DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

23 00 00 GENERAL

A. Design Considerations:

1. Supply Air Requirements: At a minimum, outside air must be supplied to occupied spaces in accordance with the latest issue of ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality. All laboratories, shops and studios where hazardous materials are used must be maintained under negative pressure with respect to areas of lower hazard (e.g. corridors, offices). Exhaust air from these areas of higher hazard must not be recirculated, and must be exhausted directly to the outdoors. Minimum occupied laboratory air change rate shall be 12 air changes per hour. Minimum unoccupied laboratory air change rate shall be 6 air changes per hour. Higher occupied and unoccupied air flow rates are discouraged unless dictated by cooling load requirements, safety considerations or inability of HVAC system to operate in a reduced flow unoccupied mode. University Facilities and REHS shall review and approve minimum occupied and minimum unoccupied laboratory air change rates on a project by project basis.

2. Ventilation intakes and discharges must be located so that exhaust air is not entrained into the building. Exhaust air discharges are to be roof mounted and air intakes must be located at ground level unless otherwise approved by University Facilities and REHS. Air intakes must be located in areas where they will not introduce air pollutants into the building (e.g. away from loading docks, high traffic areas, exhaust discharges from other buildings, etc.)

3. Building hot water for heating shall be 180^{o} F with a 40 degree temperature difference. Use 150# AISI design standards.

4. Campus high temperature water systems may be designed at 400^{o} F and 400 psig, depending on campus. The Engineer-of-Record shall verify actual design parameters for HTW systems with Rutgers Department of Utilities (in writing) prior to commencing design. Use 300# AISI design standards.

5. Campus chilled water systems may be designed at 45^{o} F with a 12^{o}F temperature difference. The Engineer-of-Record shall verify actual design parameters for campus chilled water systems with

Rutgers Department of Utilities (in writing) prior to commencing design.

6. Dual temperature systems shall be designed for 180 ^{o} F (with a 40 degree temperature difference), winter and 45^{o} F (with a 12 degree temperature difference), summer. Where chilled water is being supplied from the campus chilled water system, the Engineer-of-Record shall verify actual design parameters for campus chilled water with Rutgers Department of Utilities (in writing) prior to commencing design.

7. 4-pipe systems are preferable.

8. Hot water is preferred heating medium.

9. Steam system shall be designed for low pressure (15 psig or less) unless otherwise approved by Rutgers. When steam is obtained from a HTW steam generator, it is especially important to realize that pressures of 30 psig or greater are difficult to justify because they use an enormous flow of primary HTW. All kitchen equipment (dishwasher, steam tables, etc.) should be operated at less than this pressure. Autoclaves, sterilizers and cage washers should be capable of operating at less than 30 psig steam. If this is not possible, the use of an electrically driven steam generator that can be separately metered (electrically) can be considered.

10. HVAC - Temperature Design Standards:

    a. The following inside design conditions shall apply unless otherwise approved by Rutgers:

       Winter:
       Non-critical areas such as offices, classrooms, etc.: 70^{o} F +2^{o} F with no humidity added.

       In critical areas as much as 30% relative humidity +5% may be added. Coordinate wall and glass insulation "U" factor to avoid condensation.

       Summer:
       Non-critical areas: 77$^{o\ F}$ +2^{o} F, 50% relative humidity +5%.

       Critical areas may be designed to 72^{o} F when approved by the Project Manager.

       Recreation Center Fitness Areas:

All Recreation Center fitness areas shall maintain a temperature of 58 to 72 degrees Fahrenheit with a minimum air circulation rate of 12 air changes per hour on a year round basis.

Note that the usual range of accuracy for temperature is $+2^{o}$ F and usual range of accuracy for relative humidity is +5%. Both ranges are as measured at the location of the controlling instruments.

b. Outdoor design conditions should follow ASHRAE Fundamentals, 1985 edition for Newark, New Brunswick, and Philadelphia (for Camden campus).

c. For ordinary spaces, including offices, classrooms, and residence rooms, there are the 2-1/2% and 97-1/2% values in the ASHRAE guide:

	Winter	Summer	Range
Newark	14^{o} F DB	91^{o} F DB/73^{o} F WB	20^{o} F
New Bruns.	10^{o} F DB	89^{o} F DB/73^{o} F WB	19^{o} F
Camden	14^{o} F DB	90^{o} F DB/74^{o} F WB	21^{o} F

d. For critical laboratory spaces use the following values:

	Winter	Summer	Range
Newark	10^{o} F DB	94^{o} F DB/74^{o} F WB	20^{o} F
New Bruns.	6^{o} F DB	92^{o} F DB/74^{o} F WB	19^{o} F
Camden	10^{o} F DB	93^{o} F DB/75^{o} F WB	21^{o} F

e. For cooling towers, use 78^{o} F WB design.

11. HVAC – Acoustic Design Standards

The Engineer of Record shall bear full responsibility for designing all mechanical systems as required to achieve maximum noise levels set forth in the most recent editions of ASHRAE HVAC Applications and the ASHRAE Fundamentals handbooks pertaining to sound and vibration control for the occupancy classification of the individual space served. The University reserves the right to require more stringent acoustic design criteria be used for design on a project by project basis. The University also reserves the

right to hire an independent acoustic consultant to review "as installed" noise levels for conformance with the aforementioned acoustic design standards.

12. All designs shall conform to the requirements of the latest issue of ASHRAE/IESNA Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings.

B. Special Documentation Requirements

1. Prior to commencement of design, the Engineer-of-Record shall contact Rutgers Utilities Department to verify (in writing) design temperatures, pressures, delta "T"s and maximum available capacities at proposed points of tie-in for all utilities proposed to serve a given facility. Where these values vary seasonally, the most conservative values shall be used for purposes of design. The Engineer-of-Record shall use this information to design Plumbing, HVAC and Fire Protection systems. Design temperatures, pressures and delta "T"s as referenced in these Standards are for information only and are not to be used for final design without obtaining written confirmation from Rutgers Department of Utilities.

2. The Engineer-of-Record shall coordinate with the project architect to ensure that related mechanical and architectural plans and specification sections are properly coordinated. Specifically, fume hood configuration, controls, fixtures & appurtenances must be coordinated between engineering and architectural disciplines. Fume hoods shall be of constant volume (i.e. bypass type) or variable air volume configuration as dictated by HVAC design.

3. The engineer-of-record shall provide calculations, based on simple payback and\or life cycle cost criteria, of proposed mechanical system design(s) (and for alternate design(s) as may be requested by the University) to the Office of Facilities Project Administration for review and approval with the Design Development Submission. Calculations shall be performed using the "Trane" Trace computer program or other methodology subject to Rutgers University approval.

C. Materials and Methods of Construction

RESERVED

23 01 30.51 HVAC AIR DISTRIBUTION SYSTEM CLEANING

A. Design Considerations

1. Duct cleaning should be scheduled and closely coordinated through Rutgers University Facilities and REHS representative. Where lined ductwork is being cleaned, the condition of the existing lining must be evaluated by REHS and replaced with external duct insulation as required.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Duct Cleaning shall be based upon the National Air Duct Cleaners Association (NADCA) specification. Duct cleaning contractors shall be approved by Rutgers.

23 05 00 COMMON WORK RESULTS FOR HVAC

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. For all new construction, renovations and alterations, the Contractor shall mark-up the contract documents to indicate any changes in construction and installation due to field conditions or other deviations from the plans and specifications. The A/E shall take the record drawings and produce the As-Builts on mylar with CAD files.

2. The A/E shall be responsible for preparation and follow-up correspondence with REHS and\or the DEP for all permitting required for fuel burning equipment. This information includes, but is not limited to: a description of the fuel burning equipment, manufacturer name, model number and fuel type used. This information shall be provided by the A/E to Rutgers with sufficient lead time prior to equipment installation.

C. Materials and Methods of Construction

1. Access for mechanical devices installation and future maintenance is essential. When access doors are specified, check with the Project Manager for need of locks.

2. All equipment shall be installed with sufficient walk-around room to insure proper maintenance of equipment. Equipment shall be installed such that tube pull, filter replacement, ease of removal and replacement of strainers, ease of draining equipment, convenience for service of parts, etc. can be achieved.

3. No roof top mechanical equipment shall be located closer than 10'-0"to a roof edge or adequate guardrail protection (rail or parapet) must be provided.

4. All non-metallic underground pipes shall have trace wire to facilitate future location. Trace wire type and installation shall be in accordance with the requirements of Rutgers Department of Utilities.

5. Do not use sheet metal sleeves through outside walls. Sleeves shall be pipe conforming to ASTM A 120. At outside walls provide "leak plate" and install "Linkseal".

6. No Contractor shall connect to any hydrant owned and operated by Rutgers without first obtaining authorization from Rutgers Department of Utilities and providing a Series 009 RPZ Hydrant Backflow Preventer as manufactured by Watts at the point of connection.

23 05 13 COMMON MOTOR REQUIREMENTS FOR HVAC

RESERVED

23 05 16 EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Calculations for pipe expansion loops shall be provided by a New Jersey licensed professional engineer at Rutgers request.

C. Materials and Methods of Construction

1. Do not use expansion compensators on HTW and MTW. Use expansion bends (calculated) for all pipe flexibility situations.

23 05 19 METERS AND GAGES FOR HVAC PIPING

A. Design Considerations

1. BTU meters are required for all permanent buildings connected to central utility systems.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Use bimetallic temperature indicators in 5" diameter case. Orient gage so that special flexible joint is not needed.

2. Use materials compatible with service for pressure indicators, temperature indicators and flow meters. Use diaphragm where needed.

3. BTU meters for HTW and MTW services shall have temperature range to 400^{o}F.

4. Meters shall have output of 4-20 MA for campus automation and include totalizer.

5. BTU meters shall be manufactured by Flexim or approved equal, but all BTU meters shall be from the same source (single source responsibility).

6. Domestic water meter shall be a Sensus Omni C2 water meter connected to the BAS to monitor the flow. There shall be a bypass around the meter to allow for meter maintenance or replacement.

23 05 23 GENERAL DUTY VALVES FOR HVAC

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Chain-wheel operators for valves shall be located in a place where they will not interfere with normal access and shall be restrained at wall or column if necessary.

2. Butterfly valves shall be Lug type, with memory stop and shall have EPDM (or better) seats. Do not use butterfly valves for balancing steam or hydronic systems.

3. Triple duty valves are acceptable.

4. Adjust class of safety valves for pressure and temperature used in each system.

5. Sizing of pressure reducing valves shall be clearly shown on the Drawings for all equipment.

6. Valves for High Temperature Water Service:

    a. 3" and Larger: Shall be of the ASA 300 pound class, cast steel body, 13% Cr. stainless steel trim, flanged at connections to equipment, butt-weld at other than equipment connections, bored to match outside diameter of pipe.

    b. 2" and Smaller: Shall be of ASA 600 pound class, cast steel or forged carbon steel, socket weld pattern, 13% Cr. stainless steel trim, bored to match inside diameter of pipe.

    c. Gate Valves: Shall be solid wedge with stainless steel wedge or wedge faces, stainless steel seat rings. Stainless steel bonnet bushings and beveled collar on valve stem for back seating. Provide braided, teflon impregnated backing rings in a large, deep stuffing box suitable for high temperature water service. Insert at bottom of stuffing box, to serve as base for packing. Packing glands shall be non corrosive and shall have bolted gland flange with minimum of 2 eye bolts. Valves, with their bypasses, need to be installed for proper operating access.

        (1) Gate Valves 1-1/2" and Smaller: Provide with a minimum of 4 packing rings.

(2) Gate Valves 2" and Larger: Provide with a minimum of 6 packing rings.

(3) Gate Valves 6" and Larger: Provide with a minimum of 6 packing rings. Provide forged steel, globe valve bypass, minimum 3/4". Provide with tapered roller or ball bearing yokes and button type grease gun fittings and adapters to allow charging a reservoir with valve lubricant.

(4) Gate Valves 8" and Larger: Provide with a minimum of 6 packing rings. Provide forged steel, globe valve bypass, minimum 3/4". Provide with tapered roller or ball bearing yokes, Provide with bevel gear operators, clockwise rotation to close, lamented lubricating fittings and approved grease seals.

(5) Acceptable manufacturers: Crane, Jenkins, Vogt.

d. Globe and Angle Valves: Shall be of the cast plug disc with bevel seat, separately screwed or pressed in disc and seat rings, long disc locknut, port opening full pipe diameter. Provide stainless steel seat ring and disc: stainless steel bonnet bushing and beveled collar for back seating. Provide braided, teflon impregnated packing rings in a large, deep stuffing box suitable for high temperature water service. Insert a bottom of stuffing box to serve as base for packing. Packing glands shall be non-corrosive and shall have bolted gland flange with minimum of 2 eye bolts. Valves with their bypasses shall be installed for proper operating access.

(1) Globe & Angle Valves 1-1/2" and Smaller: Shall have minimum of 4 packing rings.

(2) Globe & Angle Valves 2" and Larger: Shall have minimum of 6 packing rings.

(3) Globe & Angle Valves 6" and Larger: Shall have minimum of 6 packing rings. Valves shall have forged steel, glove valve bypass; button-type grease gun fittings and adapters to allow charging a reservoir with valve lubricant tapered roller or ball bearing yokes.

(4) Globe & Angle Valves 8" and Larger: Shall have minimum of 6 packing rings. Valves shall have forged steel, globe valve bypass; button-type grease gun fittings and adapters to allow charging a reservoir with valve lubricant; and tapered roller or ball bearing yokes. Shall be equipped with impactor or hammer-blow hand wheel.

(5) Acceptable manufacturers: Crane, Jenkins, Powell, Vogt.

e. Check Valves: Shall be horizontal swing check, 300 lb. cast steel, with 13% Cr. stainless steel disc, disc face and barrel type seat rings. Provide full port opening. Disc and seat shall be removable without removing valve from line**.** Acceptable manufacturers: Crane, Jenkins, Powell, Vogt.

f. Gage and Instrument Valves: Shut-off valves for pressure gages and instrument isolating valves shall be of the "barstock" construction, with stainless steel body and stainless steel plug type disc integral with stem. Ends shall be I.P.S. screwed. Rating shall be 600 psig at 7500F. Valves shall be 1/2" size, Crane Co. or approved equal.

g. Blowdown Valves: Blowdown valves for cascades, expansion drums, and hot water generators shall be unit-tandem type valves, consisting of one hardseat and one seatless valve in one common steel body to conform to the ASME Boiler Code. Valves shall be rated at 400 psig and suitable for pressures to 665 psig. Valves shall have welding ends and alloy steel trim.

h. Needle Valves: For high temperature water convectors shall be of "barstock" construction with stainless steel body and stainless steel plug type disc integral with stem. Ends shall be I.P.S. screwed. Rating shall be 600 psig at 7500F., Crane Co. or approved equal.

i. Drain and Vent Valves: Drain and vent valves shall be ASA 600-pound class 1 forged steel globe or angle valves, as specified above. Drain valves need to be sized and shown on the Drawings. Unless otherwise required, vent valves shall be 1/2" size.

j. Control Valves: Flanged 300 lb. cast steel, 316 stainless steel trim, Fisher Type ES body with pneumatic 667

actuator. Valves 1-1/2" should not require a positioner; valves larger than 1-1/2" should have a positioner. Use equal percentage contour plug. Preliminary sizing shall be based on 20 psi. pressure differential (verify with Project Manager). Valves shall be capable of closing off against a 100 psi pressure difference.

23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Provide calculations for pipe line flexibility justifying pipe routing and anchor locations. Conform to ASME Code for allowable stresses. Furnish calculations for spring hangers. Calculations must address seismic considerations as required.

C. Materials and Methods of Construction

1. All piping with insulation shall be supplied with saddles and rigid insulation at pipe hanger locations.

2. Hanger spacing for copper pipe shall be as follows:

Pipe Size	Hanger Spacing
1"	6 ft.
1-1/2"	8 ft.
2"	9 ft.
3"	10 ft.
4"	12 ft.

23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

A. Design Considerations

1. Flexible connection shall be installed at pumps only when directed by Rutgers or when acoustic consultant recommendations are accepted by Rutgers.

2. Vibration control is usually not needed when pumps are mounted on basement slab. All vibration controls need to be carefully examined. Pads, isolated from the slab may be acceptable. Inertia blocks need to be considered when the pump room is in proximity to an acoustically important room.

B. Special Documentation Requirements

1. Seismic calculations shall be provided by a licensed New Jersey professional engineer as required to conform with applicable code requirements. Rutgers may require acoustic calculations be provided by a licensed New Jersey professional engineer for noise and\or vibration sensitive applications or to verify conformance with requirements referenced in these standards.

C. Materials and Methods of Construction

RESERVED

23 05 53 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Provide strap-on markers for pipe. Pressure-sensitive type markers are not acceptable.

2. Conform with ANSI 13.1.

3. All underground piping runs, both mechanical and plumbing shall be protected with buried pipeline marker. Marker to be 6 mil thick, 3" wide, fluorescent yellow polyethylene. Tape to be "metalicized" and imprinted to read "Caution- buried pipe below". Before excavation is started, call (1-800-272-1000) for utility markouts.

4. Tape to be placed 1'-0" directly above top of pipe, over entire length of run.

5. Tape to be placed on top of 4" deep x 6" wide layer of clean white sand.

6. Any existing tape which is encountered, removed or disturbed during excavation shall be replaced in conformance with items 1-3 above and to the approval of Rutgers, prior to backfilling.

23 05 93 TESTING, ADJUSTING, AND BALANCING for HVAC

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Rutgers reserves the right to bid "Testing, Adjusting, and Balancing" as a separate contract on any given project with the testing, adjusting, and balancing contractor working directly for Rutgers University. Direction shall be requested from the Office of Facilities Project Administration prior to developing design documents with regard to how the "Testing, Adjusting, and Balancing" portion of any given project will be bid.

C. Materials and Methods of Construction

1. HVAC Testing, Adjusting & Balancing contractors shall be limited to those listed below unless otherwise approved in writing by Rutgers:

   Technical Airflow, Inc. (973-827-2803)

   Effective Air Balance (973-790-6748)

   Dynamic Air Balance, Inc. (973-881-0360)

   National Air Balance Company (201-444-8777)

2. All new and relocated fume hoods shall be commissioned/balanced in accordance with the latest issue of ANSI/ASHRAE 110, "Method of Testing Performance of Laboratory Fume Hoods" both as manufactured and following installation/relocation at both full (occupied) operating velocity (100 FPM for existing "standard" performance legacy hoods, 80 FPM for new "low flow" hoods) and reduced (unoccupied) operating velocity (80 FPM for existing "standard" performance legacy hoods, 60 FPM for new "low flow" hoods) for those systems with occupied/unoccupied control

systems. "As Installed" ASHRAE field testing shall be conducted with the sash fully open. ASHRAE testing shall include airflow velocity assessments, local and large volume smoke study, and tracer gas testing (leakage test, and sash movement effect). For tracer gas testing, the mannequin test height shall be 5 feet 7 inches; however, the mannequin test height shall be adjusted to 5 feet 1 inch for ADA workstations.

3. ASHRAE testing contractors shall be limited to those listed below unless otherwise approved in writing by Rutgers:

   Micro-Clean, Inc. (800-523-9852)

   ENV-Services Testing & Certification, Inc. (800-617-3368)

4. Unless otherwise approved by University Facilities and REHS, ASHRAE testing shall be conducted after all HVAC system components have been properly commissioned and balanced. Fume hoods that maintain containment with an ASHRAE as installed rating of4.0 AI 0.05 are considered acceptable. Refer to Division 11, Section 11 53 13 'Laboratory Fume Hoods' for additional information.

23 07 13 DUCT INSULATION

A. Design Considerations

1. Interior insulation on ductwork is prohibited unless approved by REHS. Use external duct insulation for thermal purposes.

2. Where duct borne noise is a concern, utilize approved duct-mounted sound attenuators and\or double wall insulated duct (with perforated metal inner liner) as required to achieve acoustic design criteria.

B. Special Documentation Requirements

1. Insulation specification shall describe what systems and services are to be insulated.

C. Material and Methods of Construction

1. All insulation shall conform to Energy Code.

2. Staples are not acceptable for insulation installation.

3. All "raw" ends of insulation shall be sealed.

23 07 16 HVAC EQUIPMENT INSULATION

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Insulation specification shall describe what systems and services are to be insulated.

C. Materials and Methods of Construction

1. All insulation shall conform to Energy Code.

2. Staples are not acceptable for insulation installation.
3. All "raw" ends of insulation shall be sealed.

4. Mineral wool and calcium silicate may be considered for high temperature (greater than 300^{o} F.) service insulation.

23 07 19 HVAC PIPING INSULATION

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Insulation specification shall describe what systems and services are to be insulated.

C. Materials and Methods of Construction

1. All insulation shall conform to Energy Code.

2. Staples are not acceptable for insulation installation.

3. All "raw" ends of insulation shall be sealed.

4. Mineral wool and calcium silicate may be considered for high temperature (greater than 300^{o} F.) service insulation on above ground systems only.

5. High temperature hot water insulation for new piping below grade shall consist of Multi-Therm 500 Perma-Pipe System. Foamglass insulation with Pittwrap jacket shall be used for repair/replacement of insulation on existing below grade piping. See Section 33 61 00 'Hydronic Energy Distribution' for additional requirements.

23 09 00 INSTRUMENTATION AND CONTROLS for HVAC

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Approved controls vendors are as follows:

   a. Newark & Camden Campus: As directed by Rutgers Department of Utilities.

   b. For "State" facilities including University Housing (Except Newark & Camden Campuses):
   - Automated Logic Corporation of NY/NJ. Contact Zahrak Khan (973-390-2696)
   - Siemens Building Technologies. Contact Paul Parisi (973-396-4153)

   c. For Dining Services facilities:
   - Honeywell. Contact Amit Patel (A.M.E., Inc. 973-884-4100)

2. The Engineer of Record shall request direction from Rutgers Department of Utilities prior to developing design documents with regard to how the "Automatic Temperature Controls" portion of the project will be bid.

Acceptable Building Automation System (BAS) control system manufacturers, system configurations, and compatibility requirements with existing control systems and components and coordination of specifications with respect to compatibility of the BAS with factory mounted\wired equipment controls provided by others (i.e. air handling units, chillers, boilers, terminal units, etc.)

shall be reviewed and approved by both Rutgers Department of Utilities and Office of Program Development prior to developing design documents.

3. Design drawings shall include dedicated automatic temperature control drawing(s) showing control diagrams for all controlled equipment and systems as well as BAS architecture. Point-to-point wiring diagrams are preferred. Refer to Section 23 09 93 Sequence of Operations for HVAC Controls for additional documentation requirements.

C. Materials and Methods of Construction

1. Laboratory Controls:

   a. Manifold laboratory exhaust systems shall utilize pressure independent air valves of constant volume, two position or variable air volume (VAV) configuration depending upon the HVAC design under consideration. Where two-position or VAV type exhaust valves are utilized, corresponding supply valves and associated tracking controls must be provided. Exhaust valves, supply valves and associated fume hood & tracking controls shall be manufactured by Phoenix Controls unless otherwise approved in writing by the Office of Program Development

   b. In those instances where feasible and agreed to by the Office of Program Development, REHS and the end user, laboratories shall utilize ceiling-mounted occupancy sensors to provide local, independent demand-based occupied\unoccupied control of lighting (for "hood driven" labs not requiring general exhaust) or both lighting and HVAC (for labs requiring general exhaust). Occupancy sensors shall be hard-wired in parallel such that activation of any given occupancy sensor will index lab to "occupied" mode while requiring all occupancy sensors to be de-activated before enabling "unoccupied" mode after specified time delay. Occupancy sensors shall be of "dual technology" configuration employing both (adjustable) passive infrared and (adjustable) sound sensitive technologies to detect occupancy, shall "fail safe" (i.e. failure condition defaults to "occupied mode") and shall have an adjustable "delayed off" feature whereby the occupancy sensor will remain in the "occupied mode" of operation for up to 30 minutes (adjustable in one minute increments) after the laboratory has been vacated. A single,

separate, adjustable auxiliary time delay "holding" relay shall be hard-wired in parallel with ceiling mounted occupancy sensors to ensure that lights (and HVAC in labs requiring general exhaust) remain in "occupied mode" for up to 8 hours (adjustable in one minute increments) after lab has been vacated. Auxiliary time delay holding relay shall be energized (and "delayed off" countdown shall commence) upon indexing of lab from unoccupied mode to occupied mode by any ceiling mounted occupancy sensor. Auxiliary time delay relay contacts shall return to "normal" position after auxiliary relay countdown period has elapsed. The auxiliary relay shall reset when power is removed from the coil (i.e. all ceiling mounted occupancy sensors indexed to "unoccupied mode"), making the relay ready for a new cycle. The cycle shall repeat (i.e. auxiliary time delay holding relay shall be energized [and "delayed off" countdown shall commence] upon indexing of lab from unoccupied mode to occupied mode by any ceiling mounted occupancy sensor Auxiliary time delay holding relay shall be mounted in suitable, clearly labeled enclosure at accessible location in laboratory served. Ceiling mounted occupancy sensors shall be as manufactured by Watt-Stopper or approved equal. Ceiling mounted occupancy sensors, adjustable "delayed off" auxiliary holding relay and all associated wiring, devices and appurtenances as required to facilitate intended operation and accommodate applicable circuit power and voltage requirements shall be the responsibility of the electrical subcontractor as part of Division 26 work. Coordinate with Division 26 as required.

c. Occupied/unoccupied control of each lab shall be individually commissioned by the both the electrical subcontractor (local hard-wired default control mode) and the ATC subcontractor (occupancy schedule implemented remotely via BAS) under the supervision of Rutgers in-house Commissioning Agent. For commissioning purposes, electrical subcontractor shall initially adjust "delayed off" timing for all ceiling mounted occupancy sensors to 5 minutes with auxiliary "delayed off" holding relay set to zero (or its' contacts jumped out), and shall adjust sensitivity of "passive infrared" and "sonic" sensing functions at each occupancy sensor as required to eliminate "nuisance off" (i.e. lights extinguish with lab occupied prior to expiration of 5 minute delay) and "constant on" (i.e. lights remain on after lab has been unoccupied for more than 5 minutes) conditions. After local, hard-wired

occupied/unoccupied control has been demonstrated to the satisfaction of Rutgers' Commissioning Agent, the "delayed off" function of all ceiling mounted occupancy sensors shall be adjusted to thirty (30) minutes and the auxiliary "delayed off" time delay holding relay shall be set to two (2) hours. The lab shall then be kept vacated to ensure that lights (and HVAC for labs with general exhaust) are de-energized after the expiration of the 2 hour "delayed off" period. During commissioning of "local hard-wired default control mode", the BAS occupied/unoccupied "interface relay" (reference paragraph i.) shall be indexed to unoccupied mode. Rutgers' Commissioning Agent shall coordinate with laboratory supervisory staff to establish suitable occupancy schedule for each lab, and shall provide ATC subcontractor this information for programming purposes. The ATC subcontractor shall demonstrate proper programming/operation of each lab to Rutgers' Commissioning Agent with occupied/unoccupied control under the command of the BAS. Upon completion of commissioning for each lab as described above, the ATC subcontractor shall disable scheduled remote occupied/unoccupied control thru the BAS and leave each lab under local hard-wired control.

d. The number, mounting locations and wiring configuration of occupancy sensors and associated controls shall be reviewed and approved by the Office of Program Development and REHS, and shall be in full accordance with the installation recommendations of the occupancy sensor manufacturer. A sufficient number of ceiling-mounted occupancy sensors shall be provided to eliminate potential blind spots caused by building obstructions (i.e. laboratory shelving, columns, etc.). Consideration must also be given to the location of ceiling-mounted occupancy sensors in the vicinity of ceiling diffusers and other sound generating devices that may trigger a false "occupied" condition.

e. Where project program requires the ability to perform light sensitive experiments in a given lab, independent control of lighting and HVAC shall be provided such that lighting control is implemented by manual wall switch(es) with demand-based control of HVAC implemented by occupancy sensors. Coordinate this requirement with Division 26 work as required.

f. All laboratory **fume hoods that operate at reduced face velocities** (minimum face velocity shall not be reduced below 60 FPM) **when the hood is unattended**, shall be equipped with a "Zone Presence Sensor" as manufactured by Phoenix Controls or approved equal that will maintain an attended face velocity (i.e. 80 FPM for "high performance" hoods, 100 FPM for existing standard performance "legacy" hoods) in the full open position whenever anyone is in proximity to the fume hood.

g. For laboratories where design air flow requirements ***are not*** driven by fume hood exhaust requirements (i.e. labs requiring general exhaust in addition to fume hood exhaust to satisfy minimum occupied air change requirements or maintain design space temperature conditions), ceiling mounted occupancy sensors shall be provided to control lighting and ensure occupied mode minimum air change rate and temperature setpoint is maintained whenever the lab is occupied. Ceiling mounted occupancy sensors shall be in addition to and wired independently from fume hood "Zone Presence Sensor(s)" such that attended/unattended hood status will not be contingent upon laboratory occupancy status.

h. For laboratories where design air flow requirements ***are*** driven by fume hood exhaust requirements ***and*** the laboratory air change rate is greater than or equal to 12 ACH with all hoods exhausting minimum design CFM (i.e. labs not requiring general exhaust), ceiling mounted occupancy sensors shall be utilized only for lighting control (i.e. not utilized for control of laboratory HVAC) and occupied/unoccupied control of individual fume hoods shall be accomplished locally by the Zone Presence Sensor at each respective hood.

i. Occupied\unoccupied control of laboratory HVAC and lighting systems shall be locally hard-wired such that each laboratory operates independently. Where large open labs are comprised of multiple "lab modules" ("lab module" being defined as a smaller area within the larger lab having local control of temperature and supply/exhaust air flow serving that area), occupied/unoccupied control of laboratory HVAC and lighting systems shall be locally hard-wired such that each "lab module" operates independently within the larger lab. Computerized lighting control and\or global occupied\unoccupied control of

lighting and\or HVAC from the BAS shall not be permitted as a substitute for local hard-wired control as heretofore described. However, a relay contact from the BAS shall be wired in parallel with the local hard-wired occupied/unoccupied HVAC/lighting control circuit of each laboratory to facilitate remote occupied/unoccupied override control of lighting and/or HVAC for any or all labs (i.e. each laboratory would be capable of having its' own individual occupied/unoccupied occupancy schedule programmed into the BAS). ATC subcontractor shall furnish and install interface relay between BAS and local hard-wired lighting/HVAC control circuit at each lab. Electrical subcontractor shall wire contact side of interface relay. ATC subcontractor shall wire coil side of interface relay. Coordinate this work with Division 26 as required.

j. The controls contractor shall program a user defined occupancy schedule for each laboratory into the BAS but shall leave each laboratory under local control when the building is turned over to the Owner upon completion of work.

k. Each fume hood shall be equipped with a face velocity alarm monitor or controller and associated components that are compatible with the specified laboratory HVAC control system and components (i.e. supply & exhaust valves, etc.). At a minimum, the system shall have a visual indicator (with digital display) of the hood face velocity and adjustable low flow/caution alarm points with audible alarm. Low flow alarm must have dual setpoint capability to avoid nuisance alarms where reduced face velocities are maintained during the unattended mode of operation. It is also recommended that each fume hood be equipped with a local high sash alarm activated when the sash height exceeds 19 inches. High sash alarm shall be equipped with a silence button with an adjustable timing device that resets when the sash is lowered. Calibration of the fume hood face velocity alarm must be included as part of acceptance testing performed prior to project close out. Combination sash (vertically and horizontally tracked) hoods shall be equipped with a stationary sash limit switch that closes a pair of contacts when the bottom of the vertical sash is less than two inches (2") from fully closed position.

l. Fume hood controls may be either factory mounted/wired or field mounted/wired at the discretion of the engineer-of-

record. Provision and specification of fume hood controls must be coordinated with Section 11 53 13 *Laboratory Fume Hoods* of these Design Standards. The control system chosen must be approved by the Office of Program Development.

m. Phoenix Controls shall provide hardware, programming and graphics (i.e. Phoenix "Dashboard") as required to generate monthly laboratory performance trend log reports totally independent of the BAS. Trend logs shall be generated for each fume hood in each individual laboratory for large scale projects and shall be readily available via the internet to the lab coordinator, energy conservation manager and REHS. Reports shall be archived/available on a rolling three month basis. Each monthly report shall provide the following information for each hood in a given lab:

- Total number of hours hood sash(es) is (are) greater than 60% open (adjustable)
- Total number of hours hood sash(es) is (are) between 40% open and 60% open (adjustable)
- Total number of hours hood sash(es) is (are) less than 40% open (adjustable)
- Total exhaust CFM and corresponding estimated operating cost
- Total number of hours hood is unattended

In addition to hood data, monthly trend logs shall be generated for each individual lab that utilizes ceiling mounted occupancy sensors. Each monthly report shall provide the following information for each lab:

- Total number of hours lab is unoccupied

Laboratory room numbers and fume hood identification nomenclature referenced in monthly trend log reports shall match building/hood signage.

n. Each laboratory shall be equipped with a “room pressure indicator” as manufactured by Airflow Direction Incorporated (www.airflowdirection.com) or approved equal. The room pressure indicator shall be installed in the wall above or immediately adjacent to the primary access doorway(s) to each laboratory and shall visually indicate whether the lab is being maintained at the proper pressure relative to the adjacent space. Each room pressure indicator

shall be selected to visually alarm either a positive or negative pressure condition as dictated by the application.

23 09 93 SEQUENCE OF OPERATIONS for HVAC CONTROLS

A. Design Considerations:

RESERVED

B. Special Documentation Requirements

1. Design drawings shall include dedicated automatic temperature control drawing(s) showing detailed written sequence of operation adjacent to the corresponding control diagram for all controlled equipment and systems. Sequences of operation should specify all setpoints and deadbands and shall indicate which are adjustable. Refer to Section 23 09 00 *Instrumentation and Controls for HVAC* for additional documentation requirements.

A. Materials and Methods of Construction

RESERVED

23 11 13 FACILITY FUEL OIL PIPING

RESERVED

23 11 23 FACILITY NATURAL GAS PIPING

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Documentation demonstrating conformance with Factory Mutual requirements must be submitted to FM for review\approval as required.

C. Materials and Methods of Construction

1. All natural gas systems shall be installed and utilize materials in full accordance with the latest edition of NFPA 54.

2. Gas piping shall be painted yellow.

23 21 13 HYDRONIC PIPING

A. Design Considerations

1. Hydronic piping shall not be installed under any floor slab without written approval from Rutgers Project Administration. Where written approval is granted, any hydronic piping installed under the floor slab shall conform to requirements of Division 2, Section 33 61 00 'Hydronic Energy Distribution' for underground site piping. Refer to Section 33 61 00 for additional information.

B. Special Documentation Requirements

1. Hydronic piping shall not be installed under any floor slab without written approval from Rutgers Project Administration.

C. Materials and Methods

- ***Hydronic (including aqueous glycol solutions but excluding high temperature hot water) Piping, Refrigerant Vent, Safety Valve Vent and Drain Piping:***

1. Certified welders are required for all welded piping. Welders, welding procedures, performance of welders and welding operators shall comply with requirements of ANSI/ASME B31.9 and the ANSI/ASME Boiler and Pressure Vessel Code, Section IX.

2. Weld joints are required in carbon steel pipe as follows:

    a. Carbon steel pipe 3" and larger

    b. Carbon steel piping of any diameter which is inaccessible in shafts, chases or walls

3. Victaulic mechanical pipe couplings, fittings, valves and other grooved components may be used in lieu of welded steel piping for accessible aboveground hydronic piping systems, with the exception of hot water systems, in Mechanical Equipment Rooms only. All grooved components shall be by Victaulic Company of America, and conform to local code approval and/or as listed by ANSI-B-31.1, B-31.3, B31.9, ASME, UL/ULC, FM, IAPMO or BOCA. Pipe shall be carbon steel, ASTM A 53A 53M Grade B, roll or cut grooved ends as appropriate to pipe material, wall thickness, pressures, size and method of joining. Pipe ends to be grooved in accordance with Victaulic current listed standards conforming to ANSI/AWWA C-606. Victaulic couplings shall be Rigid Type (Style 107H with grade 'EHP' gasket for sizes 3"

thru 8" and Style 07 with grade "E" EPDM gasket for sizes above 8") as required to provide system rigidity/support and facilitate hanging in accordance with ANSI B31.1, B31.9 and NFPA 13. Flexible couplings (Victaulic Style 177 with grade "EHP" gasket for sizes 3" thru 8" and Style 77 with grade "E" EPDM gasket for sizes above 8") shall be used only in locations where vibration attenuation and stress relief are required and may be used in lieu of flexible connectors at equipment connections with a minimum of three flexible couplings installed in close proximity to the vibration source.

4. Minimum material requirements for designated hydronic, vent and drain piping shall be as follows (more stringent material requirements may apply as required to suit performance ratings of specific project):

    c. Pipe:

    3" and larger: Standard weight ERW or seamless carbon steel, ASTM A 53/A 53M, Grade B, dimensions to ANSI B36.10M

    2-1/2" and smaller: Schedule 40 seamless or welded carbon steel, ASTM A 53/A 53M, Grade B, ANSI B36.10 or seamless copper Type "L" tubing, ASTM B88

    b. Fittings:

    3" and larger: Steel butt weld fittings, ANSI B16.9 or steel or ductile iron (Victaulic) grooved end fittings. Welded elbows shall be long radius pattern.

    2-1/2" and smaller: Steel Pipe…malleable iron threaded fittings, Class 150, ANSI B16.3. Copper Tubing…wrought copper solder joint pressure fittings, ANSI B16.22

    c. Joining Materials:

    3" and larger: Welded or grooved joint couplings

    2-1/2" and smaller: DuPont Teflon tape or paste, 95/5 (tin antimony) solder, conforming to ASTM B32

    d. Flanges for Piping 3" and larger:

    Flanges…forged carbon steel, slip-on, ASTM A105/A 105M, raised face or flat face, dimensions to ANSI B16.5, Class 150. Flange Bolts…alloy steel, ASTM A 193/A 193M, Grade B7, threaded full length, heavy hex nuts.

Gaskets…non-asbestos with synthetic fibers and SBR binders. Garlock Style 3200 or equal.

e. Unions for Piping 2-1/2" and smaller

Brass solder or steel

f. Dielectric Fittings:

Utilize isolation flanges or dielectric nipples for connection of dissimilar metals as required to suit application. Do not use dielectric unions. Dielectric nipples shall be 'Clearflow' as manufactured by Perfection Corporation or equal. Isolation flanges shall be as manufactured by Epco or equal.

5. Terminal units shall utilize combination fittings and Venturi type flow meters as manufactured by Flow Design, Inc. or equal.

6. Use of 'Pro-press' fittings, should generally be limited to facilities with wood frame (combustible) construction in pipe sizes of 2" and below. Use of 'Pro-press' fittings requires Rutgers approval.

- ***High Temperature Hot water:***

1. All welding of high temperature/high pressure water systems shall be performed by welders certified in accordance with ASME Boiler and Pressure Vessel Code, for pressure piping, latest edition.

2. Materials for High Temperature Hot Water Systems shall be as follows:

a. Pipe:

3" and Larger	Under 3"and Smaller
Schedule 40 ASTM A 106, Grade B Carbon Steel Seamless	Schedule 80 ASTM A 106, Grade B Carbon Steel Electric Resistance Welded

b. Fittings

2" and Larger	Under 2"
Schedule 40 Wrought Steel, Seamless	3,000 pound Forged Carbon Steel

Butt-welded type	Socket weld
ASME B 16.9	ASME B 16.11
ASTM A 234 WPB	ASTM A 105 Grade B

Weld ells shall be long-radius pattern.

c. Flanges (all sizes): 300 pound class, forged steel, welding neck type, ASA B 16.5 ASTM A 181 Grade I.

d. Gaskets (all sizes): Spiral wound, type 304 stainless steel, non-asbestos filled, 3/16" thick with centering guide, 300 pound class, Flexitallic style CG**,** or approved equal.

e. Strainers (all sizes): Y-type; same size as pipe in which they are installed. Strainers shall have cast steel bodies suitable for 425^{o} F temperature and 600 psig pressure, bottoms drilled, directional arrow on body. Strainers shall be equipped with easily removable cover and basket. Basket shall be stainless steel, 3/32" perforations; net free area through back of basket shall be 2-1/2 times the area of connecting pipe. Flow shall be into basket and out through perforations.

f. Unions (normally not to be used on pipe larger than 1"): 3,000-pound class forged steel, socket-welded type, with steel to steel seat, ASTM A 105 Grade II, as manufactured by Henry Vogt Machine Co. or approved equal.

g. Bolts and Studs: Alloy steel studs threaded full length and fitted with two hexagon nuts per stud for all flanged joints. Bolting to conform to ASTM A 193 Grade B-7, threads class 7 fit. Nuts shall be semi-finished hexagonal, ASA B 18.2 ASTM A 194 Grade 2H.

- ***Pumped or Gravity Condensate Drain Piping:***

1. Piping (all sizes) shall be hard-drawn seamless copper tubing, Type L, ASTM B88

2. Fittings (all pipe sizes) shall be wrought copper solder joint pressure fittings, ANSI B16.22

3. Joints (all pipe sizes) shall be soldered 95/5 (tin/antimony), ASTM B32

4. Flanges (piping 3" and larger) shall be 150 pound cast bronze, ANSI B16.24 with ASTM A307, Grade B hex machine bolts & heavy hex nuts and Garlock Style 3200 (or equal) non-asbestos gaskets.

5. Unions (piping 2-1/2" and smaller) shall be wrought copper solder type, ANSI B16.22

6. Utilize isolation flanges or dielectric nipples for connection of dissimilar metals as required to suit application. Do not use dielectric unions. Dielectric nipples shall be 'Clearflow' as manufactured by Perfection Corporation or equal. Isolation flanges shall be as manufactured by Epco or equal.

23 21 13.33 GROUND-LOOP HEAT PUMP PIPING

RESERVED

23 21 23 HYDRONIC PUMPS

A. Design Considerations

1. Consult with Rutgers about pump selection philosophy. Limit speed to 1750 RPM. Any pumps handling HTW shall be selected with Rutger's input. Industrial pumps may be required. Selection should be made for high efficiency. Consideration of life cycle cost study of variable speed pumping should be made. Use mechanical seals when choice is available. Use cyclone separator type seal waste cleaning device on all pumps that can be equipped with it (generally on all double suction pumps).

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. For small flows and low heads, in-line circulators may be used, this application is limited to zoned residential-type (or similar) systems and may include systems intended to prevent cold freeze-up. Typical limits are 80 GPM at 25 feet TDH.

2. Vertical in-line pumps may be used for systems similar to those described in the paragraph above where a larger system head exists. Typical limits are 3", 7-1/2 HP.

3. Base-mounted close coupled and separately controlled, end suction pumps shall be used when flows are between 100 and 500 GPM. The suction connection should be less than 4". Close coupled pumps should not exceed 10 HP and should not exceed 15 HP for the separately coupled pump. Base mount or separately coupled pumps should be of the back pull-out type.

4. Base-mounted, separately coupled double-suction, horizontal split-case type pumps should be used for connections 4" and larger. B&G VSC may be used. Consider vertical pumps, such as Aurora 413, where space is at a premium.

23 22 13 STEAM AND CONDENSATE HEATING PIPING

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Use steel pipe conforming to ASTM A 53, Grade B. Use of copper pipe shall be subject to approval by Rutgers. If copper pipe is used, modify fittings accordingly.

2. Steel piping 1" or less for low-pressure steam shall be Schedule 80.

3. Use bimetallic element traps only with Rutgers approval.

4. Pipe discharge from safety valves shall be terminated at a safe height and location to prevent personnel harm.

23 22 23 STEAM CONDENSATE PUMPS

RESERVED

23 23 00 REFRIGERANT PIPING

RESERVED

23 25 00 HVAC WATER TREATMENT

A. Design Considerations

1. Water treatment is required for all heating, chilled water and condenser water loops to ensure the longevity of piping and equipment while minimizing maintenance.

B. Special Documentation Requirements

1. Documentation requirements should be discussed with Rutgers.

C. Materials and Methods of Construction

1. Water treatment should be discussed with Rutgers.

2. Water treatment systems shall be by the current water treatment maintenance vendor under contract with Rutgers University. This shall be confirmed with Rutger's Department of Utilities at time of design.

23 31 00 HVAC DUCTS and CASINGS

RESERVED

23 31 13 METAL DUCTS

A. Design Considerations

1. Hazardous Systems Exhaust:
   Laboratory fume hood exhaust and general exhaust may be combined in a common manifold system subject to applicable code requirements unless otherwise directed by Rutgers. Circular Stainless steel ductwork shall be utilized for all portions of manifold laboratory exhaust systems unless otherwise approved by University Facilities and REHS.

   a. Bio-Safety cabinets shall not be connected to the general exhaust system or the fume hood exhaust system. All requests to connect a bio-safety cabinet to an exhaust system must be reviewed and approved by REHS and meet NSF 49 requirements.

   b. The discharge point must be at a proper height above the highest point of the roof or parapet (10-15 ft.) to reduce air

streaming effects of the building. Air shall be discharged vertically with at least 3000 feet per minute stack discharge velocity. The discharge stack should be located in the prevailing downwind direction of air intake point.

c. Deflecting weather caps are prohibited on discharge stacks, as they reduce the effective stack height, reduce air velocity, are not effective rain shields, and increase final cost.

d. Each perchloric acid hood shall have an individual exhaust system (i.e., individual duct to individual fan). The ductwork shall go straight from the hood to the roof with no horizontal runs or sharp turns. "Wash-down" facilities shall be built into the hood and ductwork.

B. Special Documentation Requirements

Submit field test report certifying that ductwork does not exceed the maximum allowable leakage.

C. Materials and Methods of Construction

1. General Duct Design and Construction

   a. All general use supply, return and exhaust ductwork shall be Seal Class "A" and 4" W.G. construction (minimum) upstream of VAV terminals and 2" W.G. construction downstream of VAV terminals.

   b. Rectangular ductwork shall have Pittsburgh lock seams. Provide 'Ductmate' or TDC connections for ducts 8" and larger. Provide SMACNA Type T-2 and T-10 connections for ducts 8" and smaller.

   c. Round ductwork shall have SMACNA Type RL-1, RL-4 or RL-5 seams with type RT-1, RT-6 or RT-5 connection (with bead).

   d. Volume dampers shall have end bearing, continuous axle, locking quadrant and stand-off to clear insulation.

   e. Duct take-offs shall be equal to Buckley model 3300 with heavy duty volume damper.

2. Fume Hood Duct Design and Construction

a. Ducts shall be constructed of non-reactive, circular stainless steel with welded connections. Questions about duct compatibility with chemicals used in the laboratory should be referred to REHS for review.

b. Fume hood exhaust systems should be balanced by adjusting fan performance (i,e, fan speed, bypass air dampers, etc.). Manifolded laboratory exhaust systems should be equipped with Phoenix venturi valves (constant volume, two-position or VAV to suit application) for purposes of system balancing/control. Where manual balancing damper is required to balance fume hood, damper shall be located at the duct connection to the hood. Balancing dampers used for this purpose shall be equal to Nailor Model #1090 with all stainless steel construction and hand locking quadrant.

c. Ductwork shall take the straightest route to the roof, minimizing bends and horizontal runs. Increased distances and bends create resistance to air flow and require larger exhaust motors. When elbows are necessary, they shall have proper center-line radius (one-and-one-half times the diameter of the ducts) to minimize eddying and resistance to air flow. All elbows shall have removable wear plates when operations will involve heavy dust concentrations. Adjustable elbows and segmented standing seam elbows are prohibited. Ductwork shall not enter the blower motor on an elbow.

d. The discharge stack shall be uncapped, straight, and cylindrical. The discharge duct shall overlap the fan ductwork 6" and have a 1" greater diameter, to provide for rain drip discharge.

e. Ductwork serving hydrofluoric acid hoods shall be constructed of Teflon lined 316 or 304 stainless steel. Horizontal runs and bends in ductwork must be kept to a minimum.

3. Duct Leakage Tests

a. Leak test each new ductwork system before ductwork is insulated and concealed.

b. The A/E shall consult with Rutgers on a project by project basis to determine scope of leak testing based upon specific project requirements and budget constraints. As a basis for

discussion, the preliminary scope of leakage testing shall be as follows:

i. Test all duct risers in shafts which extend more than one floor.

ii. Test one section, not in shafts, on each floor for each duct construction pressure classification for each individual supply, return and exhaust system.

iii. In addition, test five (5) more duct sections on each floor as selected by Rutgers or Rutgers' representative.

iv. Independent leak testing of equipment (i.e. air handling units, fans, VAV terminals, etc.) to assure compliance with specified equipment leak rates, will generally not be required.

c. Follow general procedures (Chapter 3) and use apparatus (Chapter 5) as outlined in SMACNA HVAC Air Duct Leakage Test Manual as required to leak test either positively pressurized or negatively pressurized ductwork as applicable.

d. Unless otherwise approved by Rutgers, test all ductwork at 100% of the specified pressure classification, not the working pressure.

e. Unless otherwise approved by Rutgers, maximum allowable leakage rate shall be a percentage of the total rated airflow (CFM) capacity for each ductwork system tested (regardless of pressure classification) as follows:

i. Outside air, relief air and transfer air ductwork shall have maximum allowable leakage rate of 5%

ii. All other duct systems shall have a maximum leakage rate of 3%

f. All devices, including access doors, airflow measuring devices, sound attenuators, damper casings, test ports, etc. that are installed in the duct systems shall be included as part of the duct systems leakage allowance and tested accordingly.

g. Air leakage for equipment, such as fans, air handling units and terminal boxes should be accounted for separately based

upon specified equipment air leakage criteria. Equipment should be isolated during ductwork testing unless otherwise approved by Rutgers.

h. If tests show that ductwork system leakage is greater than that allowed, ductwork shall be resealed and retested until allowable leakage is not exceeded, at no additional cost to Rutgers. All tests shall be witnessed by Rutgers' Commissioning Agent.

i. A field test report certifying that ductwork does not exceed maximum allowable leakage shall be submitted to Rutgers upon completion of testing.

23 31 16.13 FIBROUS-GLASS DUCTS

RESERVED

23 31 16.1 THERMOSET FIBERGLASS-REINFORCED PLASTIC DUCTS

RESERVED

23 33 00 AIR DUCT ACCESSORIES

RESERVED

23 33 46 FLEXIBLE DUCTS

RESERVED

23 34 00 HVAC FANS

RESERVED

23 34 13 AXIAL HVAC FANS

RESERVED

23 34 16 CENTRIFUGAL HVAC FANS

A. Design Considerations

1. Exhaust fans and duct systems for hoods are to be sized and designed to provide an average hood face velocity of 80-100 LFM, as measured at the face, with the sash wide open. Deviations in this value shall not be greater than 20% at any point across the hood face. To assure this standard, the designer must work closely with the duct installer to determine the effects of duct routing on motor sizing.

2. Exhaust fans shall be located on the roof, or properly ventilated fan loft so that a negative pressure will be maintained in the ductwork and prevent escape of toxic material through holes and cracks in the duct. Exhaust motors shall be located to allow access for maintenance.

3. Manifold exhaust systems shall be equipped with 100% (i.e. n + l) redundancy such that if a single fan fails (or requires maintenance) the other fan(s) will automatically maintain uninterrupted exhaust system operation.

4. Do not use backdraft dampers on laboratory fume hood fans unless specifically approved by Rutgers.

5. Rutgers may require an analysis of effluent plume shape and dispersion by a specialist in air wake analysis. Specialist shall be approved by Rutgers. Such analysis is typical for all discharge stacks such as laboratory fume hood or other laboratory discharges.

6. Perchloric acid hoods shall utilize an air ejector system or an exhaust fan. An air ejector exhaust system eliminates the possibility of acid reaction with fan components and allows for ease of cleaning.

7. Exhaust fans and duct systems for other lab equipment (compressed gas cabinets, local exhaust trunks, autoclaves, etc. shall be designed and sized to comply with the ACGIH Industrial Ventilation Handbook, a Manual of Recommended Practice.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Drives for centrifugal fans used for general exhaust (i.e. non-fume hood) applications shall be direct drive or multi-belt. Direct drive is preferred to belt drive where practical. Where belt drives are utilized, generous size pulleys shall be used to reduce the belt bending.

2. Fans shall be provided with all factory options as required to suit application.

3. Blades of fans serving perchloric acid hoods shall be made of acid resistant metal or a metal protected by an inorganic coating. The fan shall be lubricated with fluorocarbon type grease.

4. The motor and blower housing of fans serving hydrofluoric acid hoods shall not have exposed metallic parts.

5. Fume hood exhaust fans shall be direct drive type as manufactured by Strobic Air Corporation, MK Plastics or approved equal. Fans used for general exhaust shall be as manufactured by Penn, Greenheck, Carnes or approved equal.

23 34 23 HVAC POWER VENTILATORS

RESERVED

23 34 33 AIR CURTAINS

RESERVED

23 36 00 AIR TERMINAL UNITS

A. Design Considerations

Fan-powered VAV terminals should not be used without prior approval from Rutgers. Fan-powered terminals require more maintenance than standard air terminals.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

RESERVED

23 37 13 DIFFUSERS, REGISTERS, AND GRILLES

RESERVED

23 37 23 HVAC GRAVITY VENTILATORS

RESERVED

23 38 13 COMMERCIAL KITCHEN HOODS

RESERVED

23 41 00 PARTICULATE AIR FILTERS

A. Design Considerations

1. HEPA or charcoal filters are not required for most routine uses of fume hoods. Install a filter or filter housing only if specified by REHS. Where filters are required, the housing shall be located in the fan room or roof before the blower. The filter housing shall be located to allow for easy filter changing by the bag-in bag out technique.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Filters shall be as manufactured by Cam-Farr or approved equal.

23 51 00 BREECHINGS, CHIMNEYS, AND STACKS

A. Design Considerations

1. The MASTERSPEC version of this specification can be used for relatively small, isolated boiler plants. For larger plants, consult Rutgers. Terminations of chimneys shall be "open" (without weathercap) so that an upward velocity is possible, without sideward flue gas movement. Design so that gases will not be

drawn into adjacent outdoor air intakes, windows or otherwise create a nuisance or hazard. A mechanical draft control device may be necessary at the outlet of the stack as dictated by design constraints.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Materials and methods shall be in full conformance with the latest issue of the International Mechanical Code and applicable NFPA requirements.

23 51 13 DRAFT CONTROL DEVICES

RESERVED

23 52 00 HEATING BOILERS

A. Design Considerations

1. Boiler design and sizing of boilers shall conform to the requirements of the current "Boiler Pressure Vessel and Refrigeration Code" as issued by the NJ Department of Labor; Office of Pressure Vessel Compliance. Stand alone boilers shall be designed such that a licensed operator is not required to monitor boiler plant operation. Cast iron sectional boilers, non-condensing high efficiency or high efficiency condensing boilers are the preferred boiler for remote locations and relatively small boiler plants. Boilers shall operate at 15 psig or less unless otherwise approved by Rutgers. Use hot water generators when possible.

B. Special Documentation Requirements

1. Fuel burning equipment must be registered with REHS by the A/E (care of the project team leader) during design. Fuel burning equipment with a maximum rated fuel input of 1,000,000 BTU/hr or greater will require an air permit, prior to installation. REHS will submit all air permit applications. ~~Engineer-of-Record~~ The A/E shall be responsible for preparation and follow-up correspondence with REHS and\or the DEP for all permitting required for fuel burning equipment. The A/E is responsible to supply equipment information to REHS with adequate lead-time to obtain permit (180

days prior to intended installation date.) This information includes, but is not limited to: a description of the fuel burning equipment, manufacturer name, model number and fuel type used. All documentation demonstrating conformance with Factory Mutual requirements must be submitted to FM for review\approval as required.

C. Materials and Methods of Construction

1. Refer to section of Standards pertaining to boiler type under consideration.

23 52 13 ELECTRIC BOILERS

A. Design Considerations

1. Do not use electric boilers except for small outputs which serve a special piece of equipment (5 HP or less). Electric boilers shall not be used unless approved by Rutgers.

B. Special Documentation Requirements

C. Materials and Methods of Construction

1. Selection of electric boilers shall be subject to Rutgers approval.

23 52 16 CONDENSING BOILERS

A. Design Considerations

1. Use of high efficiency condensing boilers shall be limited to new projects where design maximum hot water return temperature does not exceed 140 degrees F. Condensing boilers should not be used on renovation projects without Rutgers approval (i.e. A/E must demonstrate that the boiler can operate in condensing range given constraints of existing system).

B. Special Documentation Requirements

1. Refer to Section 23 52 00 'Heating Boilers'.

C. Materials and Methods of Construction

Condensing boilers shall be as manufactured by Patterson-Kelley, Lochinvar, or Aerco.

23 52 23 CAST IRON BOILERS

A. Design Considerations

1. Cast iron boilers, though lower in efficiency than other boiler types, have proven to be reliable and require relatively low maintenance. Refer to Section 23 52 00 'Heating Boilers' for additional design considerations.

B. Special Documentation Requirements

1. Refer to Section 23 52 00 'Heating Boilers'.

C. Materials and Methods of Construction

1. Approved cast iron boiler manufacturers are Buderus, Utica and Weil-McLain. Buy as a package unit when possible with high-efficiency burners approved by Rutgers.

23 52 33 WATER-TUBE BOILERS

RESERVED

23 52 33.13 FINNED WATER-TUBE BOILERS

A. Design Considerations

1. High-efficiency non-condensing boilers have proven to offer a good combination of reliability, and performance for renovation projects. The compact size of these boilers facilitates replacement of existing boilers without demolition of walls, etc. Refer to Section 23 52 00 'Heating Boilers' for additional design considerations.

B. Special Documentation Requirements

1. Refer to Section 23 52 00 'Heating Boilers'.

C. Materials and Methods of Construction

1. High-efficiency boilers shall be "P-K Thermific" as manufactured by Patterson-Kelly Co., or approved equal.

23 52 39 FIRE-TUBE BOILERS

A. Design Considerations

1. Such boilers may be considered for installations larger than 50 horse power. They should be multi-pass and have an efficiency of greater than 80% at the design point. Consult Rutgers for use of dual-fuel burners for type of burner to use, turn-down desired and type of control to use. Refer to Section 23 52 00 'Heating Boilers' for additional design considerations.

B. Special Documentation Requirements

1. Refer to Section 23 52 00 'Heating Boilers'.

C. Materials and Methods of Construction

1. Selection of fire-tube boilers shall be subject to Rutgers approval.

23 53 00 HEATING BOILER FEEDWATER EQUIPMENT

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Feedwater equipment and installation shall be approved by Rutgers.

23 53 16 DEAERATORS

RESERVED

23 54 00 FURNACES

RESERVED

23 55 00 FUEL-FIRED HEATERS

A. Design Considerations

1. Do not use without permission of Rutgers. When permitted, use gas-fired (not oil-fired) units with electronic ignition and stainless steel heat exchangers.

B. Special Documentation Requirements

1. Fuel burning equipment must be registered with REHS by the A/E (care of the project team leader) during design. Fuel burning equipment with a maximum rated fuel input of 1,000,000 BTU/hr or greater will require an air permit, prior to installation. REHS will submit all air permit applications. The A/E shall be responsible for preparation and follow-up correspondence with REHS and\or the DEP for all permitting required for fuel burning equipment. The A/E is responsible to supply equipment information to REHS with adequate lead-time to obtain permit (180 days prior to intended installation date.) This information includes, but is not limited to: a description of the fuel burning equipment, manufacturer name, model number and fuel type used. All documentation demonstrating conformance with Factory Mutual requirements must be submitted to FM for review\approval as required.

C. Materials and Methods of Construction

1. Refer to section of Standards pertaining to fuel-fired heater type under consideration.

23 55 13 FUEL-FIRED DUCT HEATERS

RESERVED

23 55 23 GAS-FIRED RADIANT HEATERS

RESERVED

23 55 33 FUEL-FIRED UNIT HEATERS

RESERVED

23 57 00 HEAT EXCHANGERS FOR HVAC

A. Design Considerations

1. Design steam pressure shall be 15 psig or less (low pressure) unless otherwise approved by Rutgers.

2. Domestic water generally should be heated with high temperature hot water (HTHW) when central heating system is available.

3. HTHW system operating parameters vary depending upon the system under consideration.

4. For the Busch and Livingston campuses, HTHW is provided from the Busch Central Heating Plant. HTHW leaves the plant at approximately 365 degrees F. and a pressure between 180 psi and 200 psi. Depending on where the building is located on the distribution system, the temperature will vary between 335 degrees F. and 360 degrees F. The pressure will vary between 160 psi and 200 psi. Heat exchangers shall be designed for a 100 degree temperature differential. More specific design parameters can be provided by Rutgers Utilities Department based upon actual building location.

5. For the College Avenue campuses, HTHW is provided from the College Avenue Central Heating Plant for a portion of the campus. HTHW leaves the plant at approximately 315 degrees F. and a pressure of approximately 110 psi. Heat exchangers shall be designed for a 75 degree F. temperature differential. Depending on where the building is located on the distribution system, temperatures and pressure will vary. More specific design parameters can be provided by Rutgers Utilities Department based upon actual building location.

B. Specials Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Selection and specifications for liquid-to-liquid, steam-to-liquid, air-to-air, etc. shall be reviewed with Rutgers.

2. Refer to Section 23 05 23 ‘General-Duty Valves for HVAC’ and Section 23 21 13 ‘Hydronic Piping’ for related information.

3. All heat exchangers shall comply with ASME Boiler and Pressure Vessel Code and shall be stamped with appropriate code symbols.

4. HTHW heat exchangers shall be shell and tube type. HTHW shall be in tubes. Tubes shall be 90-10 copper-nickel. Heads shall be forged steel. In water-to-water exchangers, the water flow shall be upward. In water-to-steam generators, the controls shall be similar to those used for fired steam generators, excluding low water cutoff. Provide separate over-temperature control on leaving hot water. Provide required level controls, relief and/or safety valves on water or steam generators. Provide increased tube pitch on steam generators. Shell flow shall be designed for 100% of system flow.

5. 35% propylene glycol solution should provide adequate freeze protection where freezing is a consideration. In heat recovery applications, 35% ethylene (in lieu of propylene) glycol may be used to optimize system performance. Consult with Rutgers if it is felt that a greater percentage is required.

6. Provide units with a fouling factor of 0.0005 for water or as approved by Rutgers.

7. HTHW-to-water heat exchangers shall have the operating and high limit temperature sensing elements located in the shell near the outlet nozzle or immediately adjacent to outlet nozzle.

8. Bolted flange connections shall be provided on both the primary side and secondary side of all heat exchangers.

9. HTHW heat exchangers shall be shell and tube type with HTHW in tubes. Tubes shall be 90-10 copper-nickel. Heads shall be forged steel. HTHW heat exchangers shall be as manufactured by Cemline, Yula, Bell & Gossett, or Armstrong.

23 62 00 PACKAGED COMPRESSOR and CONDENSER UNITS

A. Design Considerations

1. Use only on very small projects, with Rutgers permission. Water-cooled units may be considered for special applications such as back-up refrigeration.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Acceptable manufacturers are Trane, York, Carrier, AAON, Liebert, and as otherwise approved by Rutgers.

23 62 13 PACKAGED AIR-COOLED REFRIGERANT COMPRESSOR and CONDENSER UNITS

A. Design Considerations

1. Limit air-cooled condensers to very small systems or for equipment such as constant temperature rooms or computer room equipment unless otherwise approved by Rutgers.

2. Where air-cooled condensers are used, they shall be designed for low ambient temperature operation.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Acceptable manufacturers are Trane, York, Carrier, Liebert, and as otherwise approved by Rutgers.

23 63 33 EVAPORATIVE REFRIGERANT CONDENSERS

RESERVED

23 64 00 PACKAGED WATER CHILLERS

RESERVED

23 64 13.13 DIRECT-FIRED ABSORPTION WATER CHILLERS

RESERVED

23 64 13.16 INDIRECT-FIRED ABSORPTION WATER CHILLERS

RESERVED

23 64 16 CENTRIFUGAL WATER CHILLERS

A. Design Considerations

1. In many cases, Rutgers will pre-purchase centrifugal chillers. Rutgers requires as efficient a unit as possible. Centrifugal chillers shall use either R-123 or R-134A. Centrifugal chillers shall not be located outside of the building. A/E shall route pipe rupture disk discharge to a safe point.

B. Special Documentation Requirements

1. If the unit is pre-purchased, the A/E shall obtain pre-purchase specifications from Rutgers. Bidding contractors shall provide Rutgers with requested performance and efficiency documentation at time of bid to facilitate bid evaluation.

C. Materials and Methods of Construction

1. Acceptable manufacturers are Trane, York, and Carrier.

23 64 19 RECIPROCATING WATER CHILLERS

A. Design Considerations

1. Use only on very small projects, with Rutgers permission. Water-cooled units may be considered for special applications such as back-up refrigeration. Air-cooled units must be justified by life-cycle analysis at the request of Rutgers. Heat recovery units will require an economic evaluation including life-cycle analysis. Refrigerant type must be approved by Rutgers. Scroll type chillers are preferred to reciprocating type.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Acceptable manufacturers are Trane, York, Carrier, and as otherwise approved by Rutgers.

23 64 23 SCROLL WATER CHILLERS

RESERVED

23 64 26 ROTARY-SCREW CHILLERS

RESERVED

23 65 13.13 OPEN-CIRCUIT, FORCED DRAFT COOLING TOWERS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Cooling towers shall be packaged, stainless steel, cross-flow (induced-draft) cooling towers with propeller fan, gear box, plastic fill (plastic shall be fire retardant and Factory Mutual approved in a stainless steel casing and pan**),** 2-speed or variable speed high-efficiency fan motors, controlled and sequenced to obtain the condenser water temperatures needed.
2. Provide handrail, ladder and cage for access.
3. Provide flow control valves for all outlets. Provide all needed screens and protective devices. Discharge hoods and sound control measures shall be provided to attain noise levels acceptable to local conditions and ordinances.
4. Water level may use float switch. Water level control may also utilize a conductivity type level sensor wired to a controller located in the mechanical room. Controller should activate EP-pneumatic or slow closing solenoid valve, blow down solenoid valve and chemical feed pump. EP, BD and chemical pump should have H-O-A- selection switch.
5. Winterizing requirements shall be discussed with Rutgers. The appropriate design shall be reviewed prior to such application.
6. All cooling tower drains, bleed lines and overflow piping should be piped to a suitably sized sanitary drain.
7. Water treatment shall be specified and included in the design.

8. Centrifugal fan, forced draft towers shall not be used unless approved by Rutgers.

9. Cooling towers shall be as manufactured by Marley or approved equal.

23 65 13.16 CLOSED-CIRCUIT, FORCED DRAFT COOLING TOWERS

RESERVED

23 72 00 AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

RESERVED

23 73 00 INDOOR CENTRAL-STATION AIR HANDLING UNITS

RESERVED

23 73 13 MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Hot water and Chilled water coils shall have no more than 120 fins per foot of tube length, where possible. All coils shall be completely drainable at each row. Drainage of coil shall be accomplished by removing the drain and vent plugs; no other means shall be required. Copper tubes with aluminum fins are satisfactory. Coil headers shall be equipped with freeze plugs (where subject to freezing) and shall have copper or brass coil connections.

2. Use of factory mounted\wired automatic temperature controls may be considered subject to compatibility with campus building automation system and approval of Rutgers Department of Utilities. Where factory mounted\wired controls are utilized, the

method of integration with the campus building automation system requires the review\approval of Rutgers Department of Utilities.

3. Do not use electric heat without specific permission of Rutgers.

4. Provide a properly sized pumped water protective system for all coils when glycol is not utilized and the possibility of freezing exists at any coil (i.e. due to high percentages [30% or greater] of outdoor air). Face and bypass dampers are preferred to pumped water protective systems for 100% outdoor air systems. Face and bypass dampers shall be integral type unless otherwise approved by Rutgers. Glycol shall not be used without Rutgers permission.

5. Humidifiers should be used only with Rutgers approval.

6. 30% Filters shall be installed in manufactured filter frames. Precede higher efficiency filters with roughing filters. Use HEPA or other approved high efficiency filters when required or directed. Provide pressure differential gage to monitor filter performance on all major air handling units.

7. Modular indoor air-handling equipment shall be as manufactured by Trane, McQuay, York, Miller-Picking, Air Enterprises, Webco, Pace, Ingenia, Ventrol, Buffalo Air Handling, Environmental Air Systems or approved equal.

23 73 33 INDOOR, INDIRECT FUEL-FIRED HEATING and VENTILATING UNITS

RESERVED

23 73 39 INDOOR, DIRECT GAS-FIRED HEATING and VENTILATING UNITS

RESERVED

23 81 00 DECENTRALIZED UNITARY HVAC EQUIPMENT

- ***Rooftop***

A. <u>Design Considerations</u>

1. Utilization of rooftop air-conditioning equipment requires Rutgers approval.

2. When rooftop equipment is suggested for the project, the access to the roof shall be as a minimum a stair tower meeting applicable codes extended full-size to the roof. In addition, an available elevator may be required to extend to the roof.

3. As an alternative, the equipment may be located on an approved ground slab.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Coils shall be fully drainable and fin spacing shall not exceed 120 fins per foot as specified for coils in air handling units. Coil headers shall be equipped with freeze plugs and shall have copper or brass coil connections.

2. Heating and cooling should be from external sources of hot water (or glycol mixture) or chilled water; do not use gas fired exchangers or air cooled refrigerant (DX) systems without Rutgers approval.

3. Rooftop air-conditioning equipment shall be as manufactured by Trane, McQuay, Aaon, Governair, York, Miller-Picking, Air Enterprises, Webco, Pace Ingenia, Ventrol, Buffalo Air Handling, Environmental Air Systems or approved equal.

- ***Self-contained***

A. Design Considerations

1. Use only on very small projects, with Rutgers permission. Water-cooled units may be considered for special applications such as back-up refrigeration.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Acceptable manufacturers are Trane, York, Carrier, AAON, Liebert and as otherwise approved by Rutgers.

23 81 13 PACKAGED TERMINAL AIR CONDITIONERS

A. Design Considerations

1. Window air conditioning units shall be permitted where central air conditioning systems are not available or are not feasible.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Window air conditioning units shall be equipped with a timer which can be programmed to shut off when the space is not occupied. The timer can be part of the unit, or at the panel as appropriate.

2. Window air conditioning unit manufacturers shall be approved by Rutgers.

23 81 23 COMPUTER-ROOM AIR CONDITIONERS

RESERVED

23 81 26 SPLIT-SYSTEM AIR CONDITIONERS

RESERVED

23 81 46 WATER-SOURCE UNITARY HEAT PUMPS

A. Design Considerations

1. Water-source heat pumps shall be used only after detailed life cycle cost analysis and approval of Rutgers.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Water-source heat pumps shall be as manufactured by Trane, York, Carrier or approved equal.

23 82 16 AIR COILS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Coil connections shall be copper or brass.

2. Freeze plugs shall be provided in coil headers for rooftop air handling units and for all coils exposed to entering air conditions that may result in freezing of the coil.

23 82 19 FAN-COIL UNITS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Fan coil units shall have permanent split capacitor motors.

2. Fan coil units shall be as manufactured by Trane, York or Carrier.

23 82 23 UNIT VENTILATORS

RESERVED

23 82 29 RADIATORS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Use 18 gauge front panels on baseboards.
2. Radiators shall be as manufactured by Trane or approved equal.

23 82 39.13 CABINET UNIT HEATERS

RESERVED

23 82 39.16 PROPELLER UNIT HEATERS

RESERVED

23 83 00 RADIANT HEATING UNITS

RESERVED

23 83 13 RADIANT HEATING ELECTRIC CABLES

RESERVED

23 83 23 RADIANT HEATING ELECTRIC PANELS

RESERVED

23 84 13 HUMIDIFIERS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. <u>Materials and Methods of Construction</u>

1. Steam for user-required humidification should be generated by gas or electric unitary humidifiers, approved by Rutgers, as manufactured by Armstrong, Sarco, Carnes, Herr, Nortec or approved equal.

2. Large capacity humidification requirements shall be met by direct or indirect-fired steam generators.

23 84 16 DEHUMIDIFIERS

RESERVED