# Technical Memorandum

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| Date | October 2008 |
| Project | Tennessee State University Campus Master Plan |
| Subject | 3. Existing Campus Conditions<br>3.2 Existing Campus Infrastructure<br>3.2.4 Steam and Chilled Water |
| From | I.C. Thomasson Associates, Inc. |
| To | Tennessee State University |

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The objective of this work is to discuss the condition and capacity of the existing steam system.

## 1. STEAM

Most buildings on campus are served by the campus central steam plant, originally built in late 40's and located on the west edge of campus. The existing boilers are listed below:

| | BLR MANF | TYPE | CAPACITY (PPH) | PRESSURE (PSIG) | FUEL |
|---|---|---|---|---|---|
| | Nebraska Cleaver Brooks | Water Tube | 57,000 | 150 | Gas/Oil |
| | Cleaver Brooks | Water Tube | 75,000 | 150 | Gas/Oil |
| | Vogt | Water Tube | 75,000 | 150 | Coal |
| | **TOTAL WINTER CAP.** | | **207,000** | | |
| | Cleaver Brooks | Fire Tube | 19,000 | 100 | Gas |

While the gas and gas/oil boilers are in generally good condition, the coal fired boiler has been out of service since 2000. Several studies have been performed to determine the feasibility of restoring the coal boiler to working order. A report by IC Thomasson in 2004 estimated that the university could save approximately $285,000 annually by burning coal during the coldest part of the year. Repairing the boiler would entail the following:

- Replacing the existing baghouse
- Repairing or replacing boiler tubes, refractory, gaskets, and valves
- Repairing the coal and ash handling system
- Some asbestos abatement
- Controls upgrade
- Lining masonry stack

A recent update of the I C Thomasson Study by SSR calculated the cost for these repairs at $1,650,000.

The study also identified additional plant improvements including adding a 30,000 gallon fuel oil tank, automatic bottom ash doors, condensate polisher, control room upgrades, a new maintenance shop. In addition, the plant would benefit from the installation of a coal silo for environmental and aesthetic reasons.

The capacity of the steam system appears to be adequate for the existing buildings. Table 3.2.4.1 lists the buildings currently on the central steam system along with gross square footage date and estimated steam load. These are compared to the capacity of the installed equipment. Based on a typical per square foot heating load of 40 BTU/sf and a diversity of 80%, the total peak campus heating load is calculated at 61,106 pounds of steam per hour (pph). While the boilers have a combined capacity of 207,000 pph, and could easily serve this load, there are other factors that limit the amount of steam actually available for building heat. Without the coal fired boiler the capacity is 132,000 pph, still above the campus peak load. However the deaerator (DA) tank has a capacity of only 90,000 pph. Because all feed water must go through the DA before entering the boilers, the total plant capacity is limited to this 90,000 pph threshold. Losing the 75,000 pph gas/oil boiler would leave the system short if the coal fired boiler remains off-line. In this case the 57,000 pph boiler would be able to keep all buildings above freezing, but not necessarily at a comfortable temperature for the occupants. Note that the Cleaver Brooks “summer boiler” is not included in the total capacity of 207,000 pph because it produces steam at a lower temperature than the other boilers and cannot operate at the same time as the larger boilers unless the temperature of the entire system is decreased. It is reserved for the summer months when the larger boilers would be inefficient at low turn down rates. Finally the plant steam header is sized at 10”, which good design would limit to a maximum of 105,000 pph.

The steam is distributed through a branched system with a central 12” header running east in the rock-bored tunnel under John A. Merritt Blvd. Branches designated 2, 3,and 4 run north and south. Each branch is intersected by several under ground vaults where the piping rises out of the tunnel and continues as direct buried piping to the buildings. This system is shown in 3.2.4 figure 1. There are some steam leaks in the tunnel that can cause problems with lights and telecommunications lines in the tunnel.

The condensate return system parallels the steam distribution system. Several areas of the system have experienced insulation and jacket failure. These are indicated by asterisks on the drawings. A total of approximately 1,300 linear feet of pipe is in need of repair. In addition the tunnel needs steel grating installed in the floor of the tunnel and water-tight lighting due to water seepage present throughout the tunnel. The estimated cost of replacing this pipe is approximately $280,000.

There have also been problems with returning condensate to the central plant. Each building’s system is designed to move its condensate into the line in the tunnel. The lines from approximately ten buildings are constantly under backpressure from the static head between the building level and that of the underground vault from which that building is fed. In the case of these ten buildings, the underground vault is higher than the building’s piping. From the vaults all piping drops down into the tunnel, which is sloped toward the tunnel intersection designated DS-A. From there the condensate lines rise to the underground vault UV-1 before sloping down again into the central plant condensate return tank. This seems to be causing two separate problems. First there is excessive water build-up during system start-up due to the static head that cannot be overcome by the steam traps when they are still at low pressure. This leads to water hammer, which is potentially dangerous and very damaging to the piping. This could possibly be alleviated operationally by draining the condensate system before and during start-up. Second, water treatment consultants indicate that the condensate has a very high iron content possibly due to the piping staying in a flooded condition. This could be associated with excessive corrosion of the condensate piping, a condition which could lead to early failure of the piping system. It has been suggested that a condensate lift station be installed to facilitate the removal of condensate from the tunnel piping. However, study of the piping profiles indicates that the problem is probably occurring between the buildings and the underground vaults. Further study should be conducted to determine if the problem can be solved by installing condensate return pumps sized to overcome the backpressure and by instituting a program of draining the condensate lines before and during start-ups.

Avon Williams Campus is served by the Nashville District Energy System for heating. This system has multiple back-up boilers, but does have occasional outages for maintenance. If the university wanted to install a heater for back-up capacity, it would be recommended to go with the lowest first cost alternative available since it would only rarely be used.

**2. CHILLED WATER**

The central chilled water plant, built in 1989 , consists of two York centrifugal chillers sized at 1,500 and 2,250 tons for a total system capacity of 3,750 tons. Table 3.2.2 lists the buildings on the system and their estimated cooling loads. These loads are calculated based on factors from similar types of buildings. The total undiversified load is calculated to be 5,871 tons. Since the total installed capacity is only 3,750 tons, and TSU personnel have not indicated that they receive frequent complaints about buildings not being adequately cooled, a building diversity of 60% is assumed. This is on the low side of typical for college campuses. This puts the diversified campus load at

5,871 tons X 60% = 3,523 tons

This is almost equal to the installed plant capacity. Therefore, it appears that the campus has little room for expansion and no back-up capacity.

The primary/secondary pumping system has two B&G vertical split case pumps for distribution sized at 3,450 gallons pre minute (gpm) each. TSU personnel report that the actual chilling capacity seems to be adequate, there is not enough distribution pump capacity to move the chilled water out to the load on a peak day. The gpm required is a function of the cooling load as well as the temperature rise (DT) that occurs as the chilled water passes through the cooling coil in each building's air handler. A typical college campus DT should be on the order of 10 to 12 degrees Fahrenheit. For the best case of a 12 degree DT, the system should be capable of pumping 2 gpm/ton or 7,500 gpm. Therefore, some adjustments to the pumping capacity are needed. TSU has a performance contract in place with Tekworks to improve the temperature difference in the plant by recirculating underutilized chilled water, thereby raising the supply temperature to the loop. This could potentially solve the problem, but could lead to increased humidity in the buildings. Additional changes to the coils in each building's airhandlers will be needed to make this a truly effective solution.

The chilling plant is relatively new, and the condition of the equipment is good.

Chilled water is distributed to the buildings through a rock bored tunnel 8 feet in diameter that runs approximately 50 to 90 feet below ground. Building connections are made through manholes at downshafts, from which conventional direct buried piping is run out to the building wall. The distribution system consists of Tunnel 1 running east across campus with tunnels 2,3, and 4 branching off to the north and south. This is illustrated in Figure 3.2.2.

The condition of the chilled water piping seems to be good.

The Avon Williams campus downtown has its own chiller, a Carrier 500 ton unit installed in the last five years. The condition is generally good, although there are problems with the variable frequency drive (VFD) at low loads. The minimum recommended speed for the drive and/or pump still produces more chilled capacity than the building requires in winter. This leads to overcooling of the building.