BEST PRACTICES 2008

University of California, San Diego Chilled Water Valve Upgrades

UC San Diego upgraded the air handling units of 17 buildings with pressure-independent control valves to better regulate the flow of chilled water through the cooling coils. The retrofit greatly improves the efficiency of the campus chilled water loop during part-load conditions, saving 7,375,000 kWh annually.

Award Category

HVAC Retrofit

System Features

Increases temperature rise in campus chilled water loop

Enables chillers to be loaded to full capacity, increasing deployment of installed tonnage

Improves chiller performance during part-load conditions

Reduces pumping energy required during part-load conditions

Annual Energy Savings

7,375,000 kWh

$650,000

Scope

75 valves retrofitted in 17 buildings on the campus chilled water loop

Cost

$975,000

Completion Date

November 2008

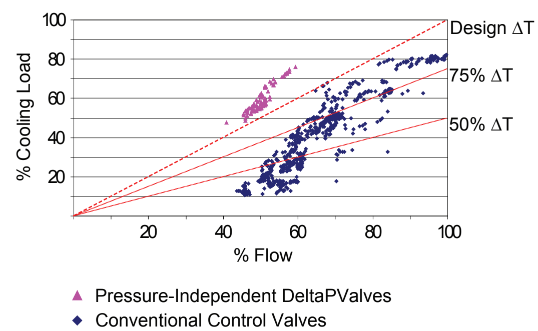
Like many large universities, UC San Diego uses a centralized chilled water loop to provide its facilities with space conditioning. The campus increased the efficiency of this system by installing pressure-independent control valves on the air handling coils of seventeen buildings. The valves bring the temperature rise in the loop closer to design conditions, enabling the campus to fully load chillers during part-load conditions.

Nearly all chilled water distribution systems have difficulty maintaining design temperature rise at part load, a problem known as "low delta-T syndrome." Delta-T refers to the temperature difference between supply water leaving the central plant and return water coming back from buildings. Low delta-T is a pervasive problem because chillers are designed to operate at peak load when delta-T is large. However, design conditions only occur for a small percentage of total operational hours every year. Outside of these limited hours, chilled water systems experience significant efficiency losses because chillers must run outside their optimal operating range and additional partially-loaded chillers must be brought online to meet the load.

The operating efficiency of a chiller can drop 30 to 40 percent when return chilled water temperature is lower than design.

While there are several potential causes of low delta-T syndrome, the problem can often be attributed to the failure of cooling coils to optimize heat exchange during low load conditions. UC San Diego found this was the case by analyzing the delta-T for several buildings. Newer facilities equipped with pressure-independent control valves were producing 20°F temperature splits under all operating conditions. This was much larger than the delta-T achieved by older buildings using two-way control valves. The difference was due to the ability of the pressure-independent valves to optimize heat transfer by precisely regulating the flow rate of chilled water through the cooling coil.

The flow of chilled water in a centralized distribution loop is constantly changing as buildings experience different loads throughout the day. Control valves respond to shifting load demands by adjusting the amount of chilled supply water entering the air handling coils to cool supply air. When flow changes, so does the heat transfer rate in the cooling coil. As flow increases it becomes more difficult for the cooling coil to exchange enough heat between outside air and water, which results in a lower delta-T.



***University of Washington Delta-T**: Empirical data shows pressure-independent control valves achieve below-design flow rates even at low loads. Image: Flow Control Industries.*

Anytime that valves in a chilled water loop open or close the change in flow creates a change in pressure. Since system pressure and flow are inversely related, pressure drops when a valve opens to increase flow. Conventional control valves are pressure-dependent and this drop in pressure causes the valve to open even further, which results in excess flow and another drop in pressure, creating a cycle that exacerbates the problem of low delta-T.

To improve this situation UC San Diego has a control strategy in place to limit pressure fluc-

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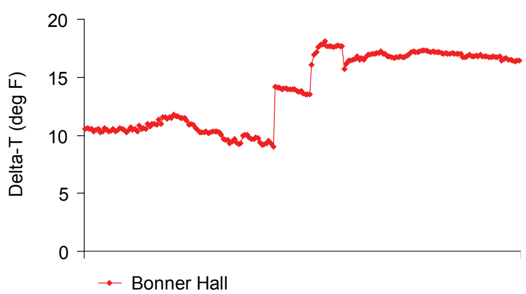
tuations in the loop. The university measures system pressure and responds to drops by speeding chilled water pumps. This improves the performance of the campus's conventional control valves by creating the pressure conditions under which they were designed to operate. The incremental energy used to speed pumps is optimized by the variable speed drives installed on all central plant pumps.

While maintaining constant pressure in the loop was improving valve performance, UC San Diego still had significant problems stemming from low delta-T during low loads. Excess flow remained an issue because conventional valve design precludes the device from controlling flow at low loads. Instead it acts like an on/off valve, permitting much more flow than necessary to satisfy the load. With high flow rates through the coil, return water was not reaching design temperatures and the problem of low delta-T syndrome persisted.



Typical control valve retrofit*: The delta-T for Bonner Hall increases significantly when its existing chilled water control valves are retrofitted with DeltaP-Valves. Image: John Dilliott.*

To get more control at the cooling coil and resolve its trouble with low delta-T, UC San Diego retrofitted seventeen older buildings on the campus chilled water loop with pressure-independent control valves. Manufactured by Flow Control Industries, DeltaPValves optimize the flow rate through the coil and increase heat gain above conventional valves, regardless of pressure changes.

The university has taken additional measures to control valve operation and guarantee high delta-T. Temperature sensors are installed in the return water line at each retrofitted building to provide another mechanism for managing flow. When the return water temperature falls short of design the valve is prevented from opening further, lowering the flow of supply water through the coil and improving heat exchange. Temperature sensors are now installed in all new construction projects as part of UC San Diego's design standards.

Pressure-independent control valves optimize heat transfer at the cooling coil by matching chilled water flow to the load regardless of pressure fluctuations.

The university has seen chilled water return temperatures rise about seven degrees for buildings retrofitted with delta-p control valves. Calculations completed by the campus found that the optimized temperature split will generate 7,375,000 kWh and $650,000 in savings annually due to improved chiller performance and reduced pumping energy. With low delta-T syndrome being an insidious problem for nearly all chilled water loops, the retrofit undertaken at UC San Diego is highly relevant to campuses throughout the UC and CSU systems facing a similar challenge.

LESSONS LEARNED

John Dilliott, Energy and Utilities Manager for UC San Diego, advises that installing pressure-independent control valves is not a silver bullet solution. It is important for a campus to "look at its distribution loop as a whole system, not just a valve and a coil," when engineering solutions for low delta-T. Mr. Dilliott also notes that the size of an existing conventional control valve is not always the right size for a pressure-independent valve, and campuses should look to each building's cooling load demands to size valves correctly.

Best Practices is written and produced by the Green Building Research Center, at the University of California, Berkeley.

The Best Practices Competition showcases successful projects on UC and CSU campuses to assist campuses in achieving energy efficiency and sustainability goals. Funding for *Best Practices* is provided by the UC/CSU/IOU Energy Efficiency Partnership.