HONORABLE MENTION: INSTITUTIONAL BUILDINGS, NEW

The water to cool the Emergency Services Training Center is not consumed and is returned to the aquifer.

AQUIFER FOR COOLING

By **Tony Costa, P.E.,** Life Member ASHRAE

The new Emergency Services Training Center at the College of the Siskiyous takes advantage of resources on its site to provide cooling using water from an existing irrigation system. The Center is at the base of Mount Shasta in the Siskiyous mountain range of Northern California in the town of Weed. Due to the large quantity of water contained within the Mount Shasta aquifer, College of the Siskiyous irrigates the campus turf and planting areas with on-site wells that deliver clean water at a constant temperature of 51°F (10.6°C).

Cooling System

The 1% ASHRAE design criteria (summer) for Weed, Calif., is 92°F (33.3°C) dry bulb and 63°F (17.2°C) wet bulb (relative humidity of 20.4%). The combination of displacement ventilation, dry ambient air, and an unlimited source of 51°F (10.6°C) water form the basis for the cooling system design.

Water obtained from the existing irrigation system is pumped through a plate-frame heat exchanger where it exchanges heat with the building closed-loop water cooling system. After exchanging heat,

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the diverted irrigation water is piped to a reinjection well, where it is returned to the aquifer (*Figure 1*).

Air System

The air system consists of a central station variable air volume (VAV) air handler, delivering constant 63°F (17.2°C) air to displacement diffusers located throughout the building. Zone control is maintained by pressure-independent VAV boxes. Fan speed is maintained by variable frequency drives responding directly to VAV damper position.

Displacement ventilation is efficient and results in high indoor air quality. Air is delivered to the space at a higher temperature than conventional mixing systems, thereby requiring less cooling. This is because the air only needs cooling to 63°F (17°C) rather than 55°F (13°C), thereby requiring less cooling capacity. It displaces warm air and contaminants, increasing indoor air quality in the occupied zone.

Additionally, the high portion of outdoor air (88%) and the use of active field-polarized filtration increase the indoor air quality significantly over a standard code-compliant air system. The filters are rated at ASHRAE MERV 11, with a low average pressure drop of approximately 0.375 in. w.c. (93.3 Pa).

Temperature controls are provided by state-of-the-art direct digital controls system, which is connected via the internet to the campus-wide infrastructure.

Heating System

ASHRAE winter design temperature for Weed is 4°F (–15.6°C). The heating system is radiant. Hot water is piped from a condensing boiler (92% thermal efficiency) to a pre-heat coil in the air handler and to several zone water manifolds. Hot water heats the floor slab through serpentine cross-linked HDPE piping. Hot water supply temperature never exceeds 120°F (48.9°C), and return water is designed for 90°F (32.2°C) or lower to ensure maximum boiler efficiency. Additionally, the radiant heating system is used to melt snow on the sidewalks and approaches to the building.

Energy Efficiency

The building's thermal performance and annual energy use were simulated using a commercially available computer modeling program. The program is certified by the California Energy Commission for use in showing compliance with California Title 24 Energy Standards. The software uses the DOE-2 engine. Results show that the building's overall proposed annual energy use exceeds the requirements of California Title 24 and ASHRAE/IESNA Standard 90.1-2007 by 34%.

The cooling and heating systems simulation show that both systems substantially exceed minimum standards. The cooling system energy use is estimated to be 0.07 kBtu/ft^2·yr (794 957 kJ/(m^2·yr) and the heating system energy use is estimated to be 2.0 kBtu/ft^2·yr (22 713 053 kJ/(m^2· yr).

The cooling system uses less than 1% of the energy allowed by the standard design and the radiant heating system uses a little more than 10% of the energy allowed by the standard design. The energy efficiency ratio (EER) Btu/h·W input for the cooling system is approximately 94. When fan energy is included, the overall EER is 21.6.

Indoor Air Quality

Minimum ventilation requirements per ASHRAE Standard 62.1, ASHRAE Standard 55, and the California Building Code were calculated to be 2,400 cfm (4,078 m^3/h).

With VAV systems, it is difficult to determine if a particular zone is getting the minimum code ventilation rate, even if ventilation air is being measured at the air handler. This difficulty is eliminated when using high outdoor air fraction and the minimum position of all VAV boxes exceeds the minimum ventilation rate. At minimum airflow (all VAV boxes at 40% capacity), the ventilation rate (with 88% minimum outdoor air quantity) is: 8,000 cfm × 0.40 × 0.88 = 2,816 cfm, which exceeds the calculated minimum rate of 2,400 cfm (4,078 m^3/h).

Using displacement ventilation systems all but eliminates drafts, and "displaces" warm air and contaminants up and away from occupants, where it is then exhausted from the building.

Using MERV 11 air filtration exceeds minimum requirements. The air handler is equipped with active field-polarized filters, attaining MERV 11 without the typical high pressure drop associated with bag or rigid filters.

Innovation

The cooling system uses water whose infrastructure exists for an entirely different purpose (irrigation). Using displacement ventilation with its relatively high delivery temperature makes it possible to fully cool the building without supplemental mechanical cooling. The low ambient moisture content and large

Building at a Glance

Name: Emergency Services Training Center

Location: College of the Siskiyous, Weed, Calif.

Owner: Siskiyous Joint Community College District

Principal Use: Classrooms

Includes: Faculty offices

Employees/Occupants: 220

Gross Square Footage: 9,885

Conditioned Space: 8,073

Substantial Completion/Occupancy: 2009

Occupancy: 100%

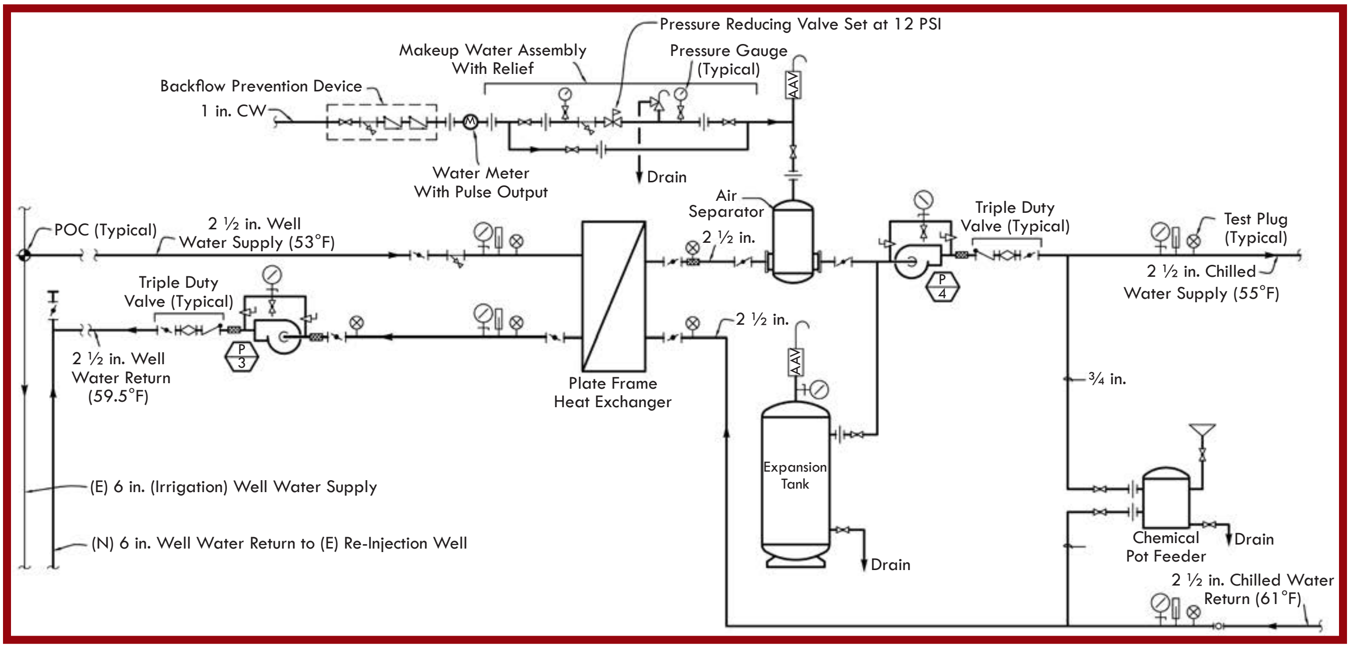

Figure 1: Chilled water piping diagram.

outdoor air fraction preclude the need for dehumidification.

Operation and Maintenance

The mechanical systems require less operation and maintenance costs than any other academic building on campus due to the lack of refrigeration machinery. The maintenance of the systems is straightforward and well within the capabilities of the maintenance staff.

The plate frame heat exchanger has no moving parts and is protected by a 100 mesh strainer. The water source is extremely clean, clear, and colorless. Suspended solids are about 300 ppm and are not likely to precipitate in the heat exchanger due to the low heat exchange temperature. Should the plates become fouled, it is a simple process to disassemble, clean, and reassemble them.

Cost Effectiveness

The mechanical systems will pay for themselves well within the life of the building. The cooling system doesn't use refrigeration machinery, and the boiler uses state-of-the-art condensing technology, with a 25 to 30 year design life. Agglomeration filtration (active field-polarization) provides clean air (MERV 11) without the typical pressure drop associated with bag or rigid filters of the same rating. The average pressure drop is less than half of that associated with conventional filtration, resulting in reduced fan horsepower.

The titanium plate frame heat exchanger takes the place of a nominal 20 ton (70 kW) chiller at a significant savings in first cost. The net savings, when taking into account space, foundation, power, and enclosure, is estimated to be $35,000, and enough to pay for the high-efficiency, condensing boiler. Ongoing fuel costs for cooling energy are significantly less than an ASHRAE Standard 90.1 compliant chiller with two 1.5 hp (1.1 kW) pumps, compared to a 24 kW air-cooled chiller plus a 1.5 hp (1.1 kW) pump at full load.

Training center lobby has displacement ventilation.

Environmental Impact

The environment impact is minimal. The water used to cool the building is not consumed and is returned to the aquifer from which it was obtained. Using water as the refrigerant in lieu of halogenated hydrocarbons has a positive environmental impact as ozone depletion and global warming potential are zero. The boiler has a low carbon footprint as it puts 92 (97 000 J) out of every 100 (105 435 J) Btus burned directly into the heating system.

Conclusion

Well water can be an effective cooling medium in arid and semi-arid climates if coupled with displacement ventilation and high outdoor air quantities. This building has performed well, and there have been no temperature or humidity-related complaints since the completion of the third-party LEED commissioning.

Bibliography

Chen, Q. and L.R. Glicksman. 2003. *System Performance Evaluation and Design Guidelines for Displacement Ventilation.* Atlanta: ASHRAE.