Arizona utility adds eutectic storage unit

Data acquisition system will monitor installation as customer demonstration

Frank Kostyun, P.E. **Douglas A. Ames**
Associate Member ASHRAE

The eutectic thermal storage system will cool the Arizona Public Service Company 120,000-square-foot Deer Valley Data Center in Phoenix. The system will reduce peak demand by 210 kilowatts.

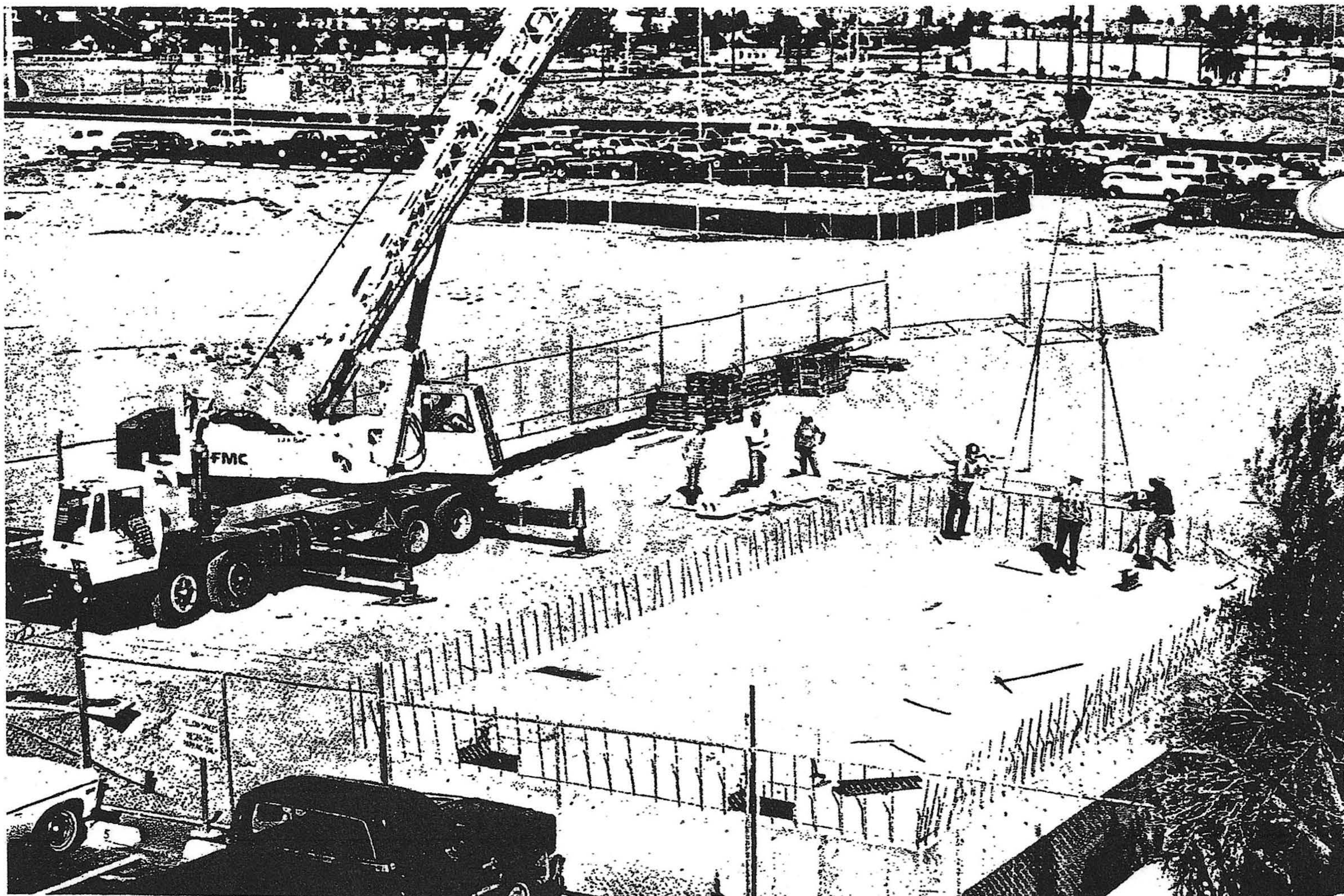
IN OCTOBER 1986, Arizona Public Service decided to install and monitor a eutectic salt storage system at its Deer Valley Data Center in Phoenix. Several large commercial customers had expressed interest in the cooling method. In keeping with the educational role of the project, a complete data acquisition system will monitor operating performance in accordance with Electric Power Research Institute (EPRI) guidelines. The company will share data with customers, other utilities and EPRI.

The eutectic salt approach combines the attractive aspects of both chilled water and ice storage systems. Eutectics provide the same storage capacity as water with one-third the tank volume and one-ninth the water.

Phase change a key

Reduced tank volume stems from the storage medium relying on a phase change, not just specific heat. With any eutectic salt, there is no need to empty tanks, diaphragms, stratified chambers or complex baffles, as is the case in chilled water systems. The tank can be above or below grade.

Eutectic storage capacity depends on the heat of fusion, not an anticipated temperature differential. Therefore, eutectics are effective in retrofit or new building applications over a wide range of air-



Prestressed concrete beams were installed to enclose the 50′ × 25′ × 8′8″ concrete tank buried in the building's parking lot.

Approximately 45,000 sealed plastic containers, each filled with 1.1 gallons of a special eutectic salt solution, were installed inside the buried concrete tank to form the heart of the latest thermal storage system installed by the utility as a demonstration project for its commercial customers.

A win/win scenario

Arizona Public Service, the state's largest utility, underscores its commitment to electrical demand management through the use of cool thermal storage. Cutting peak electrical requirements is a win/win scenario for both the company and the customer, APS notes.

APS is offering customers attractive cash incentives to shift peak air conditioning demand, and it is promoting money-saving time-of-use (TOU) rates. The incentives, $250 per kW for the first 500 kW shifted and $115 per kW above 500 kW, typically will recover up to 40 percent of the thermal storage system cost. The TOU rates can provide annual electric bill reductions of approximately 10 percent. APS is also considering a program to help businesses finance the added costs of thermal storage systems. APS benefits by reducing its need for additional power plants. The utility expects cool storage to help reduce peak electrical demand several hundred megawatts by the late 1990's.

The cost of new conventional generation ranges from $800-$2,500/kW, depending on whether the facility is peak or base load. Shifting cooling demand to off-peak uses existing base load generation more effectively and results in fuel savings of 2¢-5¢/kWh, depending on the mix of generation needed to meet system demand.

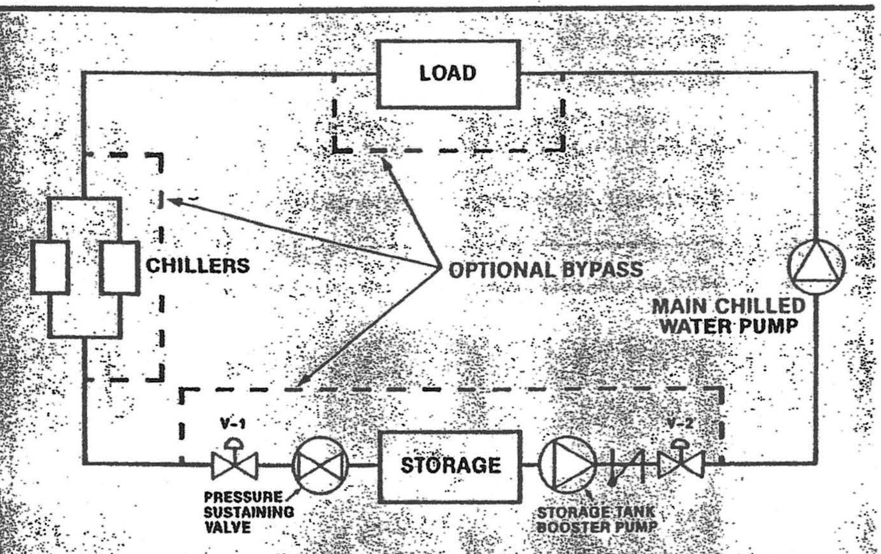


Figure 1—Full storage eutectic salt system

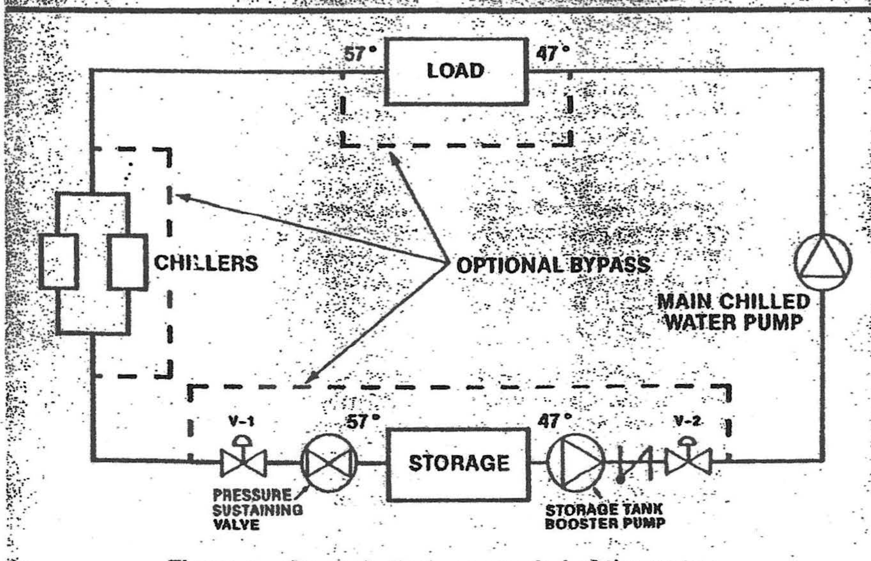


Figure 2—On-peak discharge period of the system

handling coil-design temperatures. Any standard chiller can charge a eutectic system because the salt mixture has a high freezing point, −47 F. (Ice freezes 15-20 F lower than eutectics.) Thus, there is 0.2 kW-0.3 kW per ton less electrical consumption required to freeze eutectics.

No expansion and contraction

The eutectic composition is a mixture of inorganic salts, water and nucleating and stabilizing materials. The primary salt ingredient is sodium sulfate, a common chemical found in detergents and other household products. Being inorganic, eutectics are not toxic, flammable or biodegradable. They do not expand or contract while changing between solid and liquid states, and they have a latent heat of fusion of 41 Btu per pound and a density of 92 pounds per cubic foot.

The salt mixture comes in hermetically sealed containers that have a self-stacking feature that allows water to flow between them, thus acting as a heat exchanger inside the storage tank. The containers occupy about two-thirds of the tank water volume of approximately 5.5 cubic feet per ton-hour (including internal tank piping headers).

Accelerated life cycle testing shows that the eutectic will provide a constant level of capacity in normal field use for over 10 years. With the passive inert nature of the composition, the containerization methods and the abundance of historical and scientific data accumulated on this material, APS expects the eutectic salts to outlast the chiller equipment.

Existing equipment unmodified

All existing mechanical equipment (chillers, cooling towers, chilled water and condenser water pumps) remains unmodified at the Deer Valley Data Center. This includes two 160-ton chillers (rated for 322 gpm and a 12-degree temperature differential) and one 30-hp chilled water pump (rated for 642 gpm at 110 ft).

The storage system is 1,600 ton-hours and sized to handle the building cooling load during an eight-hour window. That profile (generated for the project) shows a peak cooling load of 213 tons, based on a design dry-bulb temperature of 107 F and a design wet-bulb temperature of 71 F.

The storage tank is below grade immediately adjacent to the building. It is approximately 30 ft from the mechanical equipment room. Approximately 44,800 eutectic salt containers are inside the tank, which is approximately 50 x 24 x 8 ft plus six inches of cover. Its top has the heaviest truck traffic rating possible, H-20. Adjacent to the tank is a buried pump vault, which houses a 10-hp booster pump rated at 650 gpm at 50 ft.

Operating modes flexible

The APS system, while sized for full storage, allows flexible operating modes. This enables charging or discharging of the tank with or without a simultaneous building load.

Figure 1 shows a full storage schematic. The storage tank is in series downstream from the chiller and prior to the load. Bypasses around the load, the chiller(s) and the tank provide additional operating flexibility. A pressure sustaining valve (constant backpressure valve) is on the entrance side of the tank.

During charging, 40-42 F water flows from the chiller to the tank. Water temperature leaving the tank remains relatively flat (46-47 F) during the charging cycle. When frozen, the exiting water tank temperature drops back to 40-42 F. The temperature difference across the tank will, in most cases, correspond to the most efficient part of the centrifugal chiller performance curve.

Meeting the goals

Two important goals of energy management are reducing equipment operating time and energy consumption. Thermal storage can accomplish these,

About the authors

KOSTYUN

AMES

Frank Kostyun is administrator of alternative energy applications at Arizona Public Service, Phoenix. The eutectic system being installed is the third APS thermal storage project managed by Kostyun since he joined the utility in 1971. The system is part of the STEP (Storage of Thermal Energy for Peak) program established by the utility to encourage commercial customers to use off-peak thermal storage. Kostyun is a registered professional engineer in Arizona. He holds a BSME from Arizona State University.

Douglas A. Ames is president of Transphase Systems, Inc., Huntington Beach, California, and Tucson, Arizona. He founded Transphase Systems in 1981 to design, manufacture and install thermal storage systems. Ames was a member of the project team for the Deer Valley Data Center installation. His installation experience involves more than 30 systems. Ames holds degrees in biology and chemistry from Harvard University.

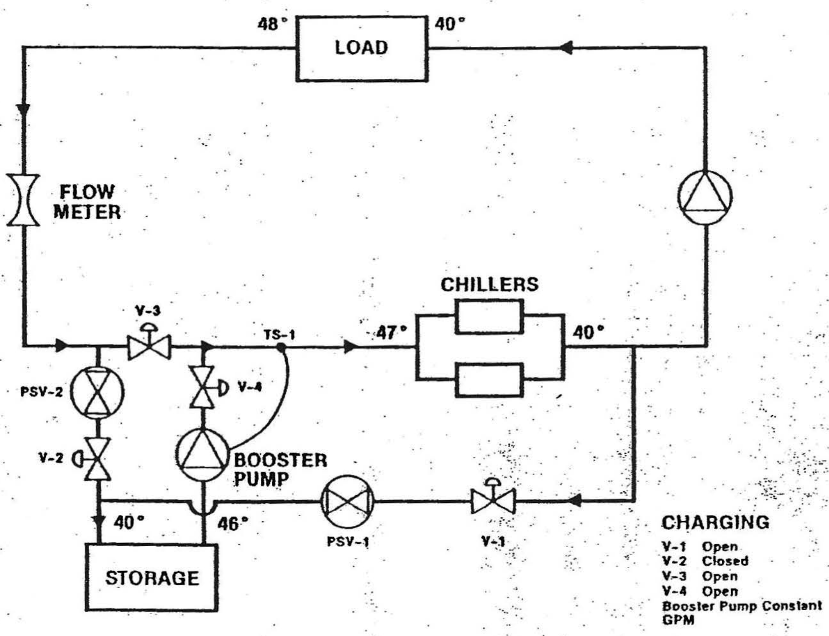


Figure 3—Pre-cooler design charging mode

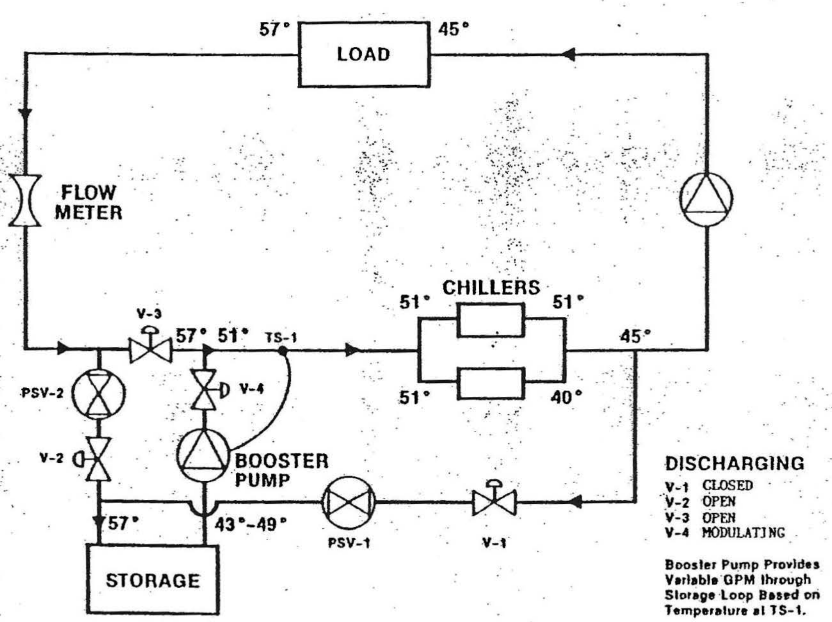


Figure 4—Pre-cooler design discharge mode

especially during winter when cooling loads are less.

Prior to the storage installation, the building air conditioning system operated 12 hours daily with a chilled-water temperature difference of only 2-3 F. With storage, the chiller plant will operate only four hours a night and supply building cooling for the entire day.

Figure 2 shows the discharging strategy, which is turning off the chiller with a time clock. During a complete discharge cycle, the water temperature leaving the tank starts at 43 F, rises and plateaus between 46 and 48 F, and, during the last hour of discharge, rises to 50 F. To achieve a constant discharge temperature, APS uses a control modulating valve on the discharge side of the tank booster pump.

The Deer Valley system includes a part storage, pre-cooler operating option. The charging mode is shown in *Figure 3* and the discharging mode in *Figure 4*. During discharge, the storage can operate in series ahead of the chiller, hence the term pre-cooler.

The design is similar to an injection-type primary/secondary pumping loop system, with the storage tank and pressure sustaining valve forming the secondary loop. This self-balancing, dynamic control is very successful and is much simpler than balancing the water flow with three-way valve systems.

In such systems, chiller and storage share the load during the on-peak period. The advantage over full storage is that it allows for greater chiller displacement in new or retrofit applications. Part storage may provide more cost savings per unit of storage investment and, in some applications, be used as full storage during winter months.

In the pre-cooler mode, it is necessary to limit the rate of discharge from the storage tank. Discharge rate is controlled using a temperature sensor (*Figure 4 - TS-1*) that controls a modulating valve on the discharge side of the booster pump. As the water temperature rises above the setpoint, the modulating valve opens, increasing the water flow rate through the storage tank and decreasing the amount of water bypassing the tank.

The valve also enables a two-chiller plant to operate more efficiently by keeping one chiller off-line while fully loading the second unit.

The pre-cooler design provides a wide variety of storage strategies including chiller priority, storage priority or constant priority.

Acknowledgment

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