2010

Retro-Commissioning Report

Retro-Commissioning

Retro-Commissioning is the process for identifying intrinsic operational and energy related issues in the facilities DDC system and providing a mechanism for repairing/ replacing and tuning up system control and sequencing modifications. The retro-commissioning process "digs in" to facility control systems and identifies operational nuisances that impact energy performance. The complexity of the control sequences and interactive impacts on energy that may not have been anticipated during the original design or periodic changes over time can impact system operations.

Proper integration helps assure system devices work properly and in concert with efficient sequence of operations. Through a customized retro-Commissioning process for our clients, CST can identify operational nuisances, document how operational problems are affecting energy performance and affecting O&M problems. CST has the capacity to manage the implementation and verification process along with ongoing commissioning verification.

The following recommendations are based on observations of the existing methods of control for projects performed by Critical Systems Testing.

RCx #1. **Maximize Economizer Operations**

Current Conditions: A large data center located outside Washington D.C. has a central plant with air cooled chillers and an airside economization system. The economization system was sequenced with four criteria to execute the economizer. Those conditions are as follow:

Outside air drybulb is less than 65°F.

Outside air enthalpy is less than 23 Btu/lb.

Outside air temperature drybulb is less than the average of the return air drybulb temperatures.

Outside air enthalpy is less than the average of the return air drybulb enthalpy.

The current approximate hours of economization in Washington D.C. at a 65°F limit on outside air temperature to allow economization is **5,568** hours. Based on direct comparison between outside air enthalpy and return air enthalpy the projection is **6,144** hours of economization. Furthermore, the approximate hours of economization for Washington D.C. at a 70°F on outside air temperature limit and a 28 Btu/lb outside air enthalpy limit to allow economization is 6,312 hours.

Proposed Modifications: Raise the outside air economization temperature limit to 70°F and the outside air enthalpy limit to 28 Btu/lb. As long as the outside air enthalpy is less than the return air enthalpy the cooling load on the chilled water coils will be minimized. Conditions may not be present for 100% economization, but the chilled water cooling load will be minimized and chillers will be able to be staged down.

By making the adjustments to setpoints recommended, this facility can realize an approximate additional 576 hours (**6144** hours – **5568** hour) of outside air economization. Although the facility will not be in full economization, chiller loads will be mitigated and reductions in energy evident. For each fully loaded chiller at 300 tons and an operational efficiency of 0.80 kW/ton, the potential annual savings are in the order of 276,500 kWh and $180,000. For each additional 300-ton facility load level the potential for energy savings increases. At 100% loading in this facility the projected annual savings would be 2,765,000 kWh and $1.8 million in annual cost savings. These savings are available by simply changing an existing operating parameter in the SCADA system.

RCx #2. Provide dewpoint control on chilled water temperature and humidification

Current Conditions: A large data center located outside Washington D.C. has a central plant with air cooled chillers and an airside economization system. The Colocation space operates with a 74°F space temperature, space humidity of approximately 50% RH and a corresponding dewpoint temperature at these operating conditions is 55°F. Any coil surface that is at a temperature lower than the space air's dewpoint will dehumidify the process airflow resulting in unnecessary latent cooling and impacting humidity control of the space.

Despite variations in relative humidity at these various locations, the psychometric process through the servers and PDUs is an exclusively sensible process air. Figure 1 demonstrates a typical profile observed during the IST Capacitance Test showing that as temperatures generally increase across the temperature distribution and relative humidity generally decreases, the Dewpoint temperature distribution remains relatively constant.

The central chilled water plant supply water temperature is currently controlled to a 45°F set point with a 57°F return water temperature. The economizer sequence is controlled based on return air enthalpy with the air handling unit(s) relative humidity being the basis for the enthalpy calculation on return air. The humidifier control is based on maintaining the relative humidity as measured at the floor level of the data center. The challenge for this client is sensor location since the relative humidity sensor location is not fixed and operations has the flexibility of locating the sensor within the region of the discharge air with cooler air and greater humidity or in the hot aisle region with warmer air and reduced relative humidity content.

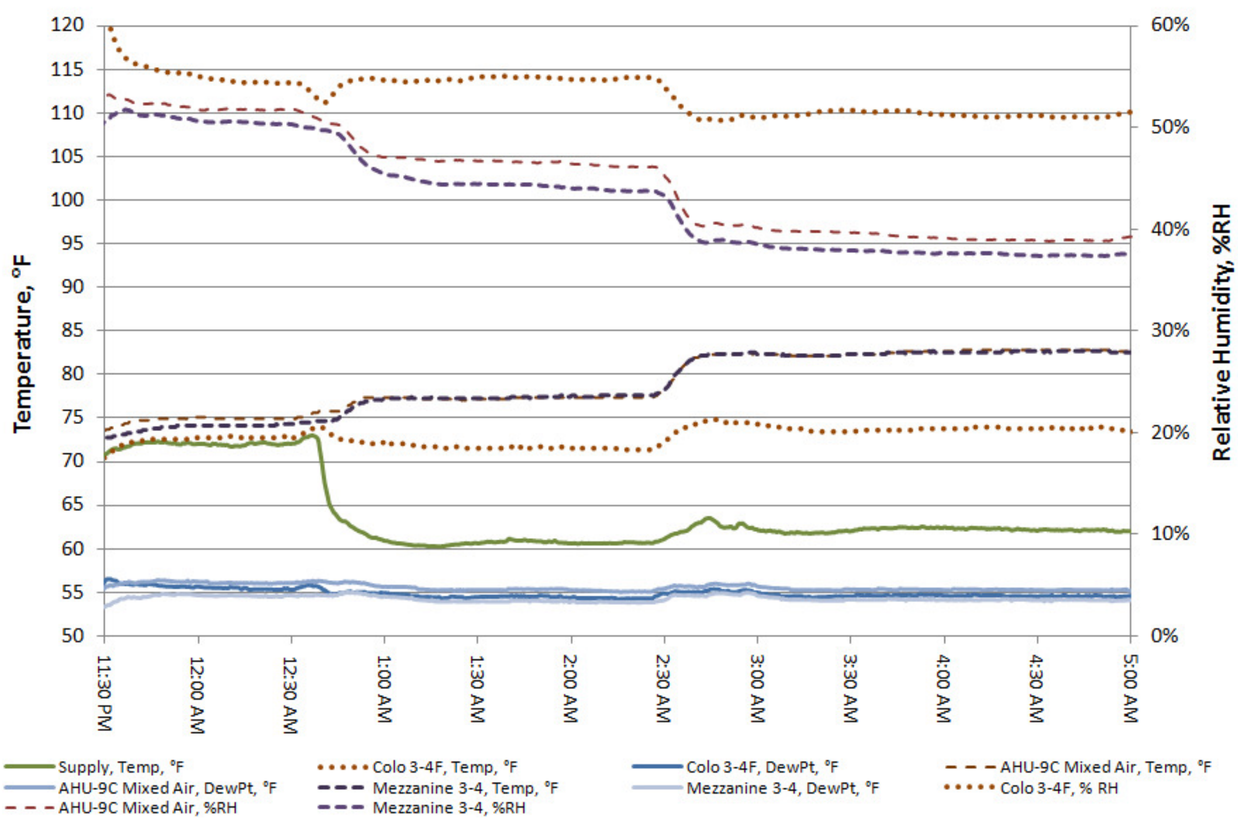

Figure 1 Drybulb temperature, relative humidity and dewpoint temperature profile

Using a fixed relative humidity setpoint with varying sensing locations has the potential to unnecessarily operate humidification equipment introducing a latent load into the data center and ultimately onto the central plant.

Proposed Modification: This project proposed modifying the method of control for chilled water temperature and humidification. The proposal for this project was to control all processes (economization, humidification and chilled water temperature) through a common process variable monitoring location; return air dewpoint for chilled water and humidification, enthalpy for economization. Using existing instrumentation the SCADA system would calculate return air dewpoint temperature at all of the facilities air handling units. Control the chillers according to the following reset function with all values operator adjustable.

Dewpoint Temperature	Chilled Water Setpoint
58°F	45°F
50°F	55°F

By raising the chilled water set point from the central plant chillers, energy savings will result in the reduction of latent loads that remove moisture, improve chiller energy through more efficient operation and reduce humidification requirements. Applied in concert with the chilled water reset, the first level of humidification control would be resetting the chilled water temperature upward toward a non-condensing setpoint. If dewpoint temperatures continue to fall below the low level condition of 50°F toward a minimum acceptable then humidification would be enabled to raise the dewpoint levels toward setpoint. The objective of using dewpoint control for both chilled water temperature control and humidification control is to maintain a primarily sensible cooling range of control and to avoid unnecessary latent cooling and humidification energy. Figure 2 provide a psychometric depiction of this control strategy.

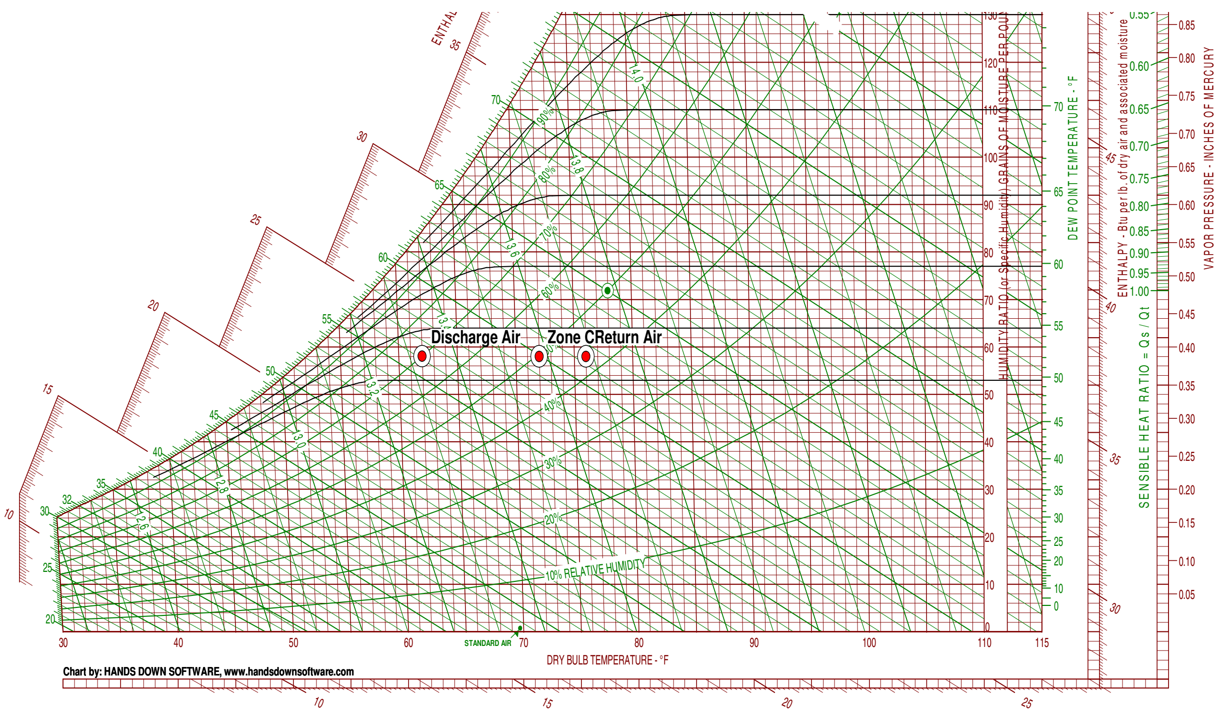

Figure 2 Psychometrics of chilled water reset

RCx #3. Modify Air Handler Staging

Current Conditions: A large data center in Los Angeles, CA provides air delivery to the data center and electrical room through an overhead air distribution system and branch damper control to each aisle. The branch damper control is based on aisle temperature floor located temperature sensors temperature setpoint. The branch damper positions among 20 branch dampers provide the primary driver for static pressure and supply air control. As the branch dampers modulate to a more open position to maintain an aisle or zone temperature setpoint the air flow requirements through the air handling units invariably increase. In addition, the air handling units supply air temperature setpoint is decreased when a single branch damper is greater than the current 95% position placing additional load on the central plant pumping and chiller loading. Similar to the consideration for relative humidity sensing for humidification control, zone temperature sensor location is of utmost consideration for optimizing energy efficiency. Locating a single zone temperature sensor in a hot spot has the potential of driving the supply air temperature setpoint for all of the air handling units to the minimum temperature setpoint and increasing central plant loading.

Proposed Modification: A more efficient method of control would be to modify stage up parameters to bring additional AHUs on at a lower average VFD speed of 75%. The current sequence of control stages air handling units based on the total measured airflow through airflow stations mounted on the air handling unit and the available capacity of the online air handling units. The demand management module for the air handling units currently stages on an additional handling unit when the deviation between the measured air flow and capacity airflow is zero cfm. By adjusting the Minimum Deviation on the stage up sequence from zero cfm to 20,000 cfm, additional AHUs will turn on when the average VFD speed on the AHUs is 75%. By making this staging adjustment, the control system will stage up more air handlers faster to allow more AHUs to operate at a lower speed where fan energy usage will be more efficient. Figure 3 demonstrates that the performance characteristics provide a more efficient level of energy performance at lower speeds than at higher speeds.

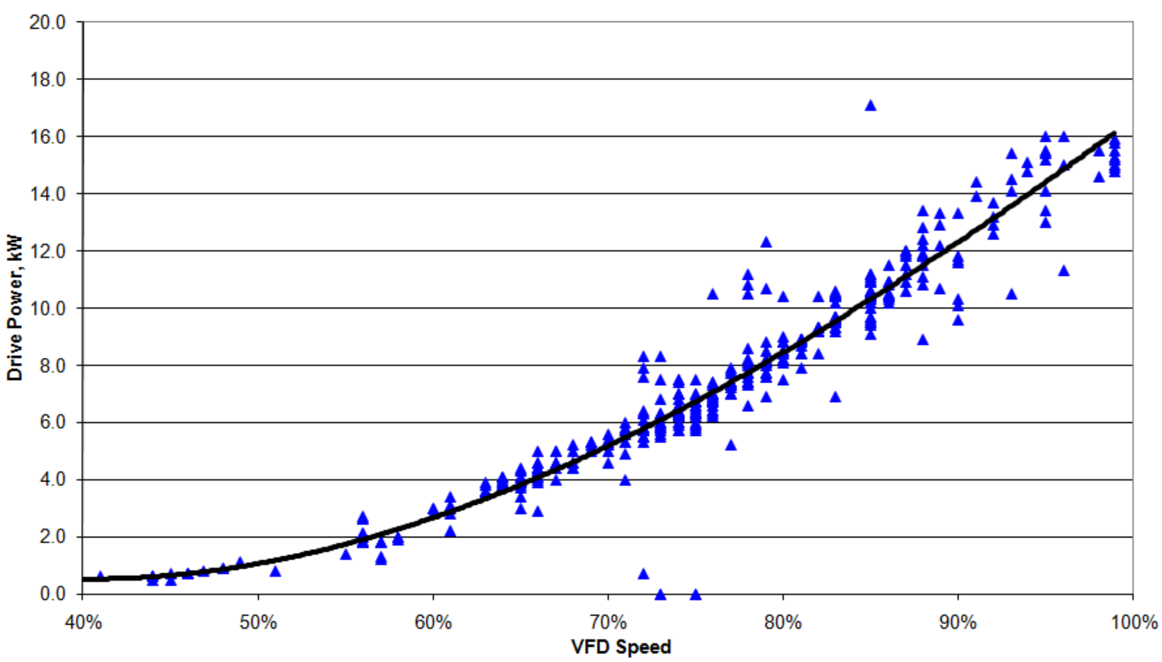

Figure 3 Air handler system performance curve

RCx #4. Modify Chiller Staging

Current Condition: A large data center located outside New York City has a central plant with water cooled chillers and a waterside economization system. The system design consisted of five 500-ton centrifugal chillers with variable speed drives and sequence of control that provide for partial free cooling and full free cooling based on varying levels of outside air wetbulb temperature. The original equipment schedule for the Trane chillers is without variable speed drives. The part load efficiency data for the non-VFD models indicates the highest efficiency rating at 100% load. Given those models it would be preferable to maintain chiller operations with any given chiller operating at peak load.

Proposed Modification: Operating centrifugal chillers with VFDs provides a different efficiency profile in which the most efficient mode of operation is typically between 30%-60% load. In this operating range, these chillers have the potential to operate in the range of 0.25 to 0.40 kW/ton year round, depending on entering condenser water temperature. The efficiency curve of these chillers with VFDs provides the facility with some opportunity to take advantage of improve operational efficiencies and PUE reductions.

During a retro-commissioning investigation the system was set to operating with a system load of 900-tons. The system was set to operate in partial free cooling in the as designed sequence of operations with a single chiller fully loaded to approximately 500 tons with 225 kW of compressor power operating at efficiency level of 0.45 kW/ton. The heat exchanger controlled to maintain the additional 400 tons of plate cooling load. During another testing of partial free cooling a second chiller was staged online and both chillers were allowed to operate at a part load of 250-tons per chiller with 56 kW of compressor power per chiller and combined chiller load of 112 kW at an efficiency level of 0.225 kW/ton. The empirical results were further applied to 100% mechanical cooling operations and resulted in modified staging parameters intent on operating multiple chillers at part load.

An additional benefit of this mode of control is enhanced reliability in maintaining a mode of "running redundancy". In a mode of "running redundancy" as equipment is taken down due to operator or fault, the remaining equipment would have the additional capacity to accommodate the current operating load.

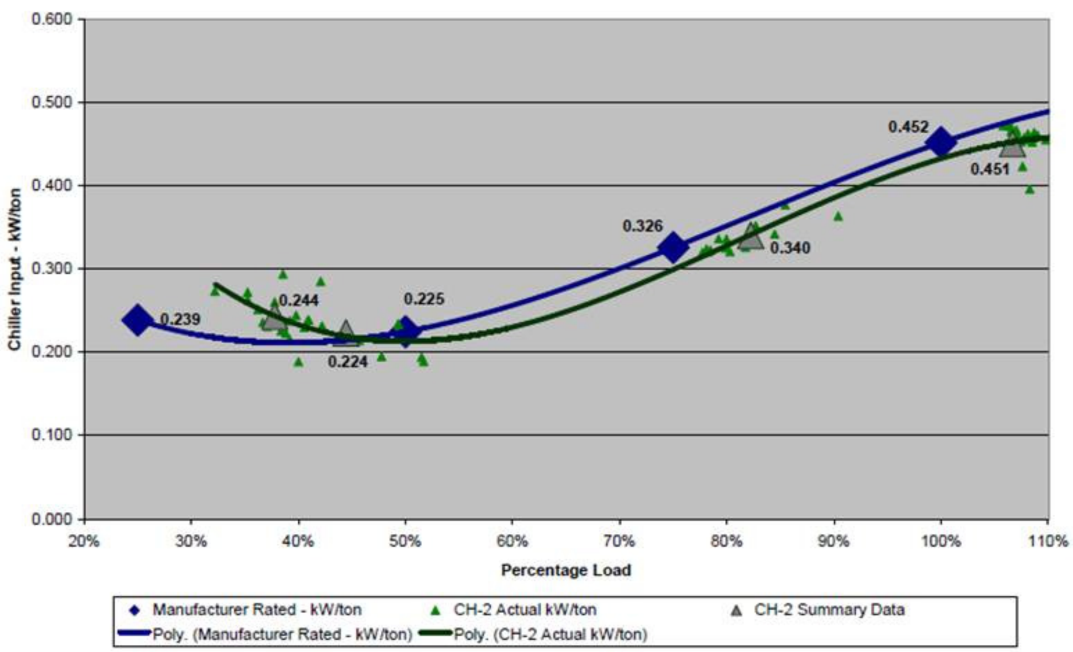

Figure 4 Chiller part load performance characteristic with variable speed control

RCx #5. Chilled Water Pumping

The nature of the performance of the pumps shown in the pump curve shown below provides negligible pumping head below 78% VFD speed with a marginal difference of 10 ft. head (4.3 psi) from full flow to no flow.

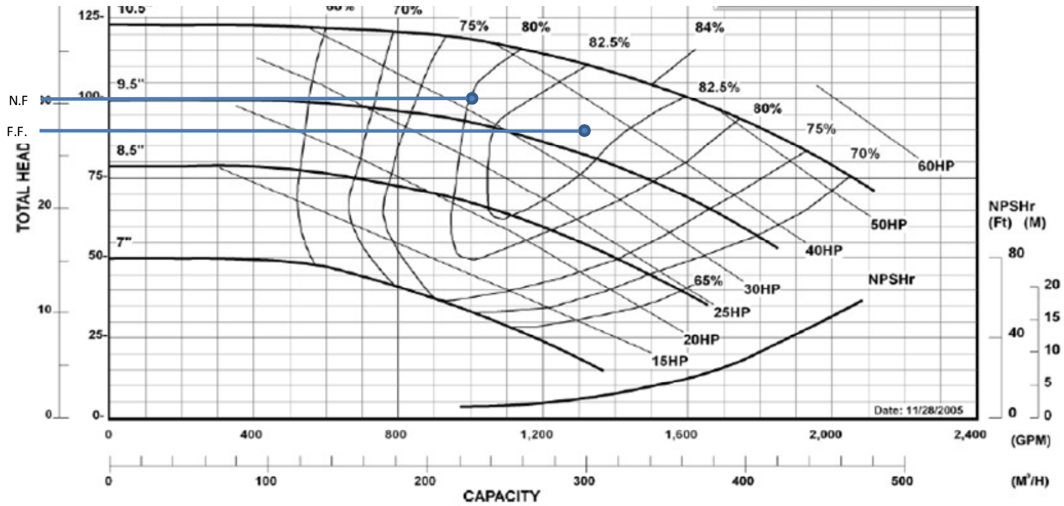

Figure 5 Pump curve

Multiple operational configurations of pumps, AHU chilled water valves and chillers operational were analyzed. Power usage characteristics at 40% load, 2400 GPM scenario is shown below. The M&V data shows that pump speed did not have any impact on system pressurization below 78% VFD speed. At 78% VFD speed and five pumps operational pumping is less efficient and the differential across the pump starts to fall off. At and above 78% VFD speed the impact to pressurization and functionality of the chilled water differential PID control was distinct. The development of the pumping power characteristic curve helped to provide clear direction for the final pumping staging sequence for the most efficient use of pumping energy.

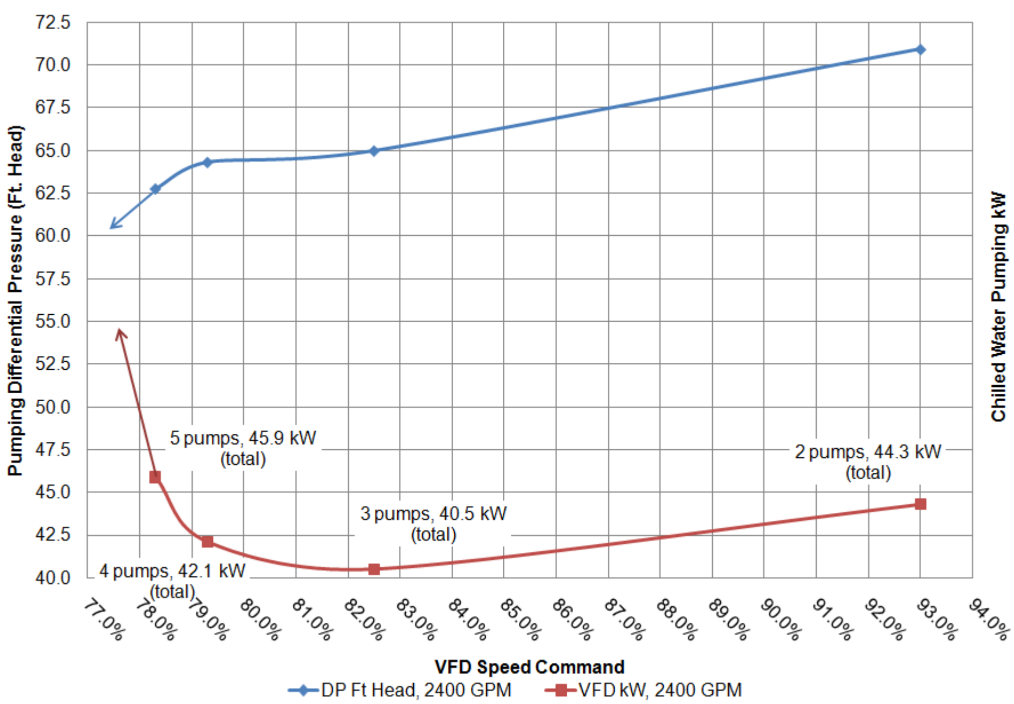

Figure 6 Pumping characteristic curve