District Heating Conversion from Steam to Hot Water
at the Savannah Regional Hospital

by

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ABSTRACT

In 1992, the Georgia Department of Human Resources decided to replace the steam and chilled water distribution systems at the 16 Building Savannah Regional Hospital in Savannah, Georgia. A Life Cycle cost comparison indicated that conversion of the system from high pressure steam to low temperature hot water was feasible and cost effective.

A comprehensive design which included a phased change over of the district system and modifications to building air handling units was conducted by RDA Engineering, Inc. A construction budget of $1.6 million was allocated. Construction began in January of 1994 and was substantially complete in December of 1994.

This paper summarizes the Life Cycle cost benefits of conversion from steam to low temperature hot water, technical aspects of the design, construction, and preliminary results of operating cost reductions.

INTRODUCTION

The Savannah Regional Hospital was constructed circa 1969. The group of buildings which make up this complex is located on an 85 acre campus approximately 2 miles south of the City of Savannah, Georgia. The facility was originally intended to provide a full range of hospital medical services with expansions of the campus planned for later years. A central energy plant located at the perimeter of the property was constructed to provide high pressure steam and chilled water utility services to the campus buildings.

Since the original construction date, two maintenance buildings and an Activities Therapy building have been constructed. The facility is currently utilized for drug and alcohol abuse treatment and long term care for certain patients. Full hospital services are not provided and no expansion of the complex is foreseen in the State's current health care program.

In 1991 and 1992 problems occurred due to leaks in the twenty-two year old underground piping distribution system. As a result, the Department of Human Resources initiated a project to

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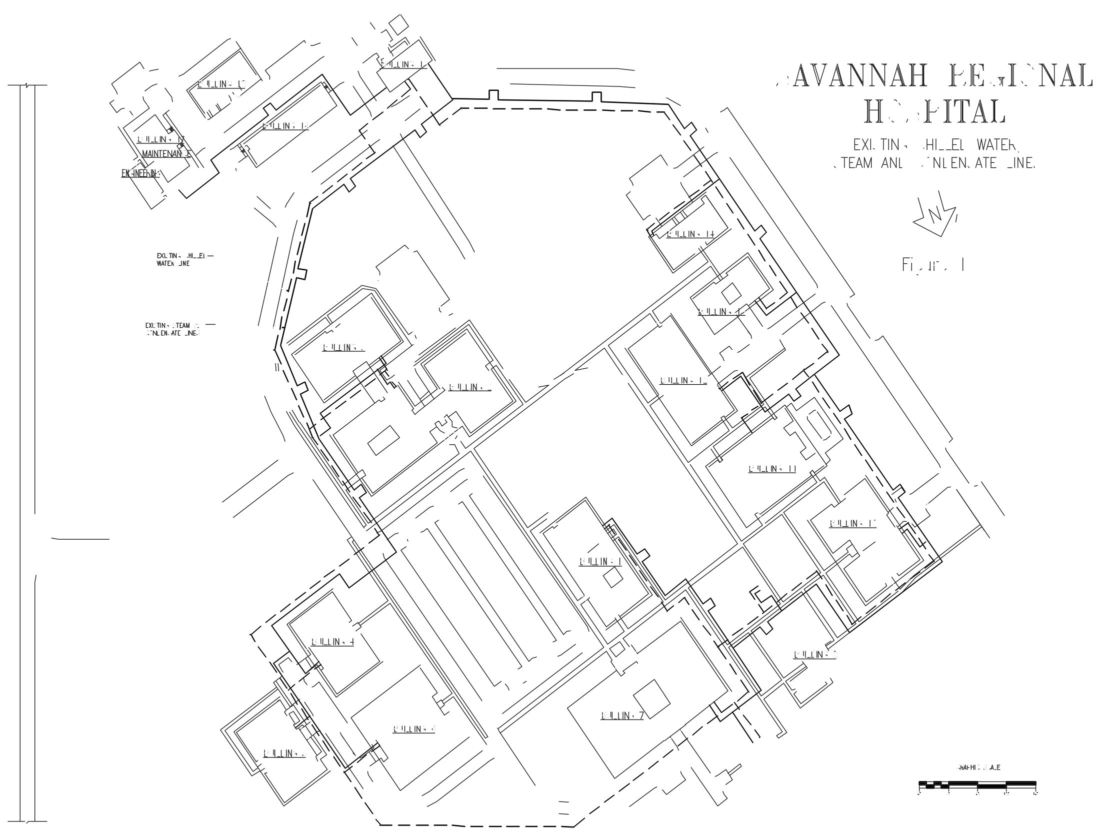
replace the underground piping from the Central Mechanical Plant to the sixteen buildings on the campus.

The modernization program has renovated building heating and air conditioning systems, replaced underground piping, converted the central boiler plant to supply hot water and installed a new computerized control system. These significant changes in the building mechanical systems have resulted in more efficient operation and provide opportunities for revised maintenance and staffing to reduce operating costs.

ORIGINAL SYSTEM DESCRIPTION

The original steam distribution system was fed by two gas/oil fired steam boilers in the Central Mechanical Plant. Each boiler was rated at 11,700,000 BTUH at 125 psig. During normal operation, one boiler was active and the other was kept in reserve as a standby.

Steam was delivered to the buildings by an underground piping system extending around the perimeter of the campus (Figure 1). Branch take-offs from the steam and condensate mains to each building were made within concrete vaults. The underground steam and condensate piping were installed together in a steel conduit totaling more than 10,600 feet in length.



Chilled water underground distribution piping included approximately 9,800 ft. of steel pipe which was insulated with cellular glass material and wrapped with a water resistant coating. The chilled water piping was installed around the perimeter of the campus, near the steam distribution piping. The Central Plant contained two chillers, each originally designed for 450 tons capacity. Normal operating procedure was to run one chiller with the other unit on standby.

Within each building, the steam piping was connected to a pressure reducing valve. Low pressure steam served steam heating coils located in one or more air handling units in each building. Steam was also used for instantaneous domestic water heaters. In the kitchen, steam was provided to steam kettles, a three-compartment steamer, coffee maker, dishwasher booster heaters, and the heating coils in eight make-up air units.

Chilled water piping in each mechanical room was connected to the underground chilled water supply and return distribution piping. In the original system, the chilled water pump in the Central Mechanical Plant served as the primary pump, and smaller pumps in each mechanical room operated as secondary pumps. Over the years, most secondary pumps were found to be unnecessary and were abandoned.

SYSTEM PROBLEMS

There were several problems with the original underground piping systems that made the replacement project necessary. The primary problem resulted from leaks in the condensate piping. Since steam and condensate mains were installed in a common conduit, when a leak occurred in a section of the condensate pipe, it resulted in flooding of the surrounding conduit. This flooding caused a breakdown of the steam and condensate pipe insulation and corrosion of the pipe casing. Large leaks resulted in flooding of the vaults and other sections of the distribution system conduits.

The hospital staff also reported several incidents of leaks in the underground chilled water piping distribution system. Investigations during repair work have shown that ground water has entered imperfections in the external wrap of the chilled water piping, broken down the pipe insulation, and corroded the pipe from the outside. As with steam piping, each time a leak related repair was made, a major shutdown of the cooling system occurred due to a lack of loops and sectional valves.

In addition to the problems being experienced in the distribution system, there were related problems within the buildings. For instance, several of the heating coils in the building air handling units had developed leaks. Several steam-to-hot water instantaneous heaters needed replacement and many of the building condensate return units were in need of major repair or replacement. Repair or replacement projects for these deficiencies had been requested by the Hospital Staff. A coordinated approach to repair and replacement of the interrelated system components appeared desirable.

REPLACEMENT OPTIONS

The Department of Human Resources project called for replacement of underground piping systems to 16 buildings at the Savannah Regional Hospital. It was anticipated that existing steam and condensate lines would be replaced by a similar system. The new system would be downsized somewhat since expansion of the campus was not anticipated. The steam system would be replaced with separate steam and condensate lines installed in a common trench. The lines would be installed along an alternate routing across the campus to minimize interference with other utilities. Sectional and branch valves would be installed in new concrete vaults. The project anticipated replacing the chilled water distribution piping mains with un-insulated ductile iron pipe.

Early in the planning process, it was discovered that capital funding had been requested for the following fiscal year to replace air handling units and heating coils, which were also considered a major maintenance problem. A thorough survey of the facility revealed no process steam uses other than kitchen requirements.

After discussions with the owner, a study was conducted to consider total renovation of the energy system to a new hot water district system, rather than continue with high pressure steam.

Advantages of this approach include:

- Costs and hazards involved with the maintenance of steam traps and valves would be eliminated.

- Maintenance and operation of heating controls would be greatly simplified.

- Maintenance of underground distribution piping would be less costly.

- Hot water piping would be installed only 2 or 3 feet below grade, making repairs less complex.

- Energy savings would be available through temperature setback and variable flow rates.

- The installed cost of the alternate hot water system would be less than a steam system. Operation and maintenance of the boilers and auxiliary equipment would be simpler and less expensive. The possibility of reducing boiler operator supervision was also considered.

CONSTRUCTION PROGRAM

In mid 1992, RDA Engineering, Inc. was selected to design a replacement steam and chilled water system for the SRH campus. The Department of Human Resources had previously determined that steam and condensate system failures along with leaks in the underground chilled water piping presented a long term problem to be corrected by installation of new distribution systems to the major buildings on campus. RDA's initial assessment of the project was presented in a Life Cycle Cost Evaluation in November of 1992.

One of the results of the Life Cycle Cost Evaluation was to recognize the benefits of combining a planned campus-wide air handling unit replacement project scheduled for the next fiscal year with replacement of the steam and chilled water distribution piping. The combination of these projects allowed replacement of the steam system with a more efficient hot water heating system and the addition of state of the art computerized controls.

Bids on the construction project were taken in October of 1993 with a total projected cost of approximately 1.6 million dollars. The work progressed throughout 1994 and was substantially complete in December of 1994.

The work covered by DHR-41 includes replacement of air handling units in each major building, cleaning of duct systems, installation of computerized monitoring and control systems in each building with telemetry to the central plant and maintenance office, replacement of domestic hot water heaters in each building, installation of variable volume terminals for limited air zoning within buildings, and balancing of air systems to current occupancy and uses. Throughout the campus, new hot and chilled water supply and return piping was installed. A small steam generator was installed at the kitchen to provide steam for cooking. At the central plant, the existing steam boilers were converted to provide hot water and auxiliary steam equipment was removed. The chilled water pumps and piping within the central plant were replaced with new variable speed pumps for efficient operation. Figure No. 2 illustrates the new underground piping system.

<u>REVISED CENTRAL PLANT REQUIREMENTS</u>

The conversion project DHR-41 substantially reduced the requirement for 24 hour staffing at the central boiler plant. Steam boilers were eliminated, automatic controls were installed to operate boilers and chillers, and remote monitoring capability was implemented.

The new heating system design uses circulating hot water to provide heating to the hospital's buildings. Hot water at a temperature of approximately 150-200° F is pumped from the central boiler plant throughout the hospital complex. Differential pressure sensors located in three remote buildings send an electronic signal back to the central control system which controls the speed of the pumps supplying hot water. This reduces energy consumption during off-peak periods. Hot water leaves the central plant at a temperature of approximately 200° F during the coldest winter conditions. An automatic temperature control valve located in the central plant resets supply temperature in relation to outside conditions to a low of approximately 150° F in the summer.

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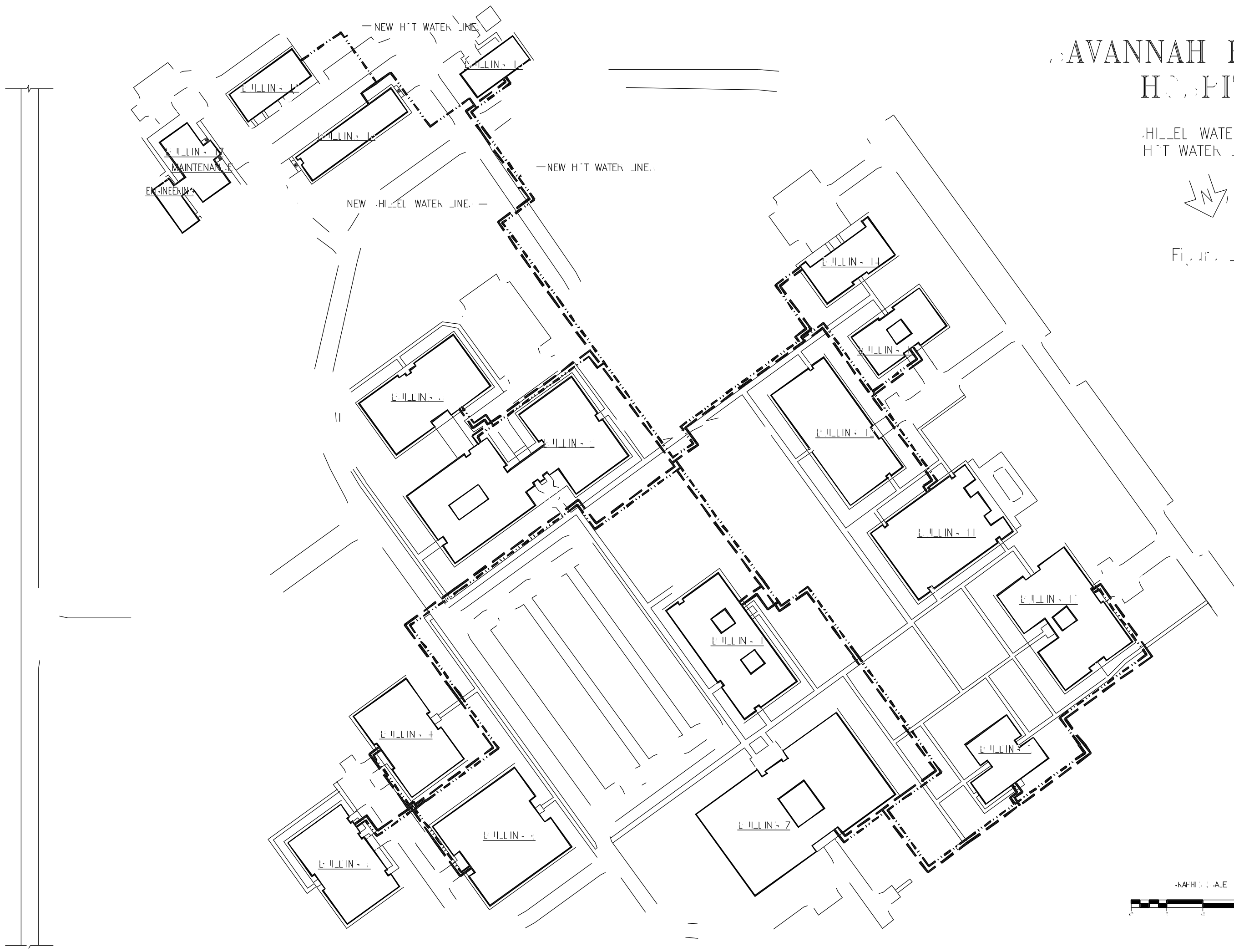

DHR-41 converted each of the steam boilers to hot water boilers. This means that the boilers are flooded with water and provide heat by warming circulating water from approximately 140° F to 200° F. No steam is produced. Without steam production, the necessity of blow down, make up water through a deaerator, extensive chemical treatment, and the danger of high pressure steam is eliminated. The hot water circulating system is completely closed and should have very little, if any, water make up requirement.

Each hot water boiler has an automatic control system which maintains discharge temperature at approximately 200° F. In the event of an abnormal operating condition, the boiler will shut down automatically and a signal will be noted by the computer control system. The computer control system will then energize the standby boiler for back-up operation. Boiler status can be checked remotely from a dial-up computer terminal.

Thermal expansion of water in the heating system is automatically accommodated in two (2) expansion tanks located in the central plant. In the event abnormal high pressure is present, a pressure relief valve will relieve pressure at the central plant. Water make up to the system is provided through a water meter with a tie-in to the computer control system. Greater than normal amounts of make up water cause an alarm condition to be reported.

The boilers will continue to need routine maintenance and daily checks, however, the absence of high pressure steam and the new automatic control revisions will allow the boilers to operate unattended during times other than the day shift. Constant operator attendance is not required.

The Project also modified the chilled water system by installing a new variable speed pump in the central plant. This pump is controlled from differential pressure signals at the three (3) building locations previously described. Existing chiller controls were left in place and an interface for on-off operation was added from the new computer control system. Automatic chilled water temperature reset is accomplished by the computerized control system in normal operation. As with the boiler system, the chillers should operate normally under their own control systems, and in the event of an abnormal condition, the computer control system is notified and an alarm generated. The chillers should receive routine maintenance and daily inspections, however, continuous operator attendance should not be necessary.

ENERGY USE EVALUATION

The hospital staff provided RDA with electrical and natural gas consumption histories for the period October 1990 through February 1995. Figure 3 illustrates the monthly consumption of natural gas.

RDA estimates that for the original steam system, approximately 48% of the energy was used for space heating, 15% for water heating and kitchen requirements, and 37% was consumed as line losses of the underground steam piping.

RDA's review of monthly energy consumption concluded that some energy waste occurred in mild weather conditions due to simultaneous heating and cooling. Replacement of air handling systems and state-of-the-art controls were expected to reduce both electrical and gas use in this area.

High natural gas consumption for line losses was due to the high temperature (320°F) of the steam system and failed insulation on the underground piping system. Boiler efficiency was also adversely affected by the high pressure steam requirements, and low summer loads. RDA estimated the steam plant's annual gas to steam efficiency at 73%.

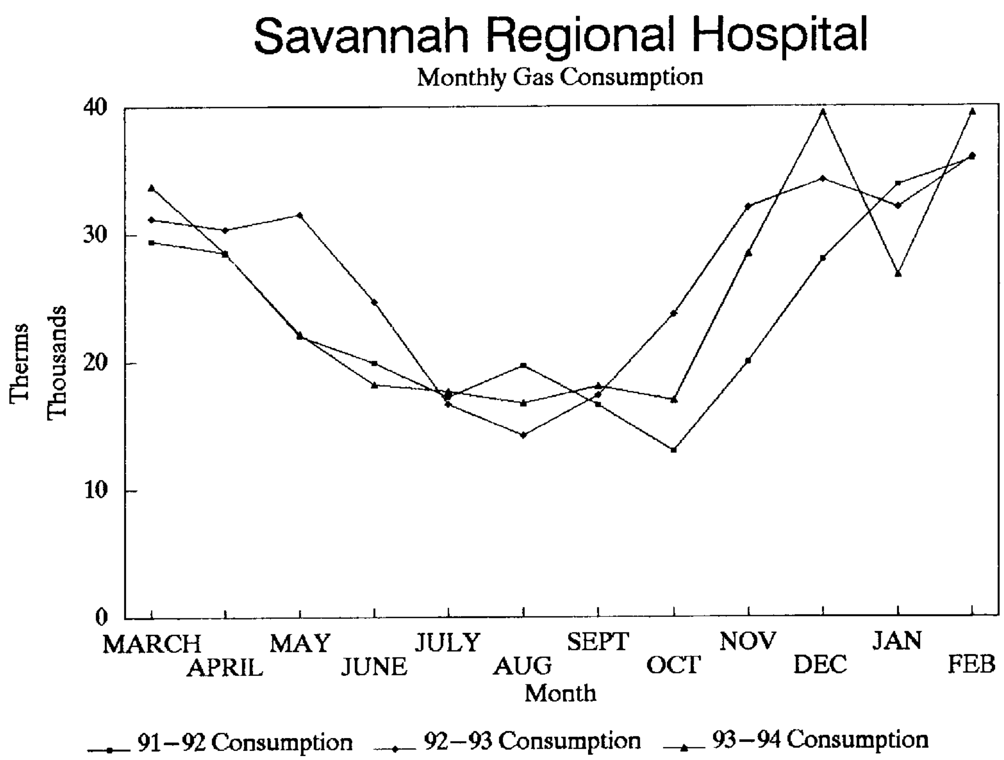

Figure 3

During the construction period, the steam system was continued in operation as changeover work was undertaken in each building. For the months of May through July, one boiler was converted to hot water while the other provided steam to the distribution system. Beginning in September 1994, the steam system was decommissioned and only the hot water operated. A review of natural gas consumption for the period from September 1994 through February 1995 reveals a dramatic reduction in energy consumption compared to the average of the previous three (3) years. Figure 4 illustrates that the new hot water system used approximately fifty eight (58) percent less natural gas for the six (6) month period than the average of previous years. This significant reduction is attributed to lower line losses, higher system efficiency, and better system control available with the hot water system.

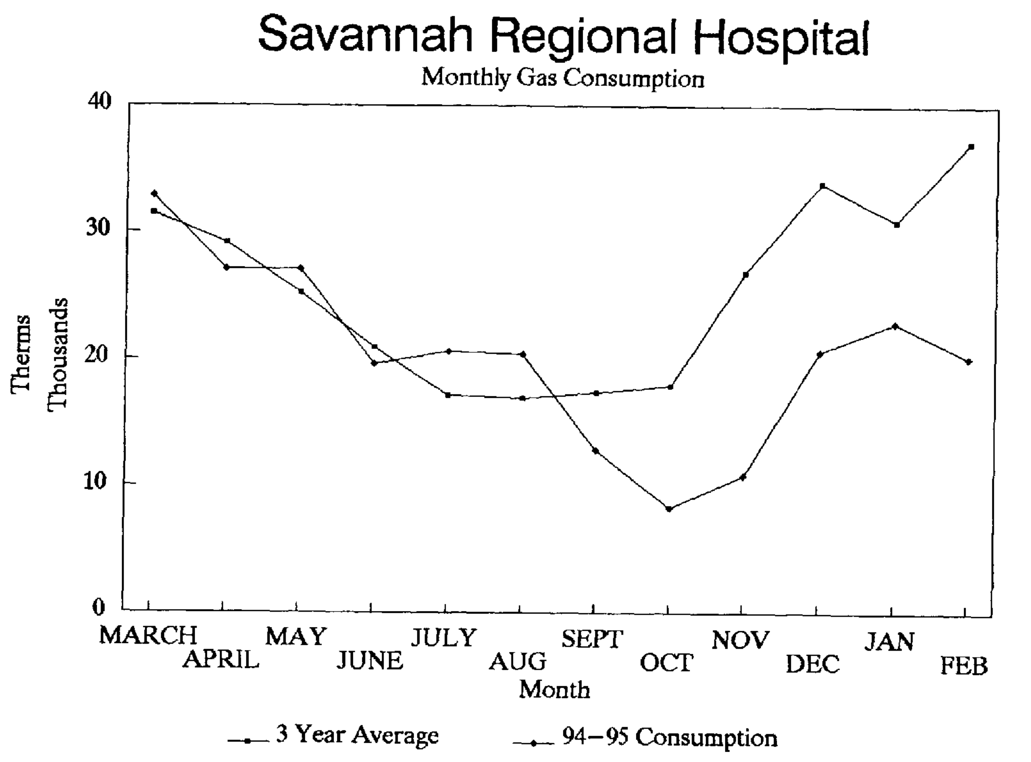

Figure 4