed stairwells, elevators, and other vertical shafts, should be assigned a room number for record purposes even though they may not receive corresponding building signage. The general format for numbering these circulation spaces is to combine the floor id, an abbreviated space type designator (e.g. STRS for stairways) and the space id, as detailed below.
  - c. Lobbies: Large entry lobbies should also be assigned room numbers in accordance with the standard numbering scheme of the building, with corresponding labeling/signage. Generally lobbies are assigned numbers 100 (for the first floor lobby), 200 (for the second floor lobby), etc. If a floor contains more than one entry lobby, these should be assigned round numbers in sequence with neighboring rooms (e.g. a lobby that provides access to rooms 151, 153 and 157, would be numbered lobby 150).
  - d. Stairways: All enclosed stairways should receive a numerical identifier (1, 2, 3, etc.) starting with 1 at the stair nearest the main entrance and ascending clockwise. This identifier should be posted in the stairwell landing at every floor. For record purposes, the footprint of the stairway at each floor should be labeled on the floor plan with the floor id, an abbreviated space type designator and the stair id, as follows: 1STRS1 (first floor, stairway 1), 1STRS2 (first floor, stairway 2), 2STRS1 (second floor, stairway 1), etc. This “room number” is only for record purposes and should not be posted in the building.
  - e. Elevators: Each elevator should receive a numerical identifier (1, 2, 3, etc.) starting with 1 at the elevator nearest the main entrance and ascending clockwise. This identifier should be posted in each elevator cab. For record purposes, the footprint of the elevator shaft at each floor should be labeled on the floor plans as follows: B1ELEV1 (first basement, elevator 1), 1ELEV1 (first floor, elevator 1), 1ELEV2 (first floor, elevator 2), etc.
  - f. Corridors/Hallways: Primary circulation spaces should be broken down into several predominantly rectangular corridors and labeled sequentially with the floor id and a corridor id (starting with 1 for the corridor nearest the main entrance), as follows: 1CORR1, 1CORR2, etc. As with rooms, corridors should be vertically stacked to the greatest extent possible, such that 1CORR1 on the first floor is directly below 2CORR1 on the second floor.
  - g. Vertical shafts: Vertical shafts that penetrate the floor area, such as air duct shafts, pipe shafts, service chutes, etc., should receive an identifier at each floor similar to the above guidelines, such as: B1SHAFT1, 1SHAFT1, 1SHAFT2, etc.
  - h. Terraces: All structurally supported, unenclosed exterior gathering spaces should be numbered in relation to the room from which they are accessed, appended with the designation ‘TER’. For instance, a terrace off of room 345 would be numbered 345TER. If the terrace or balcony is accessed from a lobby or from a circulation space without a standard room number, use the lobby number for that floor (e.g. 300TER). Room number assignments are only required for terraces with an area greater than 100 square feet.

- i. Loading Docks: If internal space, assign a room number sequentially following the standard room numbering format. If external space, loading docks should receive a number following the floor id, designator, dock id format, such as 1DOCK1, 2DOCK1, etc.
- j. Courtyards: Any uncovered, exterior gathering space that is completely or partially enclosed by the walls of the building should be numbered in relation to the interior space from which it is accessed, appended with the designation ‘CRTYD’. For instance, a courtyard accessed from lobby 100 would be assigned the number 100CRTYD. If a courtyard is accessed from a corridor space without a traditional room number, the nearest lobby number can be used when numbering the courtyard
- k. For a list of typical circulation and construction spaces and how to label them, see the below table.  
Note: All examples use floor one.

Space Type	Designator	Example Room Number (Floor ID + Designator + Space ID)
Bridge	BRDG	1BRDG1
Elevator	ELEV	1ELEV2
Loading Dock	DOCK	1DOCK1
Corridor	CORR	1CORR3
Stairway	STRS	1STRS1
Atrium	ATRM	1ATRM1
Tunnel	TUNNL	1TUNNL1
Shaft	SHAFT	1SHAFT4
Breezeway	BRZWY	1BRZWY1
Deck/Porch	DECK	1DECK1
Vestibule/Foyer/Elevator Lobby	LBY	1LBY2

7. Roof Numbering

- a. Each roof area will be designated with a primary number beginning with the prefix “RF.” If a roof area has distinct separate roof areas to be numbered, the numbers will begin at the level the roof is contiguous with. Example: If roof level two is at the fourth floor level of the building, roof areas would be numbered as follows:
  - i. RF02-400
  - ii. RF02-401
  - iii. RF02-402
- b. If a roof level is not contiguous with a floor level, it would be numbered at the next level for the building (e.g. if a building has four floors, spaces on the top roof would be numbered in the 500 series).
- c. If there is a distinct enclosed room located on a roof, separate from the primary building interiors, those room spaces will be numbered in the same manner as other rooms on that floor level with a prefix “RF” (Figure 1, Item 1). Numbered rooms on a roof level shall not interfere, or limit the available reserve of room numbers that might need to be assigned to other interior spaces on the floor in the future.
- d. Floor plans for roof levels, will specify in the title block which floor level it is contiguous with (Figure 1, Item 2).

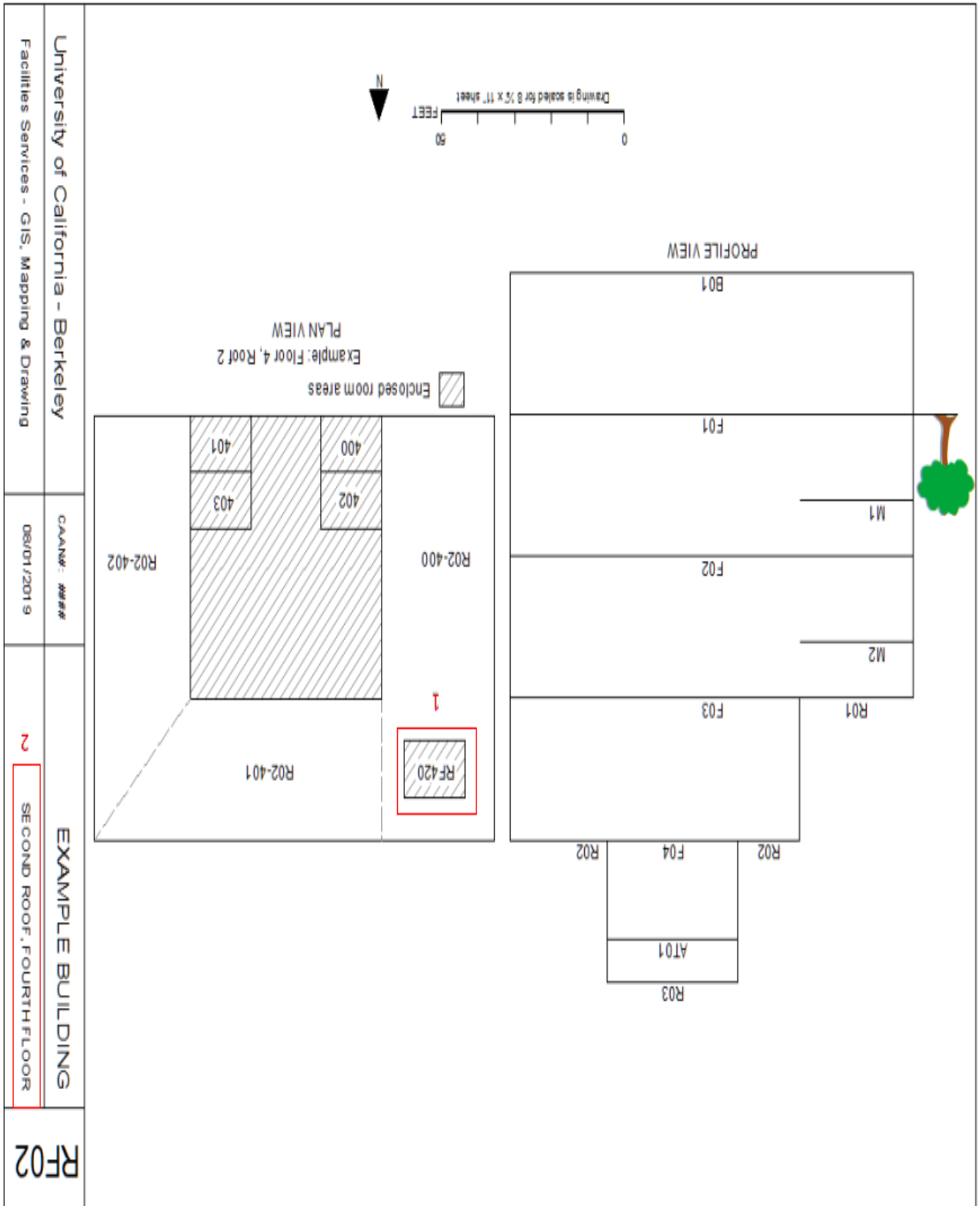
## 8. Attic Numbering

- a. Attic areas will be numbered with the prefix “AT.” The first attic area in a building will begin the numbering at 01. If an attic has distinct, separate areas to be numbered, the numbers will begin with the hundred number level the attic resides. Example: The first attic level of a building, distinct areas would be numbered:
  - i. AT01-100
  - ii. AT01-101
  - iii. AT01-102

## 9. Corresponding Guidelines

- a. Campus Signage Standards included as Appendix C of this document (above) or online at <https://facilities.berkeley.edu/design>
- b. The IST Communications Standards document is available at <https://telecom.berkeley.edu/design-and-project-management>

See next page for Figure 1



## Appendix E: Site Safety Guidelines

The purpose of these provisions is to provide guidance to support the design of public spaces which are safe and functional. They are not intended to be prescriptive but it is recommended that designers consider how to implement these suggestions in a way which is appropriate for their project. Drawings will be reviewed by UCPD and the campus Building Department for alignment with these suggestions. Questions about these guidelines should be directed to the Crime Prevention Unit of UCPD (<https://ucpd.berkeley.edu/services/crime-prevention-unit-cpu>) and the Campus Architect (<https://capitalstrategies.berkeley.edu/about-us>).

### 1. General:

- a. Site construction, furnishings, lighting and plantings should be designed to allow for clear lines of sight and to prevent concealment and discourage encampment

### 2. Site plantings:

- a. Plantings should be no more than 24" high against buildings or where they might create concealment
- b. Plantings should be placed at least six feet away from buildings
- c. Plantings should be placed in clumps rather than rows with spacing which allows for lines of sight
- d. If plantings must be placed directly against a building or be more than 24" tall, the plants should feature thorns or other uncomfortable formations which discourage contact

### 3. Site furnishings

- a. Benches and chairs should not allow for long use or reclining
- b. Backs on benches are discouraged
- c. Benches should not feature a continuous seating plane
- d. Site walls and furniture should have protrusions or gaps which discourage sleeping and skateboarding

### 4. Lighting

- a. Areas such as loading docks and overhangs should be well lit, visible and securable
- b. Lighting should conform to IES standards
- c. Public spaces should be adequately illuminated at night to discourage concealment

### 5. Fencing

- a. Visibility should be maintained into fenced areas by use of adequate spacing of fence materials or sight lines at the bottom or middle of the fence
- b. Fencing should not be able to be climbed
- c. Fenced areas must be secured with locking hardware which is easily used by maintenance personnel and allow firefighter and police access

### 6. Retaining walls and site construction

- a. Retaining walls and other site elements should not create areas which are not clearly visible from the street or the building
- b. Level, flat site areas should feature elements such as boulders or plantings which prevent encampment



## Appendix F: Custodial Guidelines

### 1. Concept

- a. The key to efficient restrooms that provide a positive experience for the user begins in the design phase. The design team needs to focus on usage and volume as it relates to space allocation and resources, particularly with regard to reducing wait time at peak usage. With high volume restrooms, the supply and exhaust air should be designed to handle maximum occupancy / plus.
- b. Restrooms must be durable and easy to clean. The trend in user behavior is a reluctance to touch surfaces in a restroom. Due to this, we have moved towards providing battery-operated towel dispensers and allowing for space at the restroom door for a free-standing waste receptacle.
- c. Typical restrooms shall have a floor drain to handle overflow of water when there are plumbing issues, and a hose bib to facilitate cleaning. Mop sinks must be located straight ahead from the custodial closet door, not around a corner.

### 2. Finishes

- a. Flooring in restrooms should be a nonporous, hard surface, with as few grout lines or seams as is practical for the type of flooring. In cleaning restroom floors, grout cleaning is always the most difficult. From a safety and sustainability perspective, UCB does not use any type of caustic, acid grout cleaners. Custodial Services has recommended that epoxy grout always be used in restrooms on floors and walls, as it is not porous and can be cleaned more effectively. Grout sealers are not needed for epoxy grout, and shall not be used.
- b. Sealed / glazed ceramic or terrazzo tile for flooring is preferred. Light colors are strongly preferred. Flooring that requires the application of floor finish is not acceptable. Vinyl or linoleum are not acceptable. Slip resistance of floor tile shall meet or exceed recommended or required accessibility values.
- c. Walls should follow the same guidelines as floors – light colors, non-porous, as few seams and grout lines as practical. Again, ceramic products are preferred and are serviceable.
- d. Toilet partitions and urinal screens should be made of a material that can be effectively cleaned with a minimum amount of labor. Phenolic type partitions meet the criteria of cost effective cleaning. Stainless steel partitions are not acceptable, unless in an iconic architectural building where stainless steel is a better fit for the architecture.
- e. Countertops around sinks should also be made of material that can be cleaned cost-effectively. The major issue with sinks / countertops is the splashing of water onto the countertops. The water either stands idle or goes on the floor. This may be a design / installation issue. Sinks need to be deep enough and faucets need to be designed to minimize splashing. The installer needs to make sure the countertops are not installed with an angle toward the front of the countertop. UCB's recommendation is to have a mock-up constructed and use the faucet / sink before purchase.
- f. A waterproofing membrane shall always be installed in showers.

### 3. Toilet Partitions And Accessories

- a. Toilet Partitions and Urinal Screens
  - i. Floor-mounted overhead-braced solid HDPE with homogenous color throughout, 1 inch thick, Class A fire rating and passing NFPA 286 (room corner test); Wall brackets shall be continuous at partitions, urinal screens and wraparound hinges. Visual gaps shall be eliminated to ensure privacy.
- b. Paper Towel Dispensers
  - i. Surface mounted paper towel dispensers are furnished by UCB for installation by the Contractor. Currently UCB is using paper towels. Surface mounting allows for easier

replacement of towels and replacement of a broken dispenser. In certain buildings there may be a preference for recessed roll towel dispensers which is acceptable.

c. Hand Dryers

- i. Electric hand dryers may be considered for replacing paper towels or as a supplement in addition to paper towels, for those who do not want to use paper. For Custodial, the cleaning of hand dryers is simple and not very time consuming. There are a number of models on the market that control the issue water on the floor. Although water on the floor for hand dryers has never been a major problem at UCB, there is a perception the water blown of someone's hand could make the floor slippery. Noise level for those outside the restrooms is a real concern as many hand dryers produce sound levels of over 60dB.

d. Soap Dispensers

- i. Surface-mounted Foam Soap Dispenser, are furnished by UCB for installation by the Contractor.

e. Toilet Paper Dispensers

- i. Surface mounted dispensers for toilet paper are furnished by UCB for installation by the Contractor.

f. Hose Bibbs

- i. Hose bibbs are required in each restroom, typically located under the sink counter, but easily accessible.

g. Electrical Outlets

- i. A ground-fault electrical outlet at counter level is required in each restroom.

4. Building Custodial Closets Design Standards

a. Requirements

- i. Custodial Closets (architects will make available "construction elevations" of the custodial closets for equipment and accessory clearances when doing the document review).
- ii. General. Provide a custodial closet on each floor of a new or renewed building.
- iii. Provide a minimum of one custodial closet per floor and for each 15,000 square feet of floor space.
- iv. Place custodial closets in central locations, adjacent to restrooms whenever possible.
- v. Do not locate custodial closets on stair landings or under stairways.
- vi. Make each custodial closet not less than 70 square feet with no linear dimension less than 6'-0".
- vii. Closet door shall be at least 36" wide, and shall be installed off-center in the wall, opening outward toward the hallway, thus permitting maximum use of interior wall space.
- viii. Do not share functions or departments in or with custodial closets.
- ix. Floor finish shall be concrete to be polished and sealed per
- x. Do not install/place any of the following in custodial closets:
  1. Water heaters.
  2. Telephone or electrical equipment,
  3. Exposed plumbing pipes trap primers, risers, drain pipes,
  4. Water softeners
  5. Access doors, valves,
  6. HVAC equipment, vertical ductwork,
  7. Exhaust or drainage pipes.
  8. Light switches not related to custodial operations
  9. Nothing is to be located directly over faucets of mop sink to allow for chemical dispenser installation (electrical shelving, pipes etc.).

- xi. On an open wall away from the sink, on wall adjacent to the closet door, but not behind shelves, provide a dedicated grounded duplex electrical outlet GFCI (120-volt) with 20amp capacity.
  - xii. Walls shall have a hard, impervious, smooth surface (gloss enamel paint is suitable).
  - xiii. Provide an overhead light, controlled by a switch located inside the closet adjacent to door.
  - xiv. Allow floor space for storage of large electrical equipment, machines and custodial cleaning cart.
- b. Mop Sink.
- i. Place mop sink in custodial closet to the rear corner of the closet adjacent to the door.
  - ii. Do not place sinks behind any closet doors.
  - iii. Provide mop sink with hot and cold water supplied through a mixing spout which includes bucket hook and threaded end for hose connection.
  - iv. Position the spout at least 36" above sink to allow a three- gallon mop bucket with wheels to be filled and removed from the sink.
  - v. Mop basin shall be a solid surface floor service sink at least 24" x 24" x 12" high, complete with cast brass 3" caulked drain with stainless steel strainer
  - vi. Faucet set shall be Chicago Faucets 305 VBRRCF Service Sink Faucet complete with wall brace, hose end, vacuum breaker and chrome finish, or approved equal.
  - vii. Include a floor drain in each custodial closet at the center of the floor. Slope floor to floor drain.
  - viii. Add FRP (Fiber Reinforced Panel-smooth) board as a sink "surround" extending 24" out from each edge of the sink both right and left with a minimum of 4' in height to prevent water damage to the walls. FRP Board is to be installed prior to the installation of the sink.
- c. Interior Features.
- i. All storage, hangers and shelving are to be designed, specified and ordered by Custodial Operations. Installation will be by custodial Operations. All will be reimbursed by FPDC to Custodial Operations.
- d. Master Custodial Closet.
- i. Provide an additional "Master Custodial Closet" for buildings exceeding 45,000 gross square feet.
  - ii. In addition to the above listed criteria, this closet shall be a minimum of 120 square feet with dimensions being no less than (12' x 10'), and located in close proximity to a loading dock/ramp or service entrance door. Master Custodial Closet may be greater in size where applicable.
  - iii. The following shall be included:
    - 1. Each interior wall space shall be provided with a minimum of two (2) dedicated GFCI, 60-HZ, 120-volt duplex electrical outlets.
    - 2. Outlets to be located adjacent to door.
    - 3. Telephone jack adjacent to door
    - 4. Cable / computer connections
    - 5. Overhead light controlled by switch located inside the closet, adjacent to the door.
    - 6. Closet door shall be at least 36" wide and will open to the outside hallway to allow maximum floor space utilization of closet space.
    - 7. All storage, hangers and shelving are to be designed, specified and ordered by Custodial Operations. Installation will be by custodial Operations. All will be reimbursed by FPDC to Custodial Operations.
    - 8. Provide adequate force ventilation to prevent Hydrogen buildup from battery recharging on self-propelled equipment.

- e. Custodial Supervisor Office.
  - i. Provide an additional “Supervisor Office” for buildings, exceeding 100,000 gross square feet.
  - ii. This office space shall be approximately 120 square feet (10’ x 12’) and shall be located on first floor in close proximity to a service entrance door.
  - iii. Office door shall be at least 36” wide and shall be installed off-center in the wall, opening out, thus permitting maximum use of interior wall space.
  - iv. Three interior wall spaces shall be provided with dedicated GFCI, 60-HZ, 120-Volt duplex electrical outlets and one interior wall will be provided a dedicated GFI, 60-HZ, 120- Volt fourplex electrical outlet next to data outlet for office electrical equipment.
  - v. An outlet for a telephone line and an outlet with a cable (CAT 5 E) for a computer terminal shall be provided.
  - vi. All storage, hangers and shelving are to be designed, specified and ordered by Custodial Operations. Installation will be by custodial Operations. All will be reimbursed by FPDC to Custodial Operations.
  - vii. An office desk & chair will be provided with appropriate filing cabinets in line with existing building furnished décor.

## Appendix G: UC Berkeley Seismic Guidelines

The latest adopted UC Berkeley Seismic Guidelines begins on the following page.

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# UCB Seismic Guidelines

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2/22/2019

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## General

### 1. Objectives

The purpose of the UCB Seismic Guidelines is to provide technically sound, clear and consistent requirements for design, retrofit and evaluation of UCB buildings. In addition to complying with the Building Code and UC Seismic Policy, design professionals working on UCB projects, whether contracted by UCB or a third party, are required to follow the *Guidelines* as a part of their contractual obligations to the University.

UCB's goals for the *Guidelines* are to provide seismically safe facilities, limit earthquake damage and promote excellence in seismic design of campus facilities in a manner that makes the greatest use of limited resources. The *Guidelines* establish a facilities classification and related performance levels for UCB buildings to make progress in achieving the following overarching earthquake risk reduction objectives:

1. Protect life safety of the UCB community
2. Maintain operations of UCB's critical infrastructure and facilities
3. Resume core teaching and research programs

The *Guidelines* are intended to be a living document that is updated to reflect changes in the understanding of how buildings perform in earthquakes, the advent of new technologies, lessons learned and/or to address UCB's changing needs.

### 2. Codes and Standards

In accordance with the University of California Seismic Safety Policy, UCB is required to enforce the current edition of the California State Building Code (CBC) as adopted by the California Building Standards Commission. The UCB Seismic Guidelines supplement the requirements of the CBC and the University of California Seismic Safety Policy. Where requirements differ, the more restrictive shall apply.

The CBC applies to all construction activity undertaken by UCB and applies to both seismic and non-seismic requirements for construction. All UCB buildings are required to comply with the requirements of either CBC Part 2, Chapter 16 for new buildings or CBC Part 10 for existing buildings. Designated historic structures may be subject to the State Historic Building Code.

The UCB Building Official is responsible for enforcement of the CBC. The UCB Seismic Review Committee (SRC) in conjunction with the project Peer Reviewer is responsible for advising the UCB Building Official on a project's compliance with the *Guidelines*.

### 3. Seismic Review Committee

The Seismic Review Committee plays a key role advising Capital Strategies on implementation of the UCB Seismic Guidelines on capital projects, and facilitating communication related to seismic issues. The SRC's primary responsibilities are in the following areas:

- Review the seismic analysis and design aspects of capital projects that include significant modifications to primary structures or building of new structures. The review may include, as appropriate, the proposed seismic performance objectives, seismic hazard representation, structural system and materials, structural modeling and analysis, acceptance criteria, quality control, nonstructural components and systems and any other considerations deemed essential to the expected seismic performance of the project as a whole. As a minimum, reviews will be during schematic design and later phases as necessary. A pre-schematic meeting may be requested.
- Review the seismic evaluation of existing buildings. The review may include, as appropriate, the proposed performance objectives, seismic hazard representation, structural modeling and analysis, acceptance criteria, retrofit concepts, nonstructural components and systems, and any other considerations deemed appropriate to achieve the desired performance. Reviews will generally be after initial analysis results are obtained. In some cases, an earlier meeting to review evaluation approach may be requested.
- Provide advice and counsel to Capital Strategies regarding the scope of peer review and when it is necessary to mediate any differences between design engineers and peer reviewers.
- Periodically review overall campus approaches to seismic evaluation, design, and design review, with the aim of incorporating best practices for seismic evaluation, design, and design review.
- Help the Campus establish priorities for seismic projects to address the Office of the President mandate included in the Seismic Safety Policy that "no University Facility with a Seismic Performance Rating of V or VI is occupied beyond December 31, 2030".

Projects shall be presented to the SRC at least one time in accordance with the presentation guidelines set forth in Appendix A.

## **4. Peer Review**

Peer review is a mandatory part of the design and construction process for most building projects undertaken by or on behalf of UCB, including Public-Private Partnerships (P3). According to the University of California Seismic Safety Policy, peer review is required for all new construction and all renovation of university facilities “that involve structural design and that are intended for human occupancy, or which affect life or safety of the occupants”. Peer review is optional for some projects as described in the University of California Seismic Safety Policy with concurrence of the UCB Building Official.

The purpose of peer review is to assure project quality and confirm that the UCB Seismic Guidelines have been followed. Peer review is an objective technical review by an independent, knowledgeable reviewer experienced in structural design, analysis, and seismic performance issues. The reviewer shall examine the available information on the building, the engineering concepts employed, and the recommendations for action. This shall include both lateral and gravity systems necessary to achieve the intended building structural and nonstructural performance.

Peer review is not intended to and does not replace the design responsibilities of the Engineer-of-Record. Peer review is not a plan check for detailed determination of the compliance of the developed plans to requirements of applicable codes and standards.

## **5. Seismic hazard, site effects, and ground motions**

Projects on the UCB campus are to use site-specific earthquake response spectra from the most recent approved UCB Seismic Hazard Analysis report. Currently this is the “2015 Update to the Site Specific Seismic Hazard Analyses and Development of Seismic Design Ground Motions” by URS Corporation dated July 15, 2015. The report provides response spectra for DE and  $MCE_R$  (aka BSE-1N and BSE-2N) earthquake levels applicable to new construction, and BSE-1E and BSE-2E earthquake levels for existing structures. For evaluation of existing buildings, spectra for BSE-R and BSE-C shall be developed and used where required for compliance with the University of California Seismic Safety Policy.

For response history analysis, projects shall use earthquake ground motion records provided by Capital Strategies’ ground motion consultant. For cases of buildings not in the area covered by the report (but still under jurisdiction of Capital Strategies) or for earthquake levels not covered by the report, the Structural Engineer of Record (SEOR) and Geotechnical Engineer of Record (GEOR) for the project shall work with Capital Strategies and the SRC to establish appropriate hazard and ground motions.

Earthquake response spectra and scaling of ground motions are permitted to include kinematic (base-slab averaging) effects, embedment effects and other effects justified by the SEOR and GEOR subject to review and acceptance by the SRC and Peer Reviewer.

## **6. General Design Intent**



UCB desires building configurations, structural systems, and attention to design of nonstructural components and systems that controls the amount and type of expected earthquake damage. UCB typically seeks building configurations with a continuous lateral load-resisting path with regular distributions of mass and stiffness in plan and elevation, and recognizes the need for a collaborative design process to achieve these goals. Program and architectural design requirements may, however, result in buildings with irregular lateral force resisting systems. The design team shall present the rationale for and implications of such irregular building configurations, including consideration of construction costs, seismic performance and post-earthquake reparability, to the SRC and Peer Reviewer for acceptance as part of the peer review process. In addition to regular building configurations, UCB recommends the use of structural systems that have demonstrated improved seismic performance in buildings. Innovative structural systems can be proposed but they need to be supported by sound analysis and testing, accepted by the SRC and Peer Reviewer, and approved by the Building Official.

While the *Guidelines* emphasize structural design, UCB expects all members of the project team to collaborate in achieving UCB's goals. The *Guidelines* encourage approaches to design that break down traditional barriers and yield more synergistic, holistic and constructible design solutions.

## **7. Performance Objectives**

UCB has established goals for building performance to protect life safety, maintain operation of critical infrastructure and restore core teaching and research following an earthquake. The performance objectives account for both structural and nonstructural components. The performance objectives are for the building as a whole (and not for particular components) and follow evaluation concepts and performance criteria similar to those contained in ASCE 41. The performance objectives have been defined so that buildings satisfying these objectives will also satisfy the current UCOP Seismic Policy, the CBC and California Existing Building Code (CEBC). The performance objectives are subject to change for alignment with changes in the UCOP Seismic Policy, codes and standards, and to address UCB's needs.

At the outset of projects campus planning and leadership will determine if the project's seismic performance objectives will be higher than the minimum prescribed by the University of California Seismic Safety Policy. In some cases, UCB will request consideration of more than one objective to help guide decision-making and resource allocations.

### **7.1 Building Performance Objectives**

UCB identifies seven seismic performance objectives for buildings as described in Table 7.1. Each attribute of the performance objectives is described below.

- 7.1.1 Rating** – A Roman numeral rating system of I (highest performance) to VII (lowest performance) is used in the University of California Seismic Safety Policy to describe “expected seismic performance levels”. For consistency with the Policy the UCB Seismic Guidelines adopt a similar system, using ratings I to VII. The rating system is maintained to facilitate communication with UCOP and for consistency with historic performance ratings.

Each rating is associated with a parenthetical descriptor that recognizes UCOP's historic rating descriptions of "Good", "Fair", "Poor" and "Very Poor". In acknowledgement of the enhanced performance associated with Ratings II and I, the description "Enhanced Safety and Performance" is used to describe a rating of II and "Operation Critical" describes a building with a rating of I.

- 7.1.2** Earthquake Hazard – Earthquake hazard levels consistent with ASCE 7-10 are used for new buildings, namely BSE-1N and 2N. For existing buildings, BSE-R and BSE-C are used for consistency with the University of California Seismic Safety Policy and Table 317.5 of the CEBC.
- 7.1.3** Structural Performance Level – Structural performance levels described in ASCE-41-17 are used for a quantitative characterization of performance. ASCE 41 is a national standard that is widely used as the basis of evaluation for both new and existing buildings.
- 7.1.4** Nonstructural Performance Level - Nonstructural performance levels described in ASCE-41-17 are used for a quantitative characterization of performance. For ratings other than I, design of nonstructural components at the BSE-2N or 2E level is not required based on the expectation that designing for the prescribed performance at BSE-1N or 1E will achieve acceptable performance at the higher earthquake hazard level. Additional project-specific nonstructural design requirements are described in Section 8.2.
- 7.1.5** Notes – Notes are included to help translate the ratings to familiar code designs. New buildings designed to satisfy a **UC** rating of **I**, **II** or **III** are expected to satisfy the requirements for CBC Risk Categories IV, III or II, respectively. Annotations associated with UCOP requirements for existing buildings are also provided.

Table 7.1 - Seismic Performance Objectives

Rating	Earthquake Hazard	Performance Level <sup>1</sup>		Notes <sup>3</sup>
		Structural	Nonstructural <sup>2</sup>	
I (Operation Critical)	BSE-1N	S-1 (Immediate Occupancy)	N-A (Operational)	Comparable to CBC Risk Category IV for New Buildings
	BSE-2N	S-3 (Life Safety)	N-D (Hazards Reduced)	
II (Enhanced Safety and Performance)	BSE-1N	S-2 (Damage Control)	N-B (Position Retention)	Comparable to CBC Risk Category III with additional life safety and damage control compared to "Good" rating
	BSE-2N	S-4 (Reduced Safety)	N-D (Hazards Reduced)	
III (Good)	BSE-1N	S-3 (Life Safety)	N-C (Life Safety)	Comparable to CBC Risk Category II. Minimum rating for new buildings.
	BSE-2N	S-5 (Collapse Prevention)	N-D (Not Considered)	
IV (Fair)	BSE-R	S-3 (Life Safety)	N-C (Life Safety)	Minimum rating for existing Risk Category I, II and III buildings <sup>4</sup>
	BSE-C	S-5 (Collapse Prevention)	N-D (Not Considered)	
V (Poor)	2/3 x BSE-R	S-3 (Life Safety)	N-C (Life Safety)	Requires retrofit
	2/3 x BSE-C	S-5 (Collapse Prevention)	N-D (Not Considered)	
VI (Very Poor)	Not able to meet Rating V			Highest priority for retrofit

<sup>1</sup> Performance levels are defined in ASCE 41-17

<sup>2</sup> See 8.2 for additional nonstructural requirements

<sup>3</sup> For definition of CBC Risk Category see CBC Table 1604.5

<sup>4</sup> See CEBC Section 317.5 for exceptions based on size of addition. Additional project-specific minimum performance objectives may apply.

## 8. Performance Evaluation

The Structural Engineer of Record (SEOR) shall determine the expected performance of the building (structural components and nonstructural components and systems) under prescribed hazard levels.

### 8.1 Structural analysis methods and modeling requirements

Based on consideration of the proposed structural system and its performance objective, the SEOR shall select an analysis approach believed to be best suited for the project. The approach should address the level of complexity of the structural system and the ability of the analysis method to represent important response characteristics. A linear dynamic analysis is generally required as a minimum. Nonlinear response-history analysis (NLRHA) may be required for performance assessment of significant structures. The fee associated with NLRHA shall be identified as an optional add service in the SEOR's project fee proposal. The SEOR's recommended analytical approach should be discussed with the SRC and Peer Reviewer to determine acceptability.

#### 8.1.1 Gravity framing system

The SEOR shall evaluate elements of the gravity framing system that affect the linear and nonlinear response of the structure to earthquake motions. The gravity structure shall be explicitly included in the seismic analysis, unless the SEOR justifies other approaches that adequately address the effects of the gravity structure, including earthquake effects on:

- Column axial forces.
- Wall shear or force in braced frames.
- Rotational demands on floor framing adjacent to lateral force resisting elements.
- Punching shear at slab-column interface.
- Pattern and mechanism of linear and nonlinear lateral deformation.
- Residual deformation.

#### 8.1.2 Soil flexibility

The effects of soil flexibility shall be considered when developing the analytical approach. In cases where it can be demonstrated that ignoring such flexibility has negligible effects on results, it need not be explicitly modeled, subject to review and acceptance by the SRC and Peer Reviewer. Effects of both vertical and lateral soil flexibility shall be considered. Soil springs employed shall be linear, linear no-tension, or nonlinear as required to effectively model relevant effects.

### **8.1.3 Residual Deformation**

When Seismic Performance Rating I or II is required, residual deformations shall be computed and considered when evaluating performance. Acceptance criteria shall be addressed in the Peer Review and included in the Basis of Design.

## **8.2 Seismic Protection of Nonstructural Components and Systems**

Performance of nonstructural components and systems should be commensurate with the specified building performance. Structural and nonstructural designs should be considered holistically to ensure that required building drifts and accelerations can be accommodated by selected nonstructural systems.

The design team shall address seismic bracing and anchorage of all nonstructural components that serve the building, including mechanical, electrical and plumbing equipment and systems (MEP), architectural components, and contents needed to satisfy the building performance objectives. Seismic bracing and anchorage may be designed by members of the design team or delegated to third parties through project-specific performance specifications. All delegated designs must be reviewed and accepted by the SEOR.

As a minimum, the design shall be based on lateral forces and drifts required by the provisions of ASCE 7 enforced at the time of permit application. Design story drifts and accelerations shall be summarized in a table that is used or referenced for design of nonstructural components. Importance Factors for design and requirements for Special Seismic Certification shall be assigned in accordance with CBC requirements and as required to achieve project-specific performance objectives. The Basis of Design (Section 9) shall include a matrix of nonstructural components and the related design and certification requirements, which will be peer reviewed and considered by the Seismic Review Committee during its review. A sample matrix is shown in Appendix B.

## **9. Basis for Design**

The SEOR shall provide a structural design criteria document prior to the beginning of schematic design that defines key assumptions and methods to be used. The design criteria document may evolve as the design is carried out and specific design decisions are made. The SEOR shall update the structural design criteria as the design proceeds and address comments by the Peer Reviewer and SRC. Typically, the design criteria document will include the proposed seismic performance objectives, seismic hazard representation, structural system and materials, structural modeling and analysis procedures, acceptance criteria, quality control, nonstructural components and systems (Appendix B) and any other considerations deemed essential to the project seismic performance.

Exceptions to specific requirements contained in the CBC or UCB Seismic Design Guidelines are permitted if justified by research or other evidence provided by the SEOR and reviewed and accepted by the Peer Reviewer and SRC. All exceptions shall be identified by the SEOR and included in the Basis of Design.

## **10. Project Delivery Methods**

A broad range of project-specific factors influences UCB's selection of a project delivery method. The *Guidelines* apply to every UCB capital project regardless of which project delivery method is used. It is particularly important for the *Guidelines* to be considered at the outset of a project when financial commitments are established early in the design process, such as with Public Private Partnerships (P3). Early review by the SRC and Peer Reviewer may be requested to support project schedule needs.

## **11. Flowcharts**

Appendix C contains flowcharts intended to guide three types of projects: (1) new building design, (2) retrofit design and (3) seismic evaluation. While each project is unique, most are expected to include each step of the applicable flowchart. Deviations are permitted with agreement of the Project Manager, SRC and Peer Reviewer.

Seismic Review Committee (SRC) review is required for the construction of new buildings, for projects that include additions or modifications to the primary structures of existing campus buildings, for seismic retrofit projects and for selected seismic evaluation projects. The design team's project manager will have an informal review/discussion with the UC Berkeley Capital Strategies Director at the beginning of the Schematic Phase to determine what reviews will be required by the SRC.

- The initial seismic review is typically conducted early in the Preliminary Design phase and includes a brief overview of the project by the Architect, followed by a presentation by the SEOR regarding project seismic performance requirements, seismic issues, seismic design criteria including ground motion, proposed earthquake-resisting systems (including structural system, foundations, and special requirements for protection of nonstructural components and contents), and proposed methods of seismic analysis.
- Another review is usually conducted at about the 50% Construction Documents stage to discuss whether the project is generally proceeding as anticipated from a seismic design perspective and whether the design has generated issues that the SRC should address. This review should include a brief presentation by the project Peer Reviewer addressing those points. At this stage, it is usually appropriate to discuss expected building performance, including major nonstructural systems and how those systems are being addressed from a seismic design perspective.

The Project Manager is responsible for scheduling a presentation to the SRC when the project is at an appropriate stage for review. The Project Manager shall submit a request to the SRC Coordinator for inclusion on the next SRC agenda. The request should identify the project name, stage, and names and organizations of team members that will present or otherwise attend, including:

- Architect
- Structural Engineer
- Geotechnical Engineer (when requested by the SRC)
- Peer Reviewer

The SRC Coordinator will notify the Project Manager of the date, time and place for the presentation. The Project Manager is responsible for informing his/her consultant(s).

The project team (Architect or Engineer) will provide an electronic draft narrative to the SRC Coordinator at least one (1) week prior to the SRC meeting for distribution to the members. This briefing is typically 3-6 pages and covers the following items:

- Building name and site location
- Building occupancy and use
- Seismic rating (for existing building)
- Seismic performance objectives and design criteria
- Description of the gravity load-carrying system
- Proposed approach to seismic system selection and validation
- A list of additional documents that are pertinent to the project that SRC members might want to request to review: Soils reports, prior seismic assessments, etc.

Consultants should be prepared to answer questions pertinent to the project and to provide a speculated building performance evaluation under defined earthquake motions.

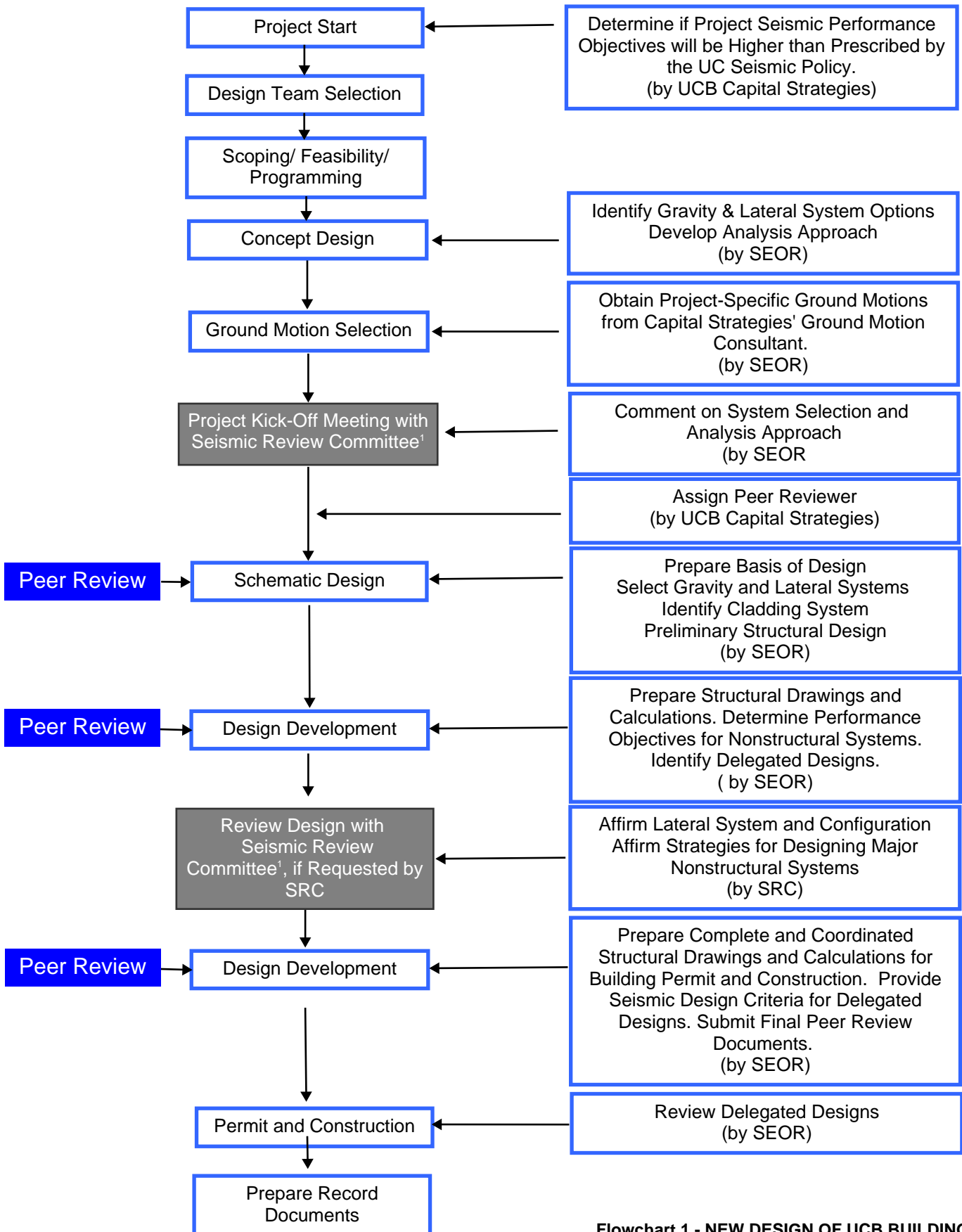
The project team will provide an electronic copy of the presentation to the SRC Coordinator for the SRC records prior to the meeting or on the day of the meeting. The presentation should include a high-level summary of the building structural/seismic characteristics, proposed analytical approaches, description of special design considerations, performance expectations, key design challenges, alternatives recommended for consideration and other considerations that would benefit from SRC input. Slides should be formatted to allow the audience to easily read and interpret them from a distance of 20 ft. Graphics that are difficult to read from a distance or contain too much information should be avoided.

The SRC Coordinator will prepare meeting minutes and distribute a draft to the SRC members for their review and comments. Once the minutes are final, they will be distributed to the Project Manager. The Project Manager is responsible for distributing the minutes to the consultant(s).





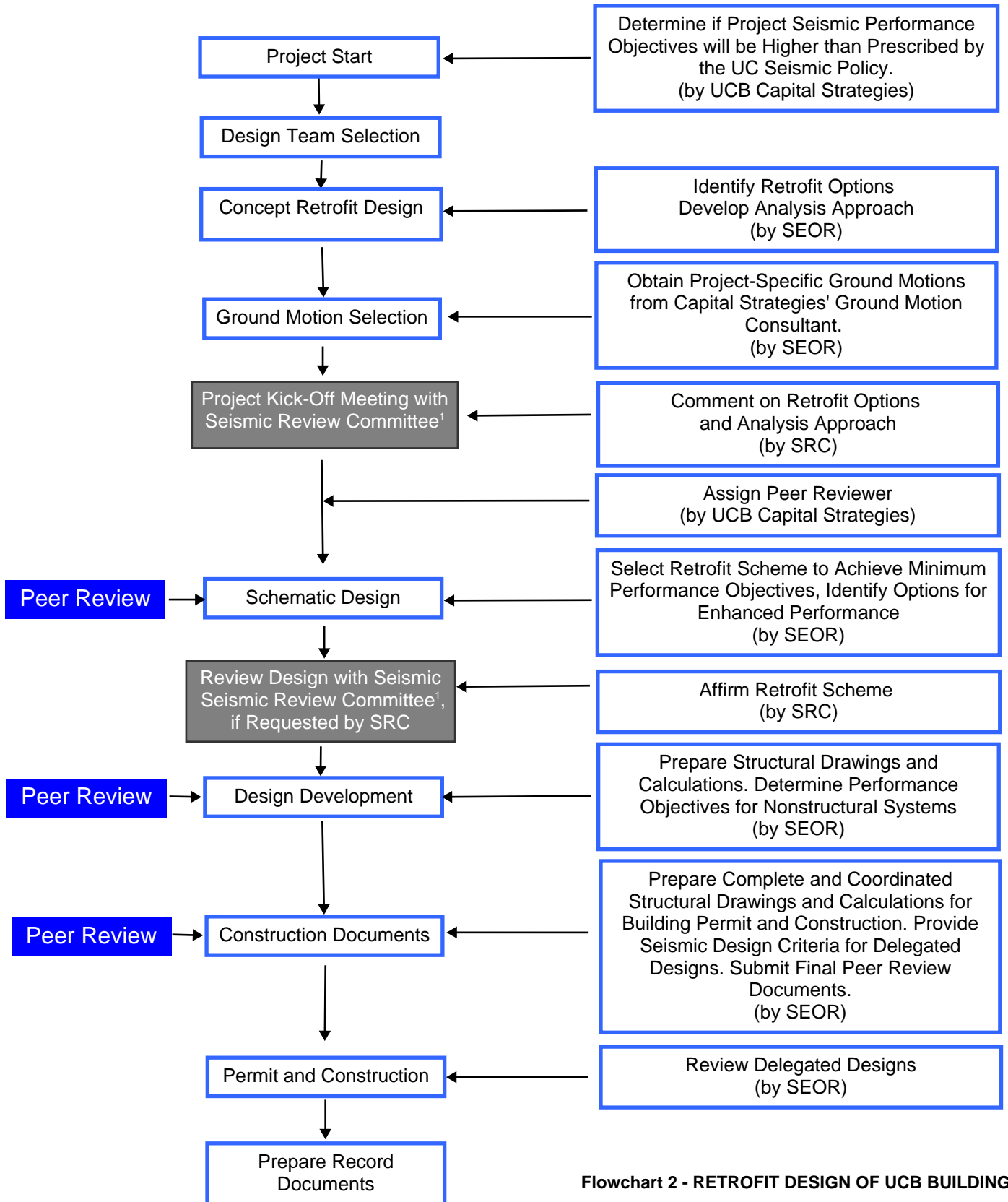
# New Design



Flowchart 1 - NEW DESIGN OF UCB BUILDINGS

¹ Timing of SRC review may be adjusted as needed to suit project schedule and needs.

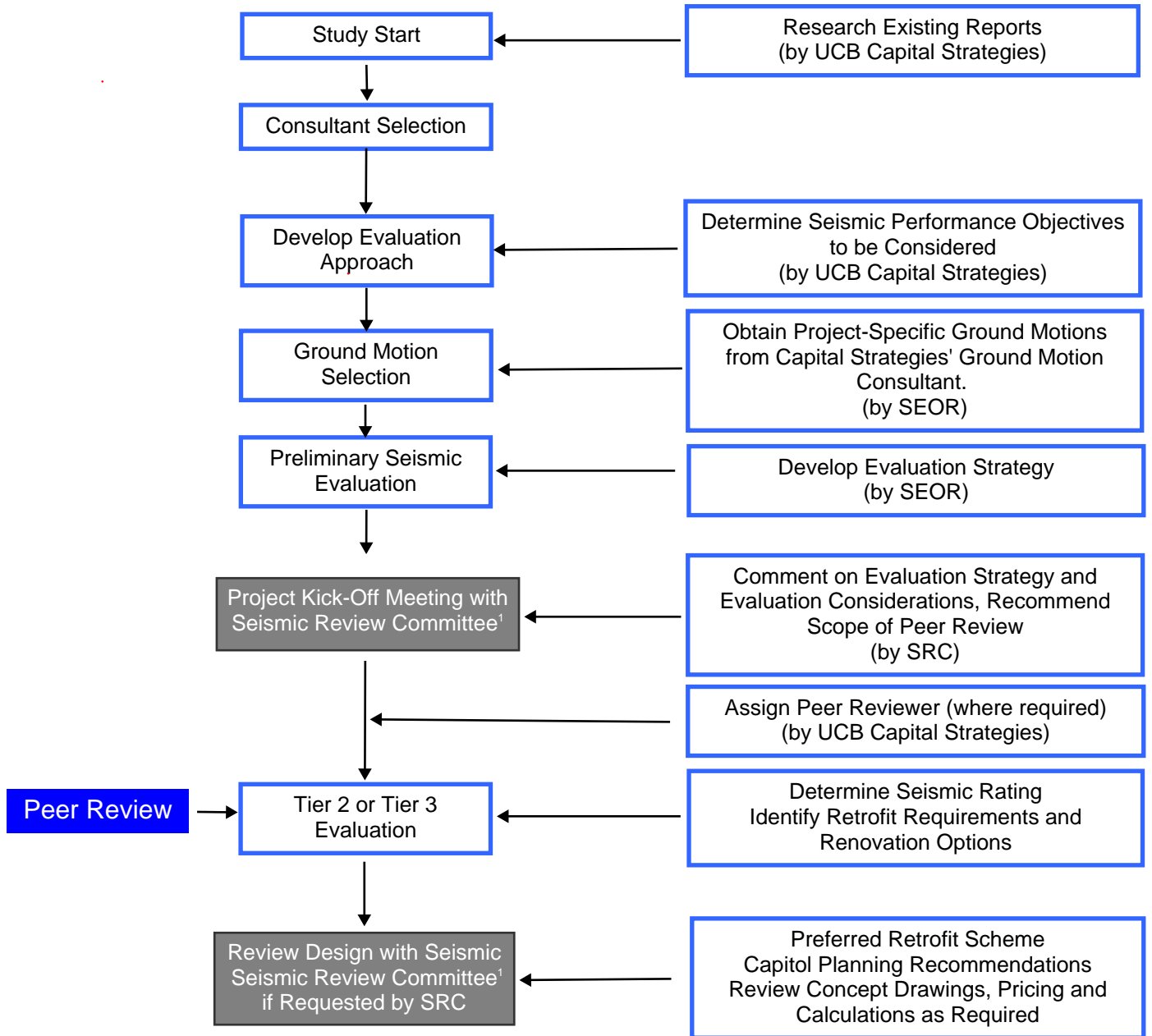
# Retrofit Design



Flowchart 2 - RETROFIT DESIGN OF UCB BUILDINGS

<sup>1</sup> Timing of SRC review may be adjusted as needed to suit project schedule and needs.

# Evaluation



Flowchart 3 - EVALUATION OF UCB BUILDINGS

¹ Timing of SRC review may be adjusted as needed to suit project schedule and needs.