Central Utility System: It is the goal of the University to provide a steam utility system comparable to that of a public utility company in terms of safety, performance and reliability. Toward that end, further development of and/or modifications to the UIUC steam distribution system shall be accomplished with that goal in mind. "Value engineering" may be appropriate for many aspects of campus building projects but not for any project associated with the central steam distribution system. This system is to be treated as a substantial step above standard building systems in terms of detailed design, quality of materials and level of construction quality control.

Combined Heat & Power: Abbott Power Plant, the University's cogeneration power plant, supports a combined heat and power system on campus. Steam, as a byproduct of electric generation, is made available to campus buildings via the steam distribution system. A separate set of design and construction standards apply to the power plant and thus are not included herein.

System Scope: The UIUC Steam Distribution System includes all steam and condensate piping from the wall of the power plant to the first valve within each building. In addition to piping systems, the distribution system includes all steam tunnels, vaults and associated structural elements. It includes all equipment and devices within these structures as well as all underground steam and condensate piping

Compliance: All piping, valves and associated devices in the steam distribution system shall comply with *ASME B31.1 Code for Power Piping as* well as all requirements presented within *Section 33 63 23 Tunnel Steam and Condensate Piping* within these *UIUC Facilities Standards*. Other systems and components associated with the steam distribution system shall comply with applicable sections within the *Standards*.

Separate Systems: Steam is distributed to campus buildings via two distinct piping systems. These are referred to as the "*Campus Steam*" system (medium pressure) and the *High Pressure Steam* system. Distributed steam is available year-round through each system. These systems are generally laid out in an interconnecting grid configuration extended to the majority of campus buildings.

Medium Pressure System: Medium pressure *Campus Steam* typically exits the power plant at pressures of 20-25 PSIG in the heat of summer and 30-40 PSIG in the cold of winter in order to maintain a typical year-round set point of 15-20 PSIG at a remote point on campus.

Corresponding pressures at intermediate locations at any given time will be somewhere between these two (see *Specific Design Information* below). Pressure delivered to a specific building device (e.g. heat exchanger) is generally regulated within each building. However, in a growing number of cases such regulation is no longer provided.

The "Campus Pressure" system is protected by safety relief valves located within the power plant. The trip setting is 125 PSIG nominal. System components shall be Pressure Class 150 minimum.

High Pressure System: High pressure steam exits the power plant at pressures up to 165 PSIG. Under normal operating conditions it is provided to campus buildings at a pressure of approximately 150 PSIG (see *Specific Design Information* below). This system is also protected by safety relief valves located within the plant.

The trip setting is 175 PSIG nominal. System components shall be Pressure Class 300 minimum.

Location and Application: Abbott Power Plant is located at the southwestern edge of campus. The Campus Steam system extends from the power plant to approximately Springfield Avenue in the northeastern portion of campus. The high pressure system parallels it and extends beyond it to the northernmost edge of campus. Where available, Campus Pressure steam shall be used for building heating. High pressure steam shall typically be reserved for specialty service such as laboratory sterilizers, animal cage washers and kitchen cleaning equipment. However, it shall be used for building heating in areas beyond the reach of the Campus Pressure system. A regional pressure regulating station exists within the North Campus Chiller Plant. This PRV station provides 60 SPIG steam to the facilities west of NCCP.

Buildings to the east of NCCP are fed directly with high pressure steam and regulated within each building.

Steam Temperature: Steam within both systems typically exits the plant at temperatures of 350-400 degrees F (superheated). See information below regarding design temperature for expansion compensation calculation.

Actual Operating Pressure/Temperature: As pointed out above the actual operating pressure and associated temperature within each system at a specific building/site at a given time is variable and is dependent upon location within the distribution system, weather conditions, time of year and time of day. Values to be used for building steam system design (e.g. pressure regulator sizing, control valve sizing) for a specific building/site shall be obtained from the *Utility Program Statement* in conjunction with input from F&S Engineering staff. In order to provide increased real-time pressure and temperature data, instrumentation shall be provided at each building service entrance as opportunity affords.

Steam Purity: Distributed steam is of high purity due to use of deionized water for system makeup. USDA/FDA approved boiler water and steam treatment chemicals are used. The steam is treated with Morpholine and DEAE to less than 25 PPM to control condensate corrosion and it meets standards for use in soil sterilization. No filming amines are used. The use of boiler additives results in negligible carryover into the distributed steam system.

Condensate pH is approximately 7.5-8.5 and conductivity is approximately 3-20 micromhos (a.k.a. microsiemens).

The steam is currently not approved for direct contact with food.

Condensate Return: A dedicated pumped condensate return system also exists that parallels the steam distribution system. Pressure in this system fluctuates widely.

However, for the sake of consistency and interchangeability, a system pressure of 50 PSIG shall be used for sizing pumping equipment within each building.

Metering: Steam consumption is metered indirectly at each building. Pumped condensate is metered in lieu of direct steam metering. Experience indicates that proper meter installation is difficult to achieve and, more importantly, typical steam meter installations do not provide enough turn-down to satisfy the large variation in steam flow rate at a campus building over the course of a year. Each condensate meter shall be connected to the digital communication network and shall provide data directly to the *eDNA* campus data historian operated by *F&S.* All steam utilizing systems/equipment on campus served by the central system shall be designed and installed so as to return 100% of the condensate back to the power plant through the central condensate return system. Exception: Contaminated condensate from process equipment shall be wasted rather than returned. Steam condensate is metered at each building. Building systems/equipment that "inject" steam or "waste" condensate are not allowed. Lab equipment such as sterilizers is an approved exception. Conductivity measurement stations are located at various points in the condensate return system. These serve to identify impurities in the system resulting from failed heat exchange equipment. As the steam distribution system is further developed additional stations shall be provided as deemed appropriate.

Operating Cost: The University's combined heat and power system produces steam as a heat source that is typically more economical than other heat sources (e.g. gas, electricity). Thus, plant steam is typically used as the primary source of heat for campus buildings/systems that are within the "reach" of the central distribution system. Operation of the medium pressure system yields higher thermal cycle efficiency than does that of the high pressure system.

Thus, in cases where both systems are available, the use of medium pressure steam is typically given priority over the use of high pressure steam to serve HVAC loads including humidification.

Tunnel/System Type: Much of the older steam and condensate distribution piping on campus is installed within full size "walkable" utility tunnels.

Most recent extensions of the distribution system have utilized shallow tunnels with removable covers.

In limited instances buried conduit steam systems have been installed. The current standard is for walkable tunnels to be provided in conjunction with large diameter steam lines (i.e. 12" or larger) and/or multiple steam lines.

Anticipated future development of the system shall be considered when making this assessment. It is acceptable to provide shallow tunnel construction in conjunction with smaller single steam mains where no infrastructure growth is anticipated. On a case-by-case basis buried steam conduit may be considered for a dedicated branch run-out to a single building in lieu of a shallow tunnel system. In rare cases, steam and/or condensate piping may be installed in a non-conduit cellular glass insulated system (i.e. Foamglas/Pittwrap). Approval from *F&S Utilities and Energy Division* is required.

Utility Tunnels: Each utility tunnel, whether of the full size or shallow type, shall be sized and configured to accommodate the installation of larger and/or additional utility piping in the future within practical limits. All valves, traps and expansion joints shall be located within accessible tunnels or vaults.

Each tunnel/vault shall be constructed water-tight. Waterproofing system shall incorporate membrane with protective sheeting. Tunnels and vaults shall typically have 36" minimum cover. Reduced depth of cover may be considered under paved surfaces if construction dictates. Construction shall ensure that tunnels passing under roadways are not vulnerable to damage by road salt. Tunnels and vaults shall be designed for HS-20 loading at 2' of cover, minimum.

A tile/gravel drain system shall be provided to minimize hydraulic pressure and protect against ground water infiltration. Complete drainage shall be provided for all tunnel segments such that no standing water persists. To the greatest extent possible ground/storm water shall be removed from tunnels via gravity into adjacent storm drainage systems.

Gravity drains shall not, however, be connected to storm drainage systems prone to surcharge. Provision shall be made within each tunnel for water to be directed by gravity to a sump pump or gravity drain. A drainage channel shall be integrated into the floor and the floor shall be pitched toward the channel. Each bump-out shall drain by gravity into an adjacent tunnel via sloped floor if possible.

Floor level piping shall not be used to provide drainage from one underground structure (i.e. vault, bump-out, tunnel) to another. Tunnel drainage shall not "free-flow" into building interior drains. Where removal by gravity is not possible a duplex pumping station shall be provided. In no case shall storm water from outside a tunnel be piped into a tunnel or vault for removal via pumping. Pumps shall specifically be designed for high temperature service.

All electrical devices including switches, outlets, lighting, controls and associated enclosures shall be rated for high temperature and humidity conditions. The use of plastic piping, conduit, enclosures, and components shall generally be avoided.

Walkable Tunnels: Walkable full size utility tunnels shall be cast-in-place steel reinforced concrete construction. Tunnels shall be sized and configured for quick, convenient passage of operation and maintenance personnel. Tunnels shall also be sized and configured for removal and replacement of system components, including assembled pumps. Piping shall be located and supported in keeping with these requirements. Pipes shall generally be "stacked" along the wall(s) of the tunnel. Branch piping shall not cross the tunnel in a manner that creates an obstruction. Lateral piping shall generally be routed overhead. Floor or intermediate level routing is strongly discouraged. All sumps shall be fitted with covers or grates for safety. A man-entrance shall be provided at each building connection.

Vaults: Each stand-alone vault or tunnel "bump-out" shall be generously sized and configured for operation of each valve and maintenance/replacement of each system component including assembled pumps. Minimum stand-alone vault dimensions shall be 10'x10'x8'. Two entrances shall be provided for each vault. Lighting shall be provided with switching at each point of entrance. As required for tunnels, especially shallow tunnels, all components shall be rated for high temperature and humidity (i.e. saturated) conditions. Provision for

complete drainage via gravity or pumping shall be provided as indicated for tunnels.

Shallow Tunnels: Shallow tunnels shall be cast-in-place steel reinforced concrete construction with flat removable covers. Covers shall be pre-manufactured to custom dimensions. Although common practice, covers shall not be used as sidewalk surfaces. Depth of cover shall typically be no less than 36". Covers shall be sealed to prevent ingress of water. Seal design shall facilitate separation during later removal. Each cover shall be fitted with appropriate "lifting points" to facilitate future removal and handling. Piping shall be wall supported to prevent contact of supports with water at the floor level. If floor supports are required concrete pedestals shall be provided. All valves, expansion joints, traps, drains and pumps shall be located within accessible vaults. All components including pipe insulation located within shallow tunnels shall be designed for high temperature and high humidity (saturated) conditions.

Corrosion Protection: Exposed steel components located within walkable tunnels, including structural steel members, shall be primed and painted on all surfaces. Steel components in contact with tunnel floor shall be epoxy coated to distance 12" above floor level. All exposed carbon steel components located within stand-alone vaults and shallow trench tunnels, including structural steel members, shall be sand-blasted, primed and epoxy coated on all surfaces. Fasteners and hardware in these locations shall be stainless steel.

Ventilation: Ventilation adequate for continuous occupancy shall be provided throughout the walkable tunnel system. Ventilation adequate for periodic occupancy shall be provided for stand-alone vaults. This is typically accomplished by provision of natural draft ventilators at vertical entrances to walkable tunnels. Installation of additional ventilators between vault locations may be warranted given that ventilators shall be no further than 300 ft. apart. Shallow tunnels shall communicate openly with properly ventilated vaults. New ventilators shall be similar in design and appearance to approved existing structures. Substantial ventilation shall be provided for each stand-alone vault. Vault ventilation shall take priority over above-grade aesthetics. If impractical to provide a vault ventilator of typical campus design a high-low natural draft system shall be provided. Natural draft piping shall be 12" degreased and epoxy or asphalt coated steel pipe no greater than 30 ft. developed length with above grade goosenecks. Other methods of termination with equal performance are acceptable.

Access: Suitable means for tunnel entrance and exit shall be provided at intervals not to exceed 300' as well as at all stand-alone vaults. Each tunnel-to-building entrance shall incorporate a heavy duty hinged lockable door as required for security and safety. Doors shall be insulated to prevent transfer of heat between tunnels and buildings. Each exterior entrance shall be fitted with a weatherproof 36"x36" hinged lockable access hatch (e.g. as manufactured by Bilco). Each hatch shall be positioned above grade to prevent entrance of surface water and to provide physical protection from mowers, etc. Each interior door and exterior hatch shall be fitted with a lockset keyed to receive the standard utility tunnel key. Keying shall be provided by *the F&S Locksmith Shop*. Exception: Entrance into spaces located beneath streets and "drivable" surfaces such as service drives and sidewalks shall be through a standard round manhole with HS-20 rating, 32" nominal diameter opening and solid lid. Entrances of all types shall be sized and configured for convenient operation of valves and for maintenance/replacement of all system components including assembled pumps. Each vertical entrance, whether hatch or manhole type, shall be equipped with a permanent OSHA approved ladder and safety post.

Buried Piping: Buried piping systems shall be of the insulated and jacketed conduit type and shall be of the highest quality available. Each steam and condensate service pipe shall be installed in a dedicated conduit. Exception: Pumped condensate and gravity return condensate piping may be installed in a common conduit.. Depth of earth cover shall be as required to accommodate construction limitations but shall be no less than 36". Design shall be based upon HS-20 loading at 2' cover. Adequate earth cover is required to protect against damage

from unauthorized surface penetrations and to protect against freezing of condensate piping. Trace wire with termination boxes and warning tape shall be provided for all buried piping. Note: Buried conduit piping systems are notably vulnerable to failure. Failures typically result from leaks at joints in the jacketing system. Thus, a high level of quality control is crucial.

GPS: After piping has been placed and prior to backfilling *F&S Facilities Information Resources* shall be contacted to perform on-site GPS data gathering. When existing utilities are uncovered the same requirement applies.

Expansion Compensation: For each of the two steam distribution systems an operating temperature of 450 degrees F minimum shall be used for the design of expansion compensation. Expansion compensation shall typically be accomplished by means of expansion loops or offsets within a welded piping system rather than by the installation of mechanical expansion joints. This often requires the installation of a vault in the tunnel system at each loop or offset to accommodate their size and movement. Where an expansion loop or offset exists, it shall be retained or replaced with a similar loop or offset unless it is not possible to do otherwise. Installation of mechanical expansion joints shall be avoided to the greatest extent possible. If a mechanical joint must be used it shall be of the packed slip type. Bellows type expansion joints are disallowed. It may be necessary to provide expansion joints with custom-located packing ports for access in tight places. Location of anchors and guides shall be carefully evaluated. Proper position of expansion joint slips at installation is critical. Piping shall not be "cold sprung" during installation due to complications that can arise should it become necessary to modify the system in the future.

Anchors and Supports: Each pipe anchor shall be welded directly to the pipe. Cast-in-place threaded anchor bolts shall be used for attachment of pipe anchors and supports. Drilled bolts for attaching pipe supports shall generally be avoided. If possible, pipe anchors shall be restrained by thrusting off concrete walls or buttresses perpendicular to the axis of restraint. Anchors, guides and supports shall be constructed of structural steel.

Piping: All significant lengths of piping shall be pitched in direction of flow. If back-grading is unavoidable pipe shall be oversized as required to accommodate reverse flow of condensate. In order to maximize system integrity only high quality components shall be utilized. Thus, all pipe and fittings shall be seamless and all valves and fittings shall have welded connections.

Examination: Nondestructive testing of selected weld joints by radiography or other means shall be as directed by *F&S Utilities and Energy Services*

Pipe Stress Analysis: When additions or modifications are made to existing steam distribution piping systems, pipe stress analysis per ASME B31.1 shall be performed as directed by *F&S Utilities and Energy Services Division.* At a minimum, stress analysis shall be performed between anchors adjacent to areas of modification.

Valves: An isolation valve shall be provided at each branch steam distribution and pumped condensate return line near its connection point to the main. Thus, each building feed shall incorporate two isolation valves, one at the main outside the building and one within the building. This allows the steam to be turned off from outside the building in case the valve within the building fails or becomes inaccessible for some reason (such as a fire or major steam leak).

A three-valve arrangement shall be provided at each main to main connection as well as each main to major branch connection in order to maximize reliability and operational flexibility. A major branch is defined as a branch that that serves multiple facilities. A two-valve blowdown line shall be provided on each side of each system isolation valve.

A warm-up line shall also be provided at each valve. In many cases it is possible to provide a combination warm-up/blowdown piping configuration.

An isolation valve shall be installed in each steam/condensate line just inside each building at its service entrance. This valve shall be considered a component of the steam/condensate distribution system just as if it was located within the tunnel system and shall be specified/selected accordingly. Thus, it shall be a high quality valve with

welded connections rather than a standard quality valve with flanged connections.

Steam Traps: Drip trap assemblies shall be provided for condensate removal from distribution piping at intervals not to exceed 500 ft. as well as at all locations required by proper design practice.
Given that variable superheated steam is distributed trap sizing can be challenging. Assistance with sizing and location shall be sought from *F&S Utilities and Energy Services.* Condensate discharge lines shall be extended and connected to condensate return units within adjacent buildings or to condensate pump stations within the tunnel system as directed by *F&S Utilities and Energy Services Division.*

Pressure Regulators: Within each building, a separate pressure regulating (PRV) station and distribution system shall be provided for each distinct steam operating pressure requirement. However, in some cases the installation of a pressure regulating station in a building steam feed from the medium pressure "Campus Steam" system may be deemed non-essential. A pressure regulator is always required in a building steam feed from the High Pressure system including the reduced pressure steam distribution system in the Engineering Quad area of north campus. See the section entitled *Building Steam Systems* within these *General Guidelines* for more information on pressure regulators and associated relief valves. :

Condensate Pumps: Condensate pumps shall typically be located within buildings but may be located within vaults or tunnel bump-outs when circumstances dictate. Condensate pumps shall typically be electric driven. However, installation of steam pressure driven pumps is encouraged where differential steam supply pressures are adequate to enable their use. (i.e. where high pressure steam is available). See section entitled *Building Steam Systems* within these *General Guidelines* for additional information.

Metering: Condensate shall be metered within each building prior to entering the central (tunnel) condensate return system. The meter shall be connected to the digital communication network and shall provide data directly to the *eDNA* campus data historian operated by *F&S Utilities and Energy Systems*. It is typically preferred that only one metering station be installed per building. It is not necessary to meter low, medium and high pressure condensate separately.
See section entitled *Condensate Metering* within these *General Guidelines* for additional information.

Specific Design Information: The following project-specific information and design directives shall be obtained from the *Utility Program Statement:*

1. Distribution system to be used for a specific project (Campus pressure vs. high pressure)
2. Operating pressure and temperature to be used for specific project design purposes
3. Type, placement and sizing of system extensions.
4. Recommended locations of anchors, valves, etc.
5. Available plant and distribution system capacities.

Responsibility: It is the responsibility of the *F&S Utilities and Energy Services Division* to provide oversight of all activities related to construction, modification, operation and maintenance of the steam distribution system. Thus, at a functional level said entity serves as the *Owner* of the system. Jurisdictionally the building primary pressure regulating stations, safety relief valves and condensate return units are under the purview of the *Utilities and Energy Services Division* as well. To ensure safety and reliability it is essential that advance notification be provided and formal approval be gained prior to any significant non-routine activity as it relates to any aspect of the larger system.

System Operation: Start-up, shut down or other operational activity related to the steam distribution system shall be under the direct supervision of the *F&S Utilities and Energy Services Division.* No steam or condensate valve shall be operated by any individual other than an assigned staff member of said entity.

Commissioning & Inspection: *F&S Utilities and Energy Services Division* shall be contacted prior to testing, commissioning or energizing system components. This

does not remove responsibility of following other project protocols including but not limited to contacting *F&S Commissioning and Inspection.*