UNIVERSITY ICE SLURRY SYSTEM

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ABSTRACT

During the summer/fall of 1998, a 380-ton ice slurry generating system was installed to cool the Stuart C. Siegel Center, a 190,000-square-foot basketball arena and athletic complex at Virginia Commonwealth University in Richmond, Virginia. The arena has a seating capacity of 7,500 people and the total complex peak design cooling load is 1,290 tons.

This paper will present a summary of an engineering and economic evaluation which led to the decision to install the slurry system. The final design and operating results of the system will be presented.

KEY WORDS

- Ice Slurry
- Thermal Storage
- Gymnasium HVAC

INTRODUCTION

Ice slurry storage offers two fundamental characteristics which provides cost savings in HVAC projects. These characteristics are:

(1) **Ability to provide chilled water supply temperature down to 30°F.**

This characteristic reduces the size; and therefore, the first cost of chilled water distribution piping, air handlers, heat exchanger, and other components.

(2) **Ability to make and store cooling when the cooling load is small and then use the stored cooling when the cooling load peaks.**

This characteristic will reduce the peak KW demand charges and can reduce first cost for many projects depending on the ratio of peak cooling load to average cooling load over 24 hours or 7-day weekly loading.

These two characteristics played a part in the decision for ice thermal storage in the project discussed here. The chilled water supply temperature is 34°F, with a return temperature of 52.9°F. The low temperature supply water resulted in down sizing of the air side equipment and offered additional dehumidification by the variable volume air supply system.

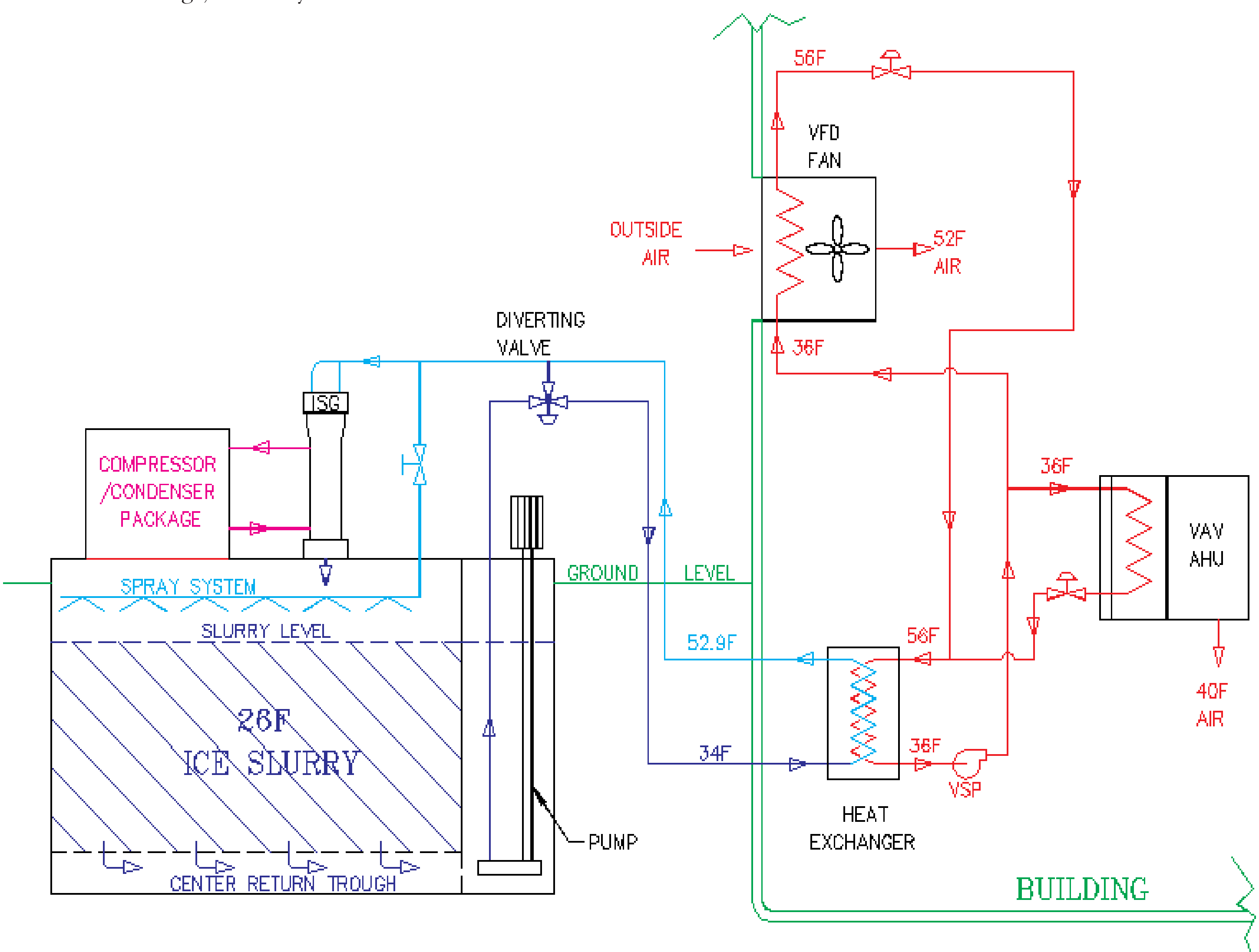
The design peak cooling load is 1,290 tons and the peak 24 hour design load is 6, 776 ton-hours. An ice slurry generator system of 380-ton capacity was selected to meet this peak load.

SYSTEM SCHEMATIC

The figure illustrates the operation of an ice slurry generator and the application to this project.

The slurry solution is 7% glycol; and therefore, has a freeze point of 28°F. Solution is pumped from the bottom of the tank and delivered to the top of the slurry generator. The solution moves through the evaporator with an average refrigerant temperature of 17°F which causes crystals to form in the solution as it falls into the tank. The slurry floats and therefore accumulates in the tank as this process continues.

The slurry generators and storage tank are located about one hundred yards from the building. The schematic illustrates the system. The slurry storage provides a 34°F solution to the building heat exchanger which, in turn provides 36°F supply water to the building air handlers. The outside air (OSA) units are equipped with variable speed drives which operate to maintain the proper fresh air in the 7,500 seat arena. Control of these OSA units is based on levels of occupancy. The outside dampers are controlled at maximum CFM for "Event" operation only. During normal occupancy, supply fans are ramped down to 30% speed and outside air dampers are reduced to 10% of full open capacity. During unoccupied periods and in the evenings, the air systems are shut down.



34°F SUPPLY WATER

The 34°F supply water provided for first cost reductions in the following components of the system:

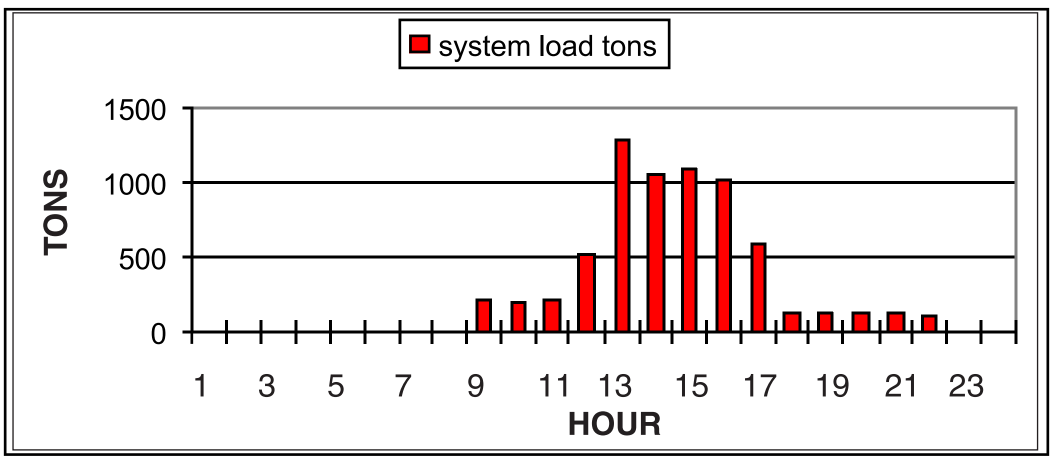
- Air Coils
- Water pumps
- Hydraulic Valves
- Pipe Size and Insulation
- Duct Size and Insulation
- Electrical Distribution
- Electric Service Size

Compared to a conventional 44°F supply water system, significant savings in first cost was realized.

SYSTEM OPERATION

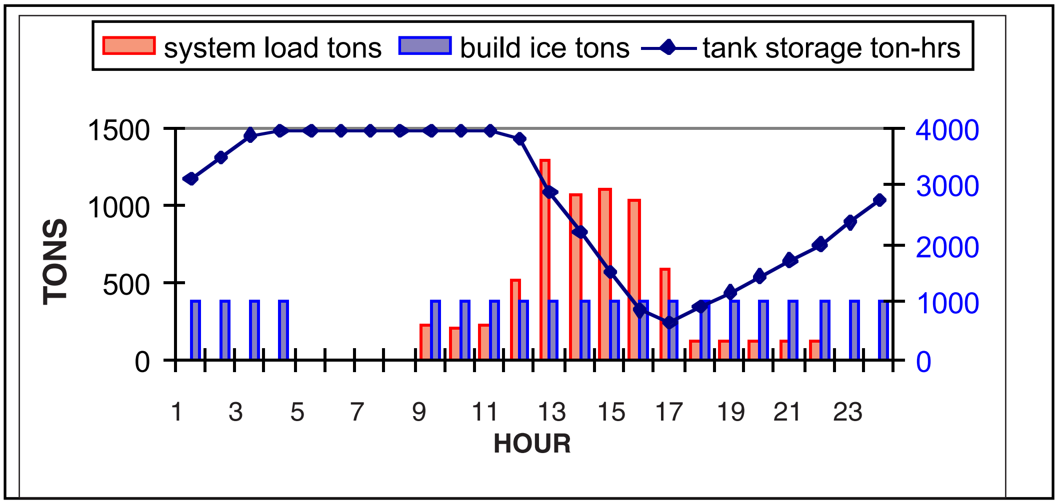
The following graph illustrates the design load which peaks at 1,290 tons at hour 13. Most of this cooling load is due to fresh air required for 7,500 occupants during a function in the arena. The timing of a major event is arbitrary, in fact, may occur at the end of the day.

The total 24-hour load is 6,776 ton-hours. Therefore, the load could be spread out over 24 hours with a thermal energy system. This system was designed with a 380-ton slurry generator.



SYSTEM OPERATION

The graph below illustrates the operation of the slurry system. The tank has 3,927 ton-hours stored at 4 a.m., and holds that amount until 12 noon when the cooling load exceeds the capacity of the slurry generator. Over the next five hours, slurry is melted to meet the cooling load, reducing the tank storage to about 640 ton-hours at hour 17. The load is less than 380 tons at hour 18 and slurry begins to accumulate in the tank reaching about 2,700 ton-hours by midnight. The ice generator shuts off at 4 a.m. when the tank again is full of ice slurry.



SYSTEM EQUIPMENT

The photograph below illustrates the slurry equipment located about 100 yards from the building seen at the top of the photograph. The building is a 190,000 square foot facility with a basketball arena that will seat 7,500 people and other spaces for athletic and teaching activities.

At the left of the photograph are the two air cooled screw machines which provide refrigerant to the six slurry generators located on the right of the photograph. One screw machine drives three 64-ton slurry generators. The storage tank is located below the equipment with the tank cover serving as the platform for the equipment. The slurry drops directly into the tank below as illustrated by the above schematic.

ECONOMICS

The ice system provides an annual operating cost savings of approximately $75,000 due to the savings in demand charges. KW demand is reduced due to:

- A 380-ton ice machine versus a 1,290-ton chiller.
- Reduced water pump sizes
- Smaller fan motors

The first cost of this ice slurry system was less than a conventional system due to the following:

- Reduced duct size
- Reduced pipe and insulation sizes
- Reduced refrigeration capacity
- Reduced motor sizes
- Reduced electrical service size

For this application, the slurry system proved to be a very attractive alternative providing both first cost savings and operating cost savings.