Steam Heating: Campus buildings are to be heated with steam from Abbott Power Plant via the central steam distribution system. Medium pressure "Campus Steam", if available, is typically to be used for this purpose. If Campus Steam is not available (e.g. at remote locations such as the Veterinary Medicine Complex and the furthest north reaches of campus) high pressure steam is typically utilized to serve building heating systems. (Reference paragraph entitled *Utility Program Statement* below.)

Natural Gas Heating: Natural gas, as opposed to electricity, typically is used to provide heating for buildings that are not served with steam from Abbott Power Plant. (Reference paragraph entitled *Utility Program Statement* below.) When natural gas is used as a heating source for an office, classroom and/or laboratory building it should not be used to heat air directly, but be used to fire steam or hot water boiler(s). The use of gas fired air heating units may be allowed in less substantial building types (e.g. residential, light commercial, farm) but must be vented type. Direct gas-fired heating units are not to be used for any application.

Electric Heating: Electric resistance heating is not allowed for applications except where integrated into a specialized packaged Heating, ventilating, and air-conditioning (HVAC) unit for the express purpose of providing humidity control. Such applications are rare.

Hydronic Heating: Steam is not to be used as a direct source of heating for a HVAC system. It is to be used in conjunction with a heat exchanger (aka hot water converter) to heat fluid within a hydronic heat transfer system. Thus, the use of steam heating coils, unit heaters, cabinet unit heaters, convectors, finned-tube elements, etc. is not allowed. Exception: In areas within existing buildings where only steam heat is available and it is impractical to provide a hydronic system, steam heating equipment is allowed if specifically approved by F&S. However, this exception is application to unitary and terminal equipment only. It is not applicable to central air handling equipment.

Boilers: As stated above, when campus steam is not available as a heat source for a hydronic heating system, natural gas will be used to fire hot water generators (boilers). Boilers shall be of the sealed combustion high efficiency type. Boilers are to be configured and operated in a manner that takes full advantage of available efficiency. Achieving "real life" efficiencies that approach that advertised by boiler manufacturers is a rare accomplishment.

Achieving Boiler Efficiency: Achieving advertised boiler efficiency requires that boiler(s) remain in continuous operation with flue gas temperatures below condensing temperature. Thus, boilers are to have enough turn-down capability to allow them to remain in operation at very low loads. Hot water systems are to be configured and operated such that the return water temperature is kept as low as possible, preferably below 130 degrees Fahrenheit (deg-F). Hot water coils may be selected for appropriate supply water temperatures to achieve this. Thus, heating coils may typically be selected two rows rather than single row. Water temperature is to be resettable based upon actual load conditions. The control system, and the control valves in particular, are to be capable of maintaining maximum supply/return temperature differential (aka delta T) in order to maintain return water temperature. Thus, pressure independent control valves may be used given that they yield higher delta T than standard control valves. The number and capacity of boilers should typically be selected to minimize boiler cycling in response to variations in load. In this vein, automatic isolation of non-operational boilers is to be provided to maximize flow through operating boilers, thus reducing boiler cycling.

Perimeter Heating: It has been the experience of the University that provision of hydronic perimeter heating consistently improves occupant comfort during cold weather conditions. Thus it is to be treated as non-optional. Each occupied space with an exterior exposure is to incorporate hydronic perimeter heating unit(s) generously sized to offset associated building envelope load. Sizing is to incorporate unanticipated envelope leakage

due to inevitable non-optimal envelope construction. Perimeter heat is to be in the form of baseboard finned tube heating elements. With specific approval of F&S, ceiling radiant heating panels may be utilized in lieu of baseboard elements if such elements would otherwise be inaccessible for service and repair. Heating units are to be strategically located adjacent to areas of greatest heat loss (e.g. beneath windows).

Public Entrances: At each public entrance one or more cabinet unit heaters are to be provided. At larger, high traffic entrances one heater is to be provided at each side of the entrance. These units may be floor supported or wall mounted. They may be either recessed or surface mounted. They are not to be installed overhead. Given that it is common for buildings to operate with negative pressurization relative to outdoors, entrances can function as makeup air intakes and the associated cabinet unit heaters end up serving as preheat coils for the building. Thus, these units shall be generously sized at a minimum of 25,000 BTUH per 3' x 7' door and include the calculated heat loss. Each such unit will be controlled via BAS with local temperature sensing.

Non-Public Entrances: The installation of cabinet unit heaters is not specifically required at low-traffic entrances. However, hydronic heating of some form (e.g. finned tube, convectors) will typically be needed to mitigate the effect of cold drafts in adjacent areas (e.g. corridors).

Loading Docks: High capacity unit heaters and/or heated air curtains are to be provided at loading docks and other high infiltration service areas.

Pressurization: Building pressurization has a substantial effect on localized occupant comfort. Negative building pressure relative to outdoors results in cold air leakage through cracks and openings. Thus, building pressure control is to be treated as a key component of occupant comfort as it relates to building heating.

Backup Equipment: A 100% backup or duplex unit is to be provided for each critical piece of heating equipment that is vulnerable to failure. This includes equipment required for freeze protection of facilities or critical service to animal rooms. Critical equipment includes boilers, hot water pumps, and steam condensate pumps along with associated equipment/systems dedicated to each.

Insulation: All hot surfaces of heating piping and related equipment, with the exception of steam traps and condensate pump volutes, must be insulated. The common practice of leaving unions, strainers, pressure regulating valves, control valves, and various specialties uninsulated is disallowed.

Utility Program Statement: Specific direction regarding which steam system(s) are to be used to serve a specific building/site and associated operating pressures and temperatures to be used for design purposes must be obtained from *F&S Utility and Energy Services Division* via a *Utility Program Statement*. As applicable, specific direction regarding the use of natural gas and associated design information is to be obtained in the same manner.