



# The Cold Front

*The Electronic Newsletter of the Industrial Refrigeration Consortium*

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## BACK TO BASICS: THE QUEST FOR ENERGY EFFICIENCY IMPROVEMENTS IN YOUR INDUSTRIAL REFRIGERATION SYSTEMS

Refrigeration is one of the more energy-intensive technologies that find use in manufacturing operations – primarily food plants. Driven by consumer demand for high quality food products including prepared meals, the trend in many food plants has been toward processes that require more not less refrigeration. The increase in refrigeration intensity is escalating overall plant end-use energy requirements. For example, the consumer appetite for frozen ready-to-cook entrees and sides seems unquenchable. These products require energy-intensive quick freezing unit operations in order to maintain high product quality. Quick freezing unit operations are among the

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most energy intensive in food plants because of the low operating temperatures required. The expanding usage of quick freezing operations results in an increase in the total energy required to produce a unit of finished product albeit at a higher quality with longer shelf life.

Coinciding with the expansion of more energy intensive plant processes, corporate executives and managers with operations responsibility are pushing to reduce the overall energy consumption in their manufacturing plants. Why? Because all indications are that the cost of primary energy to operate plants will rise into the future. With energy costs rising, it is becoming increasingly important for plants to improve their operating efficiency to maintain a competitive advantage in the marketplace. Second, the move towards sustainability demands peak energy performance. These trends are putting pressure on plant operations staff to identify effective measures that can level or reduce the energy consumption in their facilities.

This article discusses ten strategies for improving the efficiency of industrial refrigeration systems. Seemingly a simple order, the fact is that realizing energy efficiency improvement in these systems can be difficult for a number of reasons including:

- Industrial refrigeration systems are custom-engineered systems to meet specific process needs – this makes prescriptive energy conservation measures difficult to identify because each system is “one-of-a-kind.”

## UPCOMING AMMONIA COURSES

### *Process Safety Management Audits*

January 9-11, 2008                      Madison, WI

### *Ammonia Refrigeration: Uncovering Opportunities for Energy Efficiency Improvements*

February 13-15, 2008                      Madison, WI

### *Introduction to Ammonia Refrigeration*

March 5-7, 2008                              Madison, WI

### *Ammonia Refrigeration System Safety*

April 9-11, 2008                              Madison, WI

### *Introduction to Ammonia Refrigeration*

March 5-7, 2008                              Madison, WI

### *Engineering Calculations for PSM and RMP*

May 13-15, 2008                              Madison, WI

### *Design of NH<sub>3</sub> Refrigeration Systems for Peak Performance and Efficiency*

September 15-19, 2008                      Madison, WI

### *Introduction to Ammonia Refrigeration*

October 8-10, 2008                              Madison, WI

### *Intermediate Ammonia Refrigeration*

December 3-5, 2008                              Madison, WI

See [www.irc.wisc.edu/education/](http://www.irc.wisc.edu/education/) for more information.

## NOTEWORTHY

- Mark your calendars now for the **2008 IRC R&T FORUM** – May 7-8, 2008 in Madison
- Send items of note for next newsletter to **TODD JEKEL**, [tbjekel@wisc.edu](mailto:tbjekel@wisc.edu).

- Food production facilities often require refrigeration 24x7x365. Energy efficiency improvement measures that require refrigeration system or plant shutdowns are difficult to implement.
- Since refrigeration up-time is crucial, plants operations staff are risk averse to any changes that may undermine their ability to provide “cold” to the production floor.

With that background, here are ten ideas aimed at improving the efficiency of your industrial refrigeration systems. These ideas are proven – you just need to evaluate each for implementation in your own plant’s context.

1. **FLOATING HEAD PRESSURE CONTROL:** Many plants operate their systems with head (condensing) pressures higher than necessary. Although the ability to lower a system’s head pressure is limited by ambient conditions, many plants can operate with considerably lower minimum head pressures. If your ammonia-based refrigeration system’s head pressure never falls below 125 psig, you may have an opportunity to further improve system efficiency. As a rule-of-thumb, you can expect the efficiency of your system’s compressors to improve by 1.3% for each degree F in lower saturated condensing temperature (1°F is about 3 psig for ammonia).
2. **RAISE SUCTION PRESSURE/TEMPERATURE:** If your plant utilizes evaporator pressure regulators on all of its loads, there may be an opportunity to raise your system’s suction pressure set point. As a rule-of-thumb, you can expect the capacity of your system’s compressors to improve by 2.5% for each degree F in increase saturated suction temperature. Efficiency increases will depend on the starting point of your suction pressure increase but improvements in the range of 2% for each degree F increase in saturated suction temperature are possible.
3. **VARIABLE FREQUENCY DRIVES FOR EVAPORATOR FANS:** Because most evaporators do not operate at their design load 100% of the time, their capacity needs to be varied to meet the instantaneous thermal load. The efficiency of evaporators at part-load conditions can be improved in most systems by the application of variable speed drives for evaporator fans. The savings attributable to the application of variable speed drive fans will depend on a number of factors including: system suction pressure, evaporator part-load ratio, evaporator fan type, face velocity of air over evaporator coil, and others. Figure 1 illustrates the potential in a freezer application by showing the combined compressor and evaporator operating efficiency where the nominal saturated suction temperature for the system is –20°F. Note the variable speed fan option is increasingly advantageous to the fixed speed fan option as the part-load ratio of the evaporator decreases. For more information on this opportunity, see our [Cold Front](#) newsletter in **Vol. 4 No. 4 (2004)**.
4. **VARIABLE FREQUENCY DRIVES FOR COMPRESSORS:** Variable speed drives for compressors should be approached with caution. Compressors in these systems tend to be driven by large frame motors making the cost of applying a variable speed drive expensive. At most, consider having only one variable speed drive compressor per suction pressure level in the plant. The variable speed machine should then be used as a “trim machine” by using speed control for capacity modulation. For more information on this opportunity, see our [Cold Front](#) newsletter in **Vol. 4 No. 3 (2004)**.

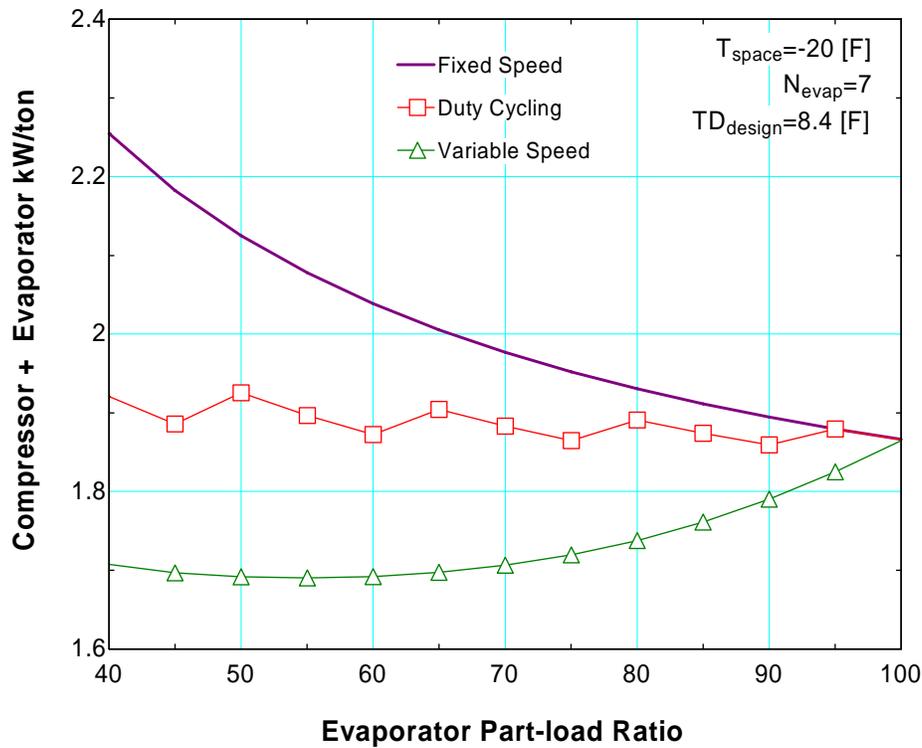


Figure 1: Compressor plus evaporator fan power for part-load evaporator operation in a freezer application.

5. **VARIABLE FREQUENCY DRIVES FOR CONDENSER FANS:** Somewhat similar to comments on applications for evaporator fans, variable frequency drives for condenser fans can yield operating costs savings. In many cases, system savings on the order of 2–3% are possible with this option. Savings will depend on a number of factors including: relationship of heat rejection capacity available to that required, minimum head pressure set point, type of condenser fans, and others. If you pursue a VFD project for condenser fans, it is important to install VFDs on all condenser fans and modulate their capacity equally to avoid liquid management problems on the system's high-side. For more information on this opportunity, see our [Cold Front](#) newsletter in **Vol. 4 No. 2 (2004)**.
6. **HEAT RECOVERY – OIL COOLERS:** It is possible to recover heat from the discharge gas on high-stage compressors; however, a more effective option to consider is heat recovery from oil cooling heat exchangers on your screw compressor packages. The heat recoverable from oil cooling heat exchangers is readily available in reasonable quantities and at a higher grade when compared to the heat capable of being recovered from the discharge gas stream. For more information on this opportunity, see our [Cold Front](#) newsletter in **Vol. 6 No. 4 (2006)**.
7. **COMPRESSOR SEQUENCING AND CONTROL:** Controls are required on compressors to match their capacity with that required by the system. The most widely used compressor technology in industrial refrigeration systems today is the screw compressor. Unfortunately, the efficiency of a screw compressor package decreases as its capacity decreases by unloading. For example a typical screw compressor operating at  $-20^{\circ}\text{F}$  suction and  $90^{\circ}\text{F}$  condensing will have a full-load efficiency of  $\sim 2.2$  BHP/ton. When unloaded to its minimum capacity (10% in

this case), the horsepower requirement for this same machine will increase to 8.8 BHP/ton! Sequences of operation should be reviewed to minimize the duration of individual machines operating at part-load ratios less than 70%.

8. **IMPROVE DEFROST SEQUENCES:**

Air-cooling evaporators that operate at low temperatures will accumulate frost. As frost accumulates on a coil, its capacity will decrease causing the efficiency of the system to correspondingly decrease. Manske (2000) estimated that poor hot gas defrost sequences and controls accounted for 13% of the electrical energy in a cold storage warehouse. Most plants can benefit by pursuing defrost sequences that avoid prolonged periods of hot gas supply (i.e. hot gas dwell times in excess of 15 minutes should be avoided) and only defrosting individual evaporators on an as-needed basis rather than simply defrosting on frequency established by a time-clock.

9. **CONVERT OIL COOLING FROM LIQUID INJECTED TO EXTERNAL:**

Screw compressors require some means of oil cooling. The use of high pressure liquid refrigerant for oil cooling is common in a number of systems. Liquid injection oil cooling results in increased compressor power and reduced capacity conspiring to reduce the system's efficiency. Converting from liquid injection to external (thermosiphon or fluid-cooled) oil coolers can yield savings in the range of 3-10%. For more information on this opportunity see these past [Cold Front](#) issues: **Vol. 3 No. 1 and No. 3 (2003)**.

10. **REDUCE PARASITIC LOADS:** Look for opportunities to eliminate the "heat leaks" into your system. Failed insulation, poor door seals, open doors, and

excessive conveyor openings, are examples of easy fixes to heat gains that rob your system of both capacity and efficiency. Visual inspections and more sophisticated thermal imaging can be used to pinpoint these hot spots. Find and fix them.

Of course each of these opportunities needs to be evaluated for an individual system.

Where can I go for more information? In 2004, the IRC published the [Industrial Refrigeration Energy Efficiency Guidebook](#) that covers these and other energy efficiency improvement strategies for industrial refrigeration systems. The process of seeking out and evaluating opportunities for energy efficiency improvements in your plant is not only enjoyable, it is rewarding.

## REFERENCES

- Manske, K. "Performance Optimization of Industrial Refrigeration Systems", M. S. Thesis, University of Wisconsin-Madison, (2000).
- Reindl, D. T., et al., [Industrial Refrigeration Energy Efficiency Guidebook](#), Industrial Refrigeration Consortium, available for purchase at:

## SEASONS GREETINGS

We at the IRC hope that you and your family have a safe and happy holiday season.



## **2008 IRC RESEARCH & TECHNOLOGY FORUM**

**MAY 7-8, 2008                      THE PYLE CENTER - MADISON, WI**

The **INDUSTRIAL REFRIGERATION CONSORTIUM** is pleased to announce that the **8<sup>TH</sup> ANNUAL RESEARCH & TECHNOLOGY FORUM** will be held on **May 7-8, 2008** at the Pyle Center in **Madison, WI**. This event will feature presentations by IRC staff, IRC member organizations, and industry experts.

The 2008 IRC R&T forum is your opportunity to receive the latest information on current refrigeration research, regulatory updates, emerging technologies. It is also a great opportunity for you to provide input on needs for future research in the area of industrial refrigeration. During this event you will also have an opportunity to meet and exchange ideas with other industry experts. We are in the process of finalizing the agenda for this day-and-a-half event but expect presentations on the following topics:

- Principles of Mechanical Integrity for Industrial Refrigeration Systems
- Safety and Process Safety Management
- Technology Update
- Trends in Sustainability
- Incidents & Accidents Lesson's Learned
- Back-to-Basics: Codes and Standards
- Interactive session refrigeration-related research at the UW and IRC tools

The Forum is an event open to everyone with an interest in industrial refrigeration. Staff from IRC-member organizations are welcome to register at no cost. A nominal registration fee of \$99 is required for non-IRC members to help recover meeting costs. Attendees will receive copies of all presentation materials. **Because seating is limited, we encourage you to register for this event today!** Register on-line [here](#).

**IRC MEMBERS** are reminded to arrive early for the Steering Committee business meeting scheduled to be held from 1-5 pm on **May 6, 2008**.

For more details on the forum and to register, visit our website [www.irc.wisc.edu](http://www.irc.wisc.edu). If you have any questions regarding presentation topics, please contact the IRC at 866-635-4721 or [info@irc.wisc.edu](mailto:info@irc.wisc.edu).