Understanding Chiller Optimization

White Paper

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Executive Summary

This purpose of this document is to explain the basic understanding of the optimization in chillers and how important chiller efficiency is to keep the energy costs to minimum.

- **Recording data from accurately calibrated meters, sensors and gauges on a regular time period (as frequently as every 15 minutes) will provide the "What and Where" of chiller performance and deliver important clues as to "why".**

- **Ensuring best preventive maintenance practices are regularly followed will provide long life and maximum operational efficiency.**

Definitions

Air-Cooled: Refers to a chiller system that uses the ambient air surrounding the condensing unit to cool and condense the refrigerant back into a liquid.

Water Chiller: A water chiller is a refrigeration apparatus that produces cold water or water/glycol mix, to cool industrial process equipment or provide comfort cooling for buildings. A water chiller uses the evaporation of a refrigerant to cool the fluid through a heat exchanger.

Compressor: A compressor in a refrigeration circuit compresses cool low pressure refrigerant gas to hot high pressure refrigerant gas that is then condensed back into a liquid to be used again.

Glycol: Glycol is added to the water in a chill water system to protect from freezing. Glycol is available as Ethylene Glycol or Propylene Glycol and can either be purchased with or without rust inhibitors. The freezing point of the fluid is dependent upon the concentration of the glycol. The higher the concentration of glycol the lower the freezing point, but as the concentration goes higher the heat transfer properties are reduced. This will reduce chiller capacity.

Portable Chiller: Portable chillers refer to any chiller that includes both the refrigeration circuit and the water circuit (pump and tank) within the same foot print. Portable chillers can include any chiller from .5 ton up to those in excess of 200 tons.

Refrigerant: A refrigerant is any substance used to cool the water in a chiller through a heat exchanger or evaporator. The substance typically has a low boiling temperature and includes Freon and ammonia.

Types of Chillers

1. Air-Cooled Chillers: They are mostly used in applications where the heat discharged is not a factor. They don't need a cooling tower and condense water pump. The maintenance of air cooled chillers is less than water cooled units. However they consume 10% more power.

2. Water Cooled Chillers: In water cooled chillers, heat is absorbed from process water and is transferred to a separate water source like a river, pond, cooling tower, etc. Mainly used at the places where the heat generated by air cooled chillers pose a problem. Due to their lower consumption of power they are usually preferred by those seeking optimum efficiency of power consumption.

3. Absorbing Chillers: Absorption chillers use heat instead of mechanical energy to provide cooling. As the main source of energy for the cooling process absorbing units use either hot water at a certain temperature (130°C) or superheated vapor (pressurized to 1 bar) to produce cooling. This absorbing type contains very few moving parts in the structure and as a result provides high reliability of the unit. The only downside is that the absorbing type of refrigeration device has a higher expenditure of energy.

4. Compressive Chillers: These chillers are based on compressive cooling cycle where fundamental structural components are a compressor, evaporator, condenser and a flow control device. All the structural components are connected sequentially with each other by tubing and thus form a closed system where the compressor is responsible for the circulation of the refrigerating fluid (Freon). The cooling process in the refrigerating device is provided by persistent circulation, boiling and condensation of the refrigerant in a closed system.

Why Maximize Chiller Efficiency

Chillers are the single largest energy-using component in most facilities, and can typically consume over 50% of the total electrical usage.

Chillers running inefficiently also result in decreased equipment reliability, increased maintenance intervals and shortened lifespan. The slightest decrease in chiller performance can have a major impact on efficiency. For instance, every 1°F increase in condenser water temperature above full load design can decrease chiller efficiency by 1% to 2%. A failing or neglected water treatment program can reduce efficiency 10% to 35% or more in extreme cases.

What is Maximum Chiller Efficiency?

A commonly held belief is that running a chiller at full load design and achieving the design kW/Ton will achieve maximum efficiency. However, this is not correct. It does not mean the chiller is running at maximum efficiency. Most chillers achieve the greatest tonnage at the lowest kilowatt usage by operating at approximately 70-75% load.

Maximum chillers efficiency is producing the greatest tonnage at the lowest kilowatt usage.

Steps to Maximize Chiller Efficiency:

1. Operational Data: Recording chiller operational data in a daily log preferably through an automated chiller management system and reviewing the same through a management dashboard. Following parameters on a daily log are essential.

a) Chiller Electrical Power (kW)
b) Chilled Water Flow (gpm)
c) Chilled Water Return Temperature (F)
d) Chilled Water Supply Temperature (F)
e) Condenser Water Flow (gpm)
f) Condenser Water Return Temperature (F)
g) Condenser Water Supply Temperature (F)
h) Outside Air Dry-Bulb
i) Outside Air Humidity

2. Accurate Data: Ensure the data collected is accurate and precise with the help of calibrated equipments for flow rates, delta pressure, temperature and other electrical parameters.

3. Increase chill water temperature: Increase the Chill Water Temperature and lower the Entering Condenser Water Temperature For constant speed chillers, every 1°F increase in chill water temperature can increase chiller energy efficiency 1 to 2%. For variable speed chillers, every 1°F increase in chill water temperature can result in a 2 to 4% efficiency increase.

4. Wet bulb conditions: Take advantage of wet bulb conditions in the cooling tower system to lower the chiller's entering condenser water temperature. This can result in a 1 to 1.5% efficiency improvement for every 1°F below the chiller full load design.

5. Water treatment program: A good and disciplined water treatment program will result in significant energy savings, maximizing the equipment life and greater chiller efficiency. This helps in reducing the overall chiller maintenance costs. Regular water treatment minimizes microbiological growth of microbes, which otherwise form a sticky slime deposits in the tube that affects the heat transfer efficiency (10% to 15%). This deposition can lead to permanent scale or iron deposits on sticky portion that leads to corrosion through out the condenser system.

6. Pretreatment: Pretreatment is essential and recommended for a new system, i.e. condenser, evaporator and tower system or when there is a new add-on to an existing system to ensure heat transfer efficiency and longer equipment life. The purpose of pretreatment is to remove oil and grease from new piping and chillers. In absence of pretreatment, the oil and grease may adhere to the heat exchanger, reducing heat transfer. Oil and grease can also provide food for microbes to grow and bloom, requiring additional costly biocide treatments.

7. Prevention of corrosion: Galvanic corrosion due to dissimilar metal coupling primarily occurs on the condenser side of a chiller and can exist in all areas of the HVAC system. This corrosion can affect the life of the chiller. Addition of chemicals in the evaporator minimizes galvanic corrosion. Most chillers have copper tubes with carbon steel tube sheets and end bells, in which a galvanic reaction can occur between the copper and carbon steel. Installing sacrificial anodes and painting the inside of the chiller end bells and tube sheet with an epoxy coating can also minimize this corrosion.

8. Maintain design flow rates: It is recommended and advisable to maintain / preserve the evaporator design flow rates. A flow rate less than 90% will reduce chiller efficiency and can cause water treatment program to fail. Similarly, a high flow rate through the chiller may cause vibration wear and erosion/corrosion of the tubes, reducing reliability and life. Cracks and pitting holes can develop causing leaks in the tube bundle.

9. Maintain Refrigerant Levels: The ability of a chiller to efficiently remove heat directly correlates to the compressor's ability to move the refrigerant per unit of time. Maintenance of proper refrigerant levels is critical because low levels cause the compressor to work harder and less efficiently. Trending refrigerant levels will help determine if the chiller has leaks.

10. Analyze Refrigerant: Regular refrigerant analysis is an important part of determining chiller inefficiencies. If oil content in the refrigerant is above the chillers manufactures guidelines, it may be reducing heat transfer. Keeping good maintenance records on oil usage in a chiller will help to avoid this condition.

12. **Monitor Refrigerant Approach Temperature:** One of the earliest signs of chiller inefficiency is an increase in Refrigerant Approach Temperature (RAT). The RAT is determined by calculating the difference between the leaving fluid (water) and the saturated temperature of the refrigerant being heated (evaporator) or cooled (condenser). Newer chillers perform this function. Older chillers may require taking the suction pressure (evaporator) and head pressure (condenser), then converting these pressures to temperature from a refrigerant temperature/pressure table. With RAT mentioned by every chiller manufacturer when exceeded, shows that a problem with heat exchange exists in the chiller. Problems associated with high RAT include low refrigerant level, non-condensable gasses, low/high flow rates, part loads at low ECWTs and finally, a scaled or fouled chiller.

13: **Following Preventive Maintenance Schedule:** This helps in taking corrective action and increasing the equipment life. Some of these are mentioned below;

- Compressor oil analysis should be performed annually.
- Replace oil filters on an as-needed basis.
- Regular lubricant change intervals.
- Cooling Tower Cleaning and Lay-up