Industrial Refrigeration
Best Practices Guide

Third Edition
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Prepared by
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Industrial Refrigeration Best Practices Guide

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Cascade Energy Engineering (Cascade) is an industrial energy-efficiency consulting firm. Cascade provides both retrofit and new-construction capital studies, tune-ups and retro-commissioning, utility demand-side-management program design and administration, research and development, and energy-management services. Cascade has multiple technical specialties, with ammonia refrigeration being a prominent example. As of the release of this version of the guide, Cascade has worked intensively with over 500 ammonia refrigeration systems.

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Background

This Guide identifies and discusses best practices for making industrial refrigeration systems both energy-efficient and productive. The highest levels of efficiency in these systems are achieved through a combination of design, construction, commissioning, operation, and maintenance coupled with a robust energy management program. This Guide provides insights into approaches to industrial refrigeration systems that cost less to operate, are reliable, can maintain accurate and consistent temperatures in refrigerated spaces, help ensure that processing equipment operates consistently, and can meet varying production needs.

This guide targets the full range of interested, influential, or affected parties associated with industrial refrigeration. This includes system operators, maintenance staff, design engineers, refrigeration contractors, equipment vendors, production staff, management, and owners. After reading this guide, it should be possible for anyone in this list to have a substantive and productive discussion about improving the performance of refrigeration systems. This guide contains a minimum of formulas, thermodynamic diagrams, and technical detail—just enough to achieve a common understanding and appreciation that enables real continuous improvement. The focus is real-world situations and solutions, not academic pursuit.

Goals

Ultimately, improving energy efficiency in industrial refrigeration is achieved by changing the business practices of food-processing companies, cold-storage and refrigerated warehouses, and the trade allies that support and serve them. Design standards and operation-and-maintenance practices that increase and maintain energy efficiency can also be adopted by users of industrial refrigeration and their engineering consultants and contractors.

In this context, the goals of this Best Practices Guide are:

- To identify opportunities to increase electrical energy efficiency in industrial refrigeration systems

The Guide specifically focuses on energy savings measured in kilowatt-hours (kWh). It is written primarily for audiences where energy costs are the largest portion (usually over 80%) of typical
electric bills. The Guide does not specifically address reducing peak monthly power demand, measured in kilowatts (kW). However, in most cases, a system that saves energy will also reduce peak demand. This Guide also does not address load-shifting strategies, where refrigeration load is shifted from a high-cost time period to a low-cost time period, nor does it address reactive power (power factor, or kVAR) or power-quality issues such as harmonics.

- To better understand industrial refrigeration as a system Energy efficiency in industrial refrigeration includes both selecting efficient components and integrating those components into an efficient system. The goal is to minimize the energy consumption of the entire system. Frequently, one or more small constraints in a system can limit the efficiency of the overall system. In other instances, reducing the energy use of one type of component may increase the energy use of another. Understanding the way the system behaves as a whole lets us avoid building in “weak links” and allows us to strike an efficient balance between components.

- To motivate system designers, contractors, plant engineers, and owners to consider life-cycle costs when installing or upgrading industrial refrigeration systems The equipment-supply and design-build businesses are very cost-competitive, and facility owners have limited capital budgets. Therefore, system design often emphasizes low initial cost rather than low life-cycle cost. Energy costs are the most significant ongoing life-cycle cost, and are a major component of the total present-value cost of a refrigeration system.

- To highlight non-energy benefits of energy-efficient practices In most situations, investments in energy efficiency can also reduce labor costs, increase productivity, increase product quality, and increase system reliability.

- To emphasize that best practices include more than just system design Commissioning and well considered operation-and-maintenance practices contribute importantly to the long-term energy performance of the system.

- Encourage facilities to implement a robust energy management program A successful energy management program allows a facility to sustain and improve upon the efficiency benefits that have been achieved. Key elements of a successful energy management program include establishing an “Energy Champion” that is accountable for system energy use, tracking Key Performance Indicators (KPIs) of system efficiency, ensuring that key personnel receive appropriate training, and creating a culture that embraces a continuous improvement philosophy towards energy efficiency.

Focus on Industrial Refrigeration

This Guide focuses solely on industrial refrigeration systems, which we define in the following broad terms.

Table I: Qualifying attributes of industrial refrigeration systems

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size:</td>
<td>100 tons or larger</td>
</tr>
<tr>
<td>Refrigerant:</td>
<td>Ammonia (R-717) in the vast majority of cases, with some R-22 applications</td>
</tr>
<tr>
<td>System Type:</td>
<td>Centralized and built-up, as opposed to commercial refrigeration equipment, which is simpler, more modular, and distributed</td>
</tr>
<tr>
<td>Load Temperatures:</td>
<td>-60°F to 55°F with normally at least one load below 40°F</td>
</tr>
<tr>
<td>Function:</td>
<td>Primarily storage and processing of food products</td>
</tr>
<tr>
<td>Industries:</td>
<td>Refrigerated warehouses, including controlled atmosphere</td>
</tr>
<tr>
<td></td>
<td>Fruit and vegetable processors, ranging from fresh product storage to highly processed pre-prepared meals</td>
</tr>
<tr>
<td></td>
<td>Breweries and wineries</td>
</tr>
<tr>
<td></td>
<td>Dairy and ice cream processors</td>
</tr>
<tr>
<td></td>
<td>Meat, poultry, and fish processors</td>
</tr>
</tbody>
</table>
Industrial refrigeration systems are distinct from two related system types, which are not covered in this Guide:

- Commercial refrigeration systems which tend to be smaller, simpler, and more modular. Examples include a grocery store rack system or rooftop-mounted air-cooled packaged unit systems.
- Large HVAC systems that cool spaces occupied by people and equipment, and that maintain space temperatures higher than 55°F. An example would be a chilled-water system that includes centrifugal chillers and cooling towers serving a commercial building or industrial process.

**Overview of this Best Practices Guide**

This Best Practices Guide is written for a wide audience. Readers (and users, for it is intended that this document be used) will certainly include:

- Owners, officers, and regional managers of food processing companies
- Plant managers, production and operation managers, and maintenance managers
- Corporate engineering staff at food processing companies
- Operators of refrigeration systems
- Personnel in utility efficiency programs
- Design engineers and energy analysts
- Contractors and vendors who serve the industrial refrigeration market

Although most of this Best Practices Guide will be of interest to all readers, some sections will be of particular interest to specific audiences. The chapters of the Guide and how each audience may find them valuable are outlined below. We hope that you will find useful information on best practices for your refrigeration system for energy efficiency, to control operating costs, and to realize productivity benefits—fundamentally, to improve your bottom line.

**Chapter 2: Best Practices Overview**, beginning on page 5, includes an overview of design, operation, and maintenance best practices, an outline of the major categories of improvement, and a guide on how to obtain best practices in industrial refrigeration systems.

**Chapter 3: Refrigeration System Basics**, beginning on page 10, reviews refrigeration basics and, if needed, will help familiarize you with industrial refrigeration concepts and equipment. Regardless of your level of familiarity with refrigeration systems and related components, this chapter will be a very useful reference.

**Chapter 4: Best Practices for Equipment, Systems, and Controls**, beginning on page 50, describes energy-efficient concepts, equipment, controls, and system types, along with recommended best practices. If you are an owner, plant engineer, or operator, we recommend that you understand these best practices and consider them, if feasible, for your facility. This chapter also highlights the benefits beyond energy cost savings that are often associated with increased energy efficiency. This chapter is not an engineering manual and should be accessible to all potential readers described above.

**Chapter 5: Best Practices for O&M and Commissioning**, beginning on page 90, addresses how operation, maintenance, and commissioning affect the energy performance of the system. This chapter is not a training manual for operation and maintenance, but addresses these points on a higher level that is suitable for most readers.

**Chapter 6: Tools for Implementing Best Practices**, beginning on page 98, explains the role of an energy management program and provides tools and concepts to help you address your system and work toward best practices. This chapter is geared more toward management personnel (owners, corporate engineers, and operators) at food processing plants. It includes a self-assessment survey that covers many of the concepts featured in this Guide, along with other energy management tools, concepts, and engineering references.

**Appendix A: Hot-Gas Defrost**, beginning on page 120, summarizes the principles, equipment, and practices associated with hot-gas defrost and how this can affect efficiency of a refrigeration system.
Appendix B: Case Studies, beginning on page 129, includes three short case studies that were selected to show how some of these best practices have been implemented in the Pacific Northwest.

You will find another useful resource at the end of Chapter 4. Beginning on page 86, under Efficiency Checklist, are three tables—one each for compressors, evaporators, and condensers—that summarize the key best practices from Chapter 4 and Chapter 5.
This section contains short case studies that were selected to show how some of these Best Practices have been implemented in the Pacific Northwest.

- Henningsen Cold Storage
- Oregon Freeze Dry
- SYSCO Food Services
- WestFarm Foods
The Project

The Henningsen family has been in the cold-storage business since 1923. When you have been in the business for more than eighty years, you take the long view, and one way to do that is to look at life-cycle costs.

Headquartered in Hillsboro, Oregon, Henningsen Cold Storage Co. is a full-service, public, refrigerated warehousing company that offers over 36 million cubic feet of frozen and refrigerated warehousing space and has locations in Idaho, North Dakota, Oklahoma, Oregon, Pennsylvania, and Washington.

In 1996, Henningsen built a state-of-the-art cold-storage warehouse in Gresham Oregon. After nearly a decade of operation, it is still an outstanding example of Best Practices in energy-efficient industrial refrigeration.

Energy Use Comparison

Benefits
- Reduced energy cost
- Less wear of equipment
- Improved temperature control

Financial Overview
- Incremental Installation Cost: $410,000
- Oregon Business Energy Tax Credit: $143,500
- Portland General Electric Incentive: ~$70,000

Energy Savings
- 58% of base energy use
- 1,140,000 kWh/year

Energy Cost Savings
- $51,000/year (1996 rates)

Resources
- Project Owner: Henningsen Cold Storage
  (503) 531-5400
  www.henningsen.com
  (509) 529-8040
  Marcus Wilcox, PE.
  marcus.wilcox@cascadeenergy.com
- Business Energy Tax Credit: Oregon Department of Energy
  1-800-221-8035 (inside Oregon)
  (503) 378-4040
  www.energy.state.or.us
- Electric Utility: Portland General Electric
  (Incentives are now available through the Energy Trust of Oregon)
  1 (866) 368-7878 (inside Oregon)
  (503) 493-8888
  www.energytrust.org
The Gresham Warehouse Story

During the summer of 1995, planning was nearing completion on the new Henningsen Cold Storage facility in Gresham, Oregon. The 50,000-square-foot facility would provide food-storage and blast-freezing services to their customers. According to Paul Henningsen, great-grandson of the company’s founder and director of corporate development, the goal for the facility was to provide high-quality services at a fraction of typical operating cost. Cascade Energy Engineering, Inc. was brought in to recommend cost-effective energy-efficiency measures.

Because this was a new construction project, a “baseline” design was developed that included standard facility design, equipment, and controls. This was compared to a system design that included state-of-the-art equipment and controls, along with extra insulation and efficient lighting. The new facility opened in June of 1996 and was built with all recommended efficiency improvements.

After a rigorous commissioning and verification process, annual energy savings of 1,140,000 kWh, worth $51,000, were documented—a 42% reduction compared to the baseline design.

The incremental cost of the upgrades in design, equipment, and controls was $410,000. These additional costs were partially offset by efficiency incentives from the serving utility, Portland General Electric and by state tax credits offered by the Oregon Department of Energy. These incentives brought the effective payback down to about four years (at 1996 energy rates).

At the time, Paul Henningsen said “This project reduces our power bill and improves our bottom line, and since we know more about what’s going on in our facility, we make better decisions. My advice is that since power rates never seem to get cheaper, installing efficient equipment will help you offset likely increases.”

These words proved to be prophetic. The four-year payback may have been a bit of a stretch at the time, but the Henningsen team’s foresight was rewarded when energy rates surged upward in 2000.

Energy Efficiency

Energy-efficiency improvements include:
- 6 inches extruded polystyrene wall insulation
- 6 inches extruded polystyrene floor insulation
- 15 inches extruded polystyrene ceiling insulation
- Three fast-acting warehouse doors serving dock
- 400W Bi-level HPS lighting fixtures
- Oversized condenser at 85°F design
- Axial condenser fans
- VFD condenser and evaporator fan control
- Evaporators sized for 10°F temperature difference
- Three diversely sized screw compressors
- Thermosiphon compressor cooling
- Premium-efficiency motors
- Computer control system
- Automatic non-condensable gas purger
- Coordinated VFD and slide-valve control on trim compressor

Continued Success

The energy-efficient system design proved its worth to the company’s bottom line, so when Henningsen more than doubled the size of the facility in 1998, efficient design, equipment, and controls were again specified. This brought an additional 660,000 kWh per year in energy savings and reduced operating costs by $30,000 annually.
Oregon’s Willamette Valley with its mild climate, 40 inches of annual rainfall and fertile soil is one of the largest food production centers in the nation. It was the perfect home in 1963 for a small firm that processed dried fruit for breakfast cereals. Over the years, the firm developed military rations and private-label food brands. It also perfected the freeze-drying process that combines the freshness, color, and aroma of frozen foods with the shelf stability and convenience of canned and dehydrated foods. Today, Oregon Freeze Dry, Inc. in Albany is the largest custom processor of freeze-dried products in the world and a technological leader in the freeze-drying process.

Oregon Freeze Dry has three manufacturing plants on its 35-acre site. Its manufacturing process is energy-intensive, especially the two-stage ammonia-based industrial refrigeration system that serves 14 freeze-dry chambers and several cold rooms.

The company’s engineering staff initiated a study, with help from Pacific Power and an energy-engineering firm. The study revealed several energy-saving opportunities that the company implemented.

In March 2003, Oregon Freeze Dry completed installation of variable-frequency drives (VFDs) on each of four screw compressors of its refrigeration system. These allow the compressor motors to vary speed to match refrigeration loads. The company also replaced an undersized 8-inch suction line with a 12-inch line. The energy savings of the VFD and suction line were substantial—nearly 2 million kilowatt-hours annually or 34% of the refrigeration system’s base energy use. In addition, the VFDs require minimal employee training and reduce motor and compressor wear.

The Project Summary

Benefits
- Reduced energy use
- Less wear of equipment
- Minimal employee training
- Improved system control

Financial Overview
Incremental Installation Cost
$241,777
Oregon Business Energy Tax Credit
$81,535
Pacific Power Incentive
$115,042

Energy Savings
34% of base energy use
1,939,000 kWh/year

Energy Demand Savings
160 kW/month (results are highly variable)

Energy Cost Savings
$77,700/year

Resources
Project Owner
Oregon Freeze Dry, Inc.
(541) 926-6001
www.ofd.com

Energy Consultant
Cascade Energy Engineering, Inc.
(503) 287-8488
Rob Morton, PE.
rob.morton@cascadeenergy.com

Business Energy Tax Credit
Oregon Department of Energy
1-800-221-8035 (inside Oregon)
(503) 378-4040
www.energy.state.or.us

Electric Utility
Pacific Power (For Oregon customers, incentives are now available through the Energy Trust of Oregon)
Inside Oregon: 1 (866) 368-7878,
www.energytrust.org
Outside Oregon: 1 (800) 222-4335
energy.expert@pacificorp.com
In industrial refrigeration systems, VFDs are often cost effective for screw compressors, evaporator fans, and condenser fans. Generally, VFDs are useful where equipment operates for long hours in systems with variable loads or light loads.

If a compressor operates at or near full speed most of the time, adding an adjustable speed drive will not be cost effective. A VFD may not always be the best way to control capacity. Sequencing of multiple compressors or the use of a reciprocating compressor for trim are other possibilities.

The use of VFDs is only one way to save energy in industrial refrigeration systems. Other ways include refrigeration computer control, thermosiphon oil cooling, high-speed energy efficiency doors, and bi-level lighting.

ABB variable frequency drives were installed on four screw compressors (two high stage and two booster compressors). The remaining four compressors are now used for base loading and back-up.

A Techni-Systems computer-control system manages which compressors run and at what speeds to meet the refrigeration load with maximum efficiency.

A 12-inch-diameter suction line supplements the old 8-inch line.

VFDs and control system efficiently vary the capacity of the refrigeration system with speed control rather than with the less efficient slide valves.

Energy savings of 1,939,000 kilowatt hours/year (34 percent of base energy use) with no reductions in production.

Energy cost savings of $77,700/year.

Reduced wear on motors and compressors due to soft starts and fewer operating hours.

The VFDs and control system require minimal employee training.

The existing compressors inefficiently varied capacity with slide valves. The VFDs would instead allow the compressor motors to vary speed to match refrigeration loads. The existing undersized suction line created a large pressure drop which required a lower (and less efficient) system suction pressure.

Oregon Freeze Dry management reviewed the report, found the financial payback and incentives attractive, and approved the installation.

Background

The engineering staff at Oregon Freeze Dry believes plant energy use is their responsibility. In 2002, they decided to look at the ammonia-based refrigeration system, one of their most energy-intensive systems. They invited Al Leake of Pacific Power to discuss energy-efficiency projects and available incentives.

Pacific Power arranged for Cascade Energy Engineering to perform an energy study to find specific ways to improve the efficiency of the refrigeration system. Their report suggested three efficiency measures: 1) installing variable-frequency drives (VFDs) on four of the eight compressors; 2) adding a new suction line between two plants, and 3) expanding computer controls to manage the VFDs.

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Oregon Freeze Dry management reviewed the report, found the financial payback and incentives attractive, and approved the installation.

Features

- ABB variable frequency drives were installed on four screw compressors (two high stage and two booster compressors). The remaining four compressors are now used for base loading and back-up.
- A Techni-Systems computer-control system manages which compressors run and at what speeds to meet the refrigeration load with maximum efficiency.
- A 12-inch-diameter suction line supplements the old 8-inch line.

Replication

- In industrial refrigeration systems, VFDs are often cost effective for screw compressors, evaporator fans, and condenser fans. Generally, VFDs are useful where equipment operates for long hours in systems with variable loads or light loads.
- If a compressor operates at or near full speed most of the time, adding an adjustable speed drive will not be cost effective.
- A VFD may not always be the best way to control capacity. Sequencing of multiple compressors or the use of a reciprocating compressor for trim are other possibilities.
- The use of VFDs is only one way to save energy in industrial refrigeration systems. Other ways include refrigeration computer control, thermosiphon oil cooling, high-speed energy efficiency doors, and bi-level lighting.
SYSCO Food Services

The Program

SYSCO has long been a market leader in the highly competitive North American food-service distribution industry. At the heart of the company are over eighty broadline distribution facilities spread throughout the United States and Canada. These facilities provide ingredients needed to prepare meals as well as other services for restaurants, hotels, schools, cruise ships, and other food-service locations.

In 2006, SYSCO established energy goals for each broadline facility to reduce use by 10% in the first year and by 25% after three years (by 2009). “Energy represented the next layer of our operating costs that could be reduced,” noted Pete Richter, SYSCO Corporate Project Manager. “We had some past experience implementing energy projects at a few of our facilities. The ROI for these projects was always excellent. We knew that a corporate-wide effort could yield tremendous cost savings.”

Energy Management Strategy

To achieve their energy efficiency goals, SYSCO implemented an energy management program at each facility:

- **Energy Champion**: An Energy Champion was assigned at each facility. The Champion is accountable for achieving SYSCO’s energy reduction goals and manages all energy related aspects at the facility. The Champion also manages key resources such as facility maintenance staff, vendors and contractors, and the local utility in order to implement energy efficiency improvements.

- **Key Performance Indicators (KPIs)**: A website tool was developed to track facility energy use and to establish KPIs which track and benchmark improvements. KPIs include tracking current facility energy use versus historic performance and plant energy use per warehouse storage volume.

- **Commissioning**: A rigorous commissioning was conducted by Cascade Energy Engineering at each facility to identify low- or no-cost opportunities to reduce energy use.

- **Capital Projects**: Each facility was tasked with identifying, prioritizing, and implementing capital projects to reduce energy use in an effort to meet SYSCO’s energy reduction goals.

- **Performance-Based Incentives**: A system was put in place to tie compensation of the energy champions and upper management to achieving and sustaining SYSCO’s energy efficiency goals.

In regards to establishing comprehensive energy KPIs, Richter commented, “SYSCO has always been a data driven company. We recognize that extending this philosophy to energy is critical towards achieving and sustaining success.”
PROJECT SUMMARY

Changes Made

Refrigeration
- Increased suction-pressure setpoint of freezer system
- Increased suction-pressure setpoint of cooler system
- Lowered condensing pressure setpoint
- Improved sequencing order of condenser pump and fan
- Optimized defrost frequency and time for each evaporator zone
- Reduced heating intensity and duty cycles of cold-storage door
- Tuned hot-gas defrost regulator
- Lowered temperature setpoint of underfloor glycol heating

Lighting
- Reduced delay times of occupancy sensors on bi-level lighting
- Relocated poorly positioned occupancy sensors on bi-level lighting

HVAC
- Lowered HVAC heating setpoints and raised cooling setpoints
- Optimized HVAC return-air setpoints

Financial Overview

Energy Savings
17% of total facility
1,700,000 kWh/year

Energy and Demand Cost Savings
$100,000/year

Resources

Project Owner
SYSCO Food Services of East Wisconsin
(262) 677-1100
www.syscoeast.com

Energy Consultant
Cascade Energy Engineering, Inc.
(509) 529-8040
Marcus Wilcox, P.E.
marcus.wilcox@cascadeenergy.com

East Wisconsin Commissioning

In April 2006, the SYSCO East Wisconsin facility was one of the first broadline facilities commissioned. The purpose of the commissioning was to identify low or no-cost opportunities to reduce energy use through improvements in the refrigeration, lighting, HVAC, and battery charger systems. Potential capital upgrades to reduce facility energy use were also identified.

The commissioning team consisted of the Tom Raimer, Energy Champion for the SYSCO East Wisconsin Facility, the facility maintenance staff, and an energy engineer and technician from Cascade Energy. A list of action items to reduce energy use was developed and the facility implemented each over the course of the next several months.

The SYSCO East Wisconsin facility realized immediate energy savings after the commissioning was performed. “A number of areas were identified where improvements could be made,” commented Raimer. “The energy savings from the changes that were made were immediately noticeable on the following month’s utility bill.”

One year after the commissioning, energy use was reduced by an average of 17 percent and peak demand was reduced by 17 percent versus the previous year, reducing energy and demand cost savings by over $100,000.
WestFarm Foods is one of the largest dairy manufacturers in the nation, with 1,200 employees at 11 processing plants in Washington, Oregon, Idaho and California. In early 1996, WestFarm Foods began planning for an expansion and modernization of their Portland, Oregon creamery.

WestFarm engineers were designing a new Extended Shelf Life (ESL) processing line and the associated cooler space. Increased loads from the ESL process and cooler would require adding a 350-hp compressor to supplement the existing 350-hp and 600-hp screw compressors. This in turn would require another condenser.

WestFarm and their Portland General Electric account representative arranged for Cascade Energy Engineering to perform a detailed energy study, starting with data logging of the existing refrigeration system. The data collected included suction pressure, condensing pressure, and compressor slide valve position. Hour meters recorded run time for the liquid solenoid valves and power measurements were made on the primary refrigeration compressor.

Data logging revealed three major issues with the existing systems. First, compressors operated unloaded much of the time because they were sequenced manually, not by computer control, to meet the wide range of plant loads. Second, the high minimum condensing pressure of 140 psig, which was required to ensure proper liquid ammonia flow throughout the sprawling plant, resulted in increased compressor power, particularly during the winter. Third, the evaporator coil liquid solenoids in the milk cooler were off much of the time, resulting in excessive fan power.
Efficiency Opportunities

A review of the baseline refrigeration bid specification revealed several opportunities to increase energy efficiency. First, the baseline design condensing temperature of 90°F would unnecessarily increase summer compressor energy use. Second, the heat rejection rate of the baseline condenser was a relatively inefficient 225 MBH/hp. Efficiencies of 300 MBH/hp or higher are possible. Third, the baseline design included neither computer control nor variable-frequency drives (VFDs).

Efficiency Measures

Implemented energy-efficiency measures include:
- Refrigeration computer control system
- Screw compressor VFD control
- Evaporator fan VFD control in ESL cooler
- Evaporator fan VFD control in milk cooler
- 90 psig condensing pressure
- Oversized/efficient evaporative condenser
- Condenser fan VFD control

Features

A computer control system was installed to provide improved compressor sequencing, tighter control of condenser fan set points, and more importantly, a “backbone” for VFD control.

A 350-hp VFD was installed on the new compressor, working in conjunction with its slide valve to provide load trim. The other compressors are now either off or at 100% capacity.

VFDs were used on the evaporator fans in the milk cooler and the new ESL cooler. The computer reduces fan speed whenever space temperature is satisfied.

A new high-pressure ammonia receiver with a booster pump was installed to ensure adequate liquid pressure to sensitive loads. This allowed the minimum condensing pressure to be reduced from 140 psig to 90 psig.

A larger, more efficient condenser was specified, and all condenser fans were equipped with VFD control to manage condenser capacity with speed rather than cycling.

Results

Implemented measures reduced annual energy consumption at the WestFarm facility by more than 2,000,000 kWh—nearly 40% of the total refrigeration energy use. Annual operating costs were reduced by about $75,000.

The entire package of improvements cost $310,000. Although this represented an attractive 4.2-year payback, incentives from Portland General Electric and a 35% tax credit from the Oregon Department of Energy reduced the final customer payback to one year.