Overview

- System components
- Design considerations
- Things to check
- Waste & inefficiencies
- Common ECM’s
Chilled Water Systems

- Components
  - Chiller
  - Cooling tower or air cooled condenser
  - Fans
  - Pumps
  - Controls
  - Coils and heat exchangers
  - Valves
  - Distribution pipe
Chilled Water System
Refrigeration Fundamentals

- A refrigerant in the gas form is compressed – adds heat and pressure
- High pressure gas is cooled in condenser and refrigerant loses heat and becomes a liquid
- Liquid refrigerant moves to another heat exchanger where it’s pressure is dropped
- The low pressure refrigerant expands to a gas which takes heat from the fluid and the refrigerant becomes cold
- In the heat exchanger another fluid gives up heat to the cold refrigerant gas which is warmed
- The refrigerant gas moves on to the compressor where its’ pressure is increased again
Chiller Types

- Refrigerant compression – uses motor driven compressor
  - Reciprocating compressor
  - Screw compressor
  - Centrifugal compressor

- Absorption chiller - uses heat to dry water from an absorbing liquid, water evaporated from this liquid travels to the evaporator section where it is sprayed. As this water evaporates into this chamber it lowers the temperature and cools the chilled water circulating through it. The evaporated water is absorbed in the liquid which is pumped to the generator section.
  - Single stage
  - Two stage
Reciprocating Chiller
Steam Absorption Chiller
Cooling Towers

- Condenser water pumped to cooling tower
- Cooling related to air humidity
- Evaporative cooling process where water temperature reduced
- Water should be treated for algae control
- Water blow-down to control dissolved solids
Cross Draft Cooling Tower
Counter Flow Cooling Tower
Typical Operating Parameters

- Chiller output - 45 F water,
- Return water 10 F to 20 F warmer
- Condenser water – 85 F in, 95 F out

Energy Use

- Electrical = .6 to .8 kWh/ton (average is $0.08/ton-hr @ $0.12/kWh)
- Absorption = 18 MBH/ton single stage ($0.22/ton-hr @ $12/million Btu), 12 MBH two stage ($0.14/ton-hr @ $12/million Btu)
Design Considerations

- Degree of humidity control and other issues that affect supply chilled water temperatures.
- Electrical demand costs
- Systems served
  - Constant or variable flow
  - Seasonal & peak requirements
- Outside temperature and humidity
- Cooling tower location
Things to Check

- Chiller load profile data
- Return water temperature
- Cooling tower condition and temperature reduction
- Amount of make-up water
- Temperature at remote locations of distribution system
Energy Waste – Chiller Systems

- Water flow through shut down equipment
- Dirty heat exchangers
- Uncalibrated poorly adjusted controls
- Cooling tower leaks and excessive blowdown
- Dirt distribution nozzles in cooling tower
- Cooling tower internal components in poor condition
Energy Waste – Chiller Systems

- No insulation on pipes $< 60^\circ$ F
- Distribution system leaks
- Unbalanced flow causing excessive pressure drop through control valves
- Too much bypass water in circulating systems
Energy Inefficiencies – Chiller Systems

- Use of air cooled condensers
- Use of oversized equipment
- Constant chilled water temperature
- Constant condenser water temperature
- Blowdown from tower basin
Energy Inefficiencies – Chiller Systems

- No duct at fan discharge for velocity pressure recovery
- No adjustment of fan blades for load or season
- High pressure pumps instead of booster pump use
- Variable flows with constant speed pumps
ECM – Raise Chilled Water Temperature

- Raising the leaving chilled water temperature increases the performance efficiency
- Could be combined with DOAS units having DX cooling
- Lowers distribution energy losses
ECM – Lower Condenser Water Temperatures

- Lowering the incoming condenser water temperature improves the chiller efficiency.
- Can vary by weather conditions.
- Will cause cooling tower energy to increase.
- Can set up chillers controls to optimize energy use of system.
ECM – Isolate Off-line Chillers

- During low cooling loads when only one chiller needs to operate, the system design has chilled water flowing through all chillers causing multiple pumps to operate and the dilution of the chilled water temperature.
- Wastes pump Hp and requires lower chilled water temperatures.
- Install new pipe and valves to allow individual chillers and cooling towers to operate isolated from others. New pumps may also be required.
ECM – Replace Air Cooled Condensers with Cooling Towers

- Air cooled condensers normally operate at a temperature difference of 20 F higher than the outdoor temperature.
- Cooling towers perform at 10 F above the wet bulb temperature which can be more than 20 F lower than the dry bulb temperature.
- The result the chiller’s condensing temperature could be more than 15 F lower with a cooling tower which has a dramatic effect on chiller performance.
ECM – Thermal Storage Systems

- Best done during addition to central chilled water system
- Cost of storage tank less than new chillers
- Reduces electrical demand charges
- Can be chilled water or ice storage
Thermal Storage – Optimizing Chillers

Cooling Load and Chiller Profile

- Using Stored Chilled Water
- Storing Chilled Water

Tons Cooling (Thousands)

Hour of Day

0 6 12 18 24
Pumps

- Rotating impeller in housing causes water flow
- Flow rates changed by
  - Changing pumps
  - Shaving impeller
  - Using variable speed motor
- Placement important – need some water pressure on pump for proper operation
Pumping Energy Waste

- Use of excessive valving to balance flow
- Failure to adjust pump for correct flow during system balance – pumps larger than 10 Hp
- Failure to use booster pumps when a portion of distribution systems requires an 20 % increase in pressure
ECM – Utilize Variable Flow Distribution

- Requires two way valves at point of use
- May require primary/secondary pumping system since chillers have a low limit for flow.
- Achieves savings in pumping horsepower
- Utilizes full temperature rise of system design
Electrical Distribution

- Components
  - Transformers
  - High voltage switch gear
  - Power distribution lines
  - Motors
Electrical Distribution

- Design Considerations
  - Building/Area electrical loads
  - Length of distribution
  - Equipment voltage requirements
  - Need for back-up power
Things to Check

- Change in building function since transformer selection
- Use of standard or high efficiency motors
- Charge for poor power factor by electrical utility company
Energy Waste - Electrical Distribution

- Oversized transformers
- Energized transformers in unused buildings
- Transformer taps not set at proper setting
Energy Inefficiency - Electrical Distribution

- Power factor less than 85%
- Use of non premium efficiency motors
ECM – Replace Lightly Loaded Transformers

- Electrical transformers are up to 98% efficient and thus there are losses in electrical energy even when the equipment being served is switched off.
- Lightly loaded transformers should be replaced with an high efficient one that is sized for the current load.
- Select the transformer with the lowest temperature rating
ECM – Power Factor Correction

- Poor power factor increases losses in the electrical distribution lines, transformers and motors
- It is caused by lightly loaded and inefficient motors
- Install properly sized motors
- Control power factor by placing capacitors before problem equipment
ECM – Utilize Premium Efficiency Motors vs. Standard Efficiency Motors

- Comparison with standard efficiency motors with replacement upon failure
- Electrical cost = $0.055/kWh

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<th>Motor Size</th>
<th>Existing Efficiency (%)</th>
<th>Proposed Efficiency (%)</th>
<th>Energy Saved (kWh/yr)</th>
<th>Energy Cost Savings ($/yr)</th>
<th>Total Cost Premium ($)</th>
<th>Additional Cost of New Motor vs. Rewinding</th>
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ECM – Utilize Premium Efficiency Motors vs. High Efficiency Motors

- Comparison with post 1997 high efficiency motors with replacement upon failure
- Electrical cost = $0.055/kWh

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ECM – Install EMCS

- Central control and optimization of HVAC systems
- Remote monitoring and evaluation of system performance
- Maintenance aid and problem anticipation
- Electrical demand monitoring and control
- Need to actively use and adopt as a tool for full benefits
ECM - Replace Lightly Loaded Motors

- Look for systems that have had loads reduced
- Reduced loads on motors result in poor power factors and inefficiencies
- Measure motor amps and compare to full load current on nameplate
- Replace motors loaded less than 60% of rating
Thank You

Questions?