**Cogeneration:** Steam for distribution to campus is generated at Abbott Power Plant, the University's cogeneration power plant.

**Campus Distribution System:** Steam is distributed to campus buildings through two distinct piping systems. These are referred to as the medium pressure system (a.k.a. "Campus Steam" system) and the high pressure system (a.k.a. "Utility Steam" system). Distributed steam is available year-round through each system. These are generally laid out in an interconnecting grid configuration encompassing the majority of campus buildings. Pressure delivered to points of use is generally regulated within each building.

**Geography:** Historically, steam from the medium pressure Campus Steam system served as the source of heating steam for essentially all campus buildings. As the campus expanded geographically it became increasingly impractical to serve remote buildings with steam from this system. Thus, the majority of the buildings located north of Springfield Avenue are served exclusively by the high pressure Utility Steam system. In this region of campus the buildings west of Mathews Avenue are served with 50-60 PSIG steam delivered through a pressure regulating station located within the North Campus Chiller Plant. The buildings east of Mathews Avenue are served with 150-165 PSIG steam directly from the Utility Steam System. The Veterinary Medicine Campus is also served by the high pressure Utility Steam system via a southward extension of the system. Throughout campus, a limited number of buildings are fed with steam from both the Campus and Utility Steam systems. These are typically buildings with laboratory sterilizing equipment, kitchen cooking equipment or laundry facilities.

**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 year-round set point of approximately 15 PSIG at the opposite side of campus (see Specific Design Information below). This system is protected by safety relief valves located within the plant. The highest trip setting for the medium pressure system is 129 PSIG. Per code, the piping system must be designed for the highest trip setting plus 6% tolerance. Thus, the design pressure for the medium pressure system with all its components is 137 PSIG.

**High Pressure System:** High pressure Utility Steam typically exits the power plant at pressures up to 165 PSIG. Under normal operating conditions high pressure steam is available at campus buildings at pressures ranging from 150 to 165 PSIG (see Specific Design Information below). This system is also protected by safety relief valves located within the plant. The highest safety valve trip setting for the high pressure system is 175 PSIG. Adding the 6% tolerance yields a design pressure for the high pressure system of 186 PSIG.

**Steam Temperatures:** Steam within both systems typically exits the plant at temperatures of 350-400 degrees F (superheated).

**Steam Purity:** Distributed steam is of high purity due to the 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. The steam meets standards for use in soil sterilization. No filming amines are used. The use of boiler additives results in negligible carryover into the steam. 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 System:** A dedicated pumped condensate return system also exists that parallels the steam distribution system. The 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 that discharges into the central condensate return system. All steam-utilizing systems/equipment on campus shall be designed and installed so as to return 100% of the condensate back to the power plant through the central condensate return system. Steam
condensate is metered at each building. Building systems/equipment that “injects” steam or “waste” condensate are not allowed. Lab equipment sterilizers are an approved exception. Conductivity measurement stations are located throughout 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.

**Actual Operating Pressure/Temperature:**
The actual operating pressure and associated temperature within each of these systems at a specific building/site at any given time depends upon it’s location along the distribution system, the weather conditions, the time of year as well as the time of day. Values that should be used for building steam system design (e.g. pressure regulator sizing) for a specific building/site shall be obtained from the Utility Program Statement.

**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. The 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.

**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 been installed in 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 growth is anticipated. On a case-by-case basis buried steam conduit may be considered for a dedicated run-out to a single building in lieu of a shallow tunnel system.

**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. It shall incorporate a vault at each valve, expansion loop/joint, sump pump and/or condensate pump location. Each vault shall be generously sized and configured to provide adequate access for operation of each valve. This may require that more than one entrance be provided for a given vault. Each tunnel/vault shall be constructed watertight. Construction shall ensure that tunnels passing under roadways are not vulnerable to damage by road salt. A tile/gravel drain system shall be provided to minimize hydraulic pressure and protect against ground water infiltration. Tunnel drainage shall not be directed into building interior drains. To the greatest extent possible it shall be removed from tunnels via gravity into adjacent storm drainage systems. It shall not, however, be connected to systems that are prone to surcharge. Where removal by gravity is not possible a duplex pumping station shall be provided. Pumps and discharge piping shall be designed for high temperature service. In no case shall storm water from outside a tunnel be piped into a tunnel or vault for removal via pumping. All electrical components within a tunnel system, including lighting, shall be designed for high temperature and humidity conditions.

**Walkable Tunnels:** When a full size utility tunnel is provided it shall be cast-in-place reinforced concrete construction. Ventilation that is adequate for periodic occupancy shall be provided. This is typically accomplished by providing a natural draft ventilator at each vault. Installation of additional ventilators between vault locations may be warranted. New ventilators shall be similar in design and appearance to existing. Adequate lighting shall be provided with switching at
each point of entrance. A man-entrance shall be provided at each point where a tunnel terminates at a building foundation wall. Tunnel entrances and passageways shall be large enough to accommodate removal and replacement of all system components as well as rescue equipment such as a Stokes litter.

**Shallow Tunnels:** When a shallow tunnel is provided it shall be of cast-in-place reinforced concrete construction with removable covers. Although common practice, covers shall not be used as sidewalk surfaces. All valves, expansion joints, traps and drains shall be located within vaults and a man-entrance shall be provided at each vault.

**Tunnel Access:** Each tunnel/vault entrance, whether from outdoors or from inside a building, shall incorporate a heavy duty lockable door such that access is limited to appropriate employees of the F&S Division. Outside entrance doors shall be weatherproof and inside doors shall be insulated. The lock serving each door shall be keyed to the standard utility tunnel key. Therefore, it will be necessary for the F&S Locksmith Shop to provide keying. Permanent ladders shall be provided at vertical entrances and other locations as needed for safe and convenient access.

**Buried Piping:** Buried piping systems shall be of insulated and jacketed conduit type. Each steam and condensate carrier pipe shall be installed in a dedicated conduit.

**Distribution Piping/Valving:** An isolation valve shall be installed in each branch steam distribution or central condensate return line near the point where it connects to a main. Where a main connects to another main, or a main branch (i.e. a branch that serves multiple facilities) connects to a main, a three-valve arrangement shall be installed to maximize reliability and operational flexibility.

**Expansion Compensation:** For each of the two steam distribution systems an operating temperature of 450 degrees F 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. If a mechanical expansion joint must be used, a sliding expansion joint with a packing manifold is required to ensure inaccessible packing ports can be reached. Location of anchors shall be carefully evaluated. Piping shall not be “cold sprung” during installation due to complications that can be created should it become necessary to modify the system in the future.

**Anchors and Supports:** Epoxy coated pipe anchor plates shall be cast into the tunnel wall. Cast-in-place bolt anchor inserts shall be used for attachment of pipe supports. Drilled bolts for attaching pipe anchors or 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.

**Valves:** An isolation valve shall be provided at each branch steam distribution and pumped condensate return line near the point where it connects to a main. 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 serves multiple facilities. A combination blow-down/warm-up line arrangement shall be provided at each system isolation valve. A “stop valve” shall be installed in each steam/condensate line just inside each building at its service entrance. This valve shall be considered a part of the steam/condensate distribution system just as if it were located within the tunnel system and shall be specified/selected accordingly (e.g. it shall be a higher quality valve with welded connections rather than a lower quality flanged valve that would typically be utilized in a building steam system).

**Traps:** Drip trap assemblies shall be provided for condensate removal from distribution piping at intervals not to exceed 500 ft. as well as at locations where required by proper design practice. 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 the Energy Service Division within F&S.

**Pipe Stress Analysis:** When modifications or additions are made to existing steam distribution piping systems, pipe stress analysis per ASME B31.1 shall be performed. At a minimum, stress analysis shall be performed upon anchor adjacent to the areas of modification. Analysis results shall be presented to the Energy Service Division within F&S.

**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 (medium 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. Available plant and distribution system capacities

**Documentation and Submittals:** The AE shall review the Project Submittal Requirements.