



Facilities Planning and Construction Design & Building Standards

DIVISION 23 – Heating, Ventilating and Air Conditioning

Preface

The Texas Tech University System's 'Design and Construction Standards', as administrated by Facilities Planning and Construction, are intended to serve as guidelines to the Design Professional and Construction Management teams for design development and construction administration of Texas Tech University System (TTUS) Capital Projects. They communicate the minimum expectations and requirements relative to specific building systems, design provisions, general specification requirements, and administrative procedures for new facilities being constructed on Texas Tech University System (ASU, MSU, TTU, TTUHSC, and TTUHSC El Paso) campuses. Several, but not all requirements for each component Institution or Agency within the TTU System are covered. Design Professionals, Construction Managers at Risk and/or Design-Build Firms shall also refer to provisions covered in their service Agreements, as well as within the project's Basis of Design (BOD) document.

In addition, the 'Design and Construction Standards' shall also be utilized in conjunction with the approved project specific Program and Schematic Design development. In the event of conflict between this document and specific project requirements, Design Professionals, Construction Managers at Risk and/or Design-Build Firms shall contact Facilities Planning & Construction for clarification.

The guidelines within the 'Design and Construction Standards' are not intended to prohibit the use of alternative design solutions, methods, systems, products or devices not covered in this document. Offered alternatives deviating from or not covered in these standards shall be documented by the Design Professional and/or Construction Management teams and submitted to Facilities Planning & Construction for approval prior to implementation.

Throughout the 'Design and Construction Standards' there are references to manufacturer specific products. These are to be considered the 'Basis of Design' to establish the expected minimum quality requirements. Design Professionals are encouraged to identify and include equivalent products and/or manufacturers offering comparable products to facilitate open bidding environments.

General Requirements for HVAC

This standard is not intended to prohibit the use of alternative methods, systems, or products not listed in this document. The Design Team is encouraged to pursue new innovative ideas to enhance the performance of the building systems. If the project team would like an exception to the standards to be considered, the request must be submitted in written form to the FP&C Project Team.

On the TTU main campus, the majority of all buildings are cooled using chilled water from Central Heating and Cooling Plant No. 1 (CHACP1). There are three steam and two electric turbine driven chillers in the plant designed to operate at a chilled water ΔT of 16 degrees Fahrenheit. Chilled water is distributed to the buildings in a network of piping located in underground utility tunnels. The network has three pairs of 30" pipes that leave the plant and connect to each building through a series of smaller branch pipes. There are also a number of pipes that connect the main pipes to each other for improved distribution. Each building has one or more booster pumps that are intended to overcome friction loss through the building piping, cooling coils, and valves. Future project locations, demands, and CHACP1 capacities will determine design and tie in capabilities.

The following mechanical system items shall be completed and approved by the FP&C Project Team prior to requesting the University to provide chilled water or steam from the campus distribution system:

1. All chilled and hot water piping systems must be complete.
2. All hydronic-piping systems must be cleaned in accordance with TTU Standards.
3. All chilled water piping must be insulated and sealed.
4. All pumps, air handlers and other and other associated equipment must be installed in their permanent location with all valves, strainers, piping, vibration isolation, electrical connections and safety devices in place.
5. Controls to regulate temperature and water flow must be in place and operational.
6. Provide and service fine mesh construction inserts in pump strainers.
7. Temporary filters must be installed on AHU's and fan powered VAV boxes during construction. Provide temporary filter media ahead of permanent filters and replace when dirty. Under no circumstance shall any AHU be started without temporary protective filters installed. All spacers shall be installed and filters tight prior to starting air handling equipment. All permanent filters for air handlers must be in place at substantial completion.
8. Factory startup of the VFD drives shall be completed prior to turning on units.

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Equipment layout including but not limited to AHU's, pumps, piping, water heaters, VFD's, PRV Stations, fire pumps, and flow meters will be approved by the Owner or Owner's Representative. All equipment/systems shall be installed per manufacturer's recommendations.

The campus furnished utilities will be measured by a BAS Energy Measurement System that shall be built and calibrated by a single manufacturer. A certificate of NIST traceable calibration shall be provided with each system component. All equipment shall be covered by the manufacturer's two-year warranty.

Avoid whenever possible installing mechanical/electrical equipment, where future access is required, above hard ceilings. If access cannot be obtained through the removable ceiling or through other means, the Contractor shall provide access doors as specified in Division 8. Equipment is to be "readily accessible" per ANSI/ASHRAE standards.

In no case shall PVC piping be installed in a return air plenum or supply/return ductwork without UL Listed and ASTM tested fire resistant plenum wrap. Plenum wrap to be 3M Fire Barrier Plenum Wrap 5A+ or approved equal.

For the safety of the workers and the spirit of LEED, mechanical rooms, fire pump rooms, and electrical rooms lighting shall be controlled by a programmable digital time switch. Specify the Watt Stopper TS-400 or approved equal. Motion or timer actuated lighting will not be allowed in elevator machine rooms and hoist ways.

When performing hydrostatic testing on piping, leave all pipe joints un-covered for visual inspection.

Specify adjustable angle thermometers. Solar powered thermometers will not be specified.

Subcontractors are to provide their own test sheets and test certificates for all mechanical testing. All testing or certifications are to be witnessed by the FP&C Project Inspector or appointed Owner's Representative and appropriate documentation is to be forwarded to the Project Manager within 5 days of the test.

For RO water, specify the Onicon Series F-1100 single turbine flow meter or approved equal for lines 2" and smaller. Specify the Onicon Series F-1200 inline electromagnetic flow meter or approved equal for

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lines 2 1/2" and larger. Locate meters in an accessible area in the mechanical room of the building being served. Meters shall communicate to BMS via BACnet D-100 controller.

For compressed air, specify the Onicon series F-2600 inline vortex mass flow meter. Utilize ANSI Class 150 pressure sensor with external 24 VDC. Meters shall communicate to BMS via BACnet transmitter.

Unless noted otherwise, the Design Professionals shall certify that the project complies with the Energy Conservation Standard and submit a copy of that certification to the State Energy Conservation Office (SECO) at least thirty calendar days prior to start of construction. This certification form can be found on the SECO website at: <http://www.seco.cpa.state.tx.us/>. The design team shall provide TTUS three bound copies containing the completed certification form and all necessary information and calculations to support certification. The project should be designed and built to meet the minimum LEED BC+D certification standards.

Pursuant to Texas Government Code 447.004 subsection (a) and the Texas Administrative Code Title 34, Part 1, Chapter 19, Subchapter C § 19.32, the State Energy Conservation Office has adopted, by reference, the latest version of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)/ Illuminating Engineering Society of North America (IESNA), Energy Standard for Buildings Except Low-Rise Residential Buildings. The new standard is ASHRAE/IESNA Standard 90.1-2010. This change applies to any construction or major renovation project with a design assignment date of September 1, 2011 or later.

Mechanical Identification

Specify to submit list of wording, symbols and letter size coding for all mechanical identification.

Specify to submit valve charts and schedules, including valve tag, number, location, function and valve manufacturer's name and model number.

Plastic nameplates to be laminated, 2-layer minimum, plastic with engraved black letters on light contrasting background color. Nameplate size minimum of 4 inches wide by 1-1/2" high. Letters to be 5/8" in height. Install with stainless steel mechanical fasteners.

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Metal tags to be brass, with stamped letters; tag size minimum 1-1/2" diameter with smooth edges. Install with corrosive-resistant chain.

Specify to furnish valves with 1-1/2" diameter brass valve tag with stamped and black-filled numbers. Service designations shall be 1/4" letters, and valve numbers shall be 1/2" letters. Service designations shall be approved by Architect/Engineer. Secure tags to valves by use of brass "S" hooks and brass chain. Secure chain to valve by use of copper or Monel meter seals. Mount charts and drawings listing functions of each valve and its location in a metal frame and behind glass placed as directed. In addition, on the record drawings, mark the symbols and furnish a valve schedule properly identifying the valve number and service with the exact location, the material being piped, and the room number of areas that the valve services.

Insulation - General

Applicator shall be a company specializing in insulation application with minimum 5 years' experience. References will be made available upon request.

Before installing insulation, build mockups for each type of insulation and finish to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Owner. Use materials indicated for the completed Work. Mockups shall include piping insulation, ductwork insulation and equipment insulation.

Pipe Insulation

This section shall be followed for minimum requirements for all pipe insulation common to several mechanical piping systems. It shall include all insulation, fittings and jacketing. The manufacturer's installation instructions shall be referenced for each and every insulation application, and the insulation shall be installed in accordance with manufacturer's installation instructions.

Subject to compliance with requirements, provide products by one of the following:

1. Cellular-Glass Insulation:
 - a. Pittsburgh Corning "Foamglass" or approved equal
2. Flexible Elastomeric Thermal Insulation:
 - a. Armstrong World Industries, Inc.
 - b. Rubatex Corp.
3. Calcium Silicate Insulation:

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- a. Owens-Corning Fiberglas Corp.
 - b. Johns-Manville-Thermo-12
4. Fiberglass:
- a. Johns Manville
 - b. Owens Corning
 - c. Pittsburgh Corning

Cellular-glass insulation to be inorganic foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.

1. Pre-formed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class 1.
2. Pre-formed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

Flexible elastomeric thermal insulation to be closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Adhesive: As recommended by insulation material manufacturer.
2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.

Calcium silicate insulation is to be pre-formed pipe sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I. Johns-Manville Thermo-12 Insulation is the standard calcium silicate insulation for use at Texas Tech.

Fiberglass insulation to be one-piece molded insulation with fire retardant multi-purpose all service jacket with a flame/smoke rating of 25-50. Temperature service range of -20 °F to 180 °F.

Prefabricated thermal insulating fitting covers shall comply with ASTM C 450 for dimensions used in pre-forming insulation to cover valves, elbows, tees, and flanges.

Specify field applied jackets as:

1. General: ASTM C 921, Type 1, unless otherwise indicated.
2. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.
3. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
 - i. Adhesive: As recommended by insulation material manufacturer.

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- ii. PVC Jacket Color: White or gray.
 - iii. PVC Jacket Color: Color-code piping jackets based on materials contained within the piping system, and in accordance with ASME A13.1.
4. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil thick, high-impact, ultraviolet-resistant PVC.
- i. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 - ii. Adhesive: As recommended by insulation material manufacturer.
5. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil-thick, high-impact, ultraviolet-resistant PVC.
- i. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 - ii. Adhesive: As recommended by insulation material manufacturer.
6. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper.
- i. Finish and Thickness: Smooth finish, 0.010 inch (0.25 mm) thick.
 - ii. Finish and Thickness: Corrugated finish, 0.016 or 0.020 inch thick.
 - iii. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.
 - iv. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish and thickness as jacket.
7. Preformed Aluminum Jacket: ASTM 0.020-inch-thick; factory cut and rolled to indicated sizes.

Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

- 1. Flexible connectors.
- 2. Vibration-control devices.
- 3. Fire-suppression piping.
- 4. Below-grade piping, unless otherwise indicated by Design Professional.
- 5. Chrome-plated pipes and fittings, unless potential for personnel injury.

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6. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.
7. Steam traps and condensate cooling (drip) legs.

Interior Insulation Application Schedule:

Service: Domestic hot and re-circulated hot water

1. Insulation Material: One-piece molded fiberglass
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: Per Design Professional
4. Vapor Retarder Required: Per Design Professional

Service: Domestic water

1. Insulation Material: One-piece molded fiberglass
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: Per Design Professional
4. Vapor Retarder Required: Per Design Professional

Service: Condensate drain piping

1. Insulation Material: Flexible elastomeric
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: None
4. Vapor Retarder Required: Yes

Service: Exposed sanitary drains and domestic water supplies and stops for fixtures for the disabled

1. Insulation Material: Flexible elastomeric
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: PVC P-trap and supply covers
4. Vapor Retarder Required: No

Service: Chilled-water supply and return

1. Insulation Material: Tunnels and Mechanical Rooms to be Foamglass or equal. Interior
a. spaces to be fiberglass or equal
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: Mechanical Room and Tunnel to have aluminum jacket with stainless

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a. steel bands

4. Vapor Retarder Required: Yes

Service: Refrigerant suction and hot-gas piping

1. Insulation Material: Flexible elastomeric
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: Per Design Professional
4. Vapor Retarder Required: Yes

Service: Heating hot-water supply and return

1. Insulation Material: One-piece molded fiberglass
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: interior building spaces per Design Professional and Aluminum in tunnel
4. Vapor Retarder Required: Per Design Professional

Service: Steam and condensate

1. Insulation Material: Calcium silicate
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: Aluminum or fiberglass Per Design Professional
4. Vapor Retarder Required: Yes

Exterior Insulation Application Schedule:

This application schedule is for aboveground insulation outside the building.

Service: Refrigerant suction

1. Insulation Material: Flexible elastomeric
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: Per Design Professional
4. Vapor Retarder Required: Yes

Service: Chilled-water supply and return.

1. Insulation Material:

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- a. Pittsburgh Corning “FoamGlass” or approved equal, with jacket (tunnel Applications).
- b. One-piece molded fiberglass.
2. Insulation Thickness: Per Design Professional
3. Field-Applied Jacket: Aluminum
4. Vapor Retarder Required: Yes.

All underground steam and condensate lines shall be Thermacor, Permapipe, or an approved equal pre-insulated pipe.

Duct Insulation

This section shall be followed for all semi-rigid and flexible duct, plenum, and breeching insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

Specify to factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

For insulation installed indoors, specify flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

For insulation installed outdoors, specify flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

Subject to compliance with requirements, provide products by one of the following for mineral-fiber insulation:

1. CertainTeed Manson.
2. Knauf FiberGlass GmbH.
3. Owens-Corning Fiberglas Corp.
4. Mansville

Mineral-fiber board thermal insulation to be glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

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Mineral-fiber blanket thermal insulation to be glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

Specify field applied jackets as:

1. General: ASTM C 921, Type 1, unless otherwise indicated.
2. All service FSK (Foil Scrim Craft) jacket: Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.
3. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
 - a. Adhesive: As recommended by insulation material manufacturer.
 - b. PVC Jacket Color: White or gray.
 - c. PVC Jacket Color: Custom color selected by the Project Manager.
4. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Standard.
 - a. Finish: Smooth finish.
 - b. Finish: Cross-crimp corrugated finish.
 - c. Finish: Stucco-embossed finish.
 - d. Finish: Factory-painted finish.
 - e. Moisture Barrier: 1-mil-thick, heat-bonded polyethylene and kraft paper.

Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

Specify to seal insulation material with glass fab membrane imbedded with adhesive. Foil tape will only be allowed with written approval from the Owner's Representative.

Insulate the following plenums and duct systems:

1. Indoor concealed supply, return and outside air ductwork.
2. Indoor exposed supply, return and outside air ductwork.
3. Outdoor exposed supply and return ductwork.
4. Indoor exposed range hood exhaust ductwork.

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5. Indoor concealed range hood exhaust ductwork (2 hour UL Rated)
6. Indoor exposed oven and dishwasher exhaust ductwork.
7. Indoor concealed oven and dishwasher ductwork.

Items not insulated unless otherwise indicated. Do not apply insulation to the following systems, materials, and equipment:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
5. Flexible connectors.
6. Vibration-control devices.
7. Testing agency labels and stamps.
8. Nameplates and data plates.
9. Access panels and doors in air-distribution systems.

No supply air duct shall be internally insulated unless approved by the FP&C Project Team for particular project specifics.

Indoor Duct and Plenum Application Schedule:

Service: Round, supply-air ducts, concealed or exposed

1. Material: Mineral-fiber blanket
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth or foil and paper
5. Vapor Retarder Required: Yes

Service: Round, return-air ducts, concealed or exposed

1. Material: Mineral-fiber blanket
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth or foil and paper
5. Vapor Retarder Required: Yes

Service: Round, outside-air ducts, concealed or exposed

1. Material: Mineral-fiber blanket

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2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth or foil and paper
5. Vapor Retarder Required: Yes

Service: Rectangular, supply-air ducts, concealed or exposed

1. Material: Mineral-fiber blanket
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth or foil and paper
5. Vapor Retarder Required: Yes

Service: Rectangular, return-air ducts, concealed or exposed

1. Material: Mineral-fiber blanket
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth or foil and paper
5. Vapor Retarder Required: Yes

Service: Rectangular, outside-air ducts, concealed or exposed

1. Material: Mineral-fiber blanket
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth or foil and paper
5. Vapor Retarder Required: Yes

Service: Rectangular, range-hood exhaust ducts, concealed or exposed

1. Material: Mineral-fiber board
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth
5. Vapor Retarder Required: Yes

Service: Rectangular, dishwasher exhaust ducts, concealed or exposed

1. Material: Mineral-fiber board or mineral-fiber blanket
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth
5. Vapor Retarder Required: Yes

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Outdoor Duct and Plenum Application Schedule:

Service: Round, supply-air ducts.

1. Material: Mineral-fiber board
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth
5. Field Applied Jacket: FSK Material
6. Field Applied Jacket: PVC
7. Field Applied Jacket: Aluminum
 - a. Aluminum Thickness: Per Design Professional Requirements
 - b. Corrugation Dimension: Per Design Professional Requirements
8. Field-Applied Jacket: Stainless steel.
 - a. Corrugation Dimension: Per Design Professional Requirements
9. Vapor Retarder Required: Yes

Service: Round, return-air ducts

1. Material: Mineral-fiber board
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth
5. Field Applied Jacket: Foil and paper
6. Field Applied Jacket: PVC
7. Field Applied Jacket: Aluminum
 - a. Aluminum Thickness: Per Design Professional Requirements
 - b. Corrugation Dimension: Per Design Professional Requirements
8. Field-Applied Jacket: Stainless steel.
 - a. Corrugation Dimension: Per Design Professional Requirements
9. Vapor Retarder Required: Yes

Service: Rectangular, supply-air ducts.

1. Material: Mineral-fiber board
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth

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5. Field Applied Jacket: Foil and paper
6. Field Applied Jacket: PVC
7. Field Applied Jacket: Aluminum
 - a. Aluminum Thickness: Per Design Professional Requirements
 - b. Corrugation Dimension: Per Design Professional Requirements
8. Field-Applied Jacket: Stainless steel.
 - a. Corrugation Dimension: Per Design Professional Requirements
9. Vapor Retarder Required: Yes

Service: Rectangular, return-air ducts.

1. Material: Mineral-fiber board
2. Thickness: Per Design Professional Requirements
3. Number of Layers: One
4. Field-Applied Jacket: Glass cloth
5. Field Applied Jacket: Foil and paper
6. Field Applied Jacket: PVC
7. Field Applied Jacket: Aluminum
 - a. Aluminum Thickness: Per Design Professional Requirements
 - b. Corrugation Dimension: Per Design Professional Requirements
8. Field-Applied Jacket: Stainless steel.
 - a. Corrugation Dimension: Per Design Professional Requirements
9. Vapor Retarder Required: Yes

Valves

This section shall be followed for all valves common to several mechanical piping systems. It shall include all valves and connections.

Use gate valves for isolation and shut off duty. Do not use for throttling or balancing duty.

Gate Valves, 2-1/2 Inches and Smaller: Class 125, 200-psi cold working pressure (CWP), or Class 150, 300-psi CWP; cast-bronze body and bonnet, solid-bronze wedge, rising stem, teflon-impregnated packing with bronze packing nut, threaded or soldered end connections; and with malleable-iron hand wheel.

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Gate Valves, 3 Inches and Larger: Class 125, 200-psi CWP, cast-iron body and bonnet, solid cast-iron wedge, brass-alloy stem, outside screw and yoke, teflon-impregnated packing with 2-piece packing gland assembly, flanged end connections; and with cast-iron hand wheel.

Ball valves shall be used for all isolation type applications, except in steam systems. Ball valves may also be used for throttling duties. It is recommended ball valves larger than 6" not be used.

Ball Valves, 2-1/2 Inches and Smaller: Class 125, 200-psi CWP, or Class 150, 300-psi CWP, bronze body and bonnet, 2-piece construction; chrome-plated brass ball, full size port; blowout proof; bronze or brass stem; teflon seats and seals; threaded or soldered end connections:

1. Operator: Vinyl-covered steel lever handle.
2. Stem Extension: For valves installed in insulated piping.
3. Memory Stop: For operator handles.

Ball Valves, 3 Inches thru 6 inches: Class 125, 200-psi CWP, or Class 150, 300-psi CWP, bronze body and bonnet, 2-piece construction; chrome-plated brass ball, full size port; blowout proof; bronze or brass stem; teflon seats and seals; flanged end connections:

1. Operator: Lever operators with lock.
2. Stem Extension: For valves installed in insulated piping.
3. Memory Stop: Where required.

Plug valves shall be used only for shut off duty.

Plug Valves: 175-psi CWP, cast-iron body and bonnet, cast-iron plug, teflon packing, flanged end connections:

- Operator: Lever or Square head.

Globe valves maybe used for both shut off and throttling duty.

Globe Valves, 2-1/2 Inches and Smaller: Class 125, 200-psi CWP, or Class 150, 300-psi CWP; cast-bronze body and screwed bonnet, bronze, or teflon disc, silicon bronze-alloy stem, teflon-impregnated packing with bronze nut, threaded or soldered end connections; and malleable-iron hand wheel.

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Globe Valves, 3 Inches and Larger: Class 125, 200-psi CWP, cast-iron body and bolted bonnet with bronze fittings, renewable bronze seat and disc, brass-alloy stem, outside screw and yoke, teflon-impregnated packing with cast-iron follower, flanged end connections; and with cast-iron hand wheel.

Butterfly valves may be used for both shut off and throttling duty.

Butterfly Valves: 200-psi CWP, 150-psi maximum pressure differential, cast-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals, lug style:

1. Disc Type: Aluminum bronze.
2. Operator for Sizes 2 Inches to 6 Inches: Lever handle with latch lock.

Swing Check Valves, 2-1/2 Inches and Smaller: Class 125, 200-psi CWP, or Class 150, 300-psi CWP; horizontal swing, Y-pattern, cast-bronze body and cap, rotating bronze disc with composition seat, threaded end connections:

Swing Check Valves, 3 Inches and Larger: Class 125, 200-psi CWP, cast-iron body and bolted cap, horizontal-swing bronze disc, flanged end connections.

Wafer Check Valves: Class 125, 200-psi CWP, cast-iron body, bronze disc/plates, stainless-steel pins and springs, Buna N seals, installed between flanges.

Lift Check Valves: Class 125, bronze body and cap (main components), horizontal or vertical pattern, lift-type, bronze disc with stainless-steel holder threaded or soldered end connections.

Isolation valves for steam supply shall be gate valves. Valves for condensate return shall be steam rated ball valves or OS&Y gate valves.

Installation of valves:

1. Install valves in horizontal piping with stem at or above the center of the pipe.
2. Install valves in a position to allow full stem movement.
3. For chain-wheel operators, extend chains to 60 inches above finished floor elevation.
4. Installation of Check Valves: Install for proper direction of flow as follows:
 - a. Swing Check Valves: Horizontal position with hinge pin level.
 - b. Wafer Check Valves: Horizontal or vertical position, between flanges.
 - c. Lift Check Valve: With stem upright and plumb.

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All soldered joints shall be made with high temperature solid string or wire solder, 95% tin, 5% antimony, using non-corrosive paste flux. 50-50 or 40-60 low temperature solder shall not be used.

Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2 Inches and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
2. Steel Pipe Sizes, 2 Inches and Smaller: threaded.
3. Steel Pipe Sizes, 2 ½ Inches and Larger: flanged.

Application Schedule:

Use gate, ball, and butterfly valves for shutoff duty; globe, ball, and butterfly for throttling duty.

Application Schedule:

Domestic Water Systems: Use the following valve types:

1. Gate Valves: Class 125, bronze or cast-iron body to suit piping system.
2. Ball Valves: Class 150, 300-psi CWP, with stem extension.
3. Plug Valves: Neoprene-faced plug, Buna N packing.
4. Globe Valves: Class 125, bronze or cast-iron body to suit piping system, and bronze disc.
5. Butterfly Valves: Nickel-plated ductile iron disc; EPDM sleeve and stem seals.
6. Bronze Swing Check: Class 125, with rubber seat.
7. Check Valves: Class 125, swing or wafer type as indicated.

Heating Water Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze or cast-iron body to suit piping system.
2. Ball Valves: Class 150, 300-psi CWP, with stem extension and memory stop.
3. Plug Valves: teflon packing.
4. Globe Valves: Class 150, bronze or cast-iron body to suit piping system, and bronze disc.
5. Butterfly Valves: Nickel-plated ductile iron disc; EPDM sleeve and stem seals.
6. Bronze Swing Check: Class 150, with composition seat.
7. Check Valves: Iron swing, wafer, or lift type, as indicated. Swing check shall be Class 150 with bronze seat ring.

Steam and Condensate Return Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze body; or Class 125, cast-iron body.
2. Ball Valves: Class 150, 300-psi CWP, with stem extension.
3. Plug Valves: teflon packing.
4. Globe Valves: Class 150, bronze body with teflon disc; or Class 125, cast-iron body.

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5. Check Valves: Class 150, bronze body swing check with composition seat; Class 150, cast-iron body swing check with bronze seat ring; or Class 125, cast-iron body wafer check.

Chilled-Water Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze body; or Class 125, cast-iron body.
2. Ball Valves: Class 150, 300-psi CWP, with stem extension and memory stop.
3. Plug Valves: Buna N packing.
4. Globe Valves: Class 125, bronze body with bronze disc; or Class 125, cast-iron body.
5. Butterfly Valves: Nickel-plated ductile iron disc; EPDM sleeve and stem seals.
6. Check Valves: Class 125, bronze body swing check with rubber seat; Class 125, cast-iron body swing check; or Class 125, cast-iron body lift check.

Condenser Water Systems: Use the following valve types:

1. Gate Valves: Class 125, bronze body; or Class 125, cast-iron body.
2. Ball Valves: Class 150, 300-psi CWP, with memory stop.
3. Plug Valves: Buna N packing.
4. Globe Valves: Class 125, cast iron body with bronze disc; or Class 125.
5. Butterfly Valves: Aluminum bronze disc; EPDM sleeve and stem seals.
6. Check Valves: Class 125, cast-iron body swing check with rubber seat

Hydronic Piping

This section shall be followed for all hydronic piping common to several mechanical systems. Standard includes piping, special-duty valves, and hydronic specialties for hot-water heating, chilled-water cooling, and condenser water systems; makeup water for these systems; blowdown drain lines; and condensate drain piping.

Materials:

Drawn-Temper Copper Tubing: **Type L Hard Drawn for interior water lines.**

Hard-Drawn Copper Tubing: Type L Hard-Drawn tubing for all below grade or below slab water lines.

Steel Pipe, **2"** and Smaller: Schedule 40, black steel, threaded ends.

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Steel Pipe, **2-1/2" through 12"**: Type E (electric-resistance welded), Grade A, Schedule 40, black steel, plain ends.

Steel Pipe, **14" through 18"**: Type E (electric-resistance welded), Grade B, Schedule 30, black steel, plain ends.

Steel Pipe, **20"**: Type E (electric-resistance welded), Grade B, Schedule 20, black steel, plain ends.

Steel Pipe Nipples: made of Schedule 40, black steel; seamless for **2"** and smaller and electric-resistance welded for **2-1/2"** and larger.

Cast-Iron Threaded Fittings: Classes 125 and 250.

Malleable-Iron Threaded Fittings: Classes 150 and 300.

Malleable-Iron Unions: Classes 150, 250, and 300.

Cast-Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

Wrought-Steel Fittings: wall thickness to match adjoining pipe.

Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

Underground pre-insulated pipe shall be PERMA-PIPE or Thermacor.

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PVC and CPVC Piping shall not be used in hydronic piping systems.

Piping Applications:

Hot and Chilled Water: 2" and smaller, aboveground, use **Type L** drawn-temper copper tubing with soldered joints. Below ground or within slabs, use **Type K** annealed-temper copper tubing with soldered joints. Use the fewest possible joints below ground and within slabs.

Hot and Chilled Water, **2-1/2"** and Larger: Schedule 40 steel pipe with welded and flanged joints.

Condensate Drain Lines: **Type L** drawn-temper copper tubing with soldered joints.

Chilled Water

The chilled water piping will include a de-coupler piping design that allows the incoming chilled water to circulate through the building system and is separated from the tunnel and other chiller systems by an interconnecting pipe from the supply and return piping. The chilled water shall circulate through the building chilled water pumps supplying as much cooling to the building without sacrificing comfort. "Cross feeding" or "short-circuiting" of the supply and return waters shall be prevented by having actuated modulating valves to return chilled water back to the tunnel or chiller at an adjustable set point temperature of 55 degrees F. The modulating valve shall be on the return line.

Specify the Onicon Series F-3500 insertion type electromagnetic flow meter or approved equal for lines 3" and larger. Specify the Onicon Series F-3100 inline electromagnetic flow meter or approved equal for lines 2 1/2" and smaller. Locate meters in an accessible area in the mechanical room of the building being served. Provide a BTU meter equal to the Onicon System-10 BTU Meter. Meters shall communicate to BMS via BACnet System 10 controller.

Steam and Condensate Piping

This Section provides for furnishing and installing low pressure (125 psig and below) steam and condensate piping, fittings, valves, strainers, vents and steam traps in tunnels, valve pits, building crawlspace and building mechanical and pump rooms.

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For Steam Condensate piping 2" and smaller in diameter, use ASTM A 53, Grade A or B, Schedule 80 seamless black steel pipe with forged steel class 300 socket weld fittings conforming with ASME B16.11.

For Steam piping 2" and smaller in diameter, use Schedule 40, seamless black steel pipe with class 300 black cast iron malleable iron threaded fittings.

For Steam pipe 2½" through 10" in diameter, use ASTM A 53, Grade A or B, seamless black steel pipe with seamless steel welding fittings conforming with ASTM A 234, Grade WPA or WPB, ANSI B16.9; standard weight for steam and Schedule 80 for condensate piping.

Provide traps where indicated or required, at least every 150' of straight run and at all steam risers and expansion joints. For pressures up to 60 psi, use float and thermostatic type. Fabricate body and covers of traps of cast iron.

Steam system shall utilize flash tanks if different pressures of systems feed to condensate.

Specify to install a steam flow meter on each system. Specify the Onicon Series F-2600 inline vortex mass flow type flow meter or approved equal. Optimize pressure sensors. Locate meters in an accessible area in the mechanical room of the building being served. Meter shall communicate to BMS via BACnet D-100 controller.

For condensate, specify the Onicon Series F-3000 inline electromagnetic flow meter or approved equal. Meter shall communicate to BMS via BACnet D-100 controller.

Steam and Condensate Pumps

Specify steam pumps to be steam powered non-electric whenever possible. Design considerations include pumping distance to the main return pipe, back pressure in the main return pipes, amount of condensate designed to be pumped back, and space limitations in the mechanical room. Specify Spirax Sarco pressure power pumps and steam traps or approved equal.

Specify vertical centrifugal pumps capable of pumping condensate at full capacity at boiling temperature. Provide duplex-type pumps with pressure gauges that are close coupled and bronze fitted.

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Furnish a cast-iron receiver tank with strainer. Provide the necessary float switches and alternator. Alternate the pumps and give standby service automatically. Furnish a receiver with condensate return, vent overflow, drain connections, water level gauge, thermometer and strainer.

Mount NEMA II control cabinet on the unit; include magnetic starters, circuit breakers, cover interlock, alternator, test button and fused control circuit transformer. Provide Domestic Series CB.

Specify Spence pressure reducing valves (PRV's) and steam pilots or approved equal.

Natural Gas Piping

Within two (2) feet of building line and above grade in accessible locations for 2" or smaller, specify black steel ASTM A53 standard weight with 150-pound black malleable screwed fittings. For 2 ½ " and larger, specify black steel ASTM A53 standard weight with welded joints and fittings.

Within two (2) feet of building line in sleeve above grade and in inaccessible areas (e.g., in walls, or in chases) all sizes shall have welded joints.

Below grade and outside of two (2) feet of building line (exact demarcation may vary due to site conditions) unless otherwise indicated, below grade gas piping shall be PE2406 polyethylene pipe and shall comply with ASTM D2513. Tracer wire shall be spirally wrapped around the pipe (minimum of 1 revolution for every 3 feet of pipe). All sizes shall be IPS, NIPAC, Driscopipe 6500, or equal approved by Engineer.

Below Grade fittings shall be butt fusion complying with ASTM D3261, or socket fusion complying with ASTM D2683. All branch connections shall be made using tees. Branch saddle or service saddle with tapping tee shall be allowed only at taps on existing mains.

Underground gas piping shall not be installed in parking lots without the approval from the Owner and Engineer.

Technicians performing fusion process shall be currently certified by the Texas Railroad Commission and shall submit documentation showing experience on comparable fusion procedures within the last twelve (12) months.

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With prior approval of Engineer and Owner's Representative, joints and fittings may be of mechanical fitting type. Mechanical fittings shall be IAPMO/UPC listed. Permaset or equal approved by Engineer. Transitions from polyethylene to steel pipe shall be by factory fabricated transition fitting (i.e., Central Double "O" Seal) or transition riser (Central Plastics Part No. 600 Series). Minimum horizontal dimension

for transition riser shall be 30 inches. Anodeless service riser may be used when interior carrier pipe complies with the specifications for the location of the pipe.

Where required in select locations and approved by Engineer, underground piping, fittings, and joints shall be black steel with factory coating as described above.

Minimum coverage for gas piping in trenches shall be 36" for low pressure and 46" for high pressure piping. Provide warning tape at 12"-16" below grade in trench as outlined in Division 2.

Specify Onicon F-5200 insertion type thermal mass gas flow meter. Meter shall communicate to BMS via BACnet D-100 controller.

Heating Ventilating and Air Conditioning (HVAC)

Specify Air Handling Units (AHU) shall have double walled casings of a minimum 18 gauge exterior and 20-gauge interior steel set on rails. Units shall provide access doors to areas that required entry for maintenance. Access doors to fan housings or blades shall have interlocking safety switches. Coils shall be designed to be capable of a minimum 16-degree delta T and be of copper with aluminum fins. Coils shall be a minimum of 8 rows and a maximum of 8 fins per inch to meet this requirement and allow the coils to be cleaned. Coil headers shall be red brass or approved material as specified by the Engineer. Provide positive drainage, sound attenuation, vibration control, and adequate locations for accessibility to unit. Filter media to meet the design parameters for the facility served and energy code minimum requirements. Units to have factory applied paint and touch will be required after installation. Each AHU shall have a dedicated internal light and receptacle. Units shall be internally insulated as required for sound attenuation. Motor bearings shall come with grease inserts accessible from outside the unit. Access doors shall have windows. Meet all ARI, ASTM, ASHRAE, and other standards that apply.

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All fresh/outside air that is utilized with any associated AHU for any facility shall be pre-heated and tempered by means other than mixing only with return air. Steam pre-heat coils are preferred if steam is available, otherwise *comfort hot water shall be used. Any other systems being considered will require approval from FP&C.*

Chiller Units may be one of the following systems dependent upon design availability and restrictions; Air-cooled variable speed screw chillers, packaged heating and cooling, outdoor split systems or others as presented by the Engineer. The selection will be based on size of facility being served, energy consumption requirements, the campus tunnel system demand and availability at the specific location of the facility, and the remoteness of the tunnel system to the facility.

Specify hot water boilers for HVAC heating as hot water induced draft boiler with horizontal grid, finned tube heat exchanger, gas burning system complete with combustion chamber, controls, and trim. State inspections shall be scheduled by the Contractor and coordinated by the Owner. System shall meet all NFPA, ASME, ASTM, UL and FM Standards for the fabrication, installation, start-ups, and operation of the unit(s). Equipment to be Lochinvar, or approved equal.

Specify tube and shell steam converters to be "U" tube style converter with cupro-nickel tubes, carbon steel or brass baffles with a carbon steel tube sheet. Unless instructed by Owner, inlet and outlet connections shall be flanged. Unit shall be designed for low pressure steam and have a vacuum breaker for tube protection. The Engineer shall size the steam trap based off anticipated design loads.

Single and Dual Duct VAV Boxes

1. The air valves shall be of the dual duct or single duct type and shall be provided in a complete package with control damper, electric actuator and variable air volume control assembly, etc. The damper shall be housed in a minimum 22-gauge galvanized steel housing of leak resistant construction with mechanical seal and with coated 1" thick insulation to resist erosion and to meet NFPA 90A and 90B requirements. The air valves shall be arranged either normally open or closed to meet the requirements of the hot or cold duct in which they are to be installed. Access to the damper and linkage shall be either through the outlet or through an access door. Scribe end of damper rod to indicate damper position. Secure damper linkage with indents and screws or through pins.
2. The DDC box controllers shall provide the characteristics of pressure independence so that the minimum and/or maximum CFM requirements of each space served will be obtained

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throughout the entire operating range of the air valve, regardless of the pressure changes in the system. Further the reset span of the electronic volume controller shall be adjustable for maximum and minimum air flow rate settings with fixed 2 deg. F. temperature range.

3. The Temperature Regulation Sub Contractor shall provide the DDC box controllers and electric actuators and deliver them to the unit manufacturer for his assembly of the air valve package. See Temperature Regulation Section. At the Contractor's option compatible actuators of other manufacture may be supplied with the terminals, and VAV box controllers may be field mounted.
4. A mixer-attenuator section is required on the discharge of the cold or hot and cold air valves if the assembly NC is greater than 35 at system pressure. Radiated sound shall not exceed 30 NC at 0.50 in. SP in. It shall be a minimum of 30" long.
5. The new either single duct (cold) or dual duct (hot and cold) air valves shall be installed in accordance with the manufacturer's instructions. The unit shall be level +/-5 degrees to meet the operating requirements of the flow logic analyzer, which is attached to the side of the unit. Should it not be possible to level the terminal unit properly the flow logic analyzer will be removed, leveled and remounted. A minimum of 1-1/2 diameters of straight round duct is required ahead of the terminal unit so that the static pressure sensor of the pressure independent control will function properly. Any turns or flexible duct will be ahead of the straight run. Maximum length of flexible ducts shall be 18".

If specified, Variable Refrigerant Flow (VRF) systems are to be a minimum of; variable capacity, heat pump heat recovery air conditioning utilizing variable refrigerant flow, 2-pipe, zoning to provide simultaneous heating and cooling via a split system heat pump and chiller. The system shall have an outdoor unit, controller, multiple indoor units and DDC controls. Indoor units can operate in either heating or cooling mode and can change with no interruption to system operation. Specify Mitsubishi Multi-City or approved equal as the basis of design.

Provide "Pete's Plugs" at all coil inlets and outlets.

Heating and cooling comfort settings will be dictated by FP&C and the TTU Physical Plant.

Ducts and Diffusers

Materials, fabrication, and installation shall meet the latest edition of the SMACNA Standard. Ducts shall be a minimum gauge that meets or exceeds the SMACNA "HVAC Duct Construction Standards",

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State, Federal, Local building and fire codes. Balancing dampers shall be provided at each branch of supply mains. Design of duct system (round, rectangular, oval, etc.) shall be coordinated with all other trades for clearances, maintenance, and proper air flows. Internally lined ducts are not preferred and will be allowed only with the Owner's consent. Dampers located above hard ceilings shall have extended balancing adjustment rods for manual adjustment. OBD grills are not preferred in the system. Ducts shall be tested according to SMACNA "HVAC Air Duct Leakage Test Manual".

Air and Dirt Separator

If required, specify Spirotherm air and dirt separator or approved equal.

Variable Frequency Drives (VFD)

Specify Toshiba or Yaskawa variable frequency drives or approved equal.

Controls and Instrumentation

Specify that building automation systems shall be compatible with existing Campus infrastructure and communicate with CHACP 1 (Central Heating and Cooling Plant I) located on the main campus. Labeling of control points on the monitoring system will be consistent with established University equipment labeling. All points will include the building name in the description for identification.

Specify to provide a complete working Building Automation System (BAS) of Direct Digital Controls (DDC), including any and all instrumentation necessary for a complete automatic control system as indicated by the requirements of the drawings and as specified herein. System shall be designed and installed so as to obtain all functions and results necessary or appropriate for the system(s), and as hereinafter specified. System shall be based on most current/latest version of hardware and software of the particular manufacturer.

The automatic temperature control system shall be a microprocessor based Direct Digital Control (DDC), Building Automation System (BAS) utilizing a combination of electric/ electronic components, as indicated. The entire system shall be provided by an approved Controls Manufacturer/ Contractor, Johnson Controls Inc. or ConTech. It shall be designed by experienced engineers and installed by competent technicians, all of which are regularly employed in the specialty field of HVAC and building controls. This system/ installation shall include temperature control components, interlock relays, and all associated electrical conduit and conductors. When adding new controls to existing buildings, verify with CHACP 1 of the current Building Automation System (BAS); new controls shall match existing

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system controls. In the event of a major renovation to a building, if applicable, the entire system shall be upgraded.

Control work includes, but is not necessarily limited to, the following systems:

1. Unitary HVAC equipment controls.
2. Packaged air conditioning unit (PACU) humidity control and high humidity override.
3. DX AHU system(s) and activation/control of zone electric duct heater.
4. Exhaust fans start/stop or enable/disable.
5. Demand controlled ventilation via CO2 sensing.
6. Monitor of fire sprinkler system alarms.
7. Monitor of lift station alarm.
8. Building automation/energy management.
9. Controls wiring and other interfaces as required for fire alarm shutdown of air systems.
10. Additional control systems and components as indicated by the drawings, as specified herein, or as necessary to accomplish the work described.
11. Monitoring, status, and alarm functions as specified in this Section, as indicated in related sections of equipment being controlled, and as indicated on drawings. Minimum points to monitor are listed in the chart below.

AHU's
OUTSIDE AIR TEMPERATURE SENSOR
RETURN AIR TEMPERATURE
MIXED AIR TEMPERATURE
DISCHARGE AIR TEMPERATURE
LOW LIMIT TEMPERATURE
CHILLED WATER VALVE
OUTSIDE AIR DAMPER
RETURN AIR DAMPER
RELIEF AIR DAMPER
FILTER STATUS
RETURN FAN COMMAND & STATUS

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RETURN FAN SPEED
SUPPLY FAN COMMAND & STATUS
SUPPLY FAN SPEED
HIGH STATIC ALARM
DISCHARGE AIR STATIC PRESSURE
TERMINAL UNITS
SUPPLY AIR TEMP
SPACE TEMP
COOLING
HEATING
FAN
SINGLE ZONE RTU's
OUTSIDE AIR TEMP (1 per building)
RETURN AIR TEMP
SUPPLY AIR TEMP
SPACE TEMP
COOLING
HEATING
FAN
FAN STATUS
CHILLED/HEATING WATER SYSTEMS
CHILLED WATER SUPPLY METER
CHILLED WATER PUMP
CHW SUPPLY / RETURN TEMP
HOT WATER PUMP
HWS SUPPLY / RETURN TEMP
STEAM
STEAM SUPPLY METER

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For Emergency Maintenance (EM), graphic screens for HVAC systems should show the air handling units, their locations and room numbers.

The manufacturer/contractor shall maintain local qualified and experienced designer, programmer and service technician, familiar with the details of this project/system, to serve the project throughout the warranty period. Such personnel shall be available on a 24-hour, seven day a week basis, and contractor/manufacturer shall provide equally qualified substitutes during such personnel's "absentee" periods.

The Contractor shall have not less than a five (5) year experience record in the design and installation of computerized building systems similar in geographic vicinity, scope, and performance to that specified herein. References will be made available upon request.

Quality assurance for automatic controls systems shall be accomplished through the Contractor's commissioning process.

The automatic controls will be installed under the direct and continuous supervision of a lead technician who is an employee of the manufacturer or an approved representative of the manufacturer (approved by the manufacturer and acceptable to the Owner).

Service personnel shall be available at all times during the warranty period, and after hours calls and response shall be provided without additional cost to the Owner.

The system shall be approved and listed by Underwriters' Laboratories, Inc., under UL916 for energy management systems.

The system shall be certified to comply with NEC (NFPA70), FCC-Part J, and ASHRAE/ANSI Standard 135 (BACnet).

The Controls Manufacturer/Contractor shall verify, prior to proposal, that sequences of operation and control approaches presented within the drawings and these specifications are appropriate for the HVAC systems and equipment to be used, and that its systems to be provided are complete.

The Controls Manufacturer/Contractor shall coordinate design and installation of the controls system with the fire alarm system and TTU CHACP1.

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The Controls Contractor or Subcontractor shall coordinate proposing/ bidding and execution of the work with that of other trades, including mechanical (ducting), testing, adjusting, and balancing, and electrical (including fire alarm). Full cooperation and coordination with the other trades shall be required. The controls contractor/subcontractor shall be responsible for verifying proper installation (to be done by mechanical trades) of all wells, ports, taps, etc. needed for installation of all control and instrumentation devices.

Specify All equipment, components, parts, materials, peripherals, etc. provided shall be the latest current versions offered by the respective manufacturer, and shall be fully compatible with all other equipment, etc. provided at any other time throughout the warranty period plus 4 years. Should updated versions of equipment be provided which are not fully compatible with earlier equipment provided (e.g. a requirement to add hardware or software "interfacing" between an earlier and later generation results in the systems not being fully compatible), Controls Contractor and Manufacturer shall replace earlier equipment with the later version at Controls Contractor's and Manufacturer's cost. This requirement shall be a binding warranty which applies regardless of the expiration of other warranties. By offering a proposal for this work, the Controls Contractor and Manufacturer both agree with and shall be bound by this requirement.

Specify all software used in/supplied to this system shall be the manufacturer's current/latest version. All software upgrades applicable to system and offered by the manufacturer/contractor for this system shall be provided at no cost to the Owner throughout the warranty period plus four years. This no cost upgrade shall include installation, programming, (sequence, color graphics, reports, etc.) modifications to field equipment, data base revisions, etc., all as appropriate.

All project developed hardware and software shall become the property of the Owner. These properties include but are not limited to: Project graphic images, record drawings, project database, job-specific application programming code, and all documentation. All workstation graphics shall be developed and installed by the Contractor. Each building shall be provided with a main graphic to which other building specific graphics shall be linked. Links shall be embedded on each floor plan that navigates to an enlarged floor plan. The Building Main Graphic shall also display the building current active alarm count, links to all building specific graphics, links to all menu/navigation graphics and building restart graphics.

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Provide an enlarged floor plan, which shall display room temperatures and provide links to Building Equipment Level graphics. On each floor plan graphic, provide navigation links to all building levels and menus with links to other building graphics. Provide one graphic for each HVAC system including fan systems, chilled water systems, hot water systems, steam systems, return fan systems and other systems as appropriate for project specifics.

Minimum graphics update rates:

Display Refresh: 20 dynamic points in 10 seconds, with automatic refresh every 20 seconds

Object Command: 5 seconds

Object Scan: 5 seconds

Alarm Response Time: 5 seconds when point goes into alarm

Multiple alarms: 3 seconds of each other

The Control Contractor/Manufacturer shall submit shop drawings of the entire control system complete with specification data sheets for all instrumentation, etc., before starting work. Shop drawings shall be neat and professionally prepared

Specify all products shall be of a single manufacturer wherever possible. Should a single manufacturer not have all products available from its product line, a minimum number of manufacturers shall be used. Each manufacturer, and quantity of manufacturers, shall be subject to the acceptance of the Design Professional and Owner. In all cases, all like devices/equipment shall be of a single manufacturer. Specify to provide all sensors, thermostats, dampers (control), operators, microprocessors, controllers, transducers, switches, indicating devices, interface equipment, transformers, power supplies, fuses, wiring, cabling, and other devices/apparatus required to properly operate mechanical system and to perform functions specified and intended.

Provide controllers that execute PID control loops at a frequency not to exceed 3 seconds. The process variable scan and updated calculated output is at the same frequency rate.

Control Loop Stability:

Air Pressure: ± 0.3 " wg

Airflow: $\pm 5\%$ of actual flow

Temperature: $\pm 2^\circ\text{F}$

Humidity: $\pm 5\%$ RH

Fluid Pressure: $\pm 3\%$ of full scale

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Fluid Flow: $\pm 3\%$ of full scale

Where recommended by controls manufacturer for the system/application involved, DDC system/components shall employ and maintain a separate, "clean earth" grounding protection. "Mixing" of grounding systems shall be prohibited.

Specify electrical materials and installation shall be in accordance with the requirements of NFPA, the National Electrical Code, and the Project's electrical specification. All electrical work included under this section shall be complete with labor, materials and installations. Electrical Contractor is to install 120V power to each terminal box and each DDC panel per Division 16.

Label all instrumentation and controls and associated conduit and cabling with clearly visible and readable identification with respect to the control record drawings and the equipment served.

When installation of system is complete, calibrate all sensors and related equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting, and final field tests shall be completed by the Contractor.

Except as noted below, all wire/cable (in walls, chases, mechanical rooms, below grade, below slabs, above ceilings, etc.) shall be run in conduit. Conduit types shall match those in the electrical division with regard to types (e.g. RGS, IMC, EMT) in particular spaces. An exception may be allowed on certain situations with the Owners consent to run control wire/cable outside of conduit if all the following conditions prevail: allowed by NFPA 72; located above accessible ceilings; plenum rated cable is used; less than 24 VAC or 24 VDC (nominal) is used; where allowed by all applicable administrative authorities; where labeled "controls" and supported in accordance with code.

Unless otherwise indicated, all conduits shall be concealed and square with building lines. In addition, comply with special requirements for conduit routing to avoid exposed placement.

At a minimum, each contractor and all materials/equipment suppliers shall guarantee all labor and materials furnished by respective entity for a period of one year unless otherwise noted. Warranty period shall extend from the date of substantial completion or upon written directive from the Owner, whichever occurs first. The warranty shall cover the repair or replacement, at the Contractor's expense, of any defective material, faulty workmanship, or incompleteness.

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The building automated system shall have an adjustable “dead band” of four (4) degrees controlling both the heating and the cooling. Building occupants shall have the capability to utilize this feature by using an override on the thermostats in their respected areas.

The temperature control shall have a programmed seasonal set-point range that will be provide by the Owner prior to the system being accepted. It is the controls contractor’s responsibility to ensure these parameters are incorporated into the submittal package prior to work commencing.

System Cleaning

System cleaning is required for the following systems: Chill water closed loops, hot water loops, and condenser water systems.

Specify the following minimums for cleaning of the piping systems:

1. Remove flow meters from building piping during flushing operation. Provide means (instrumentation) during flushing period to prove to the Owner Representative that the minimum velocities are maintained in the pipes. Submit a detailed cleaning plan for the Engineer’s and Owner’s review and approval describing in full detail the individual steps associated with this process. Plan must include a drawing indicating GPM’s required to provide minimum velocity required in the piping, phasing of systems being cleaned, locations of drains or other temporary connections required for system cleaning. Submit chemicals to be used for cleaning the system for Owner and Engineer approval.
2. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Provide whatever temporary connections and valves that are required for cleaning, purging and circulating. Provide temporary bypasses around air handling units, fan coil units, flow meters and hot water coils.
3. The pipe cleaning of the building will also include the cleaning of any new tunnel piping that serves the building.
4. The piping mains shall be flushed and cleaned prior to the installation of laterals.
5. Install temporary strainers in front of pumps, tanks, water still, solenoid valves, control valves, and other equipment where permanent strainers are not indicated.

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Keep these strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blow off valve. Provide backflow protection for the domestic water when connected to the system being flushed.

6. Circulate a chemical cleaner in chilled, heating, condenser water piping systems to remove mill scale, grease, oil and silt. Circulate Owner approved detergent with Owner approved anti-foam compound. Circulate for 48 hours or as required by Owner, flush system and replace with clean water. Dispose of circulated water with chemicals as per local code requirements. Submit all chemicals to Owner/Engineer prior to cleaning for approval.
7. Provide water treatment chemicals in piping systems as directed by Owner. Chemicals must be compatible with the chemicals in the existing distribution system. Owner will review and approve chemicals submitted.