Optimizing Efficiency with a Kaizen Blitz

An intensive kaizen blitz, combined with an appropriate system of followup and tracking, can significantly increase industrial refrigeration system efficiency.

By Marcus Wilcox and Robert Morton, Cascade Energy Engineering Inc.

Company owners and senior executives are increasingly focused on reducing energy costs and energy use, both because escalating energy costs are affecting the bottom line and because successful efforts to proactively cut energy use are seen as an important element of good corporate citizenship. Energy awareness at the executive level frequently translates into a corporate decree to cut energy use by 5 or 10 percent or more. The decree typically is not accompanied by a large capital budget to revamp or upgrade the major energy systems on site. Instead, the facility or maintenance manager must make it happen with ingenuity. In a large food processing or distribution company, it makes the most sense to wring these savings out of the biggest energy user — the industrial refrigeration system.

The kaizen blitz is a strategy that can help achieve the required energy reduction. The intent is to reach the goal quickly with lasting results and minimal challenges. Kaizen is a Japanese word that means “change for the better” or “improvement.” The English translation is “continuous improvement.” In general, kaizen focuses on eliminating waste, improving productivity and achieving continuous improvement in targeted activities and processes of an organization.

The kaizen approach involves using a team to solve problems. It is centered around employees but also involves contractors, vendors, consultants and technicians with an interest, responsibility or insight to help the process. The process relies on taking objective measurements and making fact-based decisions.

The kaizen blitz is simply a short, intensive version of this process. The team pores over the system, equipment, operations, control strategies and maintenance practices to identify and make specific changes that will improve the process and produce energy savings. Within two to three days, the effort results in a substantial list of both implemented and identified improvements.

In the blitz, the team needs to:

- Identify inefficient setpoints or control strategies that are “band-aids” on an underlying problem.
- Think through equipment specifications and system operations to differentiate between real and perceived barriers.
- Evaluate and measure performance on select refrigeration components that seem to be underperforming.
- Look at as many system components as possible to identify maintenance tasks that might yield energy savings (for example, dirty coils, scaled condensers, plugged spray nozzles or leaking hot gas valves).
- Investigate how temperature, pressure and potentiometer calibration errors might

have a hidden energy impact.

- Review control system history to observe how the system responds to varying loads, ambient conditions and production schedules.
- Contact the manufacturers or control system programmers to establish the capabilities of the existing equipment or to explore alternate uses or settings.
- Brainstorm how minor operational changes might yield major refrigeration savings.
- Dispense with long-standing misperceptions or fears regarding operational strategies and setpoints.

Low-risk changes are made on the spot and documented, and a watch list is compiled for possible problems that could arise. Other changes are phased in so that the system response can be observed over a period of days or weeks.

Clearly, the kaizen blitz is only the beginning. It is rare that all changes are completed during the event. In most cases, an extensive to-do or action-item list remains for site staff to implement as soon as possible. Often, the process works best when a single person — sometimes called the "energy champion" — manages the assignment, tracking and subsequent followup of the action items and is rewarded for successes.

The 5 Whys

The effectiveness of the kaizen process is in large part associated with a dogged pursuit of cause and effect. Toyota coined the phrase the "five whys" to describe the process of digging progressively deeper to find the root cause of a problem. Repeating "Why?" five times (or another similar probing question) will nearly always reveal a solution. An example from industrial refrigeration is provided below.

Q: Why are you running two compressors unloaded? Won't one suffice?
A: I can't run only one because the slide valves will not fully load.
Q: Why won't the slide valves fully load?
A: The motors reach their current limit and the microprocessor forces compressor unloading.
Q: Has it always done this?
A: Yes, since we purchased the compressors used. Although they served a freezer, we figured they would work fine in our cooler application.
Q: Do the compressors have an adjustable volume ratio feature?
A: Yes. In fact, you can see it sticking out on the driven side of the compressor.
Q: Was the volume ratio ever adjusted for your specific conditions?
A: No, we were in a hurry to get the compressors running.

Continuing to ask probing questions finally brought us to a solution: The volume ratio of the screw compressors was never properly set. The compressors were operating at the wrong volume ratio and were over-compressing. The horsepower penalty forced the compressors to unload due to current limiting in the microprocessor. With the volume ratio controls corrected, the compressors could fully load, and one could be shut off. The facility was able to eliminate the inefficiency of over-compression and reduce part-load efficiency penalties.

This type of dogged pursuit identifies an issue, delves into the causes and repercussions, and ultimately identifies a direct path for a solution and improvement.

The Kaizen Event Team

For an industrial refrigeration system, the kaizen team includes in-house personnel, outside vendors and contractors who sold or service the equipment, and a party or group to provide a "fresh set of eyes" to the system and processes. A typical team includes:

- The refrigeration operator.
- Refrigeration maintenance staff and supervisors.
- Production managers.
- The site general manager.
- The refrigeration contractor (service contractor or original installing contractor).
- The refrigeration equipment or control system vendor.
- A refrigeration energy consultant.
- An independent refrigeration service technician.

All of these parties bring their ideas to the table. The operators, maintenance staff and service contractors typically have a long history with the refrigeration system. Their insight into operations, past problems, system quirks and limitations are valuable in creating a plan for improvement.

It is important to strive for a broad acceptance of new ideas. For example, an operator that was trained a certain way might struggle with a particular recommendation by the energy consultant. The maintenance supervisor isn't an expert on refrigeration, so he defers to the opinion of the respected refrigeration contractor. The contractor likes the idea but would like approval from the compressor manufacturer before making any changes. The compressor manufacturer is contacted by the energy consultant and provides approval with certain conditions. The operator is then authorized to make the change. The energy consultant explains the theory behind the change, and success is achieved while ensuring the entire team is behind the effort. Long-term gains are likely as a result.

Note that an energy consultant and outside service technician enhance the process by providing a combination of theory and practicality. Both offer objective observations that kick off the "five whys," as well as other probing inquiries that increase the depth and scope of the investigation. They typically have implemented identical or similar measures in other plants. This experience lowers risk and helps home in on viable solutions quickly. They also provide the energy expertise to calculate the costs and benefits of specific changes, thereby helping to prioritize the opportunities and motivate the team. This expertise also helps keep the emphasis on true energy savings and avoids half solutions or "rabbit trails" without a true energy benefit. The energy consultant and outside service technician essentially lead the process, bring the team together, and reach out to outside vendors for information, approval or advice concerning changes.

Examples of Kaizen Blitz Successes

The following examples of the process illustrate the kaizen blitz methods and resulting benefits.

Why Are You Single-Staging Your Freezer? Walking through the engine room of a plant, we noticed that a compressor was configured for single-stage operation to serve a freezer, despite the fact that the system was designed for two-stage

Figure 1. This automatic volume ratio control slide stop was never connected to the compressor microprocessor panel.

operation. The operator indicated that the compressor could barely maintain suction and that it "really ran hot." Indeed, the compressor was drawing nearly a full load of motor current, but we attributed this to the single-stage configuration. We decided to switch the compressor into booster mode and operate in a more efficient two-stage configuration.

The engine room valve positions were changed to reassign the compressor as a booster, and the compressor was started. It ran five minutes and then shut off on low oil pressure. We had forgotten to change the microprocessor dip switch to booster mode. We adjusted the dip switch and confidently fired the compressor back up. Again, it shut off after five minutes, and "low oil pressure" was once more displayed on the microprocessor LCD display. Why was the pump turning off? The dip switch should have changed the pump from cycling to full-time operation.

We called the microprocessor manufacturer (which was different from the compressor manufacturer) and learned that the panel had been retrofit in 2001. The panel needed a firmware upgrade to operate the oil pump correctly in booster mode. We thought we had solved the issue.

Returning to the compressor, we opened the microprocessor panel to return the machine to its original configuration. That was when we noticed two wires lying in the bottom of the cabinet with a piece of tape strapped around them, on which someone had written "Slide stop not using" (figure 1).

The compressor had an automatic volume ratio adjustment feature — surely the volume ratio was being controlled. We again contacted the microprocessor manufacturer and were told that the panels were built when a competitor's patent was in place for automatic volume ratio control, so the feature was not available. A firmware upgrade and some additional input/output (I/O) devices would correct the problem.

We then contacted the compressor manufacturer to find out how we could lock the compressor into a high volume ratio until the panel was upgraded. We discovered that we could lock it into a low volume ratio, but locking it in high would require a control panel retrofit or physical modifications to the compressor.

We couldn't run the compressor as a booster because the panel wasn't capable. We wanted to return the compressor to single-stage operation, but we were forced to run it at the wrong volume ratio. The only true fix was a microprocessor panel upgrade, which is now an action item for the energy champion at this site.

Why Are These Condenser Nozzles Sucking Air? Inspecting evaporative condenser spray nozzle and water treatment is a standard step in any effort to improve refrigeration system energy efficiency. At a two-year-old site, three identical condensers were in service. Removing the drift eliminators from the top of the condenser revealed that water was barely dribbling from the nozzles. The same phenomenon was seen on all three condensers. Surprisingly, the spray nozzles closest to the pump were actually sucking air.

The team discussed many options for this odd behavior, including the pump sucking air, the pump turning in the wrong direction or something lodged in the pipe. Finally, a technician ventured to guess that the polyvinyl chloride (PVC) piping had been pushed too far into the header box. There was only one way to find out, so the water to the condenser was turned off, and the piping was disassembled. When the PVC pipe was pulled out of the head box, the problem was obvious. Indeed, the assembly process at the factory had inadvertently pushed the PVC pipe all the way into the box, bottoming it out against the metal wall of the unit. Water was highly constricted where it should have flowed freely, and the water rocketed past the first few nozzles (figure 2). The velocity of the water was causing a venturi effect, sucking air into the pipe. It was only at the end of the PVC header that the water finally slowed down and dribbled out of the nozzles.

A reciprocating saw was used to cut off the troublesome 3" of extra length on the pipe. The pipe was reinserted in the header, and everything was bolted back together. When the water pump was turned on, a pleasing blast of water cascaded over the condenser tubes. The remaining condensers were corrected by the site staff.

Now that all of the tubes are being fully wetted, the system has full condensing capacity, which has resulted in lower discharge pressure, reduced condenser energy and improved water treatment. The condenser manufacturer was notified of the unusual development in case a similar situation arises for another customer.

Figure 2. Hardly any water was flowing through this condenser because the PVC header had been inserted too far into the water distribution head box.

The kaizen blitz has proven to be an outstanding tool to achieve substantial, quick-hitting energy efficiency gains in industrial refrigeration systems. With an appropriate system of followup and tracking, energy savings of 10 to 15 percent or more are within reach. This approach is appropriate for any company using industrial refrigeration, regardless of age, size or the status of existing energy management programs. **PCE**

Marcus Wilcox is president and Robert Morton is a vice president of Cascade Energy Engineering Inc., Wilcox and Morton have been working with ammonia refrigeration systems for a combined total of more than 30 years, most recently focusing on achieving low- and no-cost energy efficiency gains through strategies such as the kaizen blitz. To date, over 100 industrial systems have benefitted from this approach.

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Reprinted from ***Process Cooling & Equipment*** ©November/December 2006

COMPANY BACKGROUND

Cascade Energy Engineering has been providing industrial energy efficiency consulting since 1993. Although industrial refrigeration and food processing facilities comprise a substantial portion of the projects, Cascade also serves the petrochemical, pulp & paper, wood products, and general manufacturing sectors with expertise in compressed air, pumping, fans, controls, VFDs; virtually all sub-systems common to industrial processes.

Cascade's services include scoping, detailed studies, design assistance, commissioning and kaizen blitzes, inspection, and program design. Cascade also offers corporate-level energy management services, including program design and long-term continuous improvement strategies. Custom energy management web sites include real-time pulse metering, utility tracking, company benchmarking, and energy efficiency action item management.

Cascade's clients range from small family-owned facilities to world-class companies such as SYSCO, Kroger, ConAgra, Nestle, and many others. Clients also include electric utility demand-side management programs such as those offered by PacifiCorp, Bonneville Power Administration, the Energy Trust of Oregon, and Southern California Edison. Cascade also works with non-profit and government agencies such as the Northwest Energy Efficiency Alliance, the Industrial Efficiency Alliance, and the Northwest Food Processors Association.

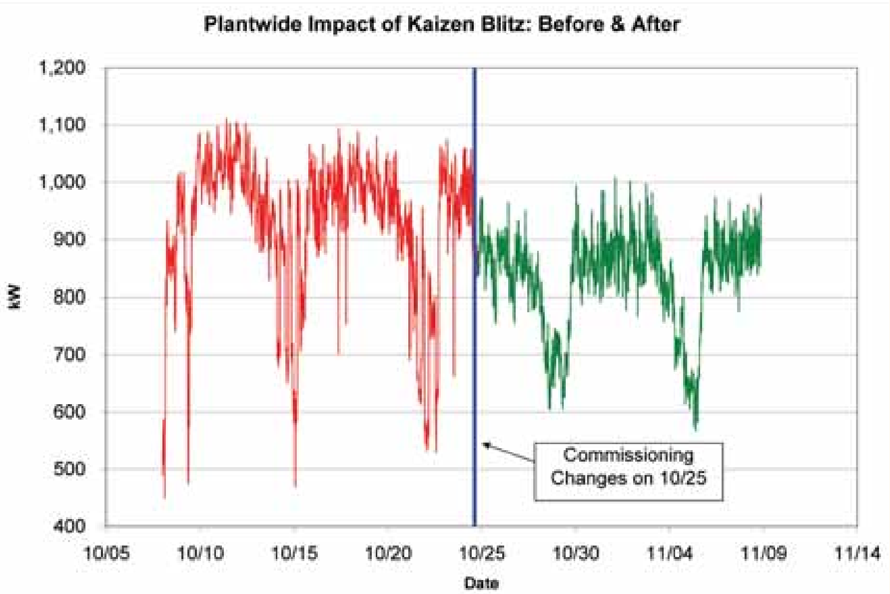

Figure 3. Facility-wide savings of 12% was realized after two days of intensive control tuning and refrigeration adjustment.

To set itself apart, Cascade focuses primarily on industrial projects, and strives to achieve a reputation of excellence, experience, and objectivity across the full spectrum of vendors, contractors, customers, utilities, and non-profit & government programs. Whether assessing a 10,000 hp ammonia refrigeration system, a complicated petrochemical pipeline & compressor system, or a rural agricultural irrigation project, Cascade provides the sound recommendations and economic justification to make successful energy efficiency projects happen.

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