FEFPA 2018
Florida Educational Facilities Planners' Association, Inc.

Role of Managers in Central Energy Plant , Design and Construction

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1. What is a typical Central Energy Plant consists of?

- **BAS controls, chillers, pumps, cooling towers, electrical distribution, piping , chemicals, heating systems, and generators.**

2. How to scope and define a CEP project?

- **What is CEP and why do we need CEP?**
- **Create utility master plan**
- **Short term and long term needs**
- **Budget**
- **Warranty and service contracts (in-house or outsource)**

3. What is the benefit of BAS for large operation?

- BAS could be a BACnet , Lonworks and Modbus.
- Monitors total consumption in $, BTUH, KW per hour, per day, per month and per year. This is good tool for DMS.
- Would have a chart as a comparison between current and previous years.
- Would display hours of operation for each chiller, pumps, and cooling towers.
- LEAD /LAG must be implemented.
- BAS should not allow the chillers to cycle more than twice per hour.
- Low flow cut-off must be on primary alarm system.

4. How REVIT lod400-500 can integrate with BAS?

- Construction and Building Operation. The final level of development represents the project as it has been constructed including as-built conditions. The model is configured to be the central data storage for integration into building maintenance and operations systems. LOD models will include completed parameters and attributes specified in the owners BIM deliverable specification.

A proper chiller plant operation requires:

- A written SOP(standard operating procedure). However: do not rely on operators to program or analyze the system. It doesn't work like that.
- Always specify "maintenance friendly" system.
- Primary-secondary pumping systems are easier to understand and use, yet variable primary systems can save a lot of pumping energy.
- Even though larger plants can be intimidating, they should be considered single stages of cooling and allow for integral controls to handle each plant.
- Best way to control pumping still is with differential pressure sensor, but location of the sensor is of utmost importance.
- Chillers are always controlled with temperature. Here is when chiller optimization come into the picture because these temperature and pressures have to be tested for efficiency. An over pressurized or under pressurized system can cost the owner and reduce life of the system.
- In order for larger plants to work properly and back each other up, system must have a true loop. The flow velocity in the loop should **NOT TO EXCEED 7 FEET PER SECOND.**
- Building's chilled water tertiary pumps would operate efficiently if they are VSD.
- If thermal storage is owner's preference, full ice storage is easier understood by the maintenance staff than partial ice.

Common causes of low ΔT syndrome include:

- Improper Coil and Control Valve Selection: Oversized or undersized coils.
- Dirty Coils (Air and Water Side): Reduces the overall heat transfer capacity of the coil, which results in the control system opening two-way control valves. This leads to increased flow and decreased return water temperature.
- Mismatched Design Conditions: System components designed for different chilled water ΔT can result in lower than plant design return water to the plant.
- Use of Three-Way Control Valves: Allows bypass of chilled water around coil at part load resulting in lower return water temperatures for all conditions except design.
- Low Supply Air Temperature Set Point: Arbitrarily lowering the supply air temperature set point below design can lead to uncontrollable operation and result in lower return water temperature.

Common causes of low ΔT syndrome include:

- System Differential Pressure Above Shut-Off Valve: Forces control valves open, leading to unwanted flow through coils, increasing system flow and resulting in lower return water temperature.
- Coil Piping Configuration: Coils must be piped such that water is counter-flow to air. If they are piped in reverse, the heat transfer efficiency of the coil will decrease resulting in lower chilled water return temperatures.
- Plant Chilled Water Mixing: Flow from chilled water supply to chilled water return through the plant neutral bridge or de-coupler occurs at part load conditions when the primary loop is pumping more than the secondary loop (primary-secondary).
- Building De-Coupler Mixing: Flow from chilled water supply to chilled water return through the building neutral bridge or de-coupler occurs in similar manner as with the plant neutral bridge.

The following is a list of the advantages to implementing a primary-secondary system:

1. Constant Flow Through Evaporator: The primary-secondary system maintains a constant flow through the evaporator of the chiller. This eliminates the concern for chiller performance and inadvertent shutdowns. Chiller capacity controls have traditionally lagged behind sudden changes in load. If the load suddenly drops, the chilled water supply temperature drops until the controls catch up. This sudden drop in supply temperature causes nuisance trips, due to low evaporator temperature. This is less of a concern today than it was in the past because of microprocessor-based controls.

2. Simplified Controls: Controls within a primary-secondary system are relatively simple and well established. Typical chiller controls packages do not have difficulty with the staging sequence for the chillers and responding to varying loads.

Advantages to implementing a primary-secondary system continued:

- 3. Past Experience: The primary-secondary system is a well established operational philosophy and plant personnel are familiar with its operation. In addition, this pumping scheme has been proven reliable if operated properly.

  4. Divided Hydraulic Head: By dividing the total dynamic head between two hydraulically independent loops, the required motor size for each pump type (primary and secondary) will be smaller when compared to a direct-primary system. This also reduces the risk that the system discharge pressure will exceed the design of equipment, piping, and valves in the buildings.

Disadvantages to implementing a primary-secondary system :

1. ***<u>Does not Resolve Low ΔT Syndrome:</u>***

- The primary-secondary system does not allow an increase in flow through the evaporator above design and; therefore, does not adjust to chilled water return temperatures that are lower than design.
- As the cooling load decreases, the secondary pump VFDs will ramp down to a lower speed, thus allowing these pumps to produce less flow.
- The constant volume circulation pumps will then over pump the primary loop causing supply water to flow through the neutral bridge and mix with return water. This mixing lowers the return water temperature and deteriorates the system ΔT as described previously

Disadvantages to implementing a primary-secondary system continued:

2. ***Capital Investment:***

- More piping for secondary/primary system versus primary system.

3. ***Higher Operating and Energy Costs:***

- The primary-secondary system uses both constant speed and variable speed pumps to circulate chilled water through the plant as well as the distribution system.
- Because the primary loop will always have a constant flow, energy is wasted within this loop at off-peak loads.
- In addition, this pumping scheme does not allow adjustable flow through the chillers and is subject to the part load operational inefficiency described above.
- These features and the need for two sets of pumps will generally yield higher energy and operating costs per annum when compared to the direct-primary system.

Disadvantages to implementing a primary-secondary system continued:

4. __Requires More Plant Space:__

- Two sets of pumps are needed to circulate chilled water through the chiller evaporator and the chilled water distribution system.
- This requires more floor space, more spare parts, and results in higher capital costs and pump maintenance costs when compared to the direct-primary system.

4-Pipe system VS 2-pipe system

- **2-pipe system**-CHWS/CHWR/HWS/&HWR
- The operation is based on outside /outdoor temperature. It uses chilled water or hot water in the same pipe.
- Its less construction cost than 4 pipe system.
- It requires more control valves for change-over for hot or chilled water.
- Extensive Sequence of operation and control setting to avoid damages.
- It requires more PM work especially on control valves.

- **4-pipe system**- 2 pipe for CHWS/CHWR and 2 pipe for HWS/HWR
- Higher construction cost than 2 pipe system
- 2 separate coils (CHW & HW).

4-Pipe system VS 2-pipe system

- **Alternative solutions:**

- Regarding chilled water/hot water 2-pipe system: It depends on geographical location. 2-pipe system are cost effective for geographical location with 100 Heating Degree Days or higher per year. Less ***change-over*** from heating to cooling or vice-versa.
- **To calculate** HDD, take the average of a **day's** high and low temperatures and subtract from 65. For example, if the **day's** average temperature is 50^{o} F, its HDD is 15.
- 4-pipe system are more cost effective for Hospitals, Labs similar places for high heating demand .
- Use of electric duct heaters for space heating and 2-pipe system for chilled water purposes.

4-Pipe system VS 2-pipe system

- Conduct a life cycle cost analysis to determine:

1. $Installation and operation(O&M) cost of 4-pipe system using chillers, and boiler per fiscal year.
2. $Installation and operation (O&M) cost of 2-pipe system using chillers, and boiler per fiscal year.
3. $Installation and operation (O&M) cost of 2-pipe system using chillers, and electric duct heaters per fiscal year.

Heating Degrees in Central Florida

Month	Base Year (2012) HDD	CDD	TDD	Comparison Year (2017) HDD	CDD	TDD	Comparison Percentages HDD	CDD	TDD
January	**12**	359	371	5	477	482		32%	29%
February	**7**	493	500	0	513	513		4%	2%
March	**0**	677	677	0	607	607		-10%	-10%
April	**0**	705	705	0	766	766		8%	8%
May	**0**	869	869	0	946	946		8%	8%
June	**0**	859	859	0	957	957		11%	11%
July	**0**	1001	1001	0	1037	1037		3%	3%
August	**0**	1003	1003	0	1070	1070		6%	6%
September	**0**	945	945	0	965	965		2%	2%
October	**0**	814	814	0	820	820		0%	0%
November	**0**	470	470	0	642	642		36%	36%
December	**2**	470	472	1	509	510		8%	8%
Annual Total	**21**	8665	8686	[illegible]	9309	9315	-71%	7%	7%

How to execute a successful CEP project?

A clear scope of work , Includes:

1. Schedule
2. Budget
3. Short-term and long-term plan for the CEP.
4. A thorough selection process. Suggest mandatory attendance. Select firms who has track records for similar projects
5. Have the design team to have weekly if not daily presence on the job site during construction.
6. Monitor the energy consumption on regular basis.
7. Commission the CEP under separate contract to act as your “eyes and ears”
8. Extend the warranties on major components
9. Ask Local power companies for energy rebates.

Useful formulas

- Pump Hp = (GPM x Total Head in ft. water) / (Pump Eff. x 3960)
- Chiller Design: Recommend minimum of 12 F Delta-T.
- kW/ton = 12/EER
- 1 Ton = 12,000 BTU/HR
- Tons = (GPM x Delta T x specific heat* x specific gravity*) / 24.   where* for fluids other than water.

Tower System Design Formulas

- Cooling Tower = 3 GPM per ton for 10F Delta –T.
- 1 Tower Ton = 15,000 BTU/ hr.
- Tower Ton = GPM x ΔT/30
- Chiller Tower = 2.4 GPM / ton
- 1 Chiller Ton = 12,000 BTU / hr.
- Chiller Ton = GPM x ΔT / 24

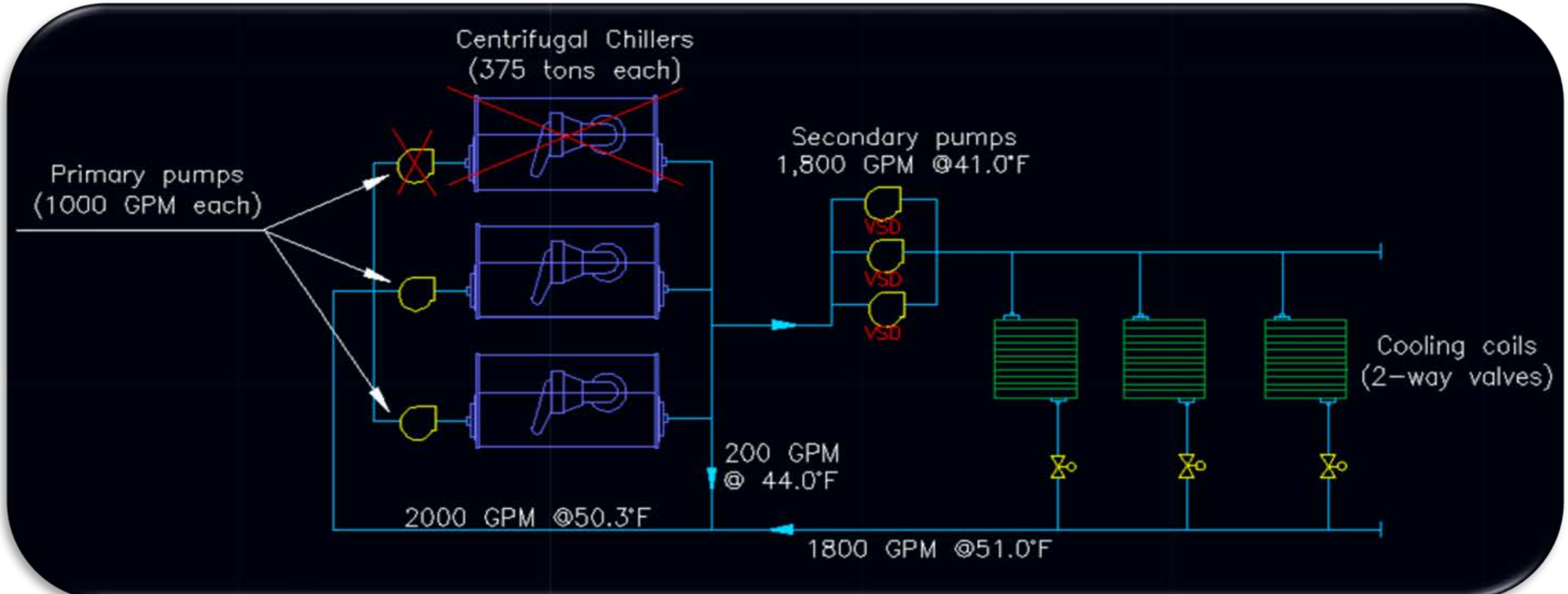
Rule of Thumb:

- There are 1.8 gallons per hour of evaporation per ton of cooling.
- Evaporation of 1 pound of water takes about 1,000 BTU of heat.
- Evaporating 1.8 Gallons of water requires 15,000 BTU of heat.

Primary/Secondary System Operating at 50%

- 8˚F delta-T, requires 2,250 GPM coil flow and all 3 chillers.

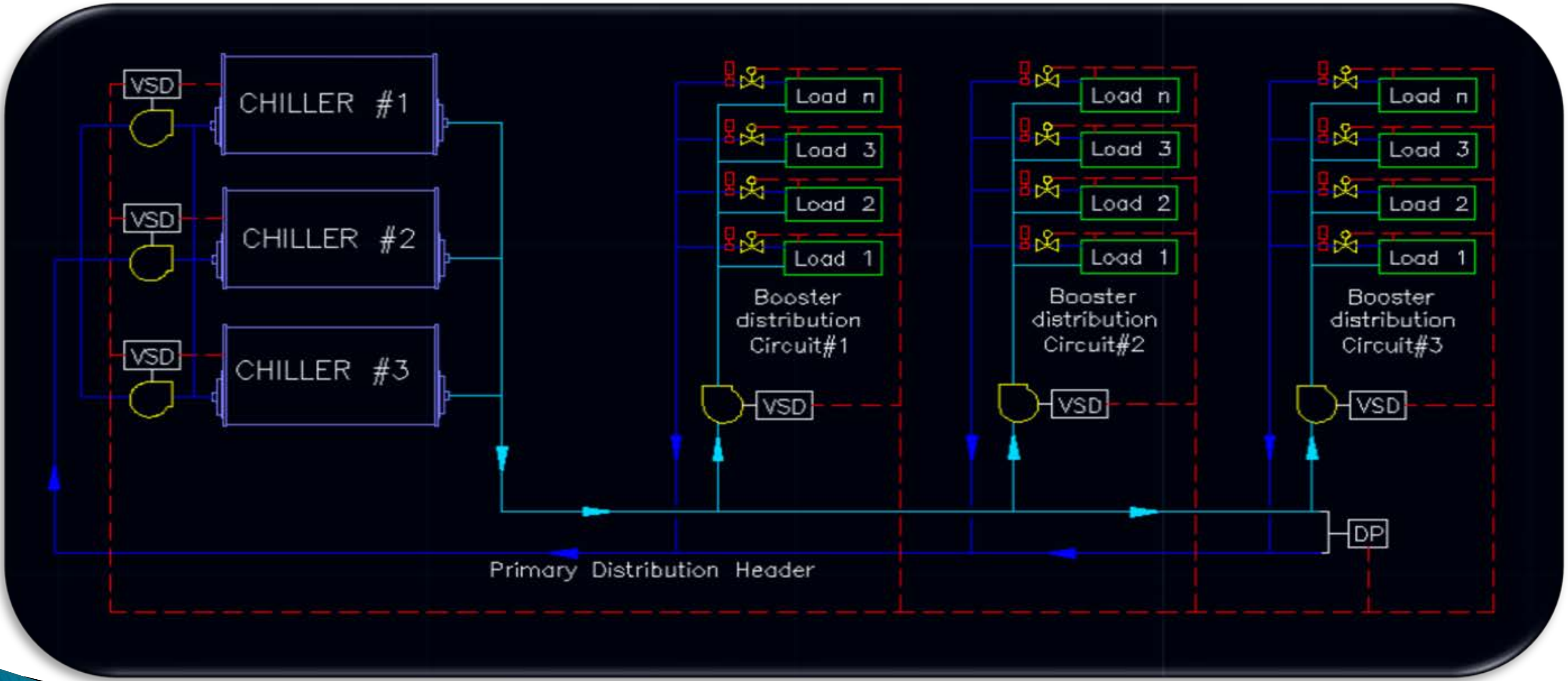
- Resetting temperature by 3˚F to 41˚F results in 10˚F delta-T, coil flow of 1,800 GPM, and the need to operate only 2 chillers.



"All-Variable Speed" Chilled Water Distribution System Configuration with Network Controls

Medium size plants

• This system ensures that every load will be satisfied and guarantees that the design Delta T is maintained at all times.



Low Delta T

Major Causes

- Dirty Coils
- Controls Calibration
- Leaky 2 Way Valves
- 3 Way Valves at end of Index Circuit

Solutions / Reduce Effects

- _Address the Cause
  - Clean Coils
  - Calibrate Controls Occasionally
  - Sealed Proper 2 way valves and maintain them.
  - No 3 way valves in design
  - Find and correct piping installation errors
- Increase delta T across chillers With CHW re-set (down)
- Use Variable Speed Chillers & sequence to operate from 30% to 70% load
- Use VPF Systems (mitigates energy waste in plant)-vector performance factor
  - Header pumps – or cross connect piping.
  - If dedicated pumping, over-size (design at 80% speed)

Conclusions

Critical Factors for Successful Project Managers

1. Must have Management Support.
2. Agree on the goals and objectives.
3. Effective Communications.
4. Manage the work effectively. Lead by example
5. Sustainable design and lowest O&M cost