THERMAL STORAGE FOR ENERGY EFFICIENT STRUCTURES
(POTEET HIGH SCHOOL CASE HISTORY)

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ABSTRACT

Poteet High School, in Mesquite, Texas, is a facility that demonstrates state-of-the-art environmental control through the application of energy conserving technologies relative to architecture, HVAC and lighting. It is also recognized as an "Intelligent Building" by virtue of the fact that it automatically adjusts to, and supports the needs of, its occupants without help from facility operating personnel. This paper provides information relative to the system components groupings of envelope, electrical systems and equipment and mechanical systems and equipment. Each of the systems operating cycles are described and the major benefits of this design concept are summarized.

INTRODUCTION

Poteet High School is the first of a series of high, middle and elementary schools designed and constructed in compliance with an energy efficiency design criteria developed in 1983. This criteria encouraged the utilization of new technologies wherever their inclusion would provide at least a six year simple payback on invested capital. Since the initiation of this project three elementary, one middle and several school additions have been constructed using this criteria. The basic systems in each case have been the same except that three different types of cooling thermal storage have been used.

DISCUSSION OF SYSTEM COMPONENTS

Poteet High is a totally integrated energy conserving concept utilizing a weather impervious envelope, minimal internal loads, and highly efficient mechanical systems coupled with heating and cooling thermal storage to generate, store and distribute thermal energy in the most efficient and cost effective manner.

By utilizing occupancy sensing equipment, all elements of the energy consuming environmental comfort systems of the facility respond instantly to the utilization desires of its occupants, never necessitating preplanning for equipment operation or seasonal operating mode selection. An example of the building's automatic ability to adapt to any situation can be shown as follows:

A school principal may decide to meet with two teachers in the administrative area conference room at 8:00 P.M. on a Thursday night. Once the building security system was cleared the lights for the building access to the conference room location would automatically be turned on and, after a short dwell time,turned off for each attendee. Mechanical systems would automatically be initiated providing heating or cooling only to the areas utilized. Ventilation air would also be provided to these areas. The areas occupied would be within extended comfort limits upon initial entry due to the facility's high thermal resistance. This activity would not create disproportionate energy costs or require any action from facility management personnel.

The primary elements of the cooling system are shown in Figure 1. A detailed listing of all the specific features follows in the outline below:

I. ENVELOPE

Less than 5% thermal glazing, average U value for walls and roof is 0.05 BTU/ft^2-^{o}F. Vestibules, with radiant heating, are located at all entrances.

II. ELECTRICAL SYSTEMS & EQUIPMENT

A Chiller, cooling tower fans, chilled water distribution pump, hot water distribution pump and ventilation air unit are equipped with Variable Frequency Drives. All electrical motors over one (1) HP are the energy efficient type.

B. High pressure sodium fixtures are used on all exterior lighting. Interior lighting is predominantly fluorescent utilizing 34 watt lamps and energy efficient ballasts. Occupancy sensors or time out switches are located in every space and control the lighting and air conditioning equipment where applicable.

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C. Electrical distribution is divided according to function and submetered for HVAC loads, lighting loads and process loads such as convenience outlets, kitchen equipment, shop equipment, lab equipment, etc.

III. MECHANICAL SYSTEMS & EQUIPMENT

A. CHILLED WATER STORAGE TANK

Two hundred and fifty thousand gallon concrete vertical stratification type without separation. Upper and lower low velocity header. Temperature measurement at six equally spaced elevations. Charged by chiller or hydronic vent cycle. 20 to 30% surplus storage capacity above and beyond one days maximum cooling requirement.

B. HOT WATER STORAGE TANK

Concrete lined steel. 12,000 gallon with four headers arranged for dual temperature storage (190°F & 120°F). Top half recharged by boilers and bottom half recharged from kitchen product refrigeration waste heat.

C. CHILLER

Variable frequency drive, 196 ton rated at 38°F. Sized for full site development peak day load while operating 16 full load hours per day. Selection of VFD based on increased efficiency at reduced condensing temperatures and not part load operation.

D. BOILERS

Pulse fired high efficiency units sized for continuous operation at peak requirement.

E. CLOSED CIRCUIT COOLING TOWER

Operates in three (3) modes. Rejects heat from chiller, generates cooling effect for facility directly with storage supplement or, indirectly through charging of chilled water storage tanks. Variable frequency drive axial fans.

F. DISTRIBUTION PUMPING

Variable frequency drive heating and cooling pumps controlled to maintain proper differential across system load elements. Hot water pump operated below 70°F during occupancy periods or for facility warm up cycle. Chilled water pump operates whenever facility is occupied or, during cool down cycle. Reverse return piping systems. System differential set points varied according to supply water temperatures and outside air conditions.

G. VENTILATION

Variable frequency drive unit providing air to only the occupied classrooms and offices. Runs only during occupied period. Unit also provides supplemental cooling to interior zones anytime it operates and the outside air is below 55°F. Supply temperature drops to 40°F before heating coil is controlled to maintain that minimum temperature. For gym and auditorium air units ventilation dampers are controlled to provide supplemental cooling or maximum CO_2 levels. All ventilation is set for 5 CFM per occupant minimum.

H. AIR UNITS & FAN & COIL UNITS

Units are automatically started whenever there is occupancy in area they serve. Thermostat modulated heating and cooling valves in sequence for temperature control. Ventilation air dampers and control valves close when units are de-energized.

I. DDC CONTROL SYSTEM

Controls equipment, provides system operation information, generates historical data files for meter readings and selected system points. Water meter inputs to this system are also provided for domestic hot water (120°F), kitchen hot water (180°F), cooling tower makeup, hot water storage tank makeup, chilled water storage tank makeup and yard irrigation. This was done to provide planning information for future schools.

OPERATING CYCLES

CHILLED WATER STORAGE RECHARGE

The primary function of the chilled water storage capability is to provide cooling capability to any part of the facilities independent of the operation of the central chilled water generating plant. Each day the central control system calculates the next days cooling requirements, the stored cooling capability, and then, operates the central plant as required to provide for the difference. During operation, the plant is run at full capacity, and the time period is centered on 2 A.M. in an attempt to operate during the lowest ambient conditions.

INDIVIDUAL SPACE CONTROL

Each occupied space is equipped with air units or fan and coil units with hot and chilled water coils. Whenever occupancy is sensed the lights and HVAC equipment are energized and automatically controlled by sequencing coil valves to maintain the temperature setting. The thermal resistance of the structure prevents the unoccupied spaces from overheating or overcooling significantly during normal unused periods. Ventilation air is delivered to each individual air system at the specified full occupancy rate.

HYDRONIC VENTILATION CYCLE

The closed circuit cooling tower provides facility cooling capability by one or more of the following methods:

<u>Direct.</u> When outdoor air temperatures are low enough to provide all of the facilities cooling requirements while it is occupied, the water circulated through the closed circuit cooling tower is also circulated as required through the cooling coils.

<u>Direct With Storage Assist.</u> Anytime the water temperature leaving the closed circuit cooling tower can be maintained at a temperature less than the chilled water return temperature from the building it is used to precool it and then blend with stored water to produce the desired chilled water supply temperature.

<u>Direct Storage Recharge.</u> Whenever the facility is unoccupied and the closed circuit cooling tower can produce water as cold as that in the bottom of the storage tank the tower is operated until the storage recharge is complete.

COOL DOWN OR WARM UP CYCLES

These cycles are initiated as required in accordance with the preprogrammed occupancy of the facility. The purpose is to insure a comfortable facility for occupants after extended periods of non-usage. During this cycle each air unit or fan coil unit is started as are the hot and chilled water distribution pumps as required. When the facility reaches desired temperatures, all equipment is de-energized. Occupancy then initiates operation as required. Ventilation air is not available during this cycle.

SECURED OPERATION

Whenever the facility is secured, "cool down" cycles are automatically initiated when space temperatures rise above 85^{o}F, or "warm up" cycles are automatically initiated as required to maintain a minimum of 55^{o}F.

RESULTS AND CONCLUSIONS

The cost of the above system was no greater than that of a two pipe heating or cooling central system for a similar facility. The installed cost per ton was much greater, but the installed cooling plant capacity requirement was less than 50% of the normal requirement.

The school district is not subject to electrical demand charges at this time, so, utility cost savings are due in total to reduced utility consumption. Energy cost for this facility between June 1, 1986 and May 31, 1987 was 0.45$/ft.^{2}. What is more important is that each classroom or office could be maintained on a year round basis at the occupant's desired temperature conditions.

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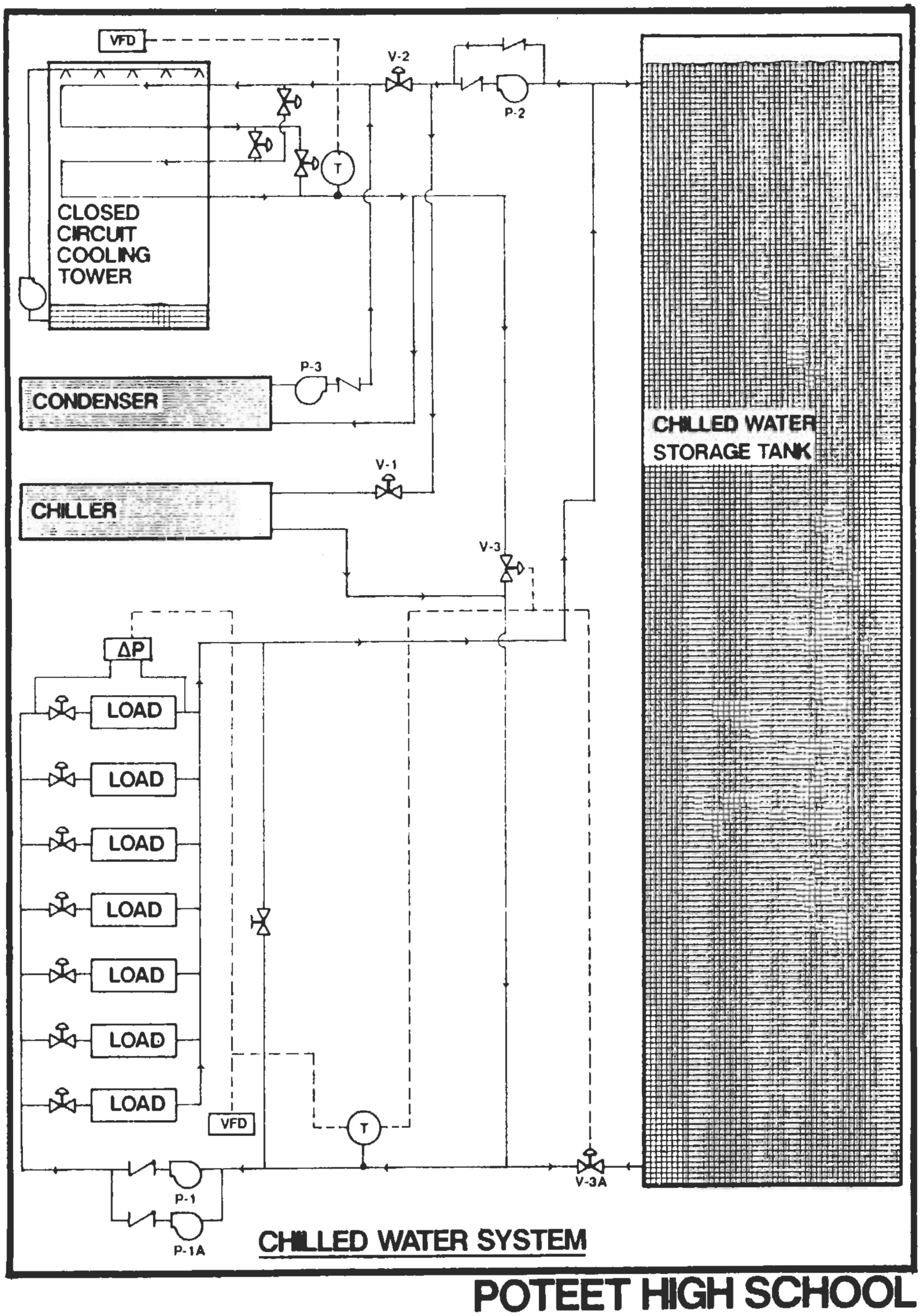
VFD
V-2
P-2
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CIRCUIT
COOLING
TOWER
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P-3
CONDENSER
CHILLED WATER
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P-1
P-1A
CHILLED WATER SYSTEM
POTEET HIGH SCHOOL

Figure 1