

Using EMS To Aid In Commissioning Central Plants & Complex HVAC Systems

Presented to

Orange Empire ASHRAE Chapter

Presented by

Verle A. Williams, P.E., CEM, CPMP, CSDP, FASHRAE
Life Member & Distinguished Lecturer
Escondido, California

September 27, 2011

Commissioning-What Is It?

- Project commissioning, the process of assuring that all systems and components of a building or industrial plant are designed, installed, tested, operated, and maintained according to the operational requirements of the owner or final client
- Building commissioning, a quality assurance process during and following building construction

Complex

- ◆ What is complex for one is simple for another
- ◆ A wise consultant converts what some feel is a series of “complex” systems to “simple” systems by conducting a great training program – with fantastic effectiveness

Sustainability

- ◆ **Sustainability** is the capacity to endure.
 - HVAC endurance “through it all”
 - Efficiency for long life
 - Endure through the operational issues

Central Plant Information

- ◆ Primary-Secondary with VFDs on Secondary Pumps
- ◆ Variable Primary with VFDs on all Pumps
- ◆ Combination Heating-Cooling Plant
- ◆ Central Chiller Plant and In-Building Heating Plant

Variable CHW Flow?

- ◆ Should vary CHW flow for efficiency
- ◆ No reason to keep constant CHW flow through chillers today
- ◆ From Chiller Manufacturer, get minimum CHW and CW flows – and program for it
- ◆ Incorporate proper controls to make operation as efficient as possible

Primary-Secondary System

- ◆ Many of these systems in existence
- ◆ Efficient operation requires good control
- ◆ Operate “just enough” chillers/boilers to satisfy the load
- ◆ Primary pumps - Variable or constant speed, to match flow and generation
- ◆ Secondary pumps – Variable speed to just match the flow/pressure needed

Variable Primary CHW System

- ◆ Requires effective controls
- ◆ System bypass valve to recirc CHWS to CHWR
 - to maintain minimum CHW flow through chiller
 - to mix CHWS into CHWR to maintain desired CHWS temperature

Combination Heating-Cooling Central Plant – 4 Pipe

- ◆ Separate control of each system
- ◆ Minimize operating pressure to maximize energy efficiency
- ◆ Maximize DT to minimize Flow
 - new or existing controls
- ◆ Watch TOTAL energy consumption
 - both plants

Central Plant Chillers & Building Boiler Systems

- ◆ Flexibility of energy sources
- ◆ Reduces major heat loss through distribution systems
- ◆ Permits operating only boilers within buildings that need heat
- ◆ Proper control system can easily control the systems as needed – temperatures and on-off scheduling

Combination Cooling-TES Plant

- ◆ Proper control and system operation critical to achieve maximum benefits
- ◆ Control systems by time of day and/or load
- ◆ Partial storage, peak shaving, capacity enhancement, or reducing maximum cooling electrical load

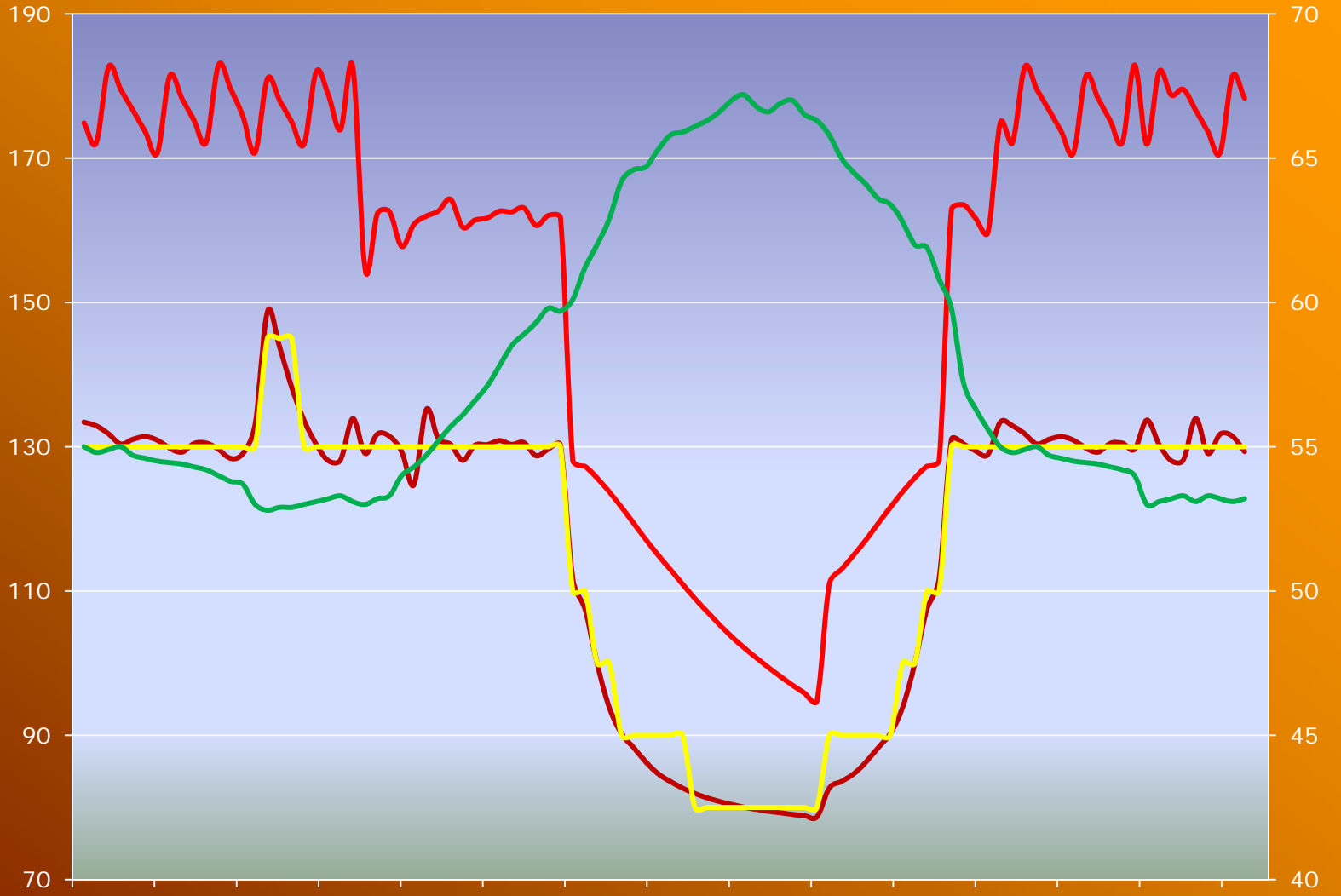
What can we do with controls?

- ◆ ANYTHING YOU WANT TO DO AND CAN AFFORD TO BUY!
- ◆ Remote access for “watch dogging”
- ◆ Essentially operator free - or operator dependent
- ◆ With proper setup, can make a sick system purr like a kitten!
- ◆ Improperly selected, installed, or operated, they can be miserable!

One Simple Example

- ◆ Resetting HWST Setpoint based on Outside Air Temp Reduces Boiler Cycling, when less than full load is required. Performance can be smooth or erratic.

Hot Water Supply Temp Boiler Temp HWS Setpoint Outside Air Temp

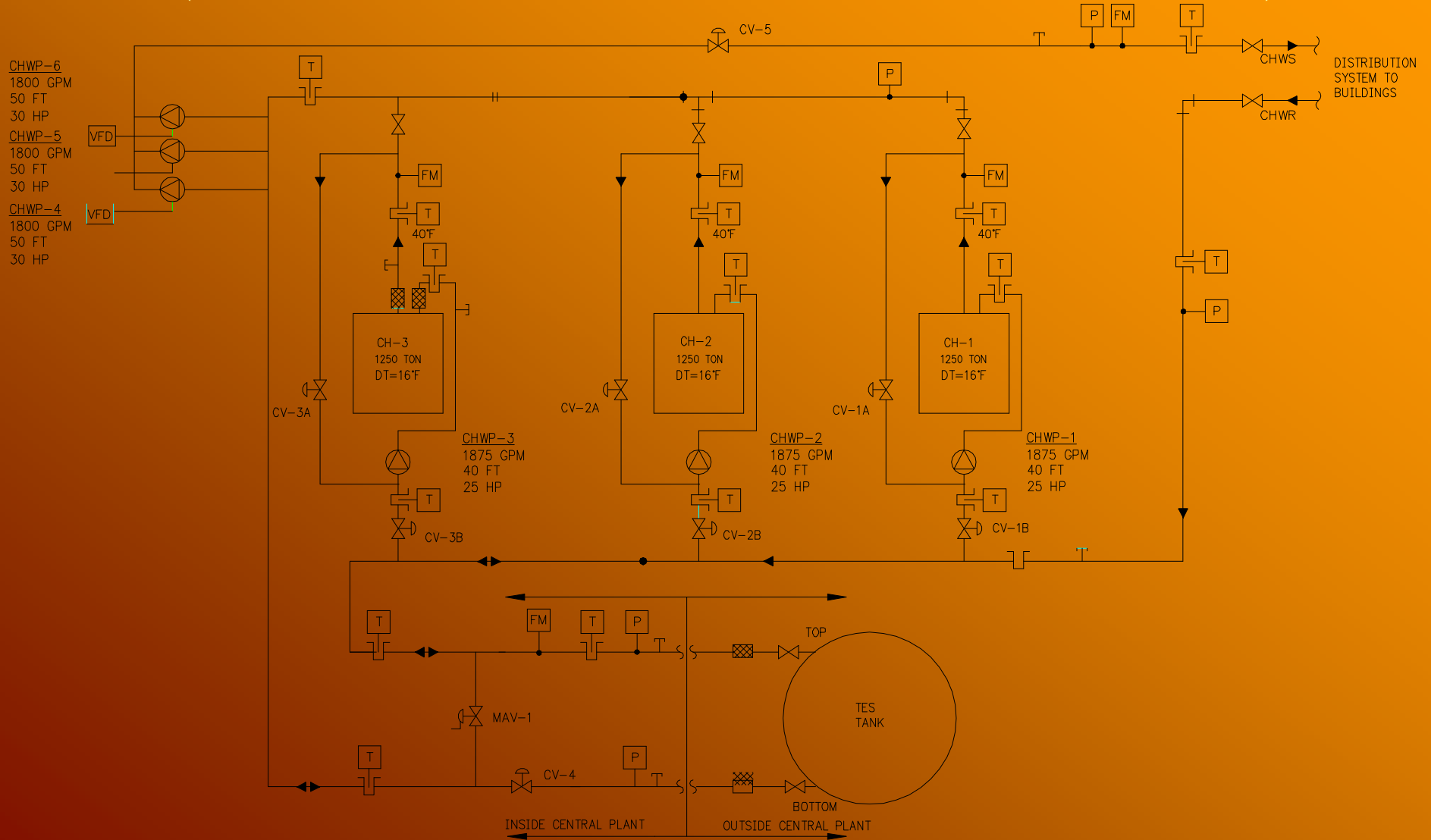


07/26/2011 11:45:36 PM
07/27/2011 01:26:24 AM
07/27/2011 03:07:12 AM
07/27/2011 04:48:00 AM
07/27/2011 06:28:48 AM
07/27/2011 08:09:36 AM
07/27/2011 09:50:24 AM
07/27/2011 11:31:12 AM
07/27/2011 01:12:00 PM
07/27/2011 02:52:48 PM
07/27/2011 04:33:36 PM
07/27/2011 06:14:24 PM
07/27/2011 07:55:12 PM
07/27/2011 09:36:00 PM
07/27/2011 11:16:48 PM

Another Example

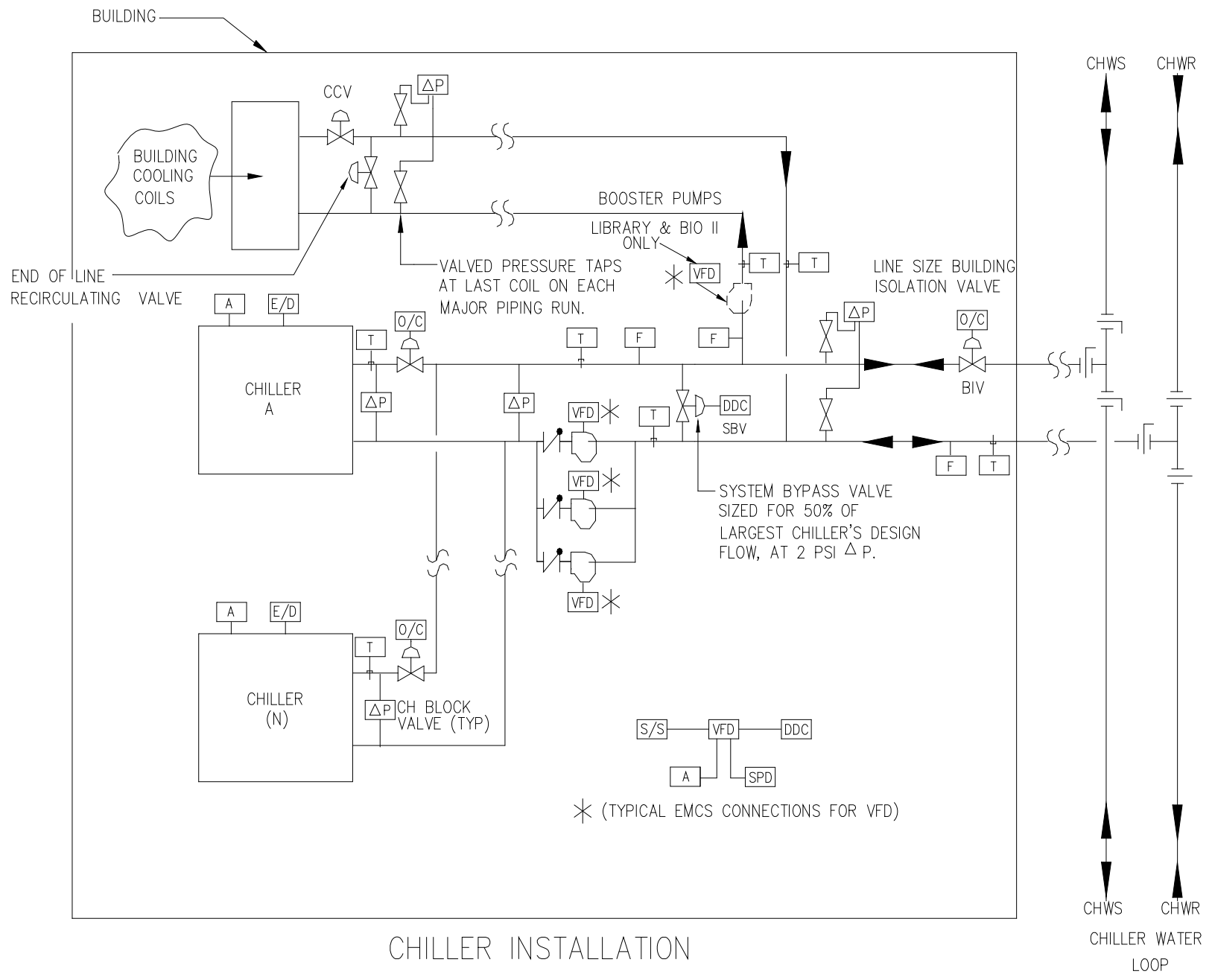
- ◆ Resetting system pressure and/or temperature by building load
 - Permits operating pumps at minimum speed/energy consumption to just meet the load
 - Monitor all ACV positions to ensure at least one is 95-100% open at all times
 - Much better performance, more accurate, lower system differential pressure

Chiller Piping Diagram (For Different Chiller Selections & TES)



Related Benefits of Piping Scheme

- ◆ Constant CHWST, regardless of load
- ◆ Different DT chillers on same loop
- ◆ Only operate equipment needed
- ◆ TES easily used "as desired or needed"
- ◆ VFD on chiller pump can provide minimum required chiller flow
- ◆ Minimum pumping power at all times



CHILLER INSTALLATION

CHWS
CHWR
CHILLER WATER LOOP

System Bypass Valve Control

- ◆ Primary: Maintain minimum flow through operating chiller(s); DP across evaporator tubes works
- ◆ Secondary: Maintain Chiller CHWRT constant regardless of CHWRT from system
- ◆ Sizing: To flow up to 75% of operating chiller design flow at 2 psi DP.

New VFDs on Pumps

- ◆ VFDs on All CHW Pumps
 - Better performance – all on same spot on curve
 - Better Control
 - Easier to lead-lag
 - Minimize energy consumption
- ◆ Sequence Chiller Systems Based on Load =
Add by CHW DP; Subtract by Tons
- ◆ Variable Flow = Diversity At All Loads
- ◆ Use Most Efficient Chillers First = Reduced Energy Consumption

Balancing Valves or Circuit Setters? None!

- ◆ Use automatic control valve (ACV) for limiting maximum flow to each building or major piping run
- ◆ Use ACV for maximum flow through AHU coil – monitor major coil DP as flow high limit control, if needed
- ◆ Modulate chiller's isolation valve to limit flow through chiller
- ◆ ACVs have no energy penalty

Condenser Water

- ◆ Control as cold as possible, per chiller manufacturer, with OAWBT limiter, to reduce wasted fan energy
- ◆ Optimize total energy consumption
- ◆ Control CTF for minimum possible CWI for chillers – about 1% improvement per 1F reduced
- ◆ With VFDs on CWP, reduce flow through operating chiller, when possible, for greater total efficiency

Cooling Towers

- ◆ VFDs on all fans and, if big plant, all CWPs – operating most hours with less than design pumps and flow
- ◆ Control fan VFDs to maintain minimum CWT at CTF design approach plus OAWBT = the best one can do
- ◆ Operate multiple CTFs, if possible, at min fan speed - must have variable CTF flow nozzles

Key Points

- ◆ System Bypass Valve (SBV)
- ◆ End of line DP sensor and $\frac{3}{4}$ " 2-position recirc ACV – each major piping run or building
- ◆ Modulating Building/Area Isolation Valve
- ◆ Pumping system DP and speed control

CHW DP

- ◆ Minimum DP = Minimum pumping HP
- ◆ Design piping systems & coils for low DP
- ◆ No 3-way valves – use small 2 position ACV at end of each major piping run
- ◆ Feedback from all AHU ACV controls
- ◆ Keep at least 1 CHW ACV per building nearly full open at all times
- ◆ All systems maintaining same DP
- ◆ Large coil ACV = Flow limitation control

End of Line 2 Position ACV

- ◆ Sometimes want to maintain cold water flow throughout piping system for “instant” response to call for cooling
- ◆ End of line $\frac{3}{4}$ " ACV when HVAC unit ACV is closed – just enough flow to keep cold water. No big penalty, like a 3" 3-way ACV at the end ACU

Building Isolation Valve

- ◆ Isolates building systems when cooling not needed in building
- ◆ Modulating BIV permits limiting flow into building – or major piping runs – during full flow requirements
- ◆ Use valve with 0 DP at full flow

EMS Operation

- ◆ Clear and accurate graphics
- ◆ Operate systems from graphics
- ◆ Dial-up capability for monitoring from off-site + controlling if needed
- ◆ Extensive trending capability for new energy conservation confirmation and reporting
- ◆ Many energy sensitive sequences of operation included

EMS Operation – Cont'd

- ◆ New system required to monitor results of new energy conservation projects, including the virtual chilled water plant.
- ◆ Utility company demanded accurate measurement and verification data to confirm value of rebate.

EMS Operation (Cont'd)

- ◆ Calculate and chart energy consumption
- ◆ Plot assigned data points to confirm proper control
- ◆ With 38F CHWST, no room for “undershooting” or “overshooting” – lose too many benefits from low temperature CHWS

EMS Operation (Cont'd)

◆ REMEMBER:

- 25% reduction in CHW DP = 44% reduction in pumping power
- 25% reduction in CHW Flow = 58% reduction in pumping power
- Dropping from 42F to 38F CHWST on a 12F DT coil provides 20F DT coil (LMTD remains constant)
- 20 vs 12F DT = 60% flow = 78% REDUCTION in pumping power!

EMS Operation (Cont'd)

- ◆ Integrates all system information to control at optimum energy
- ◆ DP reading requiring the most DP controls the CHWP speed
- ◆ AHU with CHW ACV >95% open and discharge air temperature above requirements to meet space needs controls that building's DP, which, in turn, may control CHWP speed

Controls are Critical to the Success!

- “Secret” to successful operation = close and reliable control
- Accurate instrumentation – mandatory
- Well instrumented – can’t do without it
- Thorough and accurate “calibration” and “commissioning” = high reliability
- Detailed/thorough Operator Training – maximize sustainability

Why Controls Are Critical

- ◆ “System Bypass Valve” to Control -
 - Minimum CHW flow through chiller
 - Limit CHWRT into chiller for proper CHWST out of chiller
- ◆ Chilled Water Pump Control -
 - Operate at Minimum speed = minimum energy consumed
 - Maintain minimum DP “at end” of each critical primary piping loop and each building

Why Controls Are Critical (Cont'd)

◆ AHU Automatic Control Valves

- ALL to be 2-way
- At least one, any one, per building nearly full open at all times
- Feedback from ACV control to DP control
- Feedback from Building DP control to Pump DP and speed (VFD) control

Chiller Controls

- ◆ Ensure capacity controls calibrated to $\pm 0.1\text{F}$ CHWST, using PID
- ◆ Capacity controlled easily and smoothly
- ◆ CHW flow as low as possible = optimized pumping
- ◆ Operate only enough and the right chillers to do the job needed
- ◆ Maintain lowest possible CWIT

Sensing Devices

- ◆ CHWST & CHWRT sensors should be “matched pair” or “matched trio”
 - $\leq \pm 0.25F$, for net $\leq \pm 0.1F$ DT
 - Without “matched set,” reading could be off by up to 5% of full load for 10F DT Chiller
- ◆ All water system sensors $\leq \pm .25F$
- ◆ All air system sensors $\leq \pm 0.5F$
- ◆ DP sensors $\leq \pm 0.2$ PSI

Critical Items

- ◆ Proper Design!
- ◆ Building CHW System - Flow, Pipes and Pump Head
- ◆ Accurate Instrumentation - Everywhere
- ◆ Feedback From AHU Controls
- ◆ Flexibility of Chiller Selection
- ◆ Proper Operation – Per Design

Critical Items (Cont'd)

- ◆ Selection of the Right EMS Operator
- ◆ Accountability of EMS Operator
- ◆ Proper & Repeated EMS Operator Training
 - HVAC System Performance
 - Chiller Performance
 - CHW Pumping
 - CHW Pressure Control
 - Interactive Relationships
 - Proactive Role of Operator & O&M folks

Summary

- ◆ NEVER UNDERESTIMATE THE POWER OF A WELL THOUGHT OUT CONTROL SYSTEM; AND DON'T FORGET THAT IT NEEDS TO BE (PAPEO):
 - DESIGNED WITH PROFESSIONALISM
 - INSTALLED WITH ACCOUNTABILITY
 - COMMISSIONED WITH PASSION
 - OPERATED WITH ENTHUSIASM AND OWNERSHIP!

THANK YOU!

Questions?

