

Influence of the dry cooler capacity on the efficiency of chillers

- increased energy efficiency through certification



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Energy efficiency is currently one of the most important subjects in the HVAC&R industry. When using a certified chiller with a separately installed condenser or re cooler, it is very advisable also to use a certified product in order to reach the maximum energy efficiency.

Eurovent Certification Company (ECC) started the Certification Programme for Liquid Chilling Packages (Chillers) in 1996. The programme applies to standard chillers used for air conditioning and refrigeration. In 2006 the ESEER -European Seasonal Energy Efficiency Ratio - was implemented. By the publication of the certified data on the ECC website www.eurovent-certification.com the average chiller efficiency is comparable.

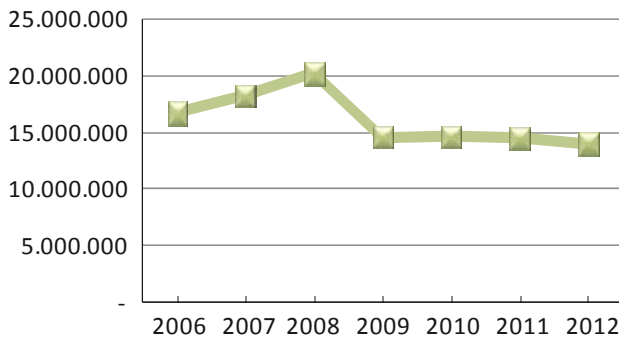


Figure 1. Chillers' sales evolution in cooling capacity, EU.

Chiller Construction Types

Water cooled chillers are built with plate and tube bundle heat exchangers as condensers. Hereby the heat is being dissipated into the ambient air by a re cooler in the secondary cycle. If the heat is being dissipated directly into the ambient air by a condenser, the system is called air cooled chiller. These are classified as either compact chiller for outdoor use with integrated air cooled condenser or chiller split system with an air cooled condenser for outdoor installation. Today, in most cases compact air cooled chillers are used.

Chiller Market

Most chillers are certified by Eurovent Certification Company. Currently 33 chiller manufacturers participate in the Certification Programme. The chillers' sales evolution in the EU in the past seven years is shown in Figure 1.

The EU sales proportion according to construction type and size is shown in Figure 2 and Figure 3 [1].

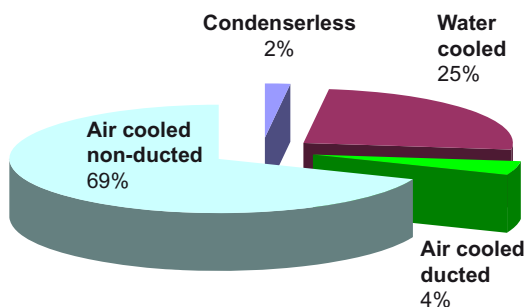


Figure 2. Chillers' sales by construction type (shares in cooling capacity, kW), EU 2011.

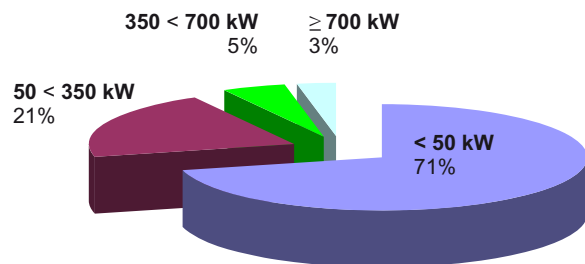


Figure 3. Chillers' sales by cooling capacity (shares in number), EU 2011.

In the following the energy consumption of the complete system water cooled chiller plus dry cooler is considered. Thereby the influence of the dry cooler's capacity on the energy efficiency of the complete system is shown.

On the initiative of the Eurovent certified heat exchanger manufacturers the performance of nine heat exchangers manufactured by seven European companies not participation in the Eurovent Certification Programme was tested in an independent test facility between 2004 and 2008. A comparison of the performance data tested with the values published in the manufacturers' product literature resulted in a capacity reduction up to 37% [2].

Calculation Model

A Eurovent certified water cooled chiller of Eurovent energy efficiency class B used for air conditioning (cooling only) is considered. The cooling capacity of 1 000 kW at full load and ambient temperature 35°C is provided by two screw compressors using refrigerant R134a. The evaporator is cooling down water from 12°C to 7°C. In the simplified model it is assumed that the temperature difference between condensing temperature and ambient temperature is fixed 12 K. The condenser is heating up the secondary fluid which is recooled by a dry cooler. In the dry cooler the secondary fluid is cooled down by 5 K to a temperature which is 5 K above the ambient temperature. The pump power of the secondary fluid is not considered. The study is comparing the efficiency of the chiller plus certified dry cooler with the chiller plus a non-certified dry cooler having a capacity gap of 25%. At full load the non-certified dry cooler is causing a 2.5 K higher condensing temperature of the chiller. At 75%, 50% and 25% part load operation the AC fans' speed of the non-certified dry cooler is raised to achieve the same condensing temperature as when using the certified dry cooler. By the calculation of the ESEER value of the complete system the energy efficiency is compared.

Results

The dry cooler fan power consumption is within the range of 10% and 20% of the total system's power consumption at the different load conditions (Figure 4).

Figure 5 shows the EER of the total system with the two different dry coolers. The ESEER value of the system using a dry cooler with capacity gap is 4.6% lower due to the higher power consumption of the chiller at full load and the higher power consumption of the fans of the dry cooler at part load operation.

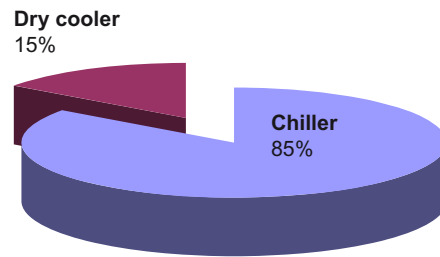


Figure 4. Power consumption of the total system chiller plus dry cooler (kW).

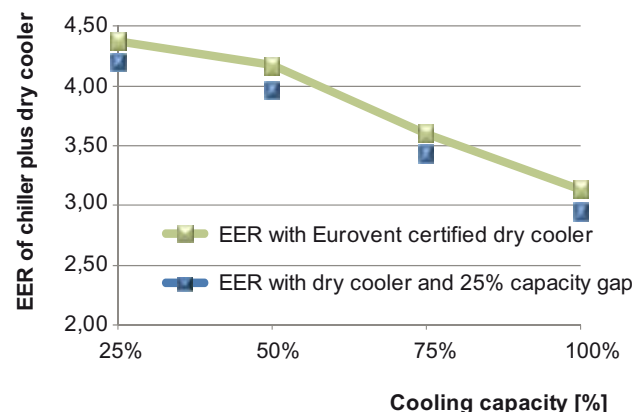


Figure 5. EER of system chiller plus dry cooler at different load.

For the City of Milan the annual energy saving of the chiller system using a dry cooler obtaining the designed capacity is around 20 000 kWh at calculated 3 542 operating hours. At energy costs of 0.15 €/kWh the saving in energy costs will be around 3 000 € per year. Assuming that a non certified dry cooler may be 10% cheaper the payback time is less than 1.7 years and every year annual savings in operating costs will be achieved. Additionally capacity gains or benefits when for example operating with free cooling are possible. For chillers with longer operating hours or chillers designed for process cooling the payback time will be even shorter.

Conclusions

The paper showed how important it is to use certified components and systems. Correct performance data for heat exchangers are absolutely essential, because they influence the energy efficiency of the entire system. In the study a water cooled chiller recooled by a dry cooler with a capacity gap of 25% was causing 4.6% higher energy costs.

References

- [1] Eurovent Market Intelligence: Chillers' Sales Data. E-mail January 2013.
- [2] Eurocent Certification Company: Flyer July 2009. 