Maximizing Energy Efficiency for Water Cooled Chiller Applications Using Direct Expansion Dedicated Outdoor Air (DX-DOAS)Units

INTRODUCTION

The trend in the industry is to continue to find methods to increase the energy efficiency of the HVAC equipment. Zero Net Energy (ZNE) buildings require all of the design elements of the building to be integrated to reduce the internal and external load and to increase the efficiency of the equipment. Some of the conclusions of this effort are to separate the latent load of ventilation air from the internal sensible load so each system can be optimized in its design.

This application note will summarize the integration of DOAS units for those applications that will use chilled beams or variable air volume (VAV) fan coil units. With the selection of these types of terminal units, the building will have a chilled and hot water loop. The selection of an appropriate heat-pump DX-DOAS in this application will save significant amounts of energy due to the ability to set all of the HVAC system components for their optimal operation points.

ADVANTAGES OF WATER COOLED SYSTEMS

HVAC equipment is more energy efficient when using a water cooled design vs. an air cooled design. There are several reasons for this with the major factor being that the water temperatures are generally lower than the air temperature thus reducing the system condensing temperature. A refrigeration system electrical energy use is greatly influenced by condensing temperatures. Analysis has shown that the integrated part load value (IPLV) of a water cooled system chiller can significantly lower energy consumption. For a chiller a 1°F condensing temperature reduction can increase efficiency by 1 to 2%.

DOAS systems that are water-cooled can also realize a similar increase in their efficiency by lowering the condensing temperature. The D/X system will operate with a similar 1 to 2% increase in efficiency for each degree that the water temperature is below the air temperature.

DX-DOAS IMPACT ON CHILLER DESIGN AND OPERATION

The most significant impact that a DX-DOAS system can have on the chiller operation and system as a whole is the ability to operate the chilled water supply temperature independent of the dehumidification needs. More specifically, if chilled water is to be used for dehumidification, the water temperature entering the coil must be in the range of 42°F to 45°F in order to achieve a target dew point of 52°F. If the chilled water loop only must be designed to maintain the sensible conditions of the space, the loop temperature can be raised or reset to 52°F to 58°F. The efficiency of the chiller will increase by 2% for every degree that the loop temperature can be raised. Therefore a 10°F increase in loop temperature will allow the chiller to operate up to 20% more efficiently. Even in a retrofit application where the terminal units are already sized for the peak load at a lower entering water temperature, significant savings will result from resetting the chilled water supply higher during off peak conditions. This can be accomplished easily with simple building management system controls.

The second part of the energy gain comes from eliminating the need for "reheat" on the terminal units. If the system discharges air at 52°F to maintain the dew point, this may cause an overcooling of the space thus mandating the use of new energy to reheat the air to a higher temperature. The DX-DOAS system uses the recovered energy (ASHRAE 90.1 requirement) to avoid overcooling.

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In the case of chilled beams, the water temperature must be delivered at a 58°F temperature to avoid the possibility of condensation on the beam's coil. In order to achieve this and still perform dehumidification with chilled water, chilled water return must be mixed with the lower chilled water supply to create a secondary loop. The DOAS-DX system simplifies the system by eliminating these pumps and valves.

While DX-DOAS system units have an initial capital cost that are higher than chilled water cooling coil based units, their costs can be offset by reducing the size of the chiller and eliminating the terminal unit reheat components. On a basis of lifecycle costs for the complete system, the energy efficiency advantages can far outweigh the initial cost differential. Payback period as a system is very short.

SYSTEM LOOP DESIGNS

There are two types of basic system designs that can be utilized for integrating a DOAS-DX heat pump system with the water cooled chiller loop system. The elements of the system are:

- **Water Cooled Chiller**
  Provides the sensible cooling fluid to the terminal units.
- **Cooling Tower**
  Rejects the heat of compression from the chiller for the sensible cooling and the excess portion from the DOAS-DX heat pump.
- **Boiler**
  Provides the sensible heating water for both the building heat loss as well as maintain the minimum loop temperature for the DOAS-DX heat pump.

Using the DOAS-DX heat pump allows the design engineer to set or reset the sensible loop temperature to optimize the energy efficiency of the system. Water loop reset strategies can be easily employed because the dehumidification requirements have been removed. In addition, the sensible devices heating design can use low temperature boiler or heat pumps as the climatic conditions allow.

DX-DOAS systems that include highly variable and efficient compressor capacity control further enhance this system layout by ensuring the DX-DOAS system is operating at the peak system efficiency. This is accomplished by controlling the leaving air dewpoint to the target condition closely by modulation of the DX-DOAS capacity. In simple terms, a system with efficient capacity controls operates at higher suction pressures and lower condensing pressures while reaching the required capacity.

The boiler can be a single system for all requirements. In this case a heat exchanger would be utilized to be able to maintain the DX-DOAS unit loop to its low temperature requirements.

An alternate design that the DX-DOAS-DX heat pump allows is to use a dedicated boiler for the DX-DOAS heat pump. This would allow the use of a smaller boiler that could be selected at higher efficiency levels and use a modulating boiler for even better efficiency since the DOAS unit requires lower water temperatures.

CONCLUSION

This application note is to provide an alternate method to design a chilled water system for any building application. Heat pumps are normally associated with geothermal type applications, but the new DX-DOAS heat pumps on the market offer many energy saving strategies. The building system can have a significant reduction in its total energy consumed thus allowing the HVAC systems to assist the building in achieving a zero net energy or LEED rating.

The concept drawings below do not include all of the required valves and pumps which are details that your design professional will include in their design package. In addition, the water system must be carefully designed in those winter climates where freezing could occur.

APPLICATION NOTE 23

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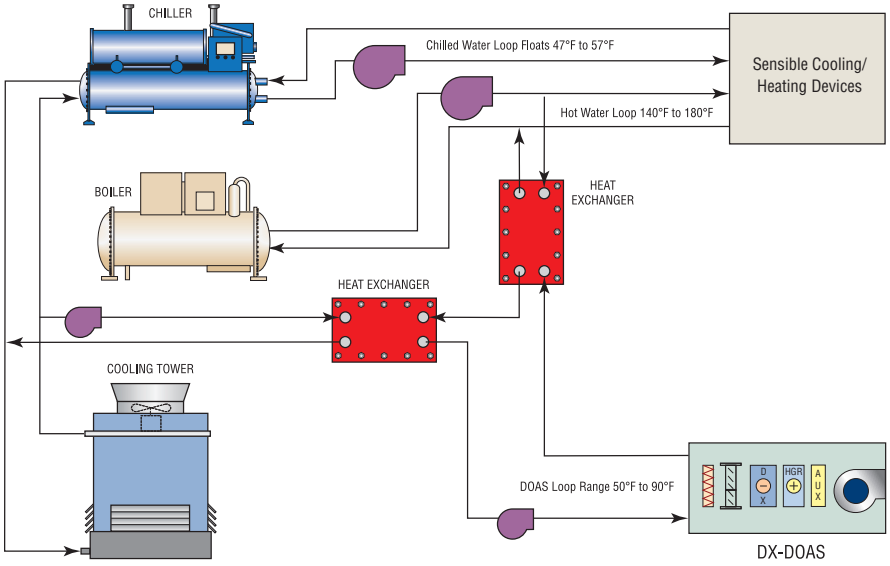

Figure 1 - System Boiler Schematic

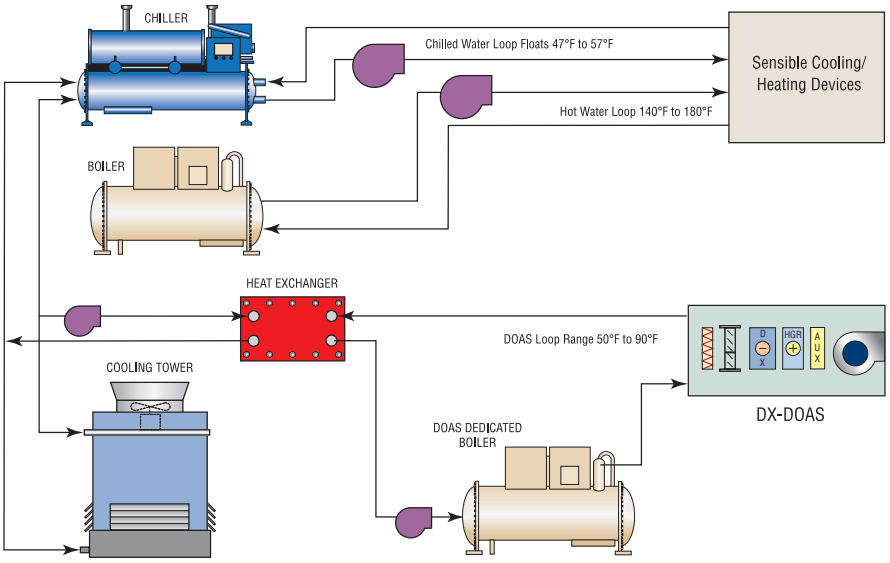

Figure 2 - Dedicated DOAS Boiler Schematic

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