Cool Concepts

For Industrial Refrigeration Systems

Issue 5— June, 2007

Industrial Refrigeration Energy Conservation

In this issue we will expand on some of the issues related to energy reduction in refrigeration systems. As might be expected this is dependent on many factors; most notably the capability of the system to respond to various operating conditions.

These conditions not only involve the facility requirements for cooling but also the daily weather conditions encountered or used for design purposes.

In order to meet the maximum duty requirement the system is often designed for a single, worse case point of operation. This is typically the warm summer months and full load/capacity requirements. As a result, the systems are rarely optimized for other operating conditions.

Refrigeration systems have specific requirements to meet their performance expectations.

The first requirement is to maintain the specified temperatures. This is accomplished by providing sufficient compressor and evaporator capacity to meet the required cooling demand.

For example, if the desired space temperature is 35°F (1.6°C), the refrigeration system must maintain a suitable lower temperature to effect heat transfer.

For this discussion, let's say the required temperature to be maintained by the refrigeration system is 25°F (-3.8°C). This is the evaporating temperature of the refrigerant.

> *"Refrigeration systems have specific requirements to meet their performance expectations."*

The 25°F evaporating temperature must be maintained to provide the 35°F space temperature so this is relatively fixed for temperature control reasons. Since this temperature is maintained as a constant, this establishes one of the compressor operating

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points, i.e., the maximum suction temperature & pressure.

During other operating conditions such as partial load requirements, it may be possible to raise the suction pressure and still meet the temperature requirements of the facility.

A similar concept occurs with the condensing pressure. As the system load decreases, the capacity required is also reduced. This causes the total system heat rejection to also decrease.

Since the suction pressure is relatively fixed due to the requirement of maintaining the proper space temperatures, the only parameter that is not constrained is the discharge pressure.

One of the common themes often repeated for energy savings is: "reduce the discharge pressure" or "allow the discharge pressure to float". The benefit of this is shown in Figure 1.

Using the example of 25°F (-3.8°C) as the saturated suction temperature and a discharge pressure of 175 psig (12.0 bar gauge) we see the overall compressor efficiency is approximately 1.0 Brake Horsepower (BHP) per Ton of refrigeration (BHP/TR). This is what you might expect to see in a normal summer day.

Note: To convert BHP/TR to kW/TR (kilowatt per Ton of Refrigeration): BHP/TR X 0.746 = kW/TR.

During other periods it is possible to allow the discharge pressure to decrease. The lower limit is usually determined by a combination of many factors, which are beyond the scope of this short article.

To continue the example, if we can operate the system with a discharge pressure of 135 psig (9.3 bar gauge), the BHP/TR ratio is reduced to approximately 0.8 BHP/TR (from Figure 1).

This is what is meant as floating the discharge pressure. As the weather conditions or heat rejection requirements change, the discharge pressure is allowed to operate through a range of pressures.

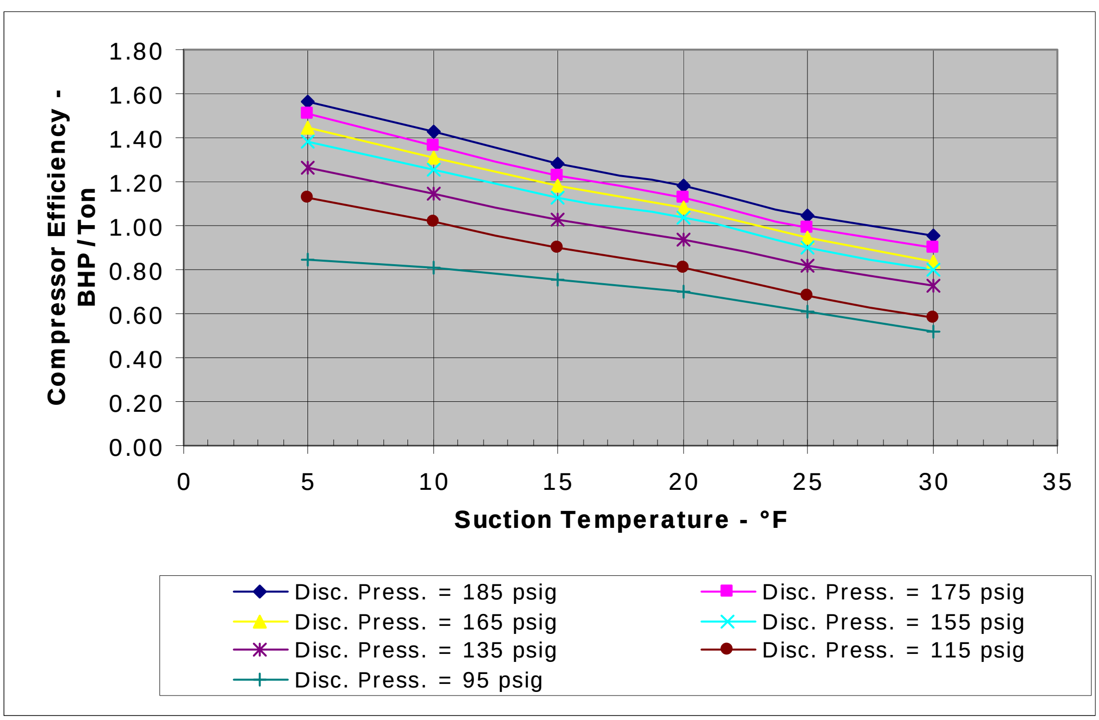

Figure 1. Energy Use versus Capacity Produced. Based on NH3 reciprocating compressor.

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The weather conditions are one of the governing factors controlling the discharge pressure. If a properly sized condenser is installed for summer full load conditions, lower discharge pressure/condensing temperatures can be attributed to a reduction in the wet bulb temperature of the air entering the condenser.

Figure 2 shows a typical range of values for air wet bulb temperatures for a Wisconsin locale. This provides an example of the range of values that might be expected over an annual period of 8,760 hours. This data also illustrates how the discharge pressure range can be viewed.

Estimating the range of potential discharge pressures is a complex subject, however, this can be simplified for an example.

Figure 3 shows a plot of a specific system and condenser capacity for various condensing temperatures. This data is specific to a fixed system and not applicable to any other. Any other system will need to have this data individually developed for the exact requirements. THIS IS FOR EXAMPLE ONLY!

In Figure 3, the horizontal line labeled "System Heat Rejection" represents the actual heat rejection of the refrigeration system at full load/capacity. The resulting intersections of condensing temperatures at

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various wet bulb temperatures shows the effect of floating discharge pressures/condensing temperatures.

These curves show the condensing temperature increasing as the entering wet bulb temperature increases. Conversely, the condensing temperatures decrease as the entering wet bulb temperature reduces.

Another important concept is found when the actual system heat rejection decreases. In this case, the horizontal line moves downward.

As the heat rejection decreases, the condensing temperature rebalances to a lower value for a fixed entering wet bulb temperature. Again, please note a lower limit will be reached on the minimum condensing tem-

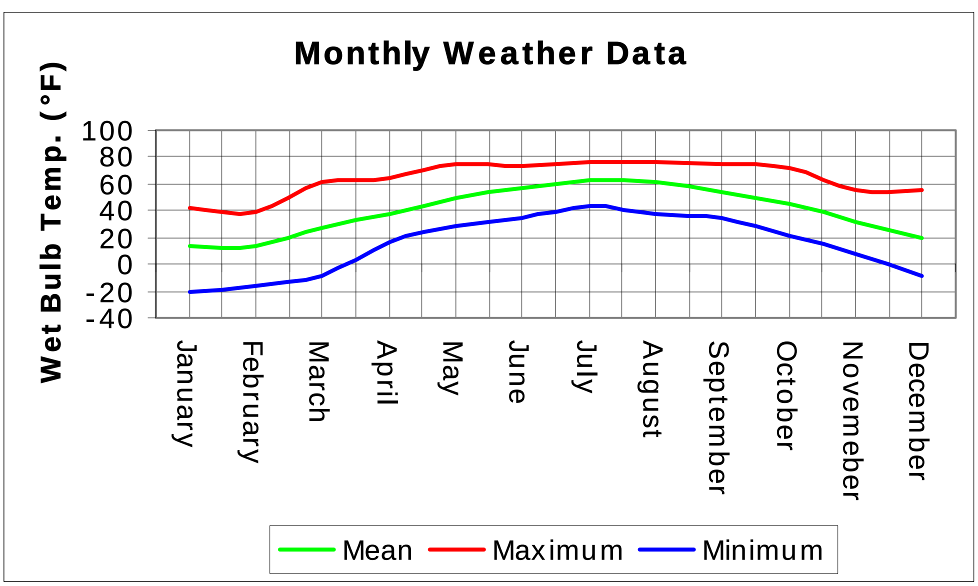

Figure 2. Typical meteorological data for location of refrigeration system.

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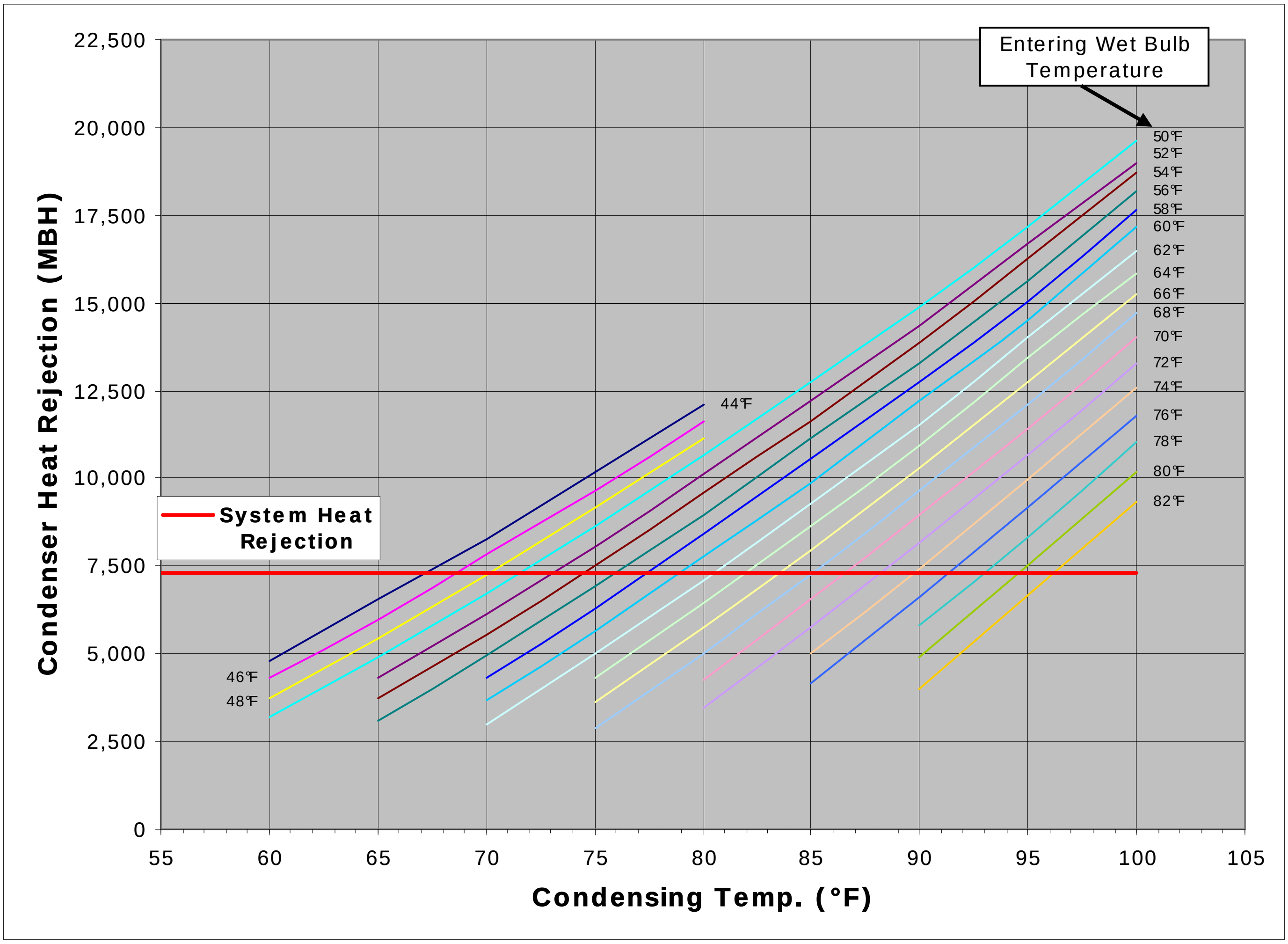

Figure 4. Example of typical range of possible operating conditions for a specific refrigeration system. Note: 1 MBH = 1,000 Btu/hour.

perature that can be achieved with this method. This lower limit is a function of the system design, and the equipment and piping installation used for any given system. The dependency on these factors, determines the reductions that are achievable.

This short article has identified the major aspects of energy conservation principles and the potential for reducing discharge pressure. If you are interested in learning more or having an analysis performed for your system, please contact us.

Cold Systems, LLC provides technical assistance to owners and other users of refrigeration systems. Using our services will provide you with long-term value and benefits of:

- Energy reduction with increased efficiency & equipment capability, and
- Reduction of challenging issues & improved operational flexibility

We offer a broad range of services designed to promote safety, reliability, and cost effectiveness for refrigeration systems. You can rely on our 35 years of experience to help solve your problems and increase the cost-effectiveness of your refrigeration system .

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