DIVISION 15

MECHANICAL

SECTION 15010: GENERAL MECHANICAL REQUIREMENTS

PART-I GENERAL

1.01 SCOPE

A. This section contains general guidelines applicable to all Division 15 Sections of work.

B. The Guidelines are intended to provide direction to Design Professionals in the design of mechanical systems for University construction projects. The Division 15 Design Guidelines are not intended to be used directly as Contract Specifications except as covered under Guide Specifications below.

C. Guide Specifications may be provided within these Guidelines for various specialized areas of mechanical work. These will be designated as such and contain wording directed towards Contractors. Only the portions of these Guidelines specifically designated as Guide Specifications are intended for incorporation in Contract Documents. The Design Professional shall be responsible for completing designated areas of Guide Specifications. Where Guide Specifications are utilized, the Design Professional shall be responsible for assuring that those specifications are without omissions, are compatible with the overall design, and are coordinated with all other sections of the work.

1.02 CODE RULES AND SAFETY ORDERS

A. Construction as called out on working drawings shall be in full accordance with the rules and regulations of all ten parts of the California Code of Regulations, Title 24 (The California Building Standards Code) per University administrative policy. Title 24 includes amended versions of the Uniform Building Code, Uniform Mechanical Code, Uniform Plumbing Code, National Electric Code and the Uniform Fire Code. Also included is the California Energy Code (Title 24, Part 6).

B. Additional government codes and regulations shall be complied with as applicable to the project. See the "University of California Facilities Manual, Volume 3, Chapter 4" for further information. (http://www.ucop.edu/facil/fmc/facilman/)

C. The regional air quality management district with jurisdiction over the UCSC Campus is the Monterey Bay Unified Air Pollution Control District ((408) 647-9411) with headquarters in Monterey, California. Mechanical systems regulated by the district include: fume exhaust systems, cooling towers, fuel burning equipment (depending on size & fuel type), paint spray booths, incinerators, and dust handling equipment. A "Permit to Construct" must be obtained from the District prior to beginning construction or modification on any system regulated by the District. The Design Professional shall be responsible for identifying project impacts requiring compliance with Air Pollution Control District regulations Alternatives for compliance shall be discussed with the UCSC Project Manager. The Design Professional shall provide UCSC with all information required to obtain a "Permit to Construct" . Permit applications, and related correspondence shall be channeled through the UCSC Environmental Health & Safety Office (Environmental Programs Manager)..

D. Systems discharging to the campus sewer system shall be in compliance with the requirements of the City of Santa Cruz Waste Water Treatment Plant (Industrial Waste Inspector (408) 429-3142). Mechanical systems discharging unusual wastes may require special provisions or may not be allowed. Triggers include high or low pH, oil, grease, chemical contamination, biological contamination, and rain water to the sewer. Mechanical systems typically impacted include commercial kitchen waste, elevator sump pump discharge, lab process waste, and water purification system waste. The Design Professional shall be responsible for confirming impacts to the project due to the City Waste Water Discharge Ordinance. Alternatives for compliance shall be discussed with the University's

Representative. Negotiations involving specific project issues shall be channeled through the UCSC Environmental Health & Safety Office (Director).

1.03 BASIC DESIGN PRIORITIES

A. Program Requirements / Design Guidelines / Government Codes: Mechanical systems shall be designed to meet the more stringent of: the user requirements as identified in the Program, the requirements these Design Guidelines, or applicable government codes and regulations. The Design Professional shall be responsible for notifying the University's Representative of conflicting requirements. The University's Representative shall provide the final decision as to how conflicts will be resolved.

B. Ease of Maintenance / Operation: Mechanical systems shall be designed to be easily maintained and operated. Access and service space shall be key considerations of the design. Equipment requiring the movement of heavy items for service shall be located such that it is assessable by a hand truck from service vehicle parking locations. Equipment requiring frequent monitoring shall be located so as to be easily accessible from service vehicle parking locations.

C. Equipment Replaceability: Mechanical equipment shall be located such that replacement is possible without building demolition. Buildings shall be provided with special provisions (oversized doors, removable louvers, access plates, etc.) as required to meet this requirement.

D. System Life: Mechanical systems shall be designed to last the life of the building. Components shall typically be institutional grade. With approval of the University's Representative, an exception to this requirement may be granted for systems to support specialized applications with a short life expectancy.

E. Energy Efficiency: Mechanical system shall be designed to minimize energy use. UCSC has a long standing tradition of frugal energy use. Design decisions which significantly impact energy use or cost shall be brought to the attention of the University's Representative. The University's Representative shall provide the final decision on such matters.

F. Water Conservation: Mechanical system shall be designed to minimize water use. UCSC has a long standing tradition of frugal water use. Design decisions which significantly impact water use shall be brought to the attention of the University's Representative. The University's Representative shall provide the final decision on such matters.

G. Utility Metering: All mechanical utilities serving a building shall be metered. This shall include Water, Natural Gas, Campus Heating Hot Water, Campus Cooling Water and Chilled Water (when produced at a plant outside the building). See applicable Sections for metering specifics. A complex of residential buildings may be master-metered with approval of the University's Representative.

1.04 DESIGN DOCUMENTATION

A. Design documentation shall be provided for all mechanical systems to assure efficiency in the mechanical design process and to serve as a reference after construction.

B. Conceptual Design Report / Mechanical Systems: At the Schematic Design phase, submit a "Conceptual Design Report" for the project's mechanical systems, covering each anticipated mechanical system in the project. A key element of the report shall be a discussion of the alternative systems available to meet the identified needs. Design Development work for the mechanical systems shall not begin until the University's Representative has approved a conceptual alternative for each mechanical system. The Conceptual Design Report shall include:

1. Identification of the mechanical services required in each type of space included in the project.

2. The base criteria to be used for capacity sizing each mechanical service to each space type within the project. Identify the source of the criteria (e.g., consultant recommendation, program requirement, building user interview, code requirement, campus standard, equipment manufacturer). State extent to which services will be oversized to accommodate future growth.

3. A discussion of the pro and cons of the design alternatives available for each mechanical system.

4. A recommended alternative for each mechanical system.

5. Space allocation required for each recommended alternative.

6. A description of access to be provided to each major piece of mechanical equipment.

C. Design Development Report / Mechanical Systems: The Design Development submittal shall include a "Design Development Report" covering each mechanical system in the project. This report shall include:

1. Room by room documentation of required mechanical services.

2. A written description of each mechanical system covering system purpose, system type, utility inputs, and locations of all major equipment.

3. The criteria to be used in sizing and laying out each mechanical system and the source of the criteria (similar to Conceptual Design Report).

4. Rough schematics of the proposed systems indicating major equipment, points of connection to existing utilities, and the rooms served by each mechanical utility.

5. A description of the required space to accommodate each major element of the proposed mechanical systems, including mechanical rooms, exterior mechanical yards, roof mounted mechanical equipment, mechanical shafts, and ceiling space provisions.

6. A complete description of access for maintenance and replacement to each piece of mechanical equipment.

7. Rough equipment sizing calculations.

8. Catalog cut sheets on all major mechanical equipment.

D. Title 24 Building Envelope Plan Check Compliance Documents: The Design Professional shall submit Title 24, Part 6; Building Envelope Plan Check Compliance Documentation no later than the 50% Working Drawing Submittal. This documentation shall include applicable portions of forms; ENV-1, ENV-2, & ENV-3.

E. Title 24 Mechanical Plan Check Compliance Documents: Title 24 The Design Professional shall submit Title 24, Part 6; Mechanical Plan Check Compliance Documentation no later than the 50

% Working Drawing Submittal. This documentation shall include applicable portions of forms; MECH-1, MECH-2, MECH-3 and MECH-4.

F. <u>Final Mechanical Calculations & Equipment Documentation:</u> Final mechanical calculations shall be submitted no later than the 50 % Working Drawing Submittal. These calculations shall document the final basis of design for all mechanical equipment and systems. Title 24 plan check documentation may be used to supplement the calculations where applicable. Also included shall be manufacturer's catalog cut sheet and sizing tables on all major mechanical equipment being used as the basis of design.

1.05 WORKING MECHANICAL DRAWINGS

A. Maintenance access space as recommended by the manufacturer shall be indicated on the drawings for all mechanical equipment Designated access spaces shall include as a minimum: equipment access door swings, control panel access, tube pulls, coil removal space, fan shaft removal space, lubrication point access, and fire box access.

B. No abbreviation or symbol shall be used on the drawings unless included in the legend.

C. No work shall be called out in a manner which is not contractually enforceable.

D. Work shall not be called out in a design / build format on drawings intended for competitive bidding unless specifically approved by the University's Representative.

E. Mechanical Equipment shall have all important features specified. (Model number alone shall not be considered sufficient) Specifications for University Projects must be open to more than one bidder per Public Works Contract Law except in very specific situations. The specifications should be written in a manner which encourages competition among vendors of equivalent mechanical equipment yet precludes inferior products. To this end the quality level of all major features should be specified. See Part 1 of the Guidelines for further guidance on the method of calling out equivalent products for University contracts.

SECTION 15300: FIRE PROTECTION

Note: This document is a listing of University requirements and is not a complete specification. Consultant shall incorporate these requirements into a specification.

PART 1 GENERAL

A. *Generally, the University requires that the consultant prepare a specification for a Contractor to design and construct (design-build) the fire protection systems to meet the specifications contained herein, including the various design and performance criteria delineated and to be responsible for the actual performance of the system according to these criteria. Verify with Project Manager that project will be design-build.*

B. *Related Work - Division 02665 - Water Distribution Standards, 16720 - Fire Alarm*

C. *Quality Assurance*

1. *Contractor to have C-16 license.*

2. *Work shall be done in accordance with the N.F.P.A., the California Administrative Code, the Campus Standards including those of the Deputy State Fire Marshal, the California Building And Fire codes, and the requirements of the California State Fire Marshal. Plans shall be stamped by a California State licensed Fire Protection Engineer or mechanical engineer.*

D. *Submittals*

1. *Provide standpipe and wet pipe fire sprinkler systems installation shop drawings, component submittal sheets and hydraulic calculations for approval of University representative and State Fire Marshal. University's Representative shall submit to Designated Campus Fire Marshal who is State Fire Marshal Representative. Do not begin installation until approval has been received.*

2. *Shop drawings shall indicate standpipe and sprinkler assembly, wiring diagrams, including zone control and detection, flow, tamper switches and supervisory devices, inspector's test valve, fire department connection, post indicating valve, etc.*

3. *Shop drawings shall indicate fire protection system connection to site water system including check assemblies.*

4. *Contractor shall notify fire alarm subcontractor if waterflow or tamper switch or P.I.V. devices are relocated from locations shown on bid documents.*

E. *Design Criteria*

1. *Contractor may with permission of the Designated State Fire Marshal, in lieu of the hydraulic calculations specified, use the prescriptive sizing method outlined in NFPA No. 13.*

2. *The sprinkler system shall provide complete automatic wet-pipe sprinkler protection throughout the building including the attic space.*

3. *The sprinkler system shall be zoned. Generally a zone should cover no more than a single floor.*

4. *The University's Representative shall work with the Deputy State Fire Marshal to determine the Project hydraulic requirements (including occupancy classification), allowing for future expansion of system, system pressure variations, and the desired margin of safety.*

5. *The following minimum pressure values should be used for sprinkler system design regardless of available site pressure values.*

   Static - 50 psi
   Residual - 40 psi
   Flow pressure - 35 psi at 1000 gpm

6. *Sprinklers shall be provided in combustible construction both below and above ceilings. Quick response heads shall be provided where required by the State Fire Marshal. On-off heads shall be provided in extra hazard areas.*

7. *Backflow prevention - Conform to AWWA recommendations for protection of potable water system. Currently this consists of a single check valve assembly.*

8. *Gongs/Bells - Use fire alarm system horns for annunciation of flow switches and monitoring of tamper switches. Do not install water gongs or bells.*

9. *Fire protection water connections to a building shall be made with a Post Indicating Valve, check valve and fire department connection that are unique to that building. For very small clusters of buildings, an exception to this policy may be made by the Fire Marshal after receiving a written request by the Project Manager and after evaluation of the site plan.*

10. *Access to main shutoff valves shall be through no more than one door which is located on the exterior of the building.*

PART 2 PRODUCTS

A. Sprinkler and Standpipe Piping

1. *Buried piping and fittings: Cement-mortar lined, ductile iron pipe conforming to AWWA C-151, Class 200, 21/45 with Tyton or as approved, mechanical joints and fittings conforming to NFPA-24. Install pipe joints anchored with tie rods and restraints. Provide concrete thrust blocks at elbows and offsets conforming to NFPA-13 and NFPA-24. Other types of UL/FM reviewed piping including PVC C900 Class 200 may be used as approved by University's Representative and the State Fire Marshal. Thrust block installation shall be inspected by State Fire Marshal.*

2. *Above ground piping and fittings: Standard weight, Schedule 40, welded and seamless black steel, ASTM A-135 or A-53 pipe conforming to NFPA-13. Fittings for pipe sizes 2-1/2 inch and smaller shall be malleable iron, black, 150 lb. standard or cast iron, 175 lb. WP, screwed ends. Fittings for pipe sizes 3 inch and larger may be as above or weld fittings, ANSI 16.9, Schedule 40, flanged or welded fittings, cast iron, 175 lb. WP. Clamp type UL/FM approved fittings may be used on concealed piping where listed by the State Fire Marshal. Piping installed outdoors shall be galvanized. Alternate piping system to be Victaulic, Grinnel, or equal grooved piping systems.*

3. *CPVC piping may be used in locations approved by NFPA 13 and the State Fire Marshal.*

C. Sprinkler and Valves

1. Flanged 175 psi minimum water pressure rating.

2. Gate (2-1/2 inch and larger): Iron body, bronze fitted 175 lb. WWP, BB, OS & Y, solid wedge flanged. Standpipe valves required shall be size 2-1/2 inch and shall have hose ends with caps and chains as required by the Deputy State Fire Marshal, bronze finish outdoors.

3. Check (2-1/2 inch and larger): Iron body, bronze fitted 175 lb. WWP, bronze disc, horizontal swing, BB, flanged.

4. Gate (2 inch and smaller): Bronze 175 lb. WWP, block pattern, OS & Y, solid wedge, screwed ends.

D. Sprinkler Heads - Heads subject to vandalism shall be protected with wire guards. Heads installed in hazardous storage areas shall be on-off type and shall be submitted to Deputy State Fire Marshall for approval.

E. Escutcheons: Install for exposed to view pipe penetrations through finished partitions, walls and floors.

F. Pressure Gauges: Dial type with 0-300 lb. range, with brass case, glass face and attachment.

G. Backflow Prevention Assembly (Where required): BEECO-Hersey, Watts, Febco or equal, reduced pressure type assembly, UL/FM approved and City of Santa Cruz approved and listed with OS & Y gate vales and tamper switches.

PART 3 EXECUTION

A. Piping runs shall be checked beforehand and with other trades to insure clearance. Provide maximum head room and run piping to maintain proper clearance for maintenance and to clear openings in exposed areas. Piping shall be run in strict coordination with mechanical ducts and equipment, structural, and architectural conditions.

B. Cutting structural members for passing sprinkler pipe or supports will not be permitted except with approval from the University.

C. Piping fittings shall not be located over electrical machinery or equipment, unless adequate insulating protection (16-gauge galvanized sheet metal pans with hemmed edges) is provided against drip caused by leaks.

D. In general, shut-off valves shall be oriented so that the valve stem is horizontal. If valves controlling sprinkler systems are inaccessible or over an elevation of 7'-0"or greater above the finished floor or grade, install permanent ladders, clamped threads on risers, chain operators or similar devices to provide access to authorized personnel.

E. Butterfly valves shall be installed with the position indicator located so it can easily be read, and the crank is within reach and easily operable.

F. Supports - Provide seismic restraints for piping and equipment as required by NFPA and C.C.R. Title 24, whichever is stricter.

G. Inspector's Test Connection - Provide test connections approximately 6 feet above the floor for the sprinkler system or portion of each sprinkler system equipped with an alarm device. Locate at the hydraulic most remote part of each system. Provide test connection piping to a location where the discharge will be readily visible and where water may be discharged without property damage. Provide discharge orifice of same size as smallest sprinkler orifice.

H. Main Drain - Provide separate drain piping to discharge at set point outside building or to sight cones attached to drain of adequate size to readily receive the full flow from drain under maximum pressure. Install main drains to the outside of the building in such a manner that full flow from the drain will not damage landscaping or surroundings.

I. Fire Department Connections - Provide connections approximately 3 feet above finish grade, of the University approved two-way type, with National Standard female 4" hose threads with plug, chain, and identifying fire department connection escutcheon plate. Connection shall be free standing (or wall mounted - coordinate with Fire Marshal).

J. Flushing and disinfection - Disinfect potable portions of the Fire Protection System as required by the State Plumbing and Health Codes and the Deputy State Fire Marshal. Newly installed piping is to be kept isolated from the system until bacteriologically acceptable. If isolation is provided by a closed gate valve, pressure testing for leakage in the new facilities shall be conducted before bacteriological acceptance. The University shall designate method and sequence of connecting mains to minimize contamination danger.

K. Tests - Tests shall be conducted at such times as directed by and in the presence of the University's Representative and the State Fire Marshal and shall be provided as required by NFPA-13, 24, and the State Fire Marshal. Piping shall be hydrostatically tested as required by NFPA-13 and NFPA-24but not less than 150 psi for two (2) hours.

L. Operating parts, including valves, waterflow detectors, and valve supervisory switches shall be tested for proper operation.

M. Contractor to submit system certification forms per NFPA-13.

SECTION 15400 PLUMBING DESIGN GUIDELINES

PART-I GENERAL

1.01 SCOPE

A. This section contains design guidelines pertaining to building plumbing systems to a point five feet outside the building foundation. Systems covered by this section include: Domestic Water, Sanitary Waste & Vent, Fuel Gas, Industrial Water, Lab Waste & Vent, Emergency Eye Washes and Showers, Pure Water, Compressed Air, Laboratory Vacuum, and Laboratory Gasses.

1.02 RELATED GUIDELINES

A. See Parts 1, 2 , & 3 of these standards for general information regarding design process, building requirements, and site requirements.

B. See Section 15010 for general mechanical design guidelines applicable to this section of the work.

C. See Section 15050 for Basic Mechanical Materials and Methods

D. See Section 15300 for Fire Protection Piping.

E. See Section 15500 for HVAC Piping

F. See Section 02665 for Underground Water Distribution five feet beyond the building foundation.

G. See Section 02685 for Underground Gas Piping five feet beyond the building foundation.

H. See Section 02730 for Sanitary Sewer five feet beyond the building foundation.

I. See Section 02810 for Irrigation Systems.

1.03 CODE RULES AND SAFETY ORDERS

A. All plumbing design shall be in accordance with the California Code of Regulations, Title 24, Part 5, The California Plumbing Code. This is an amended version of the Uniform Plumbing Code. Other codes and regulations may also apply. See Related Guidelines for further information.

1.04 CAMPUS NATURAL GAS DISTRIBUTION

A. UCSC owns and maintains the underground natural gas distribution systems throughout the campus. Gas distribution pressure is 10 PSI. The campus also has a 60 PSI distribution system. The 60 PSI distribution system is for use by the Co-Generation plant only.

B. Provide a gas regulator and meter at each new building.

C. For new buildings to be connected to the campus natural gas system, the anticipated additional gas demand should be identified early during preliminary planning. This anticipated gas demand should be submitted to the Principal Engineer for UCSC Physical Planning and Construction. Improvements to the campus system may be required to accommodate the additional demand. The Principal Engineer shall identify a suitable point of connection to the campus system and what system improvements may be necessary to accommodate the new building.

D. Refer to Section 02685, Underground Gas Distribution, for further information.

1.05 CAMPUS WATER SYSTEM

A. UCSC owns and maintains the underground water distribution system through out the campus.

B. Provide a domestic water pressure reducing valve and meter at each new building.

C. Provide a separate water meter and RP backflow preventer for irrigation at each new building.

D. Fire water should not be metered or reduced in pressure. Back flow prevention is not required for fire water.

C. For new buildings to be connected to the campus water system, the anticipated additional water demand should be identified early during preliminary planning. This water demand should be submitted to the Principal Engineer for UCSC Physical Planning and Construction. Improvements to the campus system may be required to accommodate the additional demand. The Principal Engineer shall identify a suitable point of connection to the campus system and what system improvements may be necessary to accommodate the new building.

D. Refer to Section 02685 Water System Standard for further information.

1.06 CAMPUS SANITARY SEWER

A. UCSC owns and maintains the sanitary sewer system throughout the campus.

B. For new buildings to be connected to the sanitary sewer system, the anticipated additional sewer load should be identified early during preliminary planning. This load should be submitted to the Principal Engineer for UCSC Physical Planning and Construction. Improvements to the campus system may be required to accommodate the additional load. The Principal Engineer shall identify a suitable point of connection to the campus system and what system improvements may be necessary to accommodate the new building.

C. Systems discharging to the campus sewer system shall be in compliance with the requirements of the City of Santa Cruz Waste Water Treatment Plant (Industrial Waste Inspector (408) 429-3142). Mechanical systems discharging unusual wastes may require special provisions or may not be allowed. Triggers include; high or low pH, oil, grease, chemical contamination, biological contamination, and rain water to the sewer. Mechanical systems typically impacted include: commercial kitchen waste, elevator sump pump discharge, lab process waste, and water purification system waste. The Design Professional shall be responsible for confirming impacts to the project due to the City Waste Water Discharge Ordinance. Alternatives for compliance shall be discussed with the University's Representative. Negotiations involving specific project issues shall be channeled through the UCSC Office of Environmental Health & Safety (Director).

D. For wet laboratories, the method which will be used for dealing with contaminated liquid wastes should be determined early in the design process in consultation with the University's Representative and UCSC Environmental Health and Safety (EH&S) . Contaminated liquid waste from laboratories are not allowed to be poured directly into drainage systems discharging to the campus sewers. EH&S should be consulted for procedures for dealing with liquid contaminated wastes. Contaminated wastes are typically containerized and held in the laboratory for disposal by EH&S as hazardous waste. Lab waste piping systems are provided in wet laboratories only for disposal of non hazardous liquids and as a precaution in case of an accidental spill.

F. Refer to Section 02730, Sanitary Sewer Standard, for further information.

1.07 DEFINITIONS

A. Industrial Water: Industrial Water shall be defined as a water supply system which is isolated from the potable water supply by an approved reduced pressure principle backflow preventer. See section 02665 for approved backflow preventers.

B. Lab Waste and Vent: Lab Waste and Vent shall refer to a special waste and vent system constructed of chemical resistant piping.

1.08 DESIGN CONDITIONS

A. Water System Pressure: The water pressure assumed for system pipe sizing and design shall be the lower of the following:

1. 60 PSI
2. The actual system pressure.

B. Since the water pressure in the campus water mains varies throughout the campus depending on elevation within four water pressure zones, the Plumbing Designer should request the water pressure from the University's Representative for each project. The University's Representative will provide the known pressure at a given point (usually a fire hydrant). The Plumbing Designer will be responsible for determining the pressure at the point of use and should take into account the change in elevation between the known reference point and the point of use. See section 02665 for further information on the campus water pressure zones.)

1.09 DESIGN DOCUMENTATION

See Design Documentation under Section 15010, 1.03. Additionally include the items which follow for Plumbing work.

A. Programming; For wet laboratories, studios, dark rooms, commercial kitchens, laundries, and other special use rooms requiring plumbing utilities to accommodate special functions, the Design Professional shall gather and document all information required to confirm Plumbing requirements as part of room programming. This information shall be included with the Design Development Submittal. Obtain and document the following information for each building room where special use plumbing services will be required.

1. Room name

2. Person requesting the plumbing services, Interviewer, Date

3. Room use

4. A list of required plumbing services. Include qualitative and quantitative data if available.

5. Functions / processes which the required plumbing services are intended to accommodate. Provide sufficient information to ascertain the need for special plumbing provisions such as back flow prevention, pressure regulation, drain sediment traps, etc.

6. A list of all equipment / apparatus which will require plumbing services. Include equipment manufacturer's data (connection size, use rate, etc.) if available.

7. The above programming information may be omitted for rest rooms and residential kitchens where all required design data is covered by applicable codes.

B. Calculations: The Design Professional shall include final plumbing calculations with the 50% Working Drawing submittal. These calculations shall include the following:

1. The room programming documents covered above.

2. All assumptions clearly stated. In particular, document assumptions that had to be made in order to proceed with the design in the case of insufficient data being provided by the users. The intent here is to flag assumptions which the University should verify as correct.

3. Applicable code requirements

4. Tabulated design criteria for each plumbing service by system including:

a. System

b. Location of Service (Room number)

c. Required flow quantity for each location including: water use fixture units, drainage fixture units, GPM flow rates for specialized equipment, natural gas load by both BTU/HR and CFH, CFH for air , vacuum & specialized gasses.

5. Calculated data as required to select each piece of plumbing equipment including:

a. Hot water heater demand and storage capacity.

b. Sump pump sizing data.

c. Lift station sizing data.

d. Circulation pump sizing data.

6. Pipe sizing data including: combined flow for each pipe run, developed length for each pipe run, selected pipe size based on stated criteria (sizing chart, pressure drop, fluid velocity, etc. This data may be either in tabulated form or rough pipe schematic.

7. Rainwater leader calculations

1.10 PLUMBING WORKING DRAWINGS

See Working Drawings under 15010 3.02. For Plumbing design, additionally include the items below.

A. General: Plumbing Working Drawings shall be sufficiently complete to assure high quality, fully functional plumbing systems, no contractual ambiguity, and also shall serve as a long term record of the building's plumbing systems. The following guidelines apply to all Plumbing Working Drawings:

1. No work shall be called out in a manner which is not contractually enforceable. Plumbing quality level shall be fully identified to assure fair competitive bidding as well as a quality installation.

2. Design / build format for the plumbing section of the work as is sometimes used in residential plumbing construction shall not be used on UCSC projects. An exception to this guideline shall be the case of the entire building project being design / build format when approved by the University’s Representative.

3. All points of connection to existing piping systems shall be identified.

4. All piping shall be sized .

5. The routing of all piping shall be indicated. The indicated routing shall be verified to be feasible within the furring spaces indicated in the architectural drawings.

6. All equipment and fixtures shall be located. Maintenance access space as recommended by the manufacturer shall be indicated on the drawings.

7. All piping penetrations of the building shell shall be indicated.

8. Concrete core drills of existing structures shall be identified.

B. Provide a Plumbing Legend covering all symbols and abbreviations used in the plumbing drawings in order to have a fully enforceable contract.

C. Provide a Plumbing Schedule covering factory assembled plumbing equipment and fixtures. The intent should be the easy determination of the plumbing equipment included n the project to encourage competition among comparable product suppliers. Note that when a product manufacturer's name and model are called out on the schedule to serve as the basis of design, the specifications must be also be coordinated so that the same manufacturer is the first specified. See Section 01630; Product Options and Substitutions of UCSC's standard Division 1 for further information.

D. Provide Plumbing Floor Plans to scale for each level where plumbing services are to be provided. Provide enlarged partial plans for congested areas such as public rest rooms where the normal scale plans will not adequately depict the work.

E. Sections to scale should be provided when the vertical arrangement of equipment and piping relative to other building components is critical for proper function or adequate maintenance clearance, as well as to assure the feasibility of pipe routing through tight spaces.

F. Plumbing Riser Diagrams: Plumbing riser diagrams shall be provided for multi-story buildings whenever the relative configuration of piping components cannot be depicted in the plan view alone without ambiguity. As a minimum, riser diagrams shall be provided in the Plumbing Working Drawings for the following systems: all drain waste & vent systems including lab waste, all hot water systems with circulation, all pure water systems, and any other system which includes forced circulation by pumping.

F. Plumbing Details: Plumbing details shall be provided as necessary to contractually assure a given level of quality. As a minimum, details shall be provided to cover all pipe penetrations of roofs, equipment supports, piping supports on roofs, backflow preventers, equipment installations where the relative position of plumbing appurtenances such as valves, unions, thermometer, drains, etc. are important to function, ease of service, and future replacement, pipe crossings of building expansion joints, pressure reducing assemblies, backflow prevention assemblies, roof drainage assemblies, floor drain assemblies, all pipe penetrations of exterior walls above and below grade.

G. Piping Diagrams (Schematics) shall be provided whenever the relative arrangements of plumbing components and equipment cannot be clearly depicted in the plans. As a minimum, piping diagrams shall be provided for in the Plumbing Working Drawings for water heating systems with circulation, pure water systems, and lift stations.

1.11 GENERAL PLUMBING SYSTEM DESIGN GUIDELINES BY SYSTEM

See Basic Design Priorities under 15010 1.03. For Plumbing design, additionally include the items which follow for each system.

A. Domestic and Industrial Hot & Cold Water Systems

1. Acceptable Piping Materials

a. Above Grade: Type L hard drawn copper tubing with wrought copper sweat fittings, 95/5 tin antimony solder for joining 2" and smaller pipe. 15% silver brazing conforming to AWS classification BCuP-5 for joining 2-1/2" and larger piping.

b. Below Grade: Type K hard drawn or soft copper tubing, with wrought copper sweat fittings, all connections brazed with 15% silver brazing conforming to AWS classification BCuP-5 , wrap pipe with 1 layer of 10 mil tape. Soft copper tubing with radius bends shall be used to minimize below grade fittings. (Note:Pipe layouts which place water piping under the building slab should be avoided whenever other alternatives are feasible.)

c. Below grade, beyond building footing, 3" and smaller piping, alternate material: Schedule 80 PVC pipe with socket fittings and solvent cement joints.

d. Below grade, beyond building footing ,4" and larger: Cement-mortar lined Class 150 ductile iron pipe with bell and spigot joints and cast iron fittings. Specify restraining method: thrust blocks or restrained joints. Restrained joints should be called out for pipe configurations where thrust blocking will be difficult.

c. Below grade, beyond building footing, 4" and larger, alternate material: Class 200 AWWA C-900 PVC with bell and spigot joints and cast iron fittings. Specify restraining method: thrust blocks or restrained joints. Restrained joints should be called out for pipe configurations where thrust blocking will be difficult.

2. Water Metering

a. Water meters for domestic water should be nutating disk type sufficiently accurate to record the lowest expected flow (typically the flush of a single low flush toilet). Provide compound metering if necessary to accommodate a large range of flows.

b. Provide a permanently piped full size meter bypass on all domestic water services 3" and larger. Valving should be arranged so that the meter can be removed without a disruption of water service.

c. All water meters should record in cubic feet.

d. Meters for irrigation may be either nutating disk or turbine type depending on expected flow.

3. Water Pressure Reducing Valves

a. Provide a pressure reducing valve (PRV) which will limit the supply pressure to 80 PSI at the domestic water entry point to each building. This PRV shall be provided on water services with pressure below 80 PSI as well as above in order to provide additional protection in the event of a loss of pressure control in the campus water mains.

b. For low system pressures where a PRV may cause an undesirable pressure loss an exception to this requirement may be granted upon obtaining approval from the University's Representative.

c. *Provide compound PRV's where required to accommodate a large range of flows.*

d. *Fire water should not be reduced in pressure. Separate fire water from domestic water ahead of the PRV.*

4. *Valving: Water piping systems shall be provided with manual isolation valves at the following locations:*

a. *At branch connections to underground system mains.*

b. *At all building points of entry.*

c. *On both sides of piped in devices which may need to be removed for servicing including water meters, back flow preventers, pressure reducing valves, strainers, pumps, etc.. The devices shall be removable without draining down the building system.*

Exception: On small branch lines (1 inch and less) where the quantity of building water is small, the valve on the downstream side of the device may be omitted.

d. *At each floor where branch piping connects to a riser.*

5. *Domestic / Industrial Hot Water*

a. *For water conservation, all systems shall be designed to provide near immediate hot water at fixtures by using either a hot water circulation pump or electric heat tape. An exception to this is small systems with a short distance (50 feet or less) between the water heater and the fixture. Verify with the University Representative whether heat tape or circulation will be used on a project by project basis.*

b. *For systems with a hot water circulation, verify that the pump is not over selected and that the pipe velocities due to circulation will be reasonably low. (Copper fitting failure due to high velocity scouring has been a problem)*

c. *Domestic hot water heaters shall be gas fired, to minimize campus electrical demand as well as energy use cost.*

Exceptions:

1. *Domestic hot water in buildings served by the campus central heating water system should be provided from a storage tank equipped with a double wall heat exchanger. (An exception to this may be allowed in the case of buildings with very low anticipated domestic hot water usage)*

2. *Lavatories with small usage which are remotely located from a central system may be provided with hot water from a small electric storage type water heater with a maximum electrical demand of 1.5 kW. This exception shall not apply to shower usage. Instantaneous electric water heaters are not permitted due to high electrical demand.*

d. *Provide separate heating sources for domestic hot water and space heating water except for buildings served by the campus central heating water system.*

f. Water heaters shall be installed in a sheet metal drain pan (smitty pan) with drain outlet piped to a safe location on the building exterior or floor drain.

Exception; Water heaters installed on a concrete floor slab where leakage would not damage the floor or building. Provide a floor area drain in the vicinity of the water heater.

g. All hot water piping shall be insulated.

6. Water systems shall be designed to prevent water hammer. Provide properly sized shock arrestors adjacent to all quickly closing valves including toilet flush valves, washing machines, dish washers, and solenoid valves. Provide a ball valve below each shock arrestor to allow for removal without system drain down. Provide access doors for all shock arrestors in concealed locations. Shock arrestor locations and sizes should be positively identified within the contract documents.

7. Disinfection

a. All potable water systems shall be disinfected and analyzed for bacteriological content. (Note: On UCSC projects, fire protection systems should also be disinfected, since they are installed without approved backflow protection)

b. Bacteriological analysis shall be completed by a third party laboratory approved by the UCSC Office of Environmental Health & Safety (EH&S). The laboratory shall be submitted via the University's Representative for approval by EH&S a minimum of 72 hours prior to conducting disinfection. Analysis results shall be submitted via the University Representative to EH&S to certify compliance with the specifications. Disinfection procedure shall be repeated should EH&S indicate that compliance with the applicable regulations has not been achieved.

8. Provide an industrial water system for non potable uses at all wet laboratories, faucets with serrated tip for hose connections, dark rooms, and all other locations using toxic or hazardous materials and requiring water service for uses other than drinking. Backflow protection shall be by a reduced pressure principal type back flow preventer. See section 02665 for approved backflow preventers.

B. Sanitary Waste and Vent Systems

1. Acceptable Piping Materials

a. Above Grade Sanitary Waste and Vent Piping: Service weight, no hub, cast iron soil pipe with cast iron DWV fittings, neoprene coupler with stainless steel clamp and shield.

b. Below Grade Sanitary Waste and Vent Piping: Serviceweight, no hub, cast iron soil pipe with cast iron DWV fittings, extra heavy neoprene coupler with stainless steel clamp and shield (Husky, Clamp All, or equal)

c. Above Grade Vent Piping (Alternate materials)

1. Schedule 40 galvanized steel pipe with recessed screwed cast iron drainage fittings.

2. Type DWV copper with DWV solder fittings, 50/50 equivalent lead free solder.

d. Above / Below Grade Waste and Vent Piping (Alternate material for student housing buildings up to 3 stories only) Schedule 40 ABS DWV pipe and DWV fittings with solvent cement joints.

2. Waste vents shall be located a minimum distance of 30 feet horizontally from HVAC air intakes and occupied roof areas. Additionally, waste vents shall be extended with a support system to a level seven feet above the roof when the roof is occupied (such as in the case of roof mounted green houses). Waste vents shall not be located in confined roof wells where HVAC air intakes are located.

3. Provide accessible cleanouts at all levels of the building the same as required by code for first floor and lower levels.

4. Avoid sewage lift stations where possible. Gravity flow of sewage is preferred and is usually achievable due to the significant elevation change of most building sites on the campus. If a lift station is required, minimize the required capacity by segregating out upper level waste which can be gravity flow. Lift stations should be duplex pump type, powered by emergency power, with alarm contacts provided as an input to the building management system. Lift stations which handle rest rooms sewage shall be grinder type.

5. Floor drains shall be equipped with trap primers. Trap primer shall be accessible and equipped with a shut off valve to allow for servicing without system drain down.

E. Building Storm Water

1. Acceptable Piping Materials

a. Above Grade: Service weight, no hub, cast iron soil pipe with cast iron DWV fittings, neoprene coupler with stainless steel clamp and shield.

b. Below Grade Sanitary Waste: Service weight, no hub, cast iron soil pipe with cast iron DWV fittings, extra heavy neoprene coupler with stainless steel clamp and shield (Husky, Clamp All, or equal).

2. Insulate building storm water piping inside buildings to prevent building damage due to condensation on the pipe exterior.

F. Natural Gas Systems

1. Acceptable Piping Materials

a. Above Grade 2" and smaller: Schedule 40 black steel pipe with treaded 150 pound black malleable iron fittings. Paint all exterior and exposed piping to prevent rust.

b. Above Grade 2-1/2" and larger: Schedule 40 black steel pipe with welded steel fittings. Paint all exterior and exposed piping to prevent rust.

c. Below Grade: See Section 02668 Underground natural gas.

d. Transition Riser from below grade: See Section 02668 Underground natural gas.

2. Building Gas Pressure: Regulate gas before entering buildings from 10 PSI to 7 inches water column. Size the building gas distribution system based on a pressure of 7 inches water column. For some special high gas use applications such as large boilers, *a 2 PSI mechanical room gas pressure may be allowed when approved by the University Representative and permitted by code.*

3. *Regulators: Gas Regulators should be specified to include an under pressure shut off feature to automatically shut off the gas in the event of a down stream pipe rupture.*

4. *Earthquake Valves: Provide seismic gas shut off valves on gas services to all buildings which are intended to be used for student housing or as a residence. Seismic gas shut off valves are not required on non-residential buildings.*

5. *Gas Meters*

   a. *Gas meters may be either diaphragm bellows or turbine type as appropriate for the application. Gas meters shall record in cubic feet.*

   b. *Except where covered under c., below, provide valving and connections to allow for the use of a temporary meter bypass (3/4 inch hose) when removing the meter for servicing. This bypass should be configured such that the meter may be removed while still supplying limited gas service to keep pilot lights lit.*

   c. *For large academic buildings (greater than 30,000 gross square feet), commercial kitchens, and gas service which supplies an emergency generator, provide valuing and permanent piping for a full sized bypass of the meter. The by pass shall be configured to allow for meter removal without disruption of gas service.*

6. *Gas piping shall not be routed under building floor slabs.*

7. *Prior to installing new gas appliances in existing buildings, verify the gas pressure with the University Representative. In some cases, the gas pressure has been increased to medium pressure to compensate for under sized gas piping. Provide an additional gas regulator near the appliance in the event that the existing building gas pressure exceeds the listing on the regulator to be furnished with the gas appliance. (Note: Gas appliances are often furnished with regulators which are only listed for a maximum inlet gas pressures of either 9 or 14 inches water column.) Provide regulator with a flow limiting orifice or with vent piped to outdoors as required by code. Review regulator location and safety issues with the University's Representative on a case by case basis. As a general rule, medium pressure gas should be reduced to low pressure prior to piping through spaces which are normally occupied. Medium pressure gas shall not be permitted in occupied spaces used for student housing or a residence.*

8. *Valving: Gas piping systems shall be provided with manual isolation valves at the following locations:*

   a *At building points of entry.*

   b. *At each floor where branch piping connects to a riser.*

   c. *At each gas appliance.*

   d. *At branch connections to underground system mains.*

G. *Lab Waste and Vent Systems*

1. *All wet laboratories, all fume hoods with cup sinks, and all other locations using chemicals which could damage standard DWV piping in the event of an accidental spill shall be provided with a lab waste and vent system. The lab waste and vent system shall*

be made of chemically resistant piping materials. The lab waste and vent system shall merge with the building sewer at a location outside of the building. Prior to combining the two systems, provide a lab waste sampling station (typically a manhole with a sump for sample collection).

2. *Acceptable Piping Materials*

   a. *Above and below grade Lab Waste and Vent Piping; (Preferred where permitted by code and allowed by Fire Marshal); Polypropylene acid resistant DWV piping and fittings conforming to ASTM D635 flammability requirements. Fusion welded fittings throughout except for trap connections, which shall be mechanical joint. (GSR Fuseal, Proline, or equal).*

   b. *Above and below grade Lab Waste and Vent Piping; (Alternate material); Chemical resistant coated cast iron pipe with matching mechanical joint DWV fittings. (Duriron or equal)*

   c. *Above grade Lab Waste and Vent Piping; (Alternate material); Chemical resistant glass acid piping with glass DWV mechanical joint fittings. (Pyrex , Kymax, or equal).*

3. *Lab waste vents shall be located a minimum distance of 50 feet horizontally from HVAC air intakes and occupied roof areas. Additionally, lab waste vents shall be extended with a support system to a level seven feet above the roof when the roof is occupied (such as in the case of roof mounted green houses). Lab waste vents shall not be located in confined roof wells where HVAC air intakes are located.*

4. *Provide accessible cleanouts at all levels of the building the same as required by code for the first floor and lower levels.*

5. *Floor drains shall not be provided in laboratories using hazardous materials as precaution against such materials being discharged to the sewer system. The floor system should be designed to provide containment of such materials in the event of an accidental spill.*

H. *Emergency Eye Washes & Showers*

1. *Locations where hazardous materials are used or stored shall be provided with emergency eye washes in compliance with California Code of Regulations, Title 8 (Cal-OSHA) Section 5162, ANSI Z358.1 - 1990 and applicable ADA requirements.*

2. *Emergency eye washes and showers shall be supplied from the potable water system. Industrial water shall not be used to supply these fixtures.*

3. *Emergency eye wash and shower control valves shall remain open once activated until intentionally shut off.*

4. *Emergency eye washes and showers shall be located a distance no greater that 100 feet from the hazard and shall require no more than 10 seconds for an injured person to reach.*

5. *Floor drains shall not be provided at emergency showers in order to contain hazardous materials. The adjacent floor and walls should be designed to provide containment and also to be resistant to water damage. The plumbing design professional should coordinate this issue with the project Executive Architect.*

I. *Building Pure Water Systems*

1. *Building (house) pure water systems shall be designed to guarantee a water quality level of at least Lab Grade 3 per National Committee for Clinical Laboratory Standards (NCCLS) at all times . Individual laboratories requiring a guarantee of purer water shall install additional purification equipment in the laboratory as part of the building equipment (reference; Letter of Understanding dated 3-19-90, J. West; Physical Plant to K. McCaffrey; Natural Sciences).*

2. *The makeup water shall include pre-treatment consisting of a prefilter, a water softener, an activated carbon absorption filter, and a five (5) micron filter followed by treatment which shall consist of a reverse osmosis (RO) unit, mixed bed deionizer exchange service tanks, an ultra-violet light, and a 0.2 micron filter. Make up water capacity shall be determined in conjunction with sizing of the system storage tank.*

3. *The entire piping system shall be continually circulated. Dead legs shall be limited to drops to individual lab outlets. (Confirm maximum dead leg distance for each application) The entire circulating volume shall be exposed to ultra-violet light on each circulation. Provide dual stainless steel circulation pumps to allow for continued circulation in the event of pump failure.*

4. *The system shall include a storage tank sized to allow make up to occur over a 12 hour period while accommodating maximum anticipated use with 20 % excess capacity. Determination of maximum system use shall include a diversity factors which shall be determined with the University's Representative for each system.*

5. *The system shall include a side stream polishing loop which will continually circulate a portion of the water circulating through the system back through the mixed bed deionizers prior to return to the storage tank.*

6. *Provide a back pressure valve on the return piping to the storage tank set to assure adequate pressure at the highest most laboratory faucet.*

7. *Provide pressure gauges on both sides of all filters and pumps.*

8. *Building (house) pure water systems shall be monitored by the Building Management System to provide alarms to the Physical Plant watch stander at the campus Central Heat Plant. Alarms shall be generated in the case of Water quality (conductivity) out of range, low tank level, and no flow.*

9. *Acceptable Piping Materials:*

   a. *Socket fused polypropylene prepared specifically for deionized service. Pipe shall be sterilized and capped immediately after production. Fittings, valves, and unions shall be sterilized and individually wrapped immediately after production. Continuous trough support system.*

   b. *Schedule 80 PVC with solvent weld fittings prepared specifically for deionized service. Pipe shall be sterilized and capped immediately after production. Fittings, valves, and unions shall be sterilized and individually wrapped immediately after production. Continuous trough support system.*

   c. *Confirm piping material with the University's representative on a case by case basis.*

   d. *Valves shall be diaphragm type.*

10. *Valving: Pure water piping systems shall be provided with manual isolation valves at the following locations*

a. At each floor where branch piping connects to a riser.

b. On both sides of piping elements which may need to be removed for servicing including filters, pumps, ultraviolet lights, mixed bed deionizers, and RO Units.

c. At branch connections to mains.

11. Provide provisions for system drain down to a floor drain including drain down of storage tanks.

J. Building Compressed Air Systems

1. Acceptable Piping Materials;

a. (Laboratory & Instrument Air Applications) Hard drawn ACR copper tubing with wrought copper sweat fittings. Tubing pre-washed, degreased and capped at both ends by manufacture. Fittings pre-washed, degreased and wrapped by the manufacturer. All joints brazed with 15% silver brazing conforming to AWS classification BCuP-5. Brazing shall be done with nitrogen purge to be prevent oxidation.

b. (Alternate material for Shop Air Applications Only): Schedule 40 galvanized steel pipe with treaded 150 pound galvanized malleable iron fittings.

c. (Alternate material for Shop Air Applications Only): Type L hard drawn copper tubing with wrought copper sweat fittings, 95/5 tin antimony solder

2. Building (house) compressed air shall not be shared with the building pneumatic compressed air system for HVAC controls. Building (house) compressed air and HVAC pneumatic control air shall be separate stand alone systems complete with their own dedicated compressors.

3. For laboratory and instrument air, provide oil filter with automatic drain, and refrigerated air drier. For shop air applications, confirm requirements with users.

4. Valving: Compressed air systems shall be provided with manual isolation valves at the following locations:

a. At each floor where branch piping connects to a riser.

b. At the compressor.

c. At branch connections to mains.

d. Upstream of any equipment connected to compressed air.

5. Shop air systems typically require quick couple disconnect fittings for connection of flexible hoses. Confirm requirements with users.

K. Building Vacuum Systems

1. Acceptable Piping Materials

a. Type L hard drawn copper tubing with wrought copper sweat fittings, 95/5 tin antimony solder for joining 2" and smaller pipe. 15% silver brazing conforming to AWS classification BCuP-5 for joining 2-1/2" and larger piping.

2. Likely constituents of vacuum exhaust shall be determined and documented with the users to assist determination of vacuum exhaust location and degree of hazard due to discharged gasses.

3. Vacuum exhaust shall either be piped into the fume exhaust system or directly piped to a safe exterior location 7 feet minimum above the building roof. Vacuum exhaust discharge location should be carefully chosen so as not to create nuisance odors or hazards at operable windows, paths around the building, or other occupied exterior spaces. Vacuum exhausts which may create a nuisance or hazard should be piped to the same point as fume exhaust discharge for entrainment in the fume exhaust plume. House vacuum pump should be electrically interlocked with the fume exhaust fan in cases where the vacuum exhaust is directly connected to the fume exhaust system.

3. House vacuum pumps shall be protected by a drop out pot on the vacuum side of the unit.

L. Laboratory Gasses

1. For Laboratory Buildings with a B Occupancy classification, verify that the quantity of stored gases classified as hazardous materials does not exceed the exempt quantities called out in the Building Code. H occupancy classification may otherwise be required.

2. Systems and storage for toxic gases shall be in compliance with the Uniform Fire Code including California Amendments in particular Section 8003, covering toxic compressed gases. Additionally, such systems shall be in compliance with the Toxic Gas Ordinance as written by the Western Fire Chiefs Association. Inform both the Executive Architect and University's Representative of requirements for gas storage cabinets, double containment piping, monitoring systems, and maximum quantity limitations in order to assure coordination among all disciplines.

3. Storage and piping concepts for laboratory gasses should be reviewed with UCSC Environmental Health and Safety via the University's Representative early in the design process. Issues include the possibility of asphyxiation (includes inert gasses) in confined spaces, as well as hazardous material concerns.

4. Laboratory gasses will not be used or stored in rooms having a HVAC system which returns air for recirculation.

5. Provide seismic restraint systems for all gas canisters and dewars.

6. Acceptable Piping Materials

a. Inert, Non toxic Gases (nitrogen): Hard drawn ACR copper tubing with wrought copper sweat fittings. Tubing shall be pre-washed, degreased and capped at both ends by the manufacturer. Fittings shall be pre-washed, degreased and wrapped by the manufacturer. All joints shall be brazed with 15% silver brazing conforming to AWS classification BCuP-5. Brazing shall be done with nitrogen purge to prevent oxidation.

b. Other Gasses: Piping materials shall be selected on a project by project basis to meet specific program, compatibility, and regulatory requirements. Design for all toxic or hazardous gasses shall be reviewed and approved by EH&S.

7. Valving: Laboratory gas systems shall be provided with manual isolation valves at the following locations *a. At each floor where branch piping connects to a riser.*

b. At the gas canister connections.

c. At branch connections to mains.

d. Upstream of any equipment connected to the laboratory gas system.

1.12 PLUMBING GUIDELINES FOR SPECIFIC APPLICATIONS

A. Boiler / Chiller Room Plumbing

1. Provide floor drains / sinks for relief valve drains and to allow for drain down of closed loop systems. Coordinate locations with equipment layout so that piped equipment drains will not be a trip hazard in service aisles. Select floor drains/sinks to contain spill over and splashing due to equipment drain discharge.

2. Provide make up water through a RP backflow preventer for each closed loop system.

B. Plaster / Sand Use.

1. Rooms where plaster or other sediment material is used shall be equipped with a dedicated above grade sand trap on the drain outlet of each sink. Typical applications include art studios using plaster, anthropology labs using plaster for bone castings, etc..

C. Dark Rooms

1. Provide RP back flow preventers for hot and cold water to dark room sinks.

D. Fume Hoods

1. For each plumbing fume hood plumbing service, provide a manual isolation valve and union at the piping drop above each fume hood so that the hood can be easily removed with minimal disruption of building piping.

E. Commercial Kitchens

1. Per City of Santa Cruz Waste Water Discharge Ordinance, a large outdoor grease trap is typically required. Position grease trap to allow for easy access for pumping and minimal nuisance odors at occupied locations while pumping.

F. Elevator Sump Pumps

1. See Division 11 for sump oil sensing requirements.

PART-II PLUMBING MATERIALS & EQUIPMENT

2.01 Introduction: Following is a brief description of the key features which should be incorporated in the specifications for various plumbing materials and equipment. Where a specific product is stated with model number, that product should be used as the basis of design and listed as the first named in the specifications. Manufacturers listed without model number are intended to give the designer input on manufacturers whose products have been found to be acceptable. See Section 01630, Product Options and Substitutions of UCSC's standard Division 1 for further explanation on using manufacturers and model numbers within specifications.

2.02 General Quality Level: Generally, plumbing material and equipment selected should be institutional grade. Long life and simple low cost maintenance are critical attributes for nearly all UCSC projects. Plumbing fixtures in public areas should also be selected to endure rough use and daily janitorial cleaning.

2.03 Equipment

A. Air Compressors

1. Large house systems: Liquid ring type. (Nash or equal). Provide water saving circulation option with cooling water heat exchanger.

B. Vacuum Pumps

1. Large house systems: Liquid ring type. (Nash or equal). Provide water saving circulation option with cooling water heat exchanger.

C. Water Heaters: 10 Year Tank Warranty; State, A.O. Smith, or equal

2.04 Fixtures

A. Faucets

1. Lavatory, Student Housing: Heavy duty commercial grade single handle faucet; deck mounted with 4" centerset , chrome plated finish, vandal resistant handle, brass body, washerless design, rotating ball control mechanism with replaceable non metallic seats and stainless steel socket, vandal resistant .5 GPM flow restrictors spray outlet, left rod operated metal drain (Delta Commercial Faucet 520-WFHDF or equal)

2. Lavatory, Public: Heavy duty commercial grade single handle faucet; deck mounted with 4" centerset, chrome plated finish, vandal resistant handle, brass body, washerless design, rotating ball control mechanism with replaceable non metallic seats and stainless steel socket, vandal resistant .5 GPM flow restrictor spray outlet, and grid drain (Delta Commercial Faucet, Model 523-WFHDF or equal)

3. Kitchen, Student Housing: Heavy duty commercial grade, single handle faucet, deck mounted with 8" centers, 8" swing spout, chrome plated finish , vandal resistant handle, brass body, rotating stainless steel ball control mechanism with replaceable non-metallic seats and stainless steel socket, vandal resistant 2 GPM flow restrictor aerator. (Delta Commercial Faucet, Model 100 WFELHHDF or equal)

D. Shower Valves

1. Shower, Student Housing: Institutional grade, pressure balancing, adjustable safety limit temperature stop control. (Chicago Faucet 1762 or equal).

2. Shower, Public: Institutional grade, pressure balancing, adjustable safety limit temperature stop control. (Chicago Faucet 1762 or equal).

E. Toilets

1. Student Apartments

a. Toilet shall be 1.6 GPF vitreous china round front bowl, with direct flow priming jet and reverse trap. Hydraulic performance exceeding ANSI A112.19.2 requirements. (Kohler Wellsworth Lite K-3420, American Standard Cadet II 1.6 , or equal)

Seat: All plastic, closed front with cover, stainless steel hinge. (Olsonite or equal)

2. *Public Rest rooms (including dormitories)*

    a. *Toilets shall be 1.6 GPF, wall hung with support carrier, vitreous china, elongated, flush valve type exceeding ANSI A112.19.2 requirements (Kohler Kingston Lite K-4330, American Standard Afwell EL1.6, or equal).*

    Flush valve: 1.6 GPF (Sloan, Zurn , or equal).

    Seat: All plastic, open front elongated without cover; stainless steel hinge. (Olsonite or equal)

    b. *Alternate toilet for single stall public rest rooms where light use is expected: Toilet shall be 1.6 GPF with hydro-pneumatic pressure assisted flush, vitreous china, floor mounted, elongated bowl, exceeding ANSI A112.19.2 requirements. (Wellsworth Lite PC, American Standard, Cadet EL 1.6/PA , or equal)*

    Seat: All plastic, open front elongated without cover; stainless steel hinge. (Olsonite or equal)

F. *Urinals*

1. *Maximum 1.0 GPF, vitreous china, wall hung with flush valve, exceeding ANSI A112.19.2 requirements. (Kohler, American Standard, or equal)*

    Flush Valve: 1.0 GPF; (Sloan, Zurn, or equal)

2.05 Materials

A. *Fixture Traps: Chrome plated, 17 gauge cast bronze.*

B. *Hose Bibbs: 3/4” hose connection, chrome plated, with vacuum breaker, loose key. (Chicago Faucet, Acorn, or equal)*

C. *Water Meters:*

1. *Domestic Water: Nutating disk, magnetic drive, bronze case (Hersey 562, 572, or equal).*
2. *Irrigation Water: Turbine type, magnetic drive, bronze case (Hersey MVR series or equal).*

D. *Pressure Reducing Valve: Bronze with Teflon disk and diaphragm (Bailey 30A or equal).*

E. *Valves*

1. *General Purpose Ball Valves, 2-1/2" and smaller: Nibco or equal, Provide threaded valve with downstream union.*

PART-III METHODS

3.01 Testing

A. *General*

1. *All new piping shall be tested prior to tie in to existing systems.*

2. *Do not test against existing valves when connecting into an existing system. Provide a slip blind at the valve flange or other suitable isolation.*

3. *Test gauges shall have 3" minimum dial, with oil fill and gauge cock. Gauge calibration shall be verified to the satisfaction of the University's Inspector prior to commencing testing.*

B. *Domestic and Industrial Hot & Cold Water Piping*

1. *150 PSIG test pressure for a period of 4 hours using a test medium of water.*

2. *200 PSIG test pressure for a period of 4 hours using a test medium of water for portions of the system which serve both the fire suppression system and the domestic water .*

C. *Drain, Waste & Vent Piping Including Lab Waste: 10 feet of head for a period of 1 hour using a test medium of Water.*

D. *Natural Gas Piping: 50 PSIG test pressure for a period of 4 hours using a test medium of air.*

E. *Compressed Air Piping: 150 PSIG test pressure for a period of 4 hours using a test medium of air.*

F. *Pure Water Piping Systems: 100 PSIG test pressure for a period of 4 hours using a test medium of purified water.*

SECTION 15500 HEATING, VENTILATING, AND AIR CONDITIONING

PART-I GENERAL

1.01 SCOPE

A. This section contains design guidelines pertaining to building Heating, Ventilating, and Air Conditioning Systems (HVAC)

1.02 RELATED GUIDELINES

A. See 15010 for general mechanical design guidelines applicable to this section of the work.

B. See 15050 for Basic Mechanical Materials and Methods

B. See 15990 for Air Balancing.

C. See 17920 for Building Management System (Direct Digital Controls).

D. See Parts 1, 2 , & 3 of these standards for global information regarding design process, building requirements, and site requirements.

E. See O2666 for Campus District Heating Water System.

F. See 02667 for Campus District Cooling Water System.

1.03 CAMPUS DISTRICT HEATING WATER SYSTEM

A. The core academic buildings on campus are served by a district heating water system. This system should be used as the primary heat source for space heating and hot water for all new buildings constructed in the core. Confirm primary heating source for specific buildings with the University's Representative.

B. For new buildings to be connected to the district heating system, the anticipated additional heating load should be identified early during preliminary planning. This load should be submitted to the University 's Representative for review by the Principal Engineer for Physical Planning and Construction. Improvements to the district system may be required to accommodate the additional heating load.

C. Refer to Section 02666 District Heating Water System for further information.

1.04 CAMPUS DISTRICT COOLING WATER SYSTEM

A. The core academic buildings on campus are served by a district cooling water system. This system should be used as the primary heat rejection source for HVAC chillers, process chillers, water cooled refrigeration and water cooled lab equipment for all new buildings constructed in the core. Confirm primary heat rejection source for specific buildings with the University's Representative.

B. For new buildings to be connected to the district cooling water system, the anticipated additional heat rejection load should be identified early during preliminary planning. This load should be submitted to the University's Representative for review by the Principal Engineer for Physical Planning and Construction. Improvements to the district system may be required to accommodate the additional heat rejection load.

C. Refer to Section 02667 District Cooling Water System for further information.

1.05 DEFINITIONS

A. Air Conditioning: The term, "air conditioning" shall be defined as an HVAC system which uses a refrigeration process to lower the temperature of the air. Examples are systems employing chillers, condensing units, absorption chillers, refrigeration compressors, etc.

B. Ventilation: The term ventilation shall be defined as providing cooling using outdoor air at ambient temperature. Natural ventilation shall refer to ventilation through operable windows, sky lights, and other openings in the building. Forced ventilation shall refer to ventilation systems which use fans to move the air.

1.06 DESIGN CONDITIONS

A. Outdoor Design Conditions: For the Santa Cruz Campus the following outdoor conditions shall be used as the basis for general HVAC systems design. This is the 2% design condition as published in Appendix C of the Nonresidential Manual by the California Energy Commission. For critical applications confirm design criteria with the University's Representative.

Summer Design:	*88 ^{o} F Dry -Bulb, 66 ^{o} F Wet -Bulb, 28 ^{o} F Daily Range*
Winter Design:	*27 ^{o} F Dry-Bulb*
Latitude:	*37 degrees north*

B. Indoor Design Temperature: The following shall be used as the basis of design for determining HVAC loads in general spaces.

Cooling: 75 ^{o} F (Air Conditioning)
Heating:70 ^{o} F

Notes:

1. Research labs, electronic equipment rooms, clean rooms and other specialized spaces may have different requirements. The design professional shall be responsible for identifying rooms with differing requirements as part of programming.

2. Per the Facilities Manual, 78^{o} F is the standard cooling set point to initiate mechanical cooling on systems equipped with air conditioning. A lower temperature is used as the basis of design for cooling to assure adequate capacity and also to allow for future flexibility.

C. Minimum Outside Air: All building spaces shall be provided with minimum outside air (OSA) per the requirements called out in Title 24, Part6 (California Energy Efficiency Standards). Minimum OSA air volumes shall be called out on working drawings for each air handling system.

D Acoustics: The following acoustical criteria shall be used in selection of HVAC components contributing to room noise when no specific guidance has been given in the program. The design professional shall be responsible for identifying spaces with special acoustical requirements as part of building programming.

Offices	*NC-30*
Class Rooms	*NC-30*
Lecture Halls	*NC-30*
Corridors	*NC-40*
Wet Labs	*NC-50*

1.07 DESIGN DOCUMENTATION

A. See Design Documentation under 15010 1.03. Additionally include the following for HVAC work.

B. Programming; The Design Professional shall gather and document all information required to confirm HVAC requirements as part of room programming. This information shall be included with the Design Development Submittal. Obtain and document the following information for each building room based on input from: the Users, the Physical Planning and Construction Staff, the Program, and these Standards:

1. *Room name*
2. *Interviewer, Interviewees, Date*
3. *Room use*
4. *Square footage and ceiling height.*
5. *Number of occupants in the space.*
6. *A detailed list of all heat producing equipment to be installed in the space including associated cooling loads.*
7. *Room temperature requirements. (Confirm / document if room activity requires special temperature control beyond those indicated in these standards.)*
8. *Room humidity requirements. (Confirm / document if room activity requires humidity control beyond those indicated in these standards.)*
9. *Room cleanliness requirements. (Confirm / document if room activity requires a clean room.)*
10. *Room NC Level. (Confirm / document if room activity requires special acoustical control beyond those indicated in these standards.)*
11. *A determination as to whether the room use will require single pass ventilation (wet labs, dark rooms, metal shops, copy machine center, etc.)*
12. *For laboratories requiring fume exhaust compile a detailed list of all chemicals that will be used and stored in the laboratory including quantities.*

C. Calculations: The Design Professional shall include final HVAC calculations with the 50% Working Drawing submittal. These calculations shall include the following:

1. *The room programming documents covered above.*
2. *All assumptions clearly stated.*
3. *References for equations used.*
4. *Design criteria clearly stated*
5. *Room by room design heating and cooling loads calculated in accordance with the procedures called out in the most recent edition of the ASHRAE Fundamentals Handbook. (Cooling load calculations shall be provided for areas with forced & natural ventilation, as well as air conditioned areas. Use a 75 ^{o} F interior design temperature.)*

6. *Equipment selection calculations*

7. *Minimum OSA volume calculation for each air handling system.*

8. *Room air volume calculations, including minimum OSA requirement.*

9. *Ductwork sizing data: sizing criteria, CFM by duct run, duct size for run based on stated criteria.*

10. *Pipe sizing data: sizing criteria, GPM by pipe run, associated pipe run for stated criteria.*

11. *Room air changes (where part of design criteria).*

12. *Fume hood exhaust based on sash dimensions.*

13. *Background design nformation for all custom designed local exhausts (i.e. snorkel exhaust, slot hoods, custom designed industrial exhaust hoods, etc.) included in the project. This information shall include: the design intent, the fumes to be exhausted, the required capture velocity, and the maximum safe working distance from the exhaust intake.*

1.08 HVAC WORKING DRAWINGS

A. *See Working Drawings under 15010 3.02. For HVAC design, additionally include the following.*

B. *The working drawings shall document Room HVAC Data for quick future reference. Provide a spreadsheet on the drawings documenting Room HVAC Data. In most cases, this spread sheet will have no bearing on the contract and should be labeled “For Reference Only”’ The spread sheet shall include the following:*

1. *Room number*

2. *Room Name*

3. *Room Square Footage and Ceiling Height*

4. *HVAC systems serving the room (AH-1, EF-2, etc.)*

5. *Number of people in space per Title 24 requirements for determining ventilation.*

6. *Room Design OSA Ventilation Rate (CFM) per Title 24 requirements. (For rooms where natural ventilation is being used, identify the natural ventilation opening (operable window, operable sky light, etc.), list the opening area (FT^2) , list the minimum opening size to satisfy Title 24 requirements (FT^2).)*

7. *Minimum supply air to meet Title 24 OSA requirements based on minimum OSA percentage at main air handler (Where Applicable).*

8. *(Title 24 Compliance Document Mech-4 may be used for items 5, 6, & 7 above except for rooms using natural ventilation.)*

9. *Room Design Heating Load (BTUH)*

10. *Room Design Supply Air Volume Flow Rate*

11. Criteria which Air Volume Flow Rate is Based On (i.e.; CFM @ $\underline{X}^{o}$F approach to satisfy cooling load, ACh/Hr, CFM/Ft^{2}, Match required exhaust, etc.)

Items 12 through 16 applicable to systems with air conditioning only

12. Room Total Design Cooling Load (BTUH) (Sensible / Latent)

13. Room Internal Equipment Cooling Load (Watts) incorporated in the design cooling load.

14. Room Lighting Cooling Load (Watts) incorporated in the design cooling load.

15. Room People Cooling Load (Number of People / BTUH ; Sensible & Latent) incorporated in the design cooling load.

16. Room Wall / Glass Cooling Load (BTUH) incorporated in the design cooling load.

17. List other pertinent data valuable for future quick reference. Common future issues which this spread sheet is intended to address: quantity of heat producing equipment which can be installed in the room, verification of sufficient OSA ventilation, etc.

C. Return Air Plenums / Non-Ducted Returns: For non-ducted return air systems, indicate the following reference information on the working drawings:

1. The path of return air through the ceiling plenums and other non-ducted areas include minimum sizes for all above ceiling wall openings. (Intent of this requirement is to assure coordination with full height walls.)

2. Extent of ceiling spaces which are return air plenums. (Intent of this requirement is to assure coordination with code requirements for materials in a plenum such as plenum rated data cables.)

D. For clean rooms, the intended class of each space shall be called out on the drawings for reference.

1.09 GENERAL HVAC SYSTEM DESIGN GUIDELINES

A. See Basic Design Priorities under 15010 1.03. For HVAC design, additionally include the items which follow.

B. UCSC has a policy of not providing air conditioning for human comfort. In spite of this policy, human comfort during the cooling season is an important design priority. Natural or forced ventilation shall be used to provide cooling in buildings not programmed for air conditioning. Building designs should include provisions to:

1. Minimize and delay heat gain through the building envelope; shade south, east, and west facing windows . Provide increased insulation, and mass. Avoid placing windows adjacent to heat gathering surfaces such as roof setbacks, black asphalt, etc.

2. Maximize ventilation efficiency: Use cross ventilation, air handler air intakes in cool locations, full economizers on air handlers, etc.

3. Rooms with high cooling loads should be identified early in the design process. A list of these rooms should be submitted to the University's Representative no later than the Design Development submittal. These rooms will be evaluated for air conditioning on a case by case basis. The Design Professional shall inform the University's Representative in writing of any room encountered where the design sensible cooling *load exceeds 20 BTUH per square foot, the internal equipment load exceeds 4 watts per square foot, or the occupant density exceeds 1 person per 60 square feet. The factors contributing to the cooling load shall be scrutinized in such cases in order to assure they are legitimate. If this cooling load is due to heat from the external environment (i.e. through the building envelope), it shall be reduced by improvements to the envelope.*

C. *Building areas with different hours of occupancy shall be served by separate air handling systems.*

D. *Outside air intakes shall be located such that undesirable fumes and heat cannot be drawn in to the HVAC system. Design provisions shall include the following:*

1. *OSA intakes shall be located a minimum horizontal distance of 50 feet away from areas open to regular vehicle traffic including: loading docks, parking lots, and roads.*

2. *OSA intakes shall not draw from roof areas enclosed by a parapet. Duct the OSA intake through the parapet to a non-enclosed location.*

3. *OSA intakes shall be located a minimum distance of 30 feet horizontally from all plumbing vents.*

4. *OSA intakes shall be located a minimum distance of 30 feet horizontally from toilet exhaust. Direct exhaust discharge away from the OSA intake.*

5. *OSA intakes shall be located a minimum distance of 15 feet from air handler economizer cycle exhaust. Direct exhaust discharge away from the OSA intake.*

6. *OSA intakes shall be located such that fume exhaust can not be drawn in to the HVAC system. Provide dispersion modeling to show that fume exposure is in compliance with all applicable codes and regulations.*

7. *OSA intakes for forced ventilation shall not draw from areas directly above a roof due to temperatures elevated above ambient. Duct OSA intakes to a north facing wall or other cool location.*

E. *For large foot print buildings, provide separate air handling systems for zones with differing loads (i.e. core and perimeter zones, perimeter zones with differing orientations, basement zone versus zones with exterior exposures, etc.)*

F. *Rooms with fume generation shall be 100% exhausted (i.e. no return air). This shall include: labs with chemical use, dark rooms, soldering, welding, machine shops, paint studios, lithography studios, and large copy machine rooms.*

G. *Single pass HVAC systems shall be limited to rooms with fume & odor generation. HVAC for all other areas shall include return air.*

H. *HVAC Piping system shall be provided with manual isolation valves at the following locations:*

1. *At all equipment piping connections.*

2. *At each floor where branch piping connects to riser.*

3. *At branch connections to system mains.*

4. *At the building points of entry. (When running underground piping between buildings).*

I. Rooms with high ceilings (exceeding 12 feet) shall have supply outlets and return inlets at different levels (i.e. high supply / low return or visa versa). Care should be taken to assure that supply air reaches the occupied level.

1.10 HVAC GUIDELINES FOR SPECIFIC SYSTEMS

A. Natural Ventilation

1. Natural ventilation shall be used only where permitted by Title 24 and where internal loads (equipment and lighting) are light (less than 3 Watts / Ft^2).

2. Maximize opening area. Verify opening areas exceed Title 24 required minimums.

3. Maximize cross ventilation. Provide a minimum of two openings on separate wall whenever feasible.

4. Shade east, south, & west facing windows. (Natural ventilation has limited effectiveness in addressing solar cooling load.

5. All openings shall be easily controlled by the room occupants.

B. Forced Ventilation Systems

1. Provide air volume to each occupied space based on the greater of:

a. 1.5 CFM / SQ. FT.

b. The air volume required to satisfy the design sensible cooling load based on the assumption of a 15 degree approach temperature.

2. Forced ventilation systems shall be capable of providing 100% OSA. Heating and Ventilating units shall be provided with a full air side economizer.

3. Air handler outside air intakes shall be located in the coolest possible locations. This will typically be a north facing wall. Roof air intakes should not be used due to the higher temperature normally encountered on the roof.

4. Zone control shall be VAV / Reheat for systems containing 3 or more zones and moving 10,000 CFM or more of Supply Air. The VAV box shall reverse it's action in the event that the supply air temperature exceeds the zone temperature.

5. Design system for easy future conversion to air conditioning.

a. Provide space (empty coils section) for future cooling coils in large air handlers (8,000 CFM or more).

b. Zone controls should be compatible with future air conditioning .

C. Air Conditioned Systems

1. Use VAV / Reheat zone control except for single zone systems or where constant volume is required for fume exhaust or acoustics.

2. Zone control for constant volume systems shall be by terminal heating & cooling coils. The zone controls will prevent simultaneous heating & cooling.

3. Air conditioning systems 3 tons and greater in capacity shall be equipped with air side economizer cycles. The economizer cycle controls shall maximize the use of outside air to provide first stage cooling when ambient temperatures are sufficiently cool. Temperature based controls are preferred over enthalpy based.

4. Cooling coil drain pans shall be accessible for cleaning.

5. Design cooling capacity to each room shall include an allowance for internal equipment to accommodate the greater of:

a. The actual equipment load plus 25%.

b. A minimum generic cooling load of load of 5 watts / Ft^2 to accommodate equipment excluding lighting.

c. Where the users are unable to provide annual equipment data, the Design Professional shall work with the users to develop appropriate generic cooling loads for the types of equipment intended for the space. Recommended generic cooling loads shall be submitted to UCSC for approval.

C. HVAC Piping Systems

1. General

2. Chilled Water

3. Hot Water

4. Hydronic Heating Systems

1.11 HVAC GUIDELINES FOR SPECIFIC ROOM APPLICATIONS

A. Small Single Occupant Offices

1. For small single occupant exterior offices, provide an operable window for natural ventilation and hydronic heat (base board convector). Convector should be controlled by wall mounted thermostat accessible to the occupant.

2. Shade window if south, east, or west facing.

3. Notify the University Representative of offices where the combined lighting and equipment load legitimately exceeds 4 watts/ Ft^2. These offices may be considered for forced ventilation or air conditioning.

4. Provide forced ventilation if the office use is likely to change and require an air conditioning retrofit in the future.

5. Provide forced ventilation for interior offices.

B. Small Classrooms (Less than 75 seats)

1. See class room standards.

C. Lecture Halls (75 seats or more)

1. See class room standards

2. *Lecture halls shall be provided with air conditioning.*

3. *Lecture halls shall be provided with a separate air handling system to accommodate diverse occupancy hours.*

4. *Projection booths shall be provided with a dedicated air conditioning system designed to accommodate the heat from the projection equipment. Designs which include the projection booth in the same zone as the lecture hall are not acceptable.*

D. Public Rest Rooms

1. *100% exhaust. Exhaust grilles laid out to capture odors over toilet stalls.*

2. *15 air changes per hour*

3. *Provide provisions for make up air to match exhaust*

4. *For large rest rooms, toilet exhaust fan shall be interlocked to run with the air handling system which provides the make-up air.*

5. *For small rest rooms where transfer air is used for make-up, the toilet exhaust fan may be interlocked with the light switch.*

E. Dark Rooms

1. *100% exhaust, 15 air changes per hour minimum*

2. *Local exhaust over solution baths. Slot hood: 1,000 FPM face velocity through slots.*

3. *Tempered make-up air to match exhaust.*

4. *Local 4 hour manual timer to activate system.*

F. Paint Studios

1. *100% exhaust, 10 air changes per hour minimum*

2. *High and low air inlets for exhaust*

3. *Tempered make-up air to match exhaust.*

4. *Local 4 hour manual timer to activate system.*

G. Personal Computer Labs:

1. *Personal computer labs shall be provided with air conditioning. For purposes of this standard a personal computer lab shall be defined as a room containing four or more personal computers (or work stations) that may be used simultaneously and with a density exceeding more than one computer for every 80 square feet of floor space.*

2. *Each computer lab shall be served by a separate dedicated HVAC system to accommodate differing hours of operation.*

H. Laboratory Ventilation (Wet Laboratories)

1. Laboratory ventilation shall be consistent with the requirements of ANSI / AIHA Z9.5-1992 “American Standard for Laborite Ventilation” and California Code of Regulations, Titles 8 & 24.

2. Laboratories using hazardous materials shall be directly and continually exhausted. Laboratory air shall not be recirculated or transferred through adjacent spaces.

3. Laboratories using hazardous materials shall be maintained at a pressure that is negative to corridors and adjacent non-laboratory areas. An exception to this requirement may be allowed for operations such as clean rooms which preclude a negative pressure to surrounding areas. In such cases provide intermediate rooms between clean rooms and corridors which can be maintained at a negative pressure relative to the exit corridors.

4. Ventilation Rates

a. Ventilation systems for laboratories using hazardous materials shall be designed to provide (12) twelve air changes per hour minimum.

b. VAV controls shall be provided to reduce the ventilation rate to a minimum of (6) six air changes where the degree of hazard can be determined to be sufficiently low. (The system shall remain designed to provide the (12) twelve air changes to allow flexibility of use.)

5. Fume hoods and other local exhaust shall be provided to control toxic vapor hazards such that no person will be exposed to concentrations greater than the Permissible Exposure Limit (PEL).

6. The use of local exhaust other than fume hoods (i.e. snorkel exhaust, slot hoods, custom designed industrial exhaust hoods) shall be limited to those processes which cannot practically be conducted in a fume hood. Such exhausts shall have sufficient capture velocity to entrain the hazardous chemicals being released. Custom designed local exhaust hoods shall be smoke tested by the UCSC Environmental Health and Safety Department prior to use to confirm proper operation.

5. Laboratory Supply Air

a. Make up air should be supplied in the cleanest area of the lab, away from the areas where hazardous material will be handled and exhausted.

b. Supply diffusers shall be placed so as not to disrupt air flow into fume hoods and local exhaust. Supply diffusers should not direct air flow towards the face of the hood. Cross drafts at the hood face should also be avoided. Room ambient air velocities shall be kept below 35 FPM in the vicinity of fume hoods and local exhaust air intakes.

I. Fume Hoods

1. All fume hood installations require both a “Permit to Construct” and a "Permit to Operate” from the air pollution control district. See 15010 of these standards.

2. Fume hood exhaust rate shall be based on the following:

a. General Laboratory Hoods: 100 FPM average face velocity with the sash opening set at 18”. Minimum of 70 FPM at any measured point. Air balance specification shall call out the 18” sash opening for balancing.

b. Hoods exhausting regulated carcinogens (ref. to CCR Title 8 Section 5209): 150 FPM average face velocity with the sash opening set at 18". Minimum of 125 FPM at any measured point. Air balance specification shall call out the 18" sash opening for balancing.

3. Fume hoods shall either be constant volume bypass type or VAV as applicable to the application.

4. Fume hoods shall not be located next to doors or in other locations which will inhibit egress from the laboratory in the event of fire or explosion in the hood.

5. Fume hoods shall not be located opposite sit down work stations. Material splattered or forced out of the hood could injure someone sitting at the work station.

6. Fume hoods shall be located away from building elements which may cause cross drafts or otherwise disrupt the smooth flow of air into the hood including: foot traffic paths, doors, and operable windows.

7. Fume hoods connected to multiple hood exhaust systems shall be equipped with face velocity controllers. The intent of this requirement is to allow for future modifications to the system without the need for a full system air balance.

8. Fume hoods shall be equipped with local audible and visual alarms.

9. Other notes on fume hoods;

a. See CCR Title 8 Section 5162 for emergency eye wash/ shower requirements associated with fume hoods

J. Fume Exhaust Systems

1. No later than the DD submittal, the list of chemicals used and stored in the lab shall be used to analyze fume hood exhaust for flammability, toxicity, corrosiveness, explosion hazard and incompatible chemicals. This analysis shall be used to determine the following:

a. The type of fume exhaust ductwork least susceptible to corrosion for the application: Typical types of fume exhaust ductwork include plasite coated, stainless steel, and FRP. Plasite coated fume exhaust ductwork is the most widely used on campus. Consult Physical Planning and Construction for further details.

b. The need for fire extinguishing in the ductwork: For fume exhaust containing flammable vapor, codes may require an automatic fire extinguishing system in the ductwork depending on concentrations. Such cases shall be evaluated on a case by case basis with the University's Representative, Environmental Health and Safety, and the Campus Fire Marshal. Additional hazards may be created by the fire extinguishing in some cases. Solutions which reduce the concentrations of flammable vapor below that requiring a fire extinguishing system are preferable.

c. The need for dedicated fume exhaust systems: Central fume exhaust systems are used in most lab buildings on campus. Some processes, however, require a dedicated fume exhaust system and fan due to chemical incompatibility.

2. Fume exhaust duct shall be continually sloped back towards the fume hood. The duct work shall be routed without low spots where liquids can collect.

3. *All seam in fume exhaust ductwork shall be sealed air and liquid tight using semi-permanent means.*

4. *Transverse connections in metal duct shall be flanged and bolted.*

5. *All parts of the fume exhaust system inside the building shall be under negative pressure.*

6. *Fume exhaust ductwork shall not be routed through space used as an HVAC supply or return air plenum.*

7. *Automatic dampers installed in fume exhaust ductwork shall fail to an open position.*

K. *Clean Rooms*

1. *No later than the DD submittal, establish and document with the User the cleanliness class of all rooms and work stations. Work stations may have cleaner classification than the surrounding room. Design on clean rooms shall not proceed without a commitment from the User on the acceptable class for the room's intended purpose.*

2. *No later than the DD submittal, propose / document HVAC design criteria to be used to achieve each cleanliness classification. Include air changes, HEPA coverage, relative positions of supply outlets and return inlets*

3. *No later than the DD submittal, establish how HEPA filters and lighting will be serviced. Verify if clean room is to remain clean during servicing.*

4. *No later than the DD submittal, establish and document the relative pressurization of clean rooms to adjacent spaces. Air flow should be from the cleanest classification towards dirtier areas.*

5. *No later than the DD submittal, establish and document with the users how cleanliness will be preserved when entering the room. (Verify if a change room will be required for gowning up.)*

6. *No later than the DD submittal, verify and document with users if the clean room can tolerate a shut down during a power outage.*

7. *Clean rooms shall be served by air handling units separate from the main building HVAC.*

8. *Most clean rooms require low air returns. These shall be detailed in both plan and section to assure proper height and construction for particle control.*

9. *Clean rooms are extremely energy intensive to operate. For energy conservation:*

   a. *Clean room space (square footage) should be the minimum necesary for intended use.*

   b. *Where possible, perform processes requiring extremely clean conditions (class 100 and better) in a laminar flow work station with the surrounding room less clean.*

   c. *Large clean rooms with high air change rates shall be equipped with particle counters and a means of reducing air flow during non-occupied periods. Associated fan systems shall be VFD controlled to take advantage of reduced fan energy use.*

10. *Interstitial Spaces*

    a. *Interstitial space should be considered for servicing of HEPA filters and lamps for clean rooms which cannot be shut down for servicing.*

    b. *Walk surface for interstitial space shall be selected so that they can easily be re-configured to gain access to the clean room ceiling below. The locations of HEPA filters and lighting should be easy to change without major modification to the interstitial space walk deck.*

    c. *Interstitial spaces shall be laid out in both plan & section. Access paths to equipment shall be established and kept clear of piping and ductwork.*

11. *Service Corridors*

    a. *Consider the use of non-clean service corridors for clean rooms with heavy process piping requirements, especially if the location of this piping will frequently change.*

12. *T-Bar HEPA ceiling filters shall be gasketed around the edges.*

13. *Clean rooms in new buildings shall be air balanced, cleaned, and certified prior to turning over to the users. Verify with the University Representative a contractual method to accomplish this. In some projects, it may be advantageous to accomplish this under separate contract.*

PART-II HVAC EQUIPMENT

2.01 Air Handlers

2.02 Boilers

A. *Boilers shall be located under cover for protection from tree debris and rain.*

B. *Boilers shall be located at grade level at a point accessible by hand truck from a service vehicle.*

C. *Boilers should be sized under 2,000,000 BTUH where feasible to stay under the permit threshold. Multiple small boiler is an acceptable strategy.*

D. *Condensing boilers are not acceptable due to high maintenance cost.*

E. *Furnish with trim per California Fired Pressure Vessel Safety Order (Title 17) including dual low water cut outs, dual gas valves.*

F. *Automatic reset low water cut out shall include automatic feed for increased safety (McDonald-Miller or equal).*

G. *RP back flow preventer required on make up water.*

H. *Provide line pressure manual quick fill valve.*

I. *Include contract start up and efficiency testing by factory trained technician in contract.*

J. *Boilers 100,000 BTUH and smaller.*

1. *Cast iron or steel tube with atmospheric burners.*
2. *80% minimum efficiency*

K. *Boilers 100,000 BTUH to 2,000,000 BTUH*

1. *Steel tube with atmospheric burners*
2. *80% minimum efficiency*
3. *Access required to fire box, control panel, Low Water Cut Outs.*
4. *Acceptable Manufacturers: Rite, Ajax , or equal.*

L. *Boilers 2,000,000 BTUH and Greater*

1. *Boiler permit required from air pollution control district. Design professional shall furnish to the University's Representative all required data to obtain a permit.*
2. *Provide Powered Burners*
3. *Provide Best Available Control Technology (BACT) for NOX emissions.*
4. *Steel or fire tube design acceptable.*
5. *80% minimum efficiency*
6. *Acceptable Manufactures: Clever Brooks, Kawahnee, Ajax, Rite, or equal.*

2.03 Chillers

A. *Water cooled chillers shall be located under cover for protection from tree debris and rain.*

B. *Air cooled chillers shall be used only in locations free from tree debris.*

C. *Chillers shall be located at grade level at a point accessible by hand truck from a service vehicle.*

D. *Chillers shall be matched to the system they serve so as not to operate lightly loaded for long durations. On large systems with small base loads, provide an additional smaller chiller to accommodate the base load.*

E. *Chillers 100 tons and smaller*

1. *Scroll type preferred for small chillers. Reciprocating chillers acceptable if scroll type is not available in required size.*
2. *Water cooled if tower water from the central cooling water system is available.*
3. *Air cooled at building not connected to the central cooling water system.*
4. *R-22 Refrigerant.*
5. *Small loading steps: 7.5 tons or less per step.*
6. *Acceptable Manufacturers: Trane, Carrier or equal.*

F. *Chillers over 100 Tons*

1. *No Ozone Depleting Refrigerants*

2. *5% minimum fouling factor*

2.04 Cooling Towers

2.05 Ductwork (General HVAC)

A General

1. *Except as otherwise indicated, HVAC duct work shall be rigid sheet metal unless specifically approved by the University's Representative. Alternative duct systems (flexible duct, fiberglass duct, FRP, etc.) shall only be used when specifically approved by the University's Representative.*

2. *Minimum pressure class for duct construction shall be +/- 3" inches WG. Specify higher classification where required by the application.*

3. *Dimension indicated on contract drawings and as built drawings shall be net free area.*

4. *All duct seams shall be sealed per SMACNA Standards. The use of pressure sensitive tape for sealing of duct work shall be limited to concealed locations.*

5 *Supply air ductwork shall be internally or externally insulated as required by code. External insulation shall be limited to locations protected from weather.*

6. *Provide a balancing damper at each branch take off in the ductwork system. Balancing damper shall be single blade or opposed blade multi-louver type as detailed in the SMACNA duct construction standards. Provide bearings at both ends of damper rods. Operators shall be locking quadrant type. Operators for externally insulated duct shall have stand-off mounting so that operator is clear of insulation. Ventlock 635 (or 637 for externally insulated duct), DuraDyne, Young, or equal.*

7. *Provide flexible connections at all inlets and outlets to fans. Provide sheet metal guard to shade flexible connections exposed to sun. Allow at least 1" slack to assure no vibration transmission. Flexible connections shall be made with non-combustible, neoprene coated fiber glass fabric, 6 inches wide weighing a minimum of 30 oz. per square yard. Ventfabrics " Ventglas", DuraDyne, or equal. UL approved with sheet metal attachment system.*

8. *Transitions in size of duct shall be made with uniformly tapering sections having a maximum 1 inch change in width for each 7 inches of run.*

9. *Where ductwork is concealed, provide approximately 3 feet of flexible duct connectors on the upstream side of VAV boxes and approximately 7 feet of flexible duct connector at connections to diffusers (7 feet). Flexible duct connectors shall comply with UL-181 and NFPA 90A and be rated for a minimum 6 inches WG working pressure.*

B Rectangular HVAC Ductwork

1. *Rectangular ductwork shall be minimum 24 gauge galvanized sheet metal fabricated in accordance with the more stringent of the latest edition of the SMACNA HVAC Duct Construction Standards or the Uniform Mechanical Code (including California Amendments).*

2. Rectangular ductwork elbows shall be either radius or, if mitered, equipped with turning vanes.

C Round HVAC Ductwork

1. Round ductwork shall be minimum 26 gauge fabricated in accordance with the more stringent of the latest edition of the SMACNA HVAC Duct Construction Standards or the Uniform Mechanical Code (including California Amendments). Round ductwork shall typically be spiral wound unless otherwise approved the University's Representative.

D Ductwork Accessories

3. Diffusers

a. The maximum NC level of diffusers at design air volume shall be specified in the Working Drawings.

4 VAV Boxes

a. VAV boxes shall be pressure independent.

F Ductwork Installation

1. Ductwork shall be installed in accordance with the more stringent of the latest edition of the SMACNA HVAC Duct Construction Standards or the Uniform Mechanical Code (including California Amendments).

2. Paint the flat black interior surfaces of ductwork which are visible through diffusers, grilles and registers.

3. Exposed ductwork in occupied spaces shall be fabricated with seams flat. Ductwork shall be free of tape, tool marks, and dents.

4. Ductwork exposed to weather shall be sloped to shed rain. Seal watertight with Arbol and canvas, Hardcast, or equal.

2.06 Ductwork (Fume Exhaust)

2.07 Fans

2.08 Heat Exchangers

A. Shell & tube type preferred where close approach is not required for application.

B. For close approach applications use plate & frame type

C. Select with 5% fouling factor (minimum).

2.06 Pumps

A. Valve inlet & outlet piping

B. All pumps shall be equipped with pressure gauges on inlets and outlets. Provide gauge cock to allow for gauge removal.

2.08 Water Treatment (Closed Loop Systems)

A. *All closed loop systems shall have provisions for water treatment.*

B. *Provide a minimum 2 gallon pot feeder piped across the circulation pump. Both pipe connections valved. Size pot feeder per manufactures recommendations for capacity of system.*

C. *Pot feeder must have valved drain with discharge piped to floor drain.*

D. *Pot feeders shall be placed in a location accessible by hand cart from service vehicle.*

SECTION 15990: TESTING, ADJUSTING & BALANCING

PART 1 - GENERAL:

A. Air and water balancing and sound testing of the systems shall be done by an independent test and balance agency that specializes in and whose business is limited to the testing and balancing of air and water systems and the measurement of sound. Agency shall be fully certified by the Associated Air Balance Council (AABC), National Environmental Balancing Bureau (NEBB), or equal, and shall have at least one (1) member qualified a certified test and balance and sound engineer and who has been issued certification.

B. Testing and balancing shall be performed in complete accordance with AABC, NEBB and SMACNA Standards applicable to air distribution and water balance. Standards shall include National Standards for Testing and Balancing Heating, Ventilation, and Air Conditioning Systems, published by the AABC, and Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, published by the NEBB.

C. Instruments used for testing and balancing of air and water systems shall have been calibrated within a period of six (6) months and checked for accuracy prior to start of work.

D. A minimum of five (5) copies of the complete balancing and sound testing report shall be submitted to the University's Representative. Final reports shall be signed by test and balance agency and shall include their official stamp.

E. University Representative to supply Drawings/Balance and Test Criteria for each authorization.

F. Scope of work: See authorization for systems/equipment requiring Testing, Adjusting & Balancing.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (AS APPLICABLE TO AUTHORIZED SCOPE)

A. General Balancing Procedures and Requirements

1. Do not operate air handling and other fan units before filters are properly installed. Do not operate exhaust fans without supply fan running. After completion of balancing, University may change filters with new filters.

2. Adjust Air quantities at each outlet, inlet: Within 10-percent plus or minus of quantities indicated on drawings.

3. Air distribution Systems: Air Systems including supply, return, exhaust, shall be air balanced when building is completed, windows, and doors closed and under normal traffic. Mark Volume Dampers to the "balanced" position with felt tip marker.

4. Optional scope. Spot checking: After balancing report is found satisfactory, provide one (1) person and necessary equipment, including step ladders, required to assist in checking system balance. A minimum of 10-percent of the inlets and outlets shall be checked. If during checking, errors in balancing are found, rebalance system in question, submit new report for review. Procedure described in preceding paragraph shall be repeated until systems are balanced to the specified performances.

5. *Verify that control valves fail to "normally closed (NC)" or "normally open (NO)" position on loss of service.*

6. *Site Housekeeping: Return furniture to original position, if moved. Be careful to avoid "soiling" surfaces, clean up dust/dirt generated by work in finished spaces. Anticipate movement of dust from ducts to rooms by observing age of ductwork (such as over 10 years), and observing dust loaded/plugged coils. Recommend temporary terminal filters to the University's Representative, where this may offer protection for finished spaces during testing/balancing.*

B. *Air handling and other fan equipment is specified for certain conditions listed in catalogues. Set fan RPM for delivering air quantities indicated on Drawings at actual field conditions and top pressure and leakage. If necessary to achieve proper air flows, recommend changes in drive sheaves and motors to the University's Representative during balancing. At final setting, on units and fans with adjustable sheaves, there should be reasonable leeway for increasing RPM without changing sheaves, note so in sheave recommendations.*

C. *Sound Tests:*

1. *Tests to demonstrate compliance with sound requirements shall be made at each point as selected. Unless otherwise specified in authorized scope, a minimum of five (5) rooms at each floor shall be tested. Rooms shall be as selected.*

2. *Take sound level measurements at times when building is unoccupied, or when activity in surrounding areas and background noise levels in areas tested are at minimum and relatively free from sudden changes in noise levels. Take measurements with equipment secured, except that being tested. Measure sound levels at any point within room not less than 6-feet from an air terminal or room unit, or not closer than 3-feet from floor, wall, or ceiling surface.*

3. *Meters: Measure sound levels with sound meter complying with the latest ANSI Sl.4.*

4. *Report: Record data on sound levels, taken at each selected location, as follows:*

   a. *Source of sound and location.*

   b. *Diagram or description of relationship of sound source to measuring instrument.*

   c. *"A" scale readings:*

      (1) *Equipment being testing turned off (ambient)*
      (2) *Equipment being tested turned on (operating conditions)*

   d. *Reading at each specified octave bad frequency:*

      (1) *Equipment being testing turned off (ambient)*
      (2) *Equipment being tested turned on (operating conditions)*

   e. *"Equipment components" of sound (noise) levels with applicable calculations.*

   f. *Graph showing relationship between pressure levels specified and recorded readings.*

5. *Retest (Optional): Subsequent to any corrective construction work, such as acoustic corrections, make measurements to verify that the associated air quantities, as previously measured, have not been disrupted.*

6. *Certified Report: Record sound data, and locations, after final adjustments of air systems.*

D. *Air and Water Systems Testing and Balancing*

1. *Upon completion of the installation and field testing, performance test and adjust the supply, return, make-up and exhaust air systems to provide air volume and water flow quantities indicated. Accomplish all work in accordance with the agenda and procedures specified. Allow the University opportunity to correct, air and water system performance deficiencies before balancing systems.*

2. *Adjust air handling systems to provide the required design air quantity to, or through, each component. Conduct adjusting and balancing of systems during periods of the day most approximate to maximum seasonal operation (morning heating, afternoon cooling, etc.). Establish the conditions for the maximum demand system airflow which generally is a cooling application with "wetted" coils.*

3. *Adjust equalizing devices to provide uniform velocity across inlets prior to measuring flow rates.*

4. *Balance: Use duct branch volume control devices to balance air quantities. Do not create objectionable air motion or sound.*

5. *Balancing between runs (submains, branch mains and branches). Use flow regulating devices at, or in, the divided-flow fitting. Minimize restriction imposed by flow regulating devices in or at terminals.*

6. *Make final measurements of air quantities after boxes and air terminals have been adjusted to provide optimum air patterns of diffusion.*

7. *Total air system quantities shall be varied by adjustment of fan speeds. For systems with direct-connected fans, damper restrictions of a system's total flow may be used, only if system pressure is less than 1/2-inch w.g.*

8. *Make Pitot tube traverses of each duct to measure air flow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform with the ASHRAE Handbook Fundamentals.*

9. *Test holes shall be located in straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices.*

10. *Measure flow rates by means of velocity meters applied to air terminals (including hoods) . Measurement of air quantities at each type of air terminal (inlet and outlet) shall be determined by the method approved for balancing agenda.*

11. *In addition to air motion measurements, make smoke tests to demonstrate the air distribution from air terminals.*

12. *Adjust heating systems to provide required quantity to, or through, each component.*

13. *Measure water quantities and pressures with calibrated meters. Use venturi tubes, orifices, or other metering fittings and pressure gauges. Adjust systems to provide the approved pressure drops through the heat transfer equipment prior to the capacity testing. Where flow metering fittings are not installed, determine flow balance by measuring temperature differential across the heat transfer equipment. Perform measurement of temperature differential with the air system in operation.*

14. *Position automatic control valves for full flow though the heat transfer equipment of the system during tests.*

15. *Flow through by-pass circuits at three-way valves shall be adjusted to balance that through the supply circuit.*

16. *Adjust distribution by means of balancing devices and valves. Do not use service valves for adjustment.*

17. *Use the Building Management System Portable Operator's terminal to balance each VAV box. Verify C.F.M. readouts from VAV box controller with actual field reading. Coordinate with University Representative for adjustments of VAV Box parameters.*

18. *Flow at fume hoods shall be 100 FPM across sash open eighteen (18) inches.*

E. *Air and Water Systems Report Data Requirements.*

1. *Certified reports shall be included for each air handling system with the data as listed below:*

a. *Equipment (fans and air conditioning unit):*

1) *Installation Data*

(a) *Manufacturer and Model*
(b) *Size*
(c) *Arrangement and Local Identification Data.*
(d) *Motor H.P., Voltage, Phase, Cycles, and Full Load Amps.*
(e) *Location and Local Identification Data.*

(2) *Design Data: Data listed in schedules on drawings and specifications.*

(3) *Fan Recorded (Test) Data.*

(a) *C.F.M.*
(b) *Static Pressure*
(c) *R.P.M.*
(d) *Motor Operating Amps.*
(e) *Motor Operating B.H.P.*

b. *Duct Systems*

(1) *Duct Air Quantities (Maximum and Minimum) - Main, Submains, Branches, Outdoor (Outside) Air, Total-Air, and Exhaust.*

(a) *Duct sizes*
(b) *Number of Pitot-tube (Pressure) Measurements*

(c) *Sum of Velocity Measurement, excluding pressure measurements.*
(d) *Average velocity.*
(e) *Recorded (Test) C.F.M.*
(f) *Design C.F.M.*

(2) *Individual air terminals:*

(a) *Terminal Identification (Supply, Return, or Exhaust, Location and Number Designation)*
(b) *Type, Size, Manufacturer and Catalogue Identification.*
(c) *Design and Recorded Quantities - C.F.M.*
(d) *Defector Vane or Diffusion Cone Settings*
(e) *Applicable Factor for Application, Velocity, and Area.*
(f) *Design and Recorded Velocities - F.P.M.*

(3) *Variable Air Volume Boxes:*

(a) *Box identification*
(b) *Type, Size, Manufacturer and Catalogue Identification.*
(c) *Design and Recorded quantities at full cool, at full heat - C.F.M.*
(d) *Re-heat coil test data shall be as specified for "Air Heating Coils and Equipment".*

c. *Special Systems*

(1) *Fume Hoods*

(a) *Position of fume door (normally open 18 inches)*
(b) *Exhaust Volume Rate - C.F.M. Include average duct velocity and cross-sectional area of duct used in calculations.*
(c) *Exhaust Volume Rate - C.F.M. measured at hood duct opening. Include average duct velocity and cross sectional area of duct used for calculations.*
(d) *Sketch of hood door opening showing center point areas and corresponding velocity readings.*
(e) *Average Face Velocity.*
(f) *Exhaust Volume Rate - C.F.M. calculated from face velocity measurements. Compare with 4(a) and 4 (b).*
(g) *Make-up air supply volume rate - C.F.M. Include average duct velocities and cross sectional area of duct used for calculations.*
(h) *Make-up air supply rate as a percentage of exhaust volume rate.*
(i) *Optional Scope - titanium tetrachloride test to observe whether there are reverse flows or dead air spaces at hood face.*
(j) *Optional Scope - titanium tetrachloride test to observe whether reverse flows were observed at each end of the working surface and across the working surface of hood.*
(k) *Optional Scope - hood smoke tests results with hood door open and hood door closed.*
(l) *Optional Scope - dry-ice test observations and results.*
(m) *Optional Scope - average face velocity with door open three (3) inches. Compare with specified limitations.*
(n) *Optional Scope - observations and results of auxiliary air supply smoke test with hood door (sash) open and closed.*
(o) *Optional Scope - results of test of exhaust air flow.*
(p) *Optional Scope - results of exhaust system wash down (perchloric system)*

2. Water Chilling Unit

a. Installation Data

(1) Manufacturer and Model
(2) Motor H.P., Voltage, Cycles, Phase, and Full Load AMPS.
(3) Part Load AMPS
(4) G.P.M. - Chiller
(5) Water Pressure Drop - Chiller
(6) Entering and Leaving Water temperature - Chiller

b. Recorded Data (Chiller)

(1) G.P.M.
(2) Water Pressure Drop
(3) Entering and Leaving Water Temperature
(4) AMPS

c. Recorded Data (Air-Cooled Condensers):

(1) C.F.M. and R.P.M. of fan
(2) Condenser refrigerant pressure and temperature
(3) Entering and leaving air Temperature

3. Water Heating Boiler:

a. Design Data:

(1) Manufacturer, Model and Type
(2) A.G.A. Input and Output
(3) Inlet (entering) and Outlet (leaving) Temperature
(4) Water Pressure Drop

b. Recorded Data:

(1) Manufacturer's Representative test data for boiler efficiency and stack emissions.
(2) Entering and Leaving Water Temperature - System
(3) Water Pressure Drop
(4) Heating Media Pressure and Temperature
(5) Heating Media - Flow (G.P.M.)

4. Air Heating Coils and Air Cooling Coils and Equipment:

a. Design Data

(1) Load in B.T.U.H. or M.B.T.U.H.
(2) G.P.M. at water coils
(3) Entering and Leaving water temperature of water coil.
(4) Entering and Leaving Air Conditions (Dry Bulb and Wet Bulb).
(5) C.F.M.
(6) Water Pressure Drop

b. Recorded Data:

(1) Type of Equipment and Identification (Location or Number Designation)
(2) Entering and Leaving Air Conditions (Dry Bulb and Wet Bulb)
(3) Entering and Leaving Water Temperatures
(4) G.P.M. (if metered)
(5) Temperature Rise or Drop

5. Pumps:

a. Installation Data:

(1) Manufacturer and Model
(2) Size
(3) Type Drive
(4) Motor H.P., Voltage, Phase, and Full Load Amps.

b. Design Data:

(1) G.P.M.
(2) Head
(3) R.P.M.
(4) B.H.P. and Amps.

c. Recorded Data:

(1) Discharge Pressures (Full-Flow and No-Flow)
(2) Suction Pressures (Full-Flow and No-Flow)
(3) Operating Head
(4) Operating G.P.M. (From pump curves if metering not provided)
(5) No-Load Amps. (Where applicable)
(6) Full-flow Amps.
(7) No-flow Amps.