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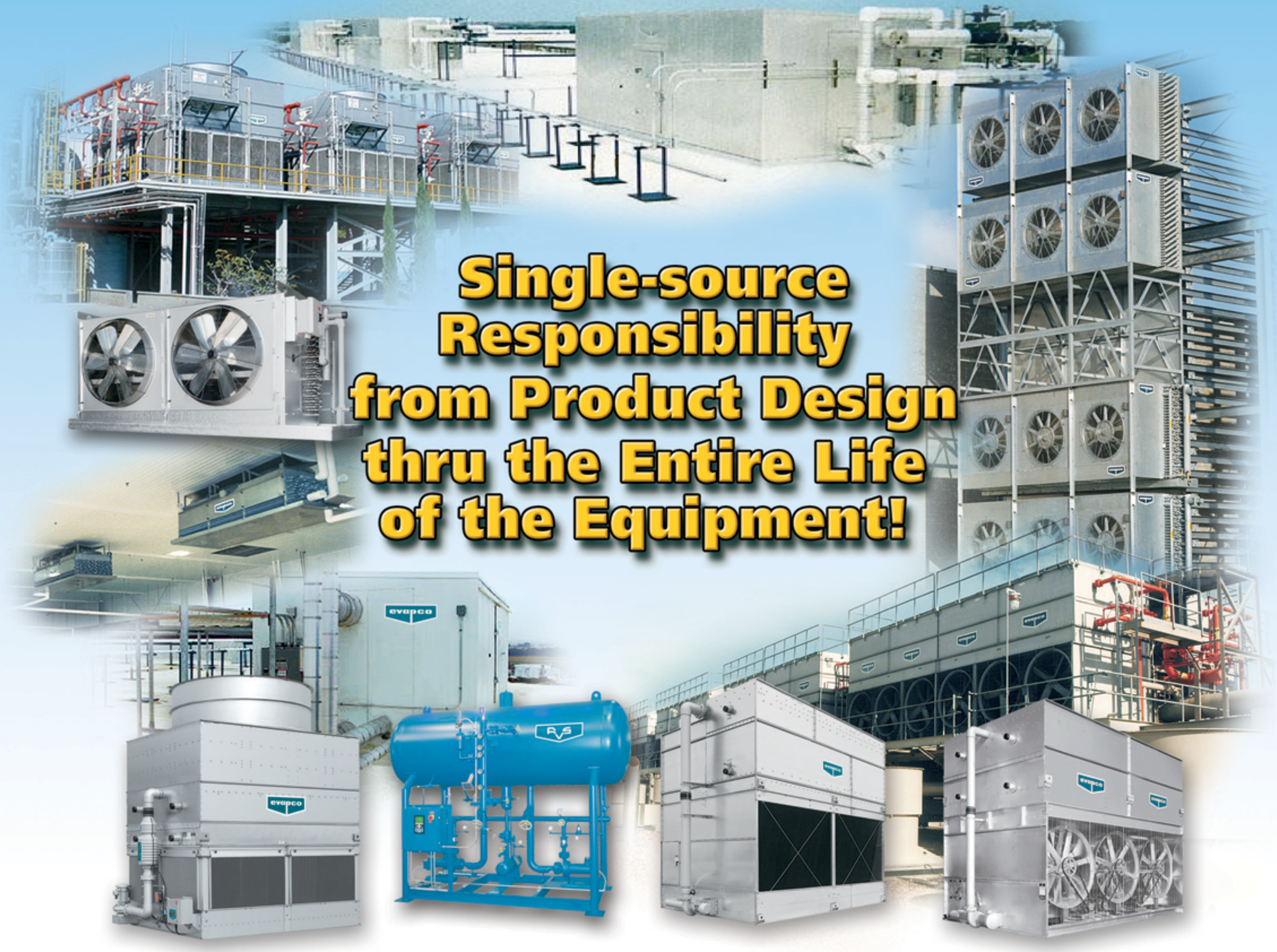

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Industry News & Notes

A New Ammonia Training Facility in North Carolina

On July 20, ground was broken for a new Ammonia Refrigeration training facility at Sampson County Community College near the town of Clinton, NC. The Industry Partners Ammonia Refrigeration Building will be a 5,000-square-foot facility that will house state of the art equipment and provide hands-on training for both the beginner and the seasoned operator. The building is scheduled for completion in February 2010. The state-funded ammonia refrigeration training program will present week-long training sessions to prepare students to take the RETA certification exam. The facility will also be a site for one-day seminars.

GEA Refrigeration Adds Carton Freezing and Chilling Systems to its Product Line

GEA Group recently acquired IntecUSA, a leading supplier of carton freezing and chilling systems headquartered in Durham, North Carolina. According to a GEA news release, the acquisition of Intec is in keeping with the company's strategy of acquiring companies which round out its technological or geographical product portfolio. Intec's carton freezer product line and technology complements the spiral and tunnel freezers of GEA Aerofreeze in North America, Europe, South America and the Middle East.

Because of the high demand for food safety and corresponding quality standards, carton freezers have become the standard technology for freezing boxes worldwide. The purpose of these freezers is the cooling, chilling and freezing of food products in a continuous process in an industrial environment. Intec's products are used across the food industry for foods such as meat, poultry, vegetables, cheese and ice cream. Intec is among the leading companies in its field in North America and is expanding in South America and the Middle East. In 2008, Intec generated sales of approximately $11.2 million with a workforce of about 20 employees. Intec USA joins GEA FES and GEA Aerofreeze as part of the company's North American operation.

BAC and Colmac Coil Announce Strategic Alliance

Baltimore Aircoil Company and Colmac Coil Manufacturing have announced the formation of a strategic alliance to provide Aircoil™ Evaporators to the Industrial Refrigeration Market. Under the agreement, the number of manufacturing facilities available will double and provide additional product depth.

"With this exciting new development, the two companies are leveraging Colmac's innovative technology and engineering expertise with BAC's strong brand, manufacturing know-how, and extensive distribution network," stated Colmac President Bruce Nelson.

Evaporators will continue to be manufactured in all materials of construction for ammonia, CO_2, and glycol/brine refrigerants in both Midwest, and Colville, Washington, production facilities. As part of the new agreement, Colmac will distribute Aircoil evaporators along with its existing line of standard and custom industrial refrigeration evaporators and air-cooled condensers exclusively through the BAC representative network in the USA, Canada and Mexico.

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CHAIR'S MESSAGE

By Don Stroud, Kraft Foods

It's the middle of August when the demand for refrigeration is at its peak in North America and many other places around the world. That also means there is a greater demand for electricity which typically leads to higher operating expenses.

As an industry, we are constantly on the lookout for new and better ideas that will reduce the cost of refrigeration. It's a topic that gets a lot of attention every year at the IIAR Industrial Refrigeration Conference & Exhibition. Next year's annual meeting in San Diego is no different. The cover article in this issue of the *Condenser* (see page 4) is a preview of just one of the technical papers that will address this topic.

The article in this issue tells the story of a new cold storage facility built in San Diego, California. The facility embraced green principles and design to improve energy efficiency as much as possible. Based on the design, the savings could be as much as 75% which gives it the potential to become the first such facility in the U.S. to achieve Leadership in Energy & Environmental Design (LEED) gold certification in cold storage. The use of an ammonia refrigeration system at the facility had a lot to do with making that possible.

The article demonstrates a point that our industry has advocated since the schedule to phase out the use of CFC and HCFC refrigerants was included in the Montreal Protocol. The use of natural refrigerants like ammonia and CO_2 is a viable alternative that does more than just reduce operating costs. It is also a responsible environmental choice.

Another article in this issue of the *Condenser* addresses the topic of packaged systems, a topic that will also be covered at the Conference & Exhibition in San Diego. The concept of packaged refrigeration systems is not new, but it is revolutionary when applied to industrial ammonia systems in the US. The Europeans have incorporated the packaged system concept for several years due to their need for smaller systems, regulations that force smaller refrigerant charges, and the cost of labor to install, operate and maintain field-erected systems.

This issue of the *Condenser* also features a report from our new Global Cold Chain Alliance Government Relations Consultant, Lowell Randell (page 10), that addresses a new pilot program from the Occupational Safety and Health Administration (OSHA) National Emphasis Program (NEP) focused on PSM-covered chemical facilities. The NEP, announced in late July, has been under development over the last three years as a result of safety incidents at chemical facilities, including some involving ammonia.

At the conclusion of the one-year pilot program, the results will be analyzed and a determination will be made about the future of the new program. During the year, programmed inspections will take place in OSHA Region 1 (New England), Region 7 (Midwest), and Region 10 (Pacific Northwest). Unprogrammed inspections will also follow the NEP procedures, so inspections of facilities that have an accident or complaint will also be subject to the NEP. In addition, facilities subject to Site-Specific Targeting (SST) inspections will also be subject to the NEP inspection procedures.

IIAR strongly encourages all members with PSM regulated facilities to insure that their PSM and RMP programs are up to date with particular attention to training and emergency preparation. If your company does not have a PSM specialist, you may want to consider using a consultant to review your PSM program and prepare for potential inspections.

IIAR and the GCCA continue to meet with OSHA to help ensure that members have the latest and best information regarding this program and how it will be administered. At the same time, we are pursuing a formal alliance with OSHA through our position as a Core partner in the Global Cold Chain Alliance. OSHA's Alliances provide parties an opportunity to participate in a voluntary, cooperative relationship with OSHA for purposes such as training and education, outreach and communication and promoting a national dialogue on workplace safety and health.

We'll be sure to keep you posted on the latest developments on these and many other topics on the IIAR website and here in the pages of the *Condenser*.

Case Study

Collaboration and Innovation Achieve Reduced Energy Costs for San Diego Cold Storage Building

By Sandi Cain

When San Diego-based Innovative Cold Storage Enterprises Inc. decided to add a second cold storage facility in suburban San Diego County, they decided to embrace green principles and design the facility to be as energy efficient as possible. ICE Inc. knew that if energy costs could be reduced by 75%, they'd realize significant savings. They also would have a shot at becoming the first such facility in the U.S. to achieve Leadership in Energy & Environmental Design (LEED) gold certification in cold storage. There is only one other LEED-certified cold storage building in the country, but it did not reach the gold certification level. ICE-II's application is pending.

"A large percentage of the energy bill comes from refrigeration," said Tom Dosch, PE, project engineer for Brea, California-based C&L Refrigeration, one of the 10 original contractors that brainstormed energy efficiency ideas for ICE-II.

ICE Inc. had learned how energy costs can impact a building's operational costs when it opened the 3.7 million cubic-foot ICE-I in 1999. Within a year, electricity rates had climbed rapidly and represented 15% to 30% of the building's overhead, taking a toll on profits.

For ICE-II, resolving refrigeration challenges in the building design, such as integration of the refrigeration system with photovoltaic panels and handling wastewater generated from the refrigeration system, was paramount. That also meant convincing ICE Inc. that ammonia was the best refrigerant for the new building.

"If you want to build a cold storage facility to LEED gold standards, then you want to select a natural refrigerant," Dosch said. Since ammonia breaks down to its natural components

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of nitrogen and hydrogen in a relatively short time, it has zero global warming potential and ozone depleting potential, earning it high environmental marks.

R-22 and ammonia have similar operating characteristics, but ammonia is more efficient. In this case, the annual energy savings was projected to be $32,700, but the payback was estimated at 5.8 years. When combined with other energy-efficiency measures such as a larger condenser, a floating head with variable speed and variable set point, variable speed control of air unit fan motors, a flash economizer, variable speed control on the screw compressors and R-50 insulation for the roof, the payback was reduced to 1.5 years. That was a more attractive selling point.

The overall inspiration for the green design of ICE-II was a Sustainable Communities Program from San Diego Gas & Electric (SDG&E), a public utility that serves 3.4 million consumers in Southern California. The program encourages green building, energy efficiency and renewable energy initiatives. In all, it provided incentive funding that totaled $244,473 from three programs for ICE-II's energy-efficient features, including a highly efficient ammonia refrigeration system.

The payoff for meeting the challenge with ICE-II: the potential to receive additional energy rebates available through Savings by Design, another SDG&E energy efficiency program launched in 2006 that encouraged supermarkets and refrigerated industrial facilities to incorporate energy-efficient refrigeration systems in new construction projects that would meet the baseline requirements. The program covered construction contracted in 2006 that was completed within 48 months. The incentive amount was based on the calculated annual kWh savings compared with a baseline-compliant building. The incentive carried a maximum of $150,000 per project and ICE-II qualified for the maximum.

Energy-Efficient Measures

Energy efficiency measures chosen specifically because of their potential for savings at ICE-II were:

- Integrating refrigeration with solar and wind power—a breakthrough that enabled the refrigeration system to adjust itself to meet the output of the solar power available on any given day during peak hours.
- An ammonia system with three equally sized screw compressors, an evaporative condenser and eight evaporator coils for the freezer that are fed with re-circulated ammonia. The condenser has a specific efficiency of 425 BTUH/Watt, much higher than the base case efficiency (the base case design was the starting point from which alternatives were considered.) Eight freezer air units with premium efficiency motors of 91% efficiency were chosen. These measures were estimated to save $32,700 annually.
- Optional equipment enhancements included: variable speed control of air unit fan motors in the freezer that would reduce speed to a 60% minimum in response to temperature and save $174,600 per year; a flash economizer vessel to cool the ammonia liquid from the condenser before going to the low temperature recirculator was projected to save $11,900 per year; and variable speed control on screw compressors to control capacity down to 30%.
- Cool roof insulation, plus insulation in the walls and ceiling of the freezer and dock were used, along with additional roof insulation to provide an R-value of 50 hr-ft2-F/BTU. The solar absorptivity of the roof was assumed to be 0.30, which is prescribed by baseline for cool roofs. The base case value is 0.70. By reducing the solar energy absorbed through the roof, the cooling load is reduced during warm weather.
- The freezer air unit fans operate at a reduced speed and deliver reduced cooling tonnage during the on-peak hours to save $15,300 annually. The ton-hours unmet during the peak period are recovered during subsequent hours. The team projected a conservative savings amount due to the difficulty of simulating the mass and thermal response of the freezer.
- Low lighting power density in the freezer area incorporates task lighting in the retrieval lifts to reduce annual costs by $87,900. To achieve maximum efficiency, aisle lighting is wired and controlled by motion sensors
- In-folding dock levelers and high speed freezer doors achieve a cost savings estimated at $18,700.

SDG&E also granted an Emerging Technology incentive of $79,773 to offset the cost of LED light fixtures activated by motion sensors in the freezer warehouse and dock areas. The LED lights turn on and off more quickly than regular lights, don't emit as much heat and use less electricity, adding to the building's energy efficiency. Later, an additional $14,700 in Emerging Technology incentive money was granted for energy monitoring software.

But before these incentives could be won, the design team had to dig in to find the best way to achieve the maximum energy efficiency. "The pursuit of LEED certification meant we were looking at many different (design) elements," Dosch said. Besides C&L Refrigeration and ICE-II, other design team members were:

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Novel Solutions

ICE-II faced challenges that were outside the norm for cold storage buildings. So the team developed solutions and worked with other contractors to find ways to achieve the objectives. The challenges included:

- A 60-foot ceiling height that was 25 feet taller than is typical for cold storage facilities. The height meant the evaporators couldn't be suspended from the ceiling and still be accessible for maintenance. As a result, penthouses were designed on the roof to house the evaporators. By using the penthouses, they were able to use just a few large evaporators rather than many small ones. The taller building also reduced the amount of light and floor space that generates heat in conventional cold storage units. Storage racks stretch 50 feet high and are set on narrow, 6-foot aisles (half the normal width) to maximize storage space and minimize travel distances.
- Reducing the heat load to attain a 75% more energy-efficient building was a key part of the project. The solution was increasing the height to 60 feet to create more storage space without more square footage on the roof. That reduced overall power needs. The new building is expected to store four times as much product at half the energy cost of ICE's first building.
- A solar photovoltaic system on the roof was needed to provide power for the refrigeration system during the hottest part of the day. In all, there are 58,089 square feet of solar modules on the roof (3,744 3-foot by 5-foot panels). They generate 1.1 megawatts, which translates to 52% of the power required by the building. At current prices, that yields $408,000 in energy savings and is 60% more efficient than the systems in most cold storage buildings. The refrigeration control system was integrated with the photovoltaic control system so that the refrigeration output would be lowered to meet the available power from the photovoltaic panels during the hottest hours. That was accomplished by adjusting the frequency on variable speed drives on each of the three high-efficiency ammonia-screw compressors that create 88.4 tons of refrigeration each. All refrigeration components have variable-speed drives and computerized controls for efficiency. The ammonia refrigeration controls regulate the compressors to take advantage of off-peak or solar-generated power through the variable speed drives. By producing the majority of the energy with photovoltaic panels, energy costs and CO_2 emissions are reduced. "Managing the electrical usage is the difference between a successful cold storage facility and an unsuccessful one," Dosch said.
- The building integrates an R-50 cool roof, based on its composition and the use of photovoltaic cells. It's made of two-inch urethane foam over six inches of rigid polystyrene insulation which itself is placed over steel decking.
- There are 10 roof-mounted wind turbines capable of producing 1,000 watts of power in a 25-mph wind. The turbines, which have five 33-inch blades, take advantage of the prevailing coastal breezes. A sophisticated control system on the back of the building reads how much power is available that day from wind and solar; from that data, a decision is made to either use the power immediately or put it on the grid for later use. Because electric rates for industrial uses vary by time of day, it saves money to turn the power off at peak times and catch up at night using cheaper power, Dosch said. "You can shut off the freezers for up to 12 hours and the frozen products inside the building will keep it cold," he said.
- Inside, the freezer floors are 12 inches thick and made of 4,000 psi concrete poured over six inches of rigid foam insulation. That's on top of a 4-inch sand base that contains the PVC pipes and tops a vapor barrier and the finished grade. The PVC pipes take advantage of natural convection to keep the ground from freezing below the concrete slab. Typically, fans are used to force warm air through the pipes. Natural convection requires no extra horsepower, thereby adding to energy savings.
- Freezer walls are R-39 with nine inches of polystyrene foam doors between a 26-gauge steel skin that reduces infiltration.
- The building is a steel structure with an overlay of insulated panels rather than the traditional concrete tilt-up building with insulated cold storage boxes inside. ICE-II was the first Hamann project with this type of construction.

By Jeffrey M. Shapiro, P.E., FSFPE

Water Diffusion Tanks – Past, Present and Future

Let's start with the basics…at its best, ammonia stinks and it's not pleasant to be around. At its worst, it can kill you. If a significant quantity of ammonia is released into a building or a community, a call to 911 is virtually guaranteed, followed by an emergency response and an evacuation. Depending on the size of the release, the evacuation may involve anything from a small portion of a building to a large portion of the surrounding community.

The good news about ammonia is that it is a *self-alarming* hazardous material. When there's a release, you know it, and there's no doubt about what's been released. Also good is the fact that ammonia's noxious odor and other side effects drive exposed individuals to seek safety elsewhere.

The bad news about ammonia is that it's so effective at being self-alarming, and it's so uncomfortable to be around when a release occurs, that the natural response is to automatically assume great danger. It's also a common reaction to assume that the worse a hazardous material smells, the more dangerous it is, even though this is entirely untrue. Odorless gases, such as carbon monoxide, can be far more dangerous because they don't elicit a self-preservation response.

By now, you may be asking, "OK, when are we going to get to water tanks?" Well, here's the point. Model codes that regulate the built environment are developed to protect building occupants, emergency responders and the general public from many hazardous conditions, among them hazards associated with refrigeration systems. In the case of ammonia refrigeration, codes have traditionally taken a very conservative approach in specifying safety controls to mitigate the perceived consequences of a leak, key word being "perceived." One such safety control is water diffusion tanks.

THE PAST

The use of water diffusion tanks dates back many decades. I recall being told by one industry *long-timer* that water diffusion tanks originated as an emergency control measure for early air conditioning systems used in brownstone apartments that utilized ammonia as a refrigerant. These early systems were apparently equipped with some type of emergency control that allowed ammonia to be discharged into water in the event of a system mishap.

Years later, the concept of emergency control boxes and associated water diffusion systems was incorporated into the Uniform Fire Code (UFC) which started in California and eventually spread into 26 states. Diffusion tanks required by the UFC eventually grew to be quite large, with early editions of the code requiring storage of two gallons of water for every pound of ammonia in the system charge. The assumption was that the entire system charge could be dumped into a diffusion tank if a *dump* valve in the emergency control box were opened (that's not the case, as discussed in my May, 2008 *Condenser* column on emergency control boxes).

Prior to 1994, there were no model code requirements for emergency relief valves to be routed to a water tank or other treatment system. In Western states, refrigerant relief valve discharge was regulated by the Uniform Mechanical Code (UMC), not the UFC, and the UMC specified atmospheric termination of relief valves. From a design engineering perspective, the UMC's approach made good sense, as relief valves serve as the last line of defense to prevent a rupture due to an overpressure event. As I understood the UMC perspective at the time, it was "do you really want a vent line, the last line of defense before a rupture, terminating at the bottom of a water tank where it cannot be easily inspected to confirm that it remains unobstructed?"

Then, things changed. During the development process for the 1994 UMC, a consultant practicing in the mechanical refrigeration field rewrote the UMC's chapter on mechanical refrigeration. Among the recommended changes contained in the rewrite was a new requirement for relief valves on ammonia refrigeration systems to terminate into a treatment or flaring system or a water diffusion tank. Even though there was no specific justification for this change offered in the proponent's reason statement and even though there was no incident history identified as a basis of substantiation, the chapter rewrite was approved with this new requirement included.

When this change was published in 1994, water diffusion tank requirements became even further entrenched into the codes because the tanks now had two purposes, not just one: 1) the original purpose of handling ammonia released from a manual emergency control box, and now 2) handling ammonia released from over-pressure relief lines.

It's interesting to point out that the 1994 requirement for treatment, flaring or diffusion of relief valve discharges from ammonia refrigeration systems was (and remains today) unique to refrigeration applications. Relief valves on any other equipment associated with ammonia, such

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By Lowell Randel

OSHA Chemical Facility National Emphasis Program Established

On 27 July, the Occupational Safety and Health Administration (OSHA) announced the establishment of a new National Emphasis Program (NEP) focused on PSM-covered chemical facilities. The NEP has been under development over the last three years as a result of safety incidents at chemical facilities, including some involving ammonia. It is important for facilities utilizing ammonia refrigeration to understand the NEP and review their process safety management programs to ensure that they are functioning properly.

OSHA's National Emphasis Programs are designed to focus limited inspection resources on industry sectors that are deemed to be high risk nationwide. The stated purpose of the chemical facility NEP is to reduce or eliminate workplace hazards associated with the release of highly hazardous chemicals (HHCs). Ammonia is included in the HHC category and inspections of ammonia facilities are specifically included in the new NEP.

The NEP will begin with a one year pilot program. OSHA will analyze the results of the pilot and make a determination on the future of the NEP. In the first year, three OSHA regions will conduct programmed inspections under the NEP. The three regions are: Region 1 (New England – Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island and Vermont), Region 7 (Midwest – Iowa, Kansas, Missouri and Nebraska), and Region 10 (Pacific Northwest – Alaska, Idaho, Oregon and Washington). It is estimated that 400-500 programmed inspections will take place in the pilot year. State OSHA programs have the option to adopt the NEP and may use the program procedures in their PSM related inspections.

It is important to note that the NEP will also be implemented for unprogrammed OSHA inspections nationwide. This means that facilities that experience accidents, complaints or referrals will also be subject to the NEP during their inspections. In addition, facilities subject to Site-Specific Targeting (SST) inspections will also be impacted by the NEP. OSHA's SST program provides the largest source of programmed inspections and targets facilities that have a high DART rate (days away from work, restricted work activity, or job transfer for every 100 full time employees) and a high DAFWII rate (days away from work due to injury and illness).

As with other National Emphasis Programs, the Chemical Facility NEP will not apply to facilities participating in the OSHA Voluntary Protection Programs (VPPs). VPPs are cooperative arrangements between facilities and OSHA. To qualify, a facility must have an effective, ongoing occupational health and safety program. Participants are selected based on their written health and safety plans and OSHA conducts on-site evaluations to judge how well the protective system is working. VPP sites are exempt from programmed inspections, such as NEPs, but facilities are still subject to the requirements of the Occupational Health and Safety Act.

Inspection sites will be selected randomly from a master list of covered facilities. The list of facilities will be compiled using data from the Environmental Protection Agency's Risk Management Program (RMP), NAICS codes known to be PSM but not covered by RMP, facilities identified by OSHA Regional and Area offices and facilities identified in OSHA's IMIS database. OSHA has stated that the selection process is structured to give all identified facilities an equal chance of being inspected.

Programmed inspections conducted through the pilot program will be **unannounced**. A selected facility will be visited by a team of Compliance Safety and Health Officers (CSHOs). The OSHA directive establishing the NEP states that for ammonia refrigeration inspections, at least one member of the team must have completed several OSHA Training Institute courses related to PSM and the chemical industry and have prior experience with the chemical industry or ammonia refrigeration.

Upon arrival, the team will ask to speak with the highest ranking official at the facility for a pre-inspection meeting. During the opening conference CSHOs will confirm that the facility has a PSM covered process. The actual inspection will likely begin with a facility walkthrough. The CSHOs will examine PSM related documents such as operating procedures, process hazard analysis, inspection documents and compliance audits.

OSHA indicates that inspections will place more emphasis on PSM implementation than on documentation. Inspectors will have a list of approximately 15 questions that will be administered during the inspection. The questions are designed to gather facts related to requirements of the PSM standard, and include guidance for reviewing documents, interviewing employees, and verifying implementation. For ammonia facilities, approximately ten of the questions will focus on ammonia specific PSM components and approximately five questions will address general PSM issues. Inspection questions will not be published, and will change periodically.

CSHOs will be instructed that the questions are designed to elicit "Yes," "No" or "Not Applicable" answers to determine PSM compliance. According to the OSHA Directive, a determination of "No" for any question will be seen as a potential indicator of non-compliance. Any "No" will normally result in a citation for a violation of the indicated provisions, provided that other elements of a violation are established.

At the end of the inspection, CSHOs will hold a close out meeting with company officials. OSHA has stated that if a facility successfully answers these questions, the inspection will be complete. If a facility fails on any of the questions, the inspection could become more in-depth. CSHO's will be authorized to expand the inspection and citations for non-compliance are likely.

OSHA currently operates several NEP programs covering a variety of industries. On average, OSHA estimates that NEP inspections result in approximately three violations per facility. Because of the nature of NEP subject matter, NEP violations almost always fall in the "serious" category. The average fine for violations identified through NEP inspections is approximately $950 per violation.

The Chemical Facility NEP differs somewhat from the Petroleum Facility NEP, the only other PSM-focused NEP administered to date. Under the Petroleum NEP, all federal non-VPP facilities were subject to inspection.

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An End-User's Dilemma:
Mechanical Integrity Inspection and Testing in a 24/7 Production Environment

By: Ron Miller, Director of Facilities Engineering, General Mills, Inc.; Garth Weidall, Principal Facilities Engineer, General Mills, Inc.; Ted Iverson, Facilities Engineering Manager, General Mills, Inc.; Kirby Plank, Utilities Manager, General Mills, Inc.; Art Swanson, Refrigeration Group Leader, General Mills, Inc.

The Mechanical Integrity Challenge

The purpose of a Mechanical Integrity (MI) Program for an Ammonia Refrigeration System is to ensure the reliability of all system components, equipment, piping, and controls. Though the goal is to maximize safety and avoid a catastrophic release, an effective MI program will also help maintain system capacity, productivity, and efficiency. It could be said that for an End User in the food industry, the ultimate goal of MI is to ensure system availability whenever production capacity is required. Ironically, this goal is in conflict with certain procedures of MI, which require partial or full system outages in order to complete some of the inspections, tests, and calibrations that are the very bedrock of a good MI program.

While scheduling MI in the production environment can be difficult, there are a number of approaches that can allow End Users to meet the dual challenges of ensuring that equipment is operated safely and efficiently while adhering to a demanding production schedule. Careful planning and preparation, combined with the use of a few logical tools and techniques, can significantly improve the likelihood that MI requirements will be met without major disruption to the operation.

It is important to gain the support of Plant Management for the MI program. Building commitment should not be difficult, provided there is an understanding of the overall benefits. MI not only complements the existing plant safety program, it opens the door to significant improvements in system reliability and plant productivity as well. The bottom line for End Users is that while we would all agree that MI inspection and testing are necessary, how can we ensure that the required steps are taken in a plant that must run 24/7?

Mechanical Integrity Program Planning

There are several important considerations in developing an MI strategy for an operating plant:

1) Focus on lowering risk. Prioritize inspections based on risk analysis, especially for piping systems, and in particular where there is an impact on plant operations.
2) Plan ahead and leverage best practices. Develop methods to perform MI inspection and testing while the plant is running. Add isolation systems or redundancy where possible to allow MI tasks to be completed while in operation.
3) Work closely with management. When the inspection of piping, components and sub-systems requires a system shutdown, plan for it to occur during a scheduled plant outage.

When first considering the scope of an MI program, an End User might be overwhelmed by the sheer magnitude of effort required. For instance, many plants have large systems with miles of refrigerant piping to be maintained. However, it must be recognized that much of the plant piping represents a low risk of failure. The key to focusing MI efforts is determining the fraction of piping that represents a high risk of failure (most likely to develop corrosion or other mechanical deterioration) and to spend precious time and resources on inspecting and testing these critical areas, which may comprise only 10% or 20% of the system. Once the critical areas are identified, the MI program can be structured around those items that can be regularly inspected or tested during operation (un-insulated piping, devices with isolation valves, redundant equipment), and those that require a system outage or partial pump-down to address (level probes, vessels, evaporators). In order to identify the high-risk areas of an ammonia refrigeration system, there are some common factors for that should be considered.

Mechanical Integrity Program Elements

The high-risk elements in an ammonia system typically include piping and vessels, critical shutoff valves and control functions.

Figure 1 – Example of severely corroded hot gas return piping

Among piping and vessels, the characteristics that commonly define high risk elements include:

1) Insulated piping that undergoes temperature change, which may cause moisture to form
   a. Liquid transfer lines
   b. Hot gas lines located in cold environments
   c. Liquid lines feeding vessels above 45 PSIG
   d. Defrost condensate return lines
   e. Low-temperature lines with intermittent duty
   f. Any other lines subjected thermal cycling
2) All insulated and non-insulated vessels
3) Other piping identified as high-risk as a result of system dynamics or past experience

Critical shutoff valves are those that have the potential to contain or isolate a large quantity of ammonia. The highest potential risk from a shutoff valve occurs in:

1) High-pressure liquid lines
2) Low-pressure liquid lines
3) Hot gas and discharge piping

Control functions can present high risk of failure because of the dynamic effect they can have on system operation. These areas include:

1) Power loss events, both transient and sustained
2) Monitoring and alarm functions
3) Hot gas defrost operations
4) Gas pressure driven liquid transfers
5) High-level liquid cut-outs
6) Machine room ventilation systems
7) Ammonia sensors and interlocks to ventilation systems

The identification of high-risk areas cannot be overstated as a key element to the effectiveness of an operating plant's overall MI strategy. However, careful attention to day-to-day operating conditions in a 24/7 plant can be an important indicator of system health and mechanical integrity as well.

Routine Observations

Routine rounds conducted by operators, including temperature and pressure checks, equipment monitoring, and visual observations not only will ensure proper system performance, but also can reveal MI conditions that require follow-up. Conditions that might signal a problem include:

1) Ice build-up where there was none before
2) Condensate on pipes, vessels, or floor where there was none before
3) Pipe/vessel corrosion or pitting not previously observed
4) Missing valve tags, valve caps or handles
5) Damaged or missing insulation, pipe covering or labels
6) Abnormal sounds, vibrations or movement
7) Any smell of ammonia no matter how slight
8) Foreign matter or rust on equipment or on the floor
9) Bumps, bulges, peeling paint on piping or insulation
10) Broken or damaged equipment, gauges, supports, flexible hoses, etc.

The discovery of any of these conditions or other abnormalities should trigger an immediate analysis of the underlying cause. A decision can then be made whether immediate mitigation is required, or if further investigation and future follow up is appropriate. Once an action plan is determined, there are several tools and techniques that can be employed to accomplish these tasks in the most efficient manner.

Best practices for MI

The first important "tool" for maintaining an MI program is a concise documentation system. The checklist included in IIAR Bulletin 109 is the data collection document most often used to collect MI data. This checklist can be customized for each plant's operation and the completed forms are an important part of the PSM or ARM recordkeeping process. There are also several good database programs available to collect and consolidate MI information and provide historical tracking and trending. Many Bulletin 109 checklist items can be inspected while the plant is in operation. The remainder must be scheduled as part of the plant Preventive Maintenance (PM) program or outage planning process.

Another important element of an MI program is the use of maintenance scheduling and job plans. If MI inspections are embedded in the plant's PM program, they become part of a routine system of observations that can identify trends and highlight changes in system integrity. The use of PM job plans ensures consistency each time an MI inspection task is carried out, thus minimizing the impact of the related tasks on plant operations. In addition to scheduled MI activities, one-time MI work orders can be generated based on visual observations or issues identified during ongoing operator monitoring.

Mechanical Integrity continued on page 14

Mechanical Integrity continued from page 13

Vessel Checklist			
Facility Data:			
Plant Owner:	Company X, Inc.		
Address:	100 Main St., Anytown, USA		
Contact:	Engine Room Group Leader		
Telephone:	630-888-9999		
Inspector:	John Doe		
Date:	1/1/2009		
Location:	Production Engine Room		
Vessel ID:	LPR #51-510-06		
Application (check one):			
High Pressure Receiver		Intercooler	
Accumulator		Oil Pot	
Pump Recirc., Low Temp.		Other	
Pump Recirc., High Temp.		(Describe):	

Vessel Data:	
Normal Oper. Press. (psig)	8.8 in. Hg
Temperature (°F)	–40
Vessel Size (Dia.x L or H, ft)	9' dia. x 26.5' long
Normal Liquid Level (ft)	32%
Normal Inventory (cu ft)	503
Design Capy: (w/conditions)	18,000 lbs. @ 32% full

Figure 2 – Example of customized B-109 checklist

PM-XXX-COMP (Monthly)

____ 1. Lubricate compressor/pump/motor bearings
____ 2. Inspect for oil leaks
____ 3. Inspect for NH_3 leaks
____ 4. Check/calibrate transducer,slide valve,slide stop
____ 5. Check cutout on discharge PSI
Lower setting 5 psig below head pressure
Check for shutdown
____ 6. Check separator low temp cutout
Put probe in ice water
Check temp 32 degrees
Ensure no start on machine
____ 7. Reduce discharge temp. setting by 5 deg F
Check for cutout
____ 8. Shut down machine
Turn off oil pump
Check to ensure no start

Figure 3 – Example of Job Plan with MI tasks

Visual inspection of refrigeration piping is always the first line of defense against exterior pipe corrosion. When indications of surface rust are identified however, a more definitive test may be needed to determine the extent of the problem. Also, insulated piping presents a particular inspection problem for the refrigeration industry. The use of non-destructive examination (NDE) for high-risk components and piping in these situations is another important tool for MI testing. Ultrasonic Testing (UT) and Guided-Wave Ultrasonic (GUL) are two common NDE technologies that can be used while the plant is in operation or during partial outages. UT is a fast, cost-effective method of thickness testing which can be used in small areas or for checking known trouble spots. GUL is a comprehensive diagnostic tool that can be used to evaluate long piping runs from a single attachment point by sending radio waves down the pipe. GUL also provides a documented record of pipe condition and can show where insulation is moisture-saturated. The use of NDE technology minimizes the barriers to MI testing since complete evacuation of piping or components is not required, removal of insulation is minimized and major disruption of plant operations can usually be avoided.

A convenient way to enable MI inspection activities during operation is to build MI functionality into the system. Replacing corroded piping is a good first step, but making sure to apply a protective coating on a pipe before re-insulating can yield huge long-term benefits. Physical elements such as isolation valves, redundant equipment, line purging capability and component labeling can be incorporated to facilitate critical MI activities. Take for instance the use of three-way manifolds at the inlet of dual safety relief valves, which allows replacement of individual relief valves on a scheduled basis without shutting down the system. Yes, this is a code requirement for external relief systems anyway, but it is a great example of providing isolation and redundant capability for critical safety systems. Other places these concepts might be used to facilitate MI testing without impact on production include:

1) Duplex pump systems
2) Multiple compressor systems
3) Level columns
4) Ammonia detectors and sensors

A final means of removing barriers to MI during production is the use of Continuous Improvement techniques to analyze failures and prevent future events. Tools such as Focused Improvement, Why-Why Analysis, and FMEA that are typically applied to the manufacturing or reliability processes can yield big benefits if adapted to the MI process as well. Using these tools, End Users can investigate the root cause of isolated component failures and apply the findings to the entire system, and even to other plants. A Continuous Improvement program is often the process used by Production folks to improve plant

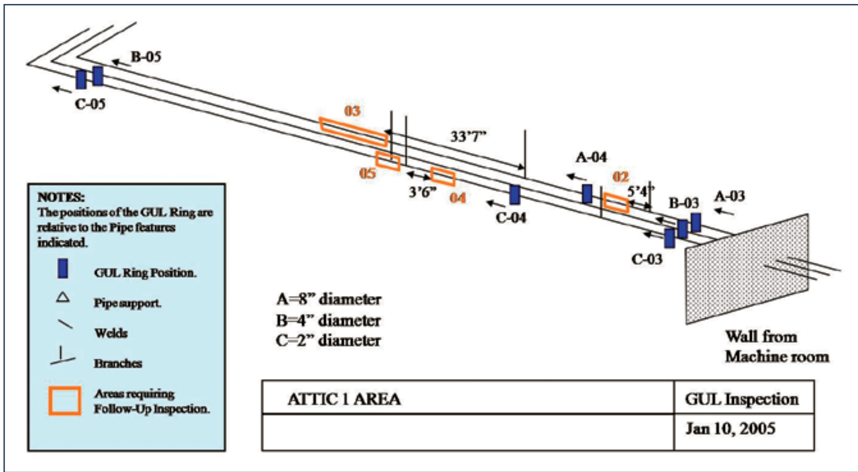
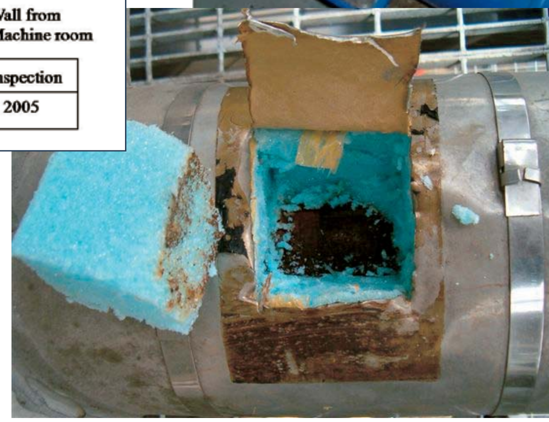


Figure 4 – Example of GUL map for an ammonia piping system



(above) Figure 5 – Example of purge capability for a dual relief manifold

(left) Figure 6 – Example of an MI inspection plug on large suction line

productivity and efficiency. Applying these same methods to the refrigeration utility not only provides a way to enhance MI effectiveness, but also offers another way to build bridges with the Production department towards reaching the common goals of ensuring system safety and availability.

Scheduled Outages

While many MI tasks can be taken care of via regular observations, ongoing checks, PMs, and operational procedures, a full plant or partial plant shutdown may be required for certain MI tasks. Tasks that must be done during a full or partial shutdown include:

1) High-level cutouts. Since the function of these devices is to shut down the entire machine room, testing is difficult if not impossible during normal operation of a production system. Testing of high-pressure cutouts almost always requires a full plant shutdown.
2) Level controller testing. If hand-off auto devices are present, this may be done during operation for most level controllers. If not, testing of low-level pump shutdown must be done during a full plant outage.
3) Compressor testing. May be done during operation if sufficient capacity exists, or during short production breaks (changeovers, sanitation, etc.) If plant activity varies by time of day or season, schedule flexibly to take advantage of reduced load or shed non-critical loads (AC or off-line cooling) if possible.
4) Insulated piping and vessels. If high-risk lines or vessels can be isolated and pumped down, they can be stripped and inspected while the remainder of the plant is in operation. For central vessels, main lines, and component piping, inspection must be done during a full plant shutdown.

An important factor in successfully ensuring MI program compliance is alignment with the plant's overall production schedule. That can be accomplished by early communication of the requirements, so MI can be considered in the planning of other plant shutdown activities. While an outage specifically intended to address MI is rare, most plants can integrate MI activities into a scheduled production outage, given advance notice.

Mechanical Integrity Has Business Value

Barriers to effective MI programs are minimized by using a risk-based analysis, by implementing best practices, and by working closely with Plant Management. Identification of critical MI components allows End Users to focus on the right areas. Constant vigilance of system operating conditions can help identify and address potential MI issues before they occur. Both new and existing systems can often be configured to enable MI tasks during production. Leveraging Continuous Improvement techniques for root cause analysis helps to prevent repetition of failures. When MI tasks do require a plant shutdown, collaboration with the Production folks can result in a unified approach to outage planning and execution.

Since the onset of OSHA PSM in the early 1990's, ammonia refrigeration systems have come under increasing regulatory scrutiny. While this initially triggered anxiety and skepticism on the part of End Users, in the long run the result has been improved industry awareness and safety. Despite concerns regarding how an End User can accomplish MI in a 24/7 production environment, we believe the thoughtful implementation of a Mechanical Integrity program will not only improve plant safety, but will ultimately enhance system reliability, productivity and plant capacity as well. Viewed in this manner, MI becomes more that just a preventive program; it can yield real business value as well.

CO_2 Technology and Training Centre Opens in South America

eurammon
refrigerants delivered by mother nature

In the current energy and environment situation, carbon dioxide is an excellent refrigerant. At first glance, it may seem astonishing that of all things, carbon dioxide, the Number One greenhouse gas, should be used in refrigeration as a means of protecting the climate. "In principle, the carbon dioxide used as a refrigerant comes from existing, mainly natural sources," says Monika Witt, Chairwoman of eurammon, the European initiative for natural refrigerants. More than 90 percent comes from fermentation processes that occur in breweries. The remaining share is generated as a waste product in chemical processes, for example in the production of carbonates. "The energy required for these procedures and the resulting carbon emissions are so low compared to those generated in global industrial processes that they are practically negligible," continues Monika Witt.

CO_2 Technology Centre inaugurated

To promote the use of carbon dioxide as a natural refrigerant particularly in North and South America, a compressor manufacturer has opened a Technology and Training Centre in Sao Paulo, Brazil. "Five-day courses will inform technicians, engineers, planners, system engineers and students about new procedures and know-how for using carbon dioxide as a refrigerant," explains Alessandro da Silva, application engineer at Bitzer Compressores Brazil. "In addition, the Centre offers the possibility of comparing the energy efficiency of systems operating with different refrigerants."

Three refrigerating systems with similar cooling capacities have been installed. These consist of a cascade system with carbon dioxide for subcritical operation and the HFC R404A (pump circuit for normal refrigeration and direct expansion for deep-freezing), an R404A system, and a system with the HCFC R22. They cool two storage rooms down to 0 to 2 °C and a deep-freeze room to –25 °C. There are also two deep-freeze islands working at –25 °C that are connected just to the carbon dioxide circuit. The cooling capacity for normal refrigeration is about 20 kW, and about 10 kW in the deep-freeze range. The evaporators of the three refrigerating systems are designed as air coolers and fitted under the ceiling of each cold room. The condensers operate with either air or water cooling. All machines and cold rooms are equipped with infrared sensors and a carbon dioxide extraction system. Only one system is in use at any one time to permit energy comparisons.

Each circuit is equipped with electronic control for constant monitoring of the machines. All the relevant information comes together in a central monitoring unit that the service staff can control also via LAN and the internet. If staff should happen not to be on site, the central control informs them by SMS and fax of any irregularities.

Saving costs with carbon dioxide

All three refrigerating systems are equipped with semihermetic compressors. The carbon dioxide circuit (cascade) is fitted with compressors that have been optimised especially for use with this refrigerant: their design makes them very energy efficient in operation. The use of carbon dioxide also brings advantages when it comes to material usage. It is possible for example to considerably reduce the cross sections of the intake and pressure gas pipes, thus reducing the costs of the piping installation. Real test runs have also shown that the carbon dioxide system also consumes less energy than the R404A and R22 systems.

"Carbon dioxide has been used as a refrigerant since the 19th century, but faded in significance with the introduction of synthetic refrigerants in the 1950s," says Monika Witt. "It was only when researchers and practitioners started their intensive search for environmentally-friendly alternatives for refrigeration and air-conditioning that it was rediscovered in the early '90s." Carbon dioxide is a climate-friendly refrigerant because it does not contribute to depletion of the ozone layer and has a low direct global warming potential with the reference value of 1. Thanks to its specific thermodynamic properties, including high operating pressure, low critical temperature and low viscosity, it offers great scope for new energy-efficient product and system developments that will put the refrigeration and air-conditioning industry on a more sustainable footing.

Technical data for the three refrigeration systems at the Bitzer Technology Centre

	CO_2/R404A	R404A	R22
Evaporation and condensation temperature (MT)	t_O = -5 °C (CO_2 pump circuit) t_O = -10 °C (R404A cascade stage) t_C = 40 °C (R404A cascade stage)	t_O = -10 °C t_C = 40 °C	t_O = -10 °C t_C = 40 °C
Evaporation and condensation temperature (LT)	t_O = -30 °C (CO_2 DX) t_C = -5 °C (CO_2)	t_O = -30 °C t_C = 40 °C	t_O = -30 °C t_C = 40 °C
Cooling capacity (MT)	21.0 kW	21.0 kW	19.82 kW
Cooling capacity (LT)	9.81 kW	10.66 kW	9.9 kW
Refrigerant quantity	32 kg	125 kg	115 kg

Ozone Depletion and Global Warming Potential of Refrigerants

	Ozone Depletion Potential (ODP)	Global Warming Potential (GWP)
Ammonia (NH_3)	0	0
Carbon dioxide (CO_2)	0	1
Hydrocarbons (Propane C_3H_8, Butane C_4H_{10})	0	3
Water (H_2O)	0	0
Chlorofluorocarbons (CFCs)	1	4680–10720
Partially halogenated chlorofluorocarbons (HCFCs)	0.02–0.06	76–12100
Per-fluorocarbons (PFCs)	0	5820–12010
Partially halogenated fluorinated carbons (HFCs)	0	122–14310

Carbon dioxide (CO_2)

Carbon dioxide has a long history in refrigeration, extending back to the mid-19th century. It is a colourless gas that liquefies under pressure, with a slightly sour odour and taste. Carbon dioxide has no ozone depletion potential (ODP = 0) and negligible direct global warming potential (GWP = 1) when used as a refrigerant in closed cycles. It is non-flammable, chemically inert and heavier than air. Carbon dioxide is narcotic and harmful to human health at moderately high concentrations. Because carbon dioxide has a lower critical temperature than other refrigerants, recent research has focused particularly on optimizing system design, and more and more effective refrigeration plants are being developed to close this gap. Carbon dioxide is available in abundance, and there is no need for recycling or waste disposal.

Ozone Depletion Potential (ODP)

The ozone layer is damaged by the catalytic action of chlorine and bromine in compounds, which reduce ozone to oxygen when exposed to UV light at low temperatures. The Ozone Depletion Potential (ODP) of a compound is shown as an R11 equivalent (ODP of R11 = 1).

Global Warming Potential (GWP)

The greenhouse effect arises from the capacity of materials in the atmosphere to reflect the heat emitted by the Earth back onto the Earth. The direct Global Warming Potential (GWP) of a compound is shown as a CO_2 equivalent (GWP of a CO_2 molecule = 1). iiar

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Ammonia Refrigeration Foundation Funds Research Project to Develop Pressure Relief Valve Bench Testing Procedure

There has been a longstanding debate among members of the industrial refrigeration industry in the United States regarding the validity of the prescriptive five year replacement requirement for atmospherically vented pressure relief valves.

The May 2008 issue of *Condenser*, included an article on this topic written by Jack Piho, president of Piho Engineering. This article reviewed the history behind the five year replacement requirement, its introduction by IIAR in 1978 as a recommendation, confirmation that the requirement pre-dates the formation of IIAR and that interpretations of this requirement by OSHA inspectors have on occasion resulted in OSHA citations to IIAR member companies. An explanation of ongoing investigations and recommendations by the IIAR Research Committee was included in the article along with a detailed review of the several revisions made to the Section 6.6.3 Pressure Relief Devices in IIAR Bulletin 110.

The wording of the pressure relief valve prescriptive replacement requirements in the latest revision of IIAR Bulletin 110, Section 6.6.3 provided the basis for further action:

> *Pressure relief devices shall be replaced or recertified in accordance with one of these three options:*
>
> *1) Every five (5) years from the date of installation. IIAR originally recommended (in 1978) that pressure relief valves be replaced every five years from the date of installation. This recommendation represents good engineering practice considering the design and performance of pressure relief devices; or*
>
> *2) An alternative to the prescriptive replacement interval, i.e., five years, can be developed based on documented in-service relief valve life for specific applications using industry accepted good practices of relief valve evaluation; or*
>
> *3) The manufacturer's recommendations on replacement frequency of pressure relief devices shall be followed.*
>
> <u>*Exception:*</u> *Relief devices discharging into another part of the closed-loop refrigeration system are not subject to the relief valve replacement practices.*

The pressure relief devices referred to in the part of Section 6.6.3 cited above protect refrigeration system components from exceeding their maximum allowable working pressure (MAWP). Each pressure relief device must be certified by the National Board of Boiler and Pressure Vessels for both set pressure and capacity (i.e., flow rate) and compressed air is utilized for the certification of relief devices used within the industrial refrigeration industry.

Pressure relief devices which reclose after actuation are termed *pressure relief valves* and functionally incorporate a spring loaded closing mechanism, or disc. The most common type of reclosing pressure relief valve has operational characteristics whereby pressure changes downstream of the valve (back pressure) affect its relieving capacity. A more sophisticated design variant of the common pressure relief valve incorporates a compensating or external reference mechanism which minimizes the effects of back pressure on the operational characteristics. This later variant is often utilized to relieve over pressure into a lower pressure zone of the closed-loop refrigeration system.

Section 6.6.3, sub-section 2), above, provides the framework for establishing a performance based service life for *reclosing* pressure relief *valves*. Any such program requires that:

i) The replacement interval be data driven from records obtained by testing replaced relief valves against established criteria to determine suitability for ongoing service.

ii) The tests be documented in a standardized format.

iii) A database be established from these records.

iv) And the resulting information be carefully considered in the process of creating a reliability program for pressure relief valves.

The above-mentioned *Condenser* article concluded by noting that the IIAR Research Committee was working on establishing a national database for industrial refrigeration pressure relief valves and gave an example of the type of data that would need to be collected.

However, data collected from multiple sources must use a standardized test procedure in order to be useful. To this end the IIAR Research Committee developed the project scope for a comprehensive pressure relief valve bench testing procedure suitable for in-house testing at individual plant level, or at third party facilities.

The resulting detailed project specification and proposal from the

AMMONIA REFRIGERATION FOUNDATION

Industrial Refrigeration Consortium (IRC) was approved by the Research Committee and submitted to the Ammonia Refrigeration Foundation (ARF) for funding consideration. ARF has authorized the project. The Foundation is a non-profit research and education foundation organized by members of the International Institute of Ammonia Refrigeration (IIAR) to promote educational and scientific projects related to industrial refrigeration and the use of ammonia and other natural refrigerants. This study will help ARF achieve its dual mission of promoting research and educational opportunities.

The objective of the Testing Procedure is to quantitatively determine the opening pressure and qualitatively verify operation (i.e., lift or flow) of a reclosing pressure relief valve after removal from service. Note that flow measurement is not required to meet the test objectives. IRC has set an aggressive project schedule with completion anticipated by January 2010. The resulting Pressure Relief Valve Testing Procedure will be introduced to the IIAR membership through a formal Technical Paper to be presented by the project manager, Dr. Todd Jekel of IRC at the IIAR 2010 Annual Meeting in San Diego.

"The development and publication of a standardized Testing Procedure is a vital step in IIAR's long term objective to create and populate a pressure relief valve service life database," said Brian Marriott, the ARF Chairman. "This project could not have been funded without the benefit of generous donations made to ARF by the IIAR membership. This is truly the result of your donation money at work."

Safety Day:

An 8-Hour Event That Could Save Your Life

In addition to funding groundbreaking research that benefits the entire industrial refrigeration community, The Ammonia Refrigeration Foundation (ARF) also co-sponsors Safety Days with the International Institute of Ammonia Refrigeration (IIAR), the Global Cold Chain Alliance (GCCA), The International Association of Fire Chiefs (IAFC), and The Refrigerating Engineers and Technicians Association (RETA). Safety Days are educational opportunities that are designed to enhance the safety of everyone who comes into contact with ammonia.

This year's Safety Day events feature Ammonia Safety and Emergency Response Training (ASERT). ASERT training is tailored to ammonia industry personnel and emergency response personnel such as fire department and hazmat team members who respond to ammonia incidents. ASERT training sessions provide participants with a balanced presentation on the safe use of ammonia. Safety Days include hands-on demonstrations and topics covered include prevention, mitigation and preparedness. The goal of the training is to prevent all accidental ammonia releases or, at the very least, stop them when they are small.

The Ammonia Safety Training Institute (ASTI) will develop a schedule for annual safety and emergency response training in locations across the country. The Safety Day event locations for 2010 will be posted on the ARF web site (www.nh3foundation.org) as information becomes available.

Building a Foundation

ARF needs your support to build a firm financial foundation for our research and educational activities. In the present sluggish economy, you can make your dollars do double duty—a donation to ARF can help ensure the financial health of our industry and your own economic security as well.

Benefactor and Stakeholder Contributions: Become a Benefactor with a $1,000 contribution or become a Stakeholder for a $50 contribution. Simply write a check or use a credit card. Your Benefits: Immediate income tax deduction. Removes property from estate.

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Life Insurance Annual Premium for 10 Years*

Gift Amount

Age	$ 25,000	$ 50,000	$ 100,000
60	$ 1,458	$ 2,506	$ 3,935
50	$ 1,038	$ 1,541	$ 2,566
40	$ 603	$ 654	$ 1,422

* Estimated values are based upon a healthy non-smoking male

Gift of Retirement Assets: Avoid the twofold taxation on IRAs or other employee benefit plans. Name ARF as the beneficiary of the remainder of the assets after your lifetime. Your Benefits: Make the gift from the most highly taxed assets, leaving more for family. Avoids income and estate tax.

Outright Gift of Securities: Avoid tax on capital gains. Transfer stock or appreciated securities from your brokerage account to ARF's brokerage account. Your Benefits: Immediate charitable deduction of full fair market value. Avoidance of capital gains tax.

Over 70-1/2 Years of Age? Make a gift to avoid income tax on mandatory IRA distributions. Transfer a gift up to $100,000 to ARF in lieu of taking part or all of the mandatory income distribution. Your Benefits: Avoids income tax on that charitable distribution amount. The transfer does not generate taxable income nor an itemized deduction, you benefit even if you do not itemize your tax deductions.

Outright Gift of Cash: Make a quick and easy gift by simply writing a Check or use a Credit Card. Your Benefits: Immediate income tax deduction. Removes property from estate.

Bequest In Will: Defer a gift until after your lifetime. Name ARF in your will (designate a specific amount, a percentage or a share of the residue). Your Benefits: Donation is exempt from federal estate tax. Control of asset for your lifetime.

Memorial Gifts: Many ARF donors make gifts to honor the memory of friends and loved ones. This is a wonderful tribute.

For additional details on ways to donate, please contact Belinda Ross at 703.312.4200 or by e-mail at belinda_ross@nh3foundation.org.

ARF continued on page 20

Get on the Ball

at ARF's Annual Golf Tournament in Sunny San Diego

Looking for an opportunity to gain your clients' undivided attention and good will? Treat them to a golf outing at the ARF's Annual Golf Tournament. This year's ARF Golf Tournament will be held before the start of the annual IIAR conference on Saturday March 13, 2010, at the Maderas Golf Club in San Diego, CA, (www.maderasgolf.com).

Located only 30 minutes from downtown San Diego, the Maderas Golf Club was voted the #1 course in San Diego by the 2002, 2003, and 2004 Zagat Survey. The course was designed by former PGA Tour player Johnny Miller and Robert Muir Graves, a pioneer in landscape architecture. It features stunning views of rolling hills studded with hundred-year-old oak trees, three crystalline lakes, five waterfalls, and forty acres of native wildflowers. The clubhouse features a bar and restaurant with indoor and outdoor seating, locker rooms and an upscale golf shop. A 25-station driving range and an oversized practice putting green round out this extraordinary golf experience.

Tee time for the ARF Tournament is at 8 a.m. with a shotgun start. The format for the golf outing differs from the typical "scramble" type of play and allows everyone to play their own ball throughout the match. This unique scoring system for the event will challenge the avid golfers to compete for the prize of individual champion while allowing the more casual golfers an opportunity to have fun while helping their foursome compete for team prizes.

Included in your green fees is free roundtrip transportation between the hotel and golf course and free golf club rentals. Green fees are $400 for an individual player and $2000 for a foursome. Your company will gain visibility and the esteem of your colleagues by sponsoring the golf tournament. Details on sponsorship opportunities will be mailed out to you in the ARF golf packet. The golf registration form will also be posted on the ARF website (www.nh3foundation.org).

Should you have any questions or desire additional information, please contact Belinda Ross at 703.312.4200. iiar.

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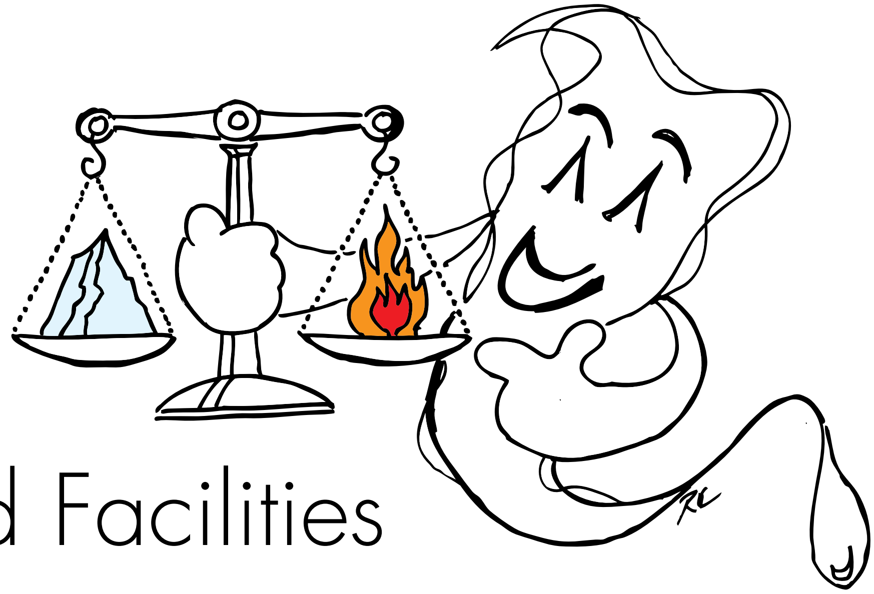
Mass and Energy Balance for Refrigerated Facilities



By Marcos Braz, MRBraz & Associates

Introduction

The Mass and Energy Balance document is the starting point for decisions regarding new, expanded or retrofitted refrigeration systems. Concerns with safety, regulatory compliance and maximizing profits intersect at the Mass and Energy Balance document. It serves as the common ground, the reference point for all subsequent decisions.

Process Safety Management (PSM) requires large refrigerated facilities with holding coolers, freezers, and/or cooling or freezing processes to be balanced to sustain final production performance, product quality and system safety. An unbalanced, overloaded system could result in compressor liquid slugging or higher compressor head pressure with the consequent overstress of the system. This could result in poorer product quality.

Mass and Energy Balance Thermodynamics

The *mass and energy balance* is generally defined at the beginning of a new refrigeration project or through reverse engineering of an existing system when working to balance the thermal loads with the capacity installed. It is the key to ensuring that your equipment has the capability to meet your capacity goals.

The difference, in temperature, between the process fluid and the refrigerant will determine the actual energy that will be transferred and carried by the system. The process fluid media can be air, water, glycol, or any fluid that will carry heat.

The energy balance is based on continuity and the First Law of Thermodynamics of Energy Conservation following a Carnot cycle. The First Law as applied to a refrigeration system, is described as the change in the internal energy (BTU/LB) of the refrigerant in a closed thermodynamic system equal to the sum of the amount of heat energy supplied (evaporator) to or removed (condenser) from the system and work done on the system (compressor).

In a formula;

Delta E = Q + W

<u>Delta E</u> – Internal Energy Increased or Decreased in the Refrigerant at Closed Refrigeration System

<u>Q</u> – Heat transferred to the Refrigerant or rejected by the Refrigerant

<u>W</u> – Work done to the Refrigerant

Making few simplified assumptions for each component of the Refrigeration System we have:

Q = Delta E for Evaporators and Condensers (work is negligible)

W= Delta E for Compressors (heat transfer is negligible – adiabatic)

When developing a Mass and Energy Balance, one should consider the thermal peak load under normal operation of the refrigerated facility. It should be straightforward. Observing the thermodynamic properties of the refrigerant, one quantifies the mass flow of refrigerant in its several states (liquid and vapor saturated, subcooled liquid, superheated vapor) required to carry the energy from each piece of equipment to the next in a closed cycle. Once the mass flow and thermodynamic properties are determined, the energy balance between the phases of the cycle (evaporation, compression and condensing) can be established for the entire refrigeration system.

For example, if we look at evaporators (cooling units) in a room; the air temperature in the room and the suction temperature in the evaporator provides us with the actual thermal load sent to the installed system. In this case;

Room Temperature: (Highest Temperature allowed in the room) is typically taken as the Air Returning to the Evaporator.

Evaporator Temperature: Assumed to be the Saturated Suction Temperature at the tubes, therefore the Metal

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Temperature in contact with the Room Air returning to the evaporator.

The Total Heat (thermal) Load absorbed by a given evaporator will be directly proportional to the Differential Temperature = Air Return Temperature – Saturated Suction Temperature at the Tubes.

The ratings of evaporators (power/differential temperature), compressors and condensers are well publicized by manufacturers. Using this information in conjunction with the First Law of Thermodynamics and SUM of Mass In = SUM of Mass Out, one can follow the refrigeration system as explained above.

The evaporator coil temperature can be read by suction pressure; however, an inefficient liquid distribution could skew the ratings and consequently misrepresent the load carried by the equipment versus the manufacturer's rated load. Also the temperature of the media (air, for example) could be misrepresented by the air distribution inside the room or area being analyzed.

In a given plant, the several phases of operation, from loading and shipping, to washing down rooms and equipment, to production sequence and scheduled hours, are utilization factors that affect the peak thermal load that the system maintains. These factors complicate the task of determining Mass and Energy Balance.

OSHA PSM Guidelines state, "…If the capacity increase is due to process changes made to existing equipment and/or chemistry, such as increase/decrease in flows, temperatures, pressures etc., or efficiency gains, these modifications would not constitute a new process, and would not be required to have a material and energy balance."

Therefore, the thermal load changes typically found at the plant do not require a new mass and energy balance calculation for your Process Safety Information (PSI). This is regardless of load changes that exceed the refrigeration system recommendations by as much as 30 percent! However, equipment performance is another matter.

The Disconnect

The thermal load imposed on the refrigeration system starts with four main components:

- Conduction – Heat conducted through the building envelope (walls, ceiling, roof, floor)
- Infiltration – Outside air coming in between spaces or from doors and other openings
- Product Load – Latent and sensible heat of the product being processed.
- Service Load – Includes operation equipment, battery rooms, washing cycles, cleaning equipment and ancillary thermal loads

These factors vary, based on ambient conditions, quantity of product, operations and traffic of people and products.

The energy balance refers to the heat transfer areas of the refrigeration system as they are exposed to the thermal loads that originate from plant operations and the diversity of equipment utilized. It is the actual load compared to the projected load.

Compare this to loading your truck or car. The car maker always builds in an extra margin of safety, but it is not wise to push this margin to the limit by overloading your vehicle. Although taxing the system to the limit may work, there are penalties that may include impaired operational safety and higher equipment lifecycle costs (fuel, tires, brakes, etc).

These concerns relate to our understanding of energy use and the balance of that energy with the installed refrigeration equipment.

Although this analysis seems quite simple, the measurement of media and refrigerant temperature at a typical hour/day/season is the most important information required to perform a thorough energy balance analysis at a given refrigerated facility.

Typically the best test of a successful and efficient calculation of thermal loads, transferred to the refrigeration system, will be KWh utilization of the compressors, pumps and fans. However, there are other electrical loads captured at the electrical grid that are not supposed to be included. This is because they are complex systems, and impossible to separate from lighting, offices, water pumps, kitchens and process equipment and areas that are not refrigerated by the installed refrigeration system.

It should obvious by now, that the adjustment of the plant and refrigeration equipment operations has a huge effect on balancing the capacities of the refrigeration equipment installed at the plant.

Diversity Factor

The *diversity factor* is defined as the percentage of the refrigeration system installed that is necessary to provide normal operation of the plant or refrigerated facility.

For example, a battery of jacketed vessels; evaporators in one room, or any other heat exchanger devices are meant to work in accordance with the plant operation schedule and its maximum peak load is defined by their utilization. The true load will vary with the utilization time and degree of thermal load imposed on the line or room.

So the correct path is to understand the plant usage of the equipment installed (operation parameters) and avoid making assumptions based upon estimated percentages of nominal capacity installed.

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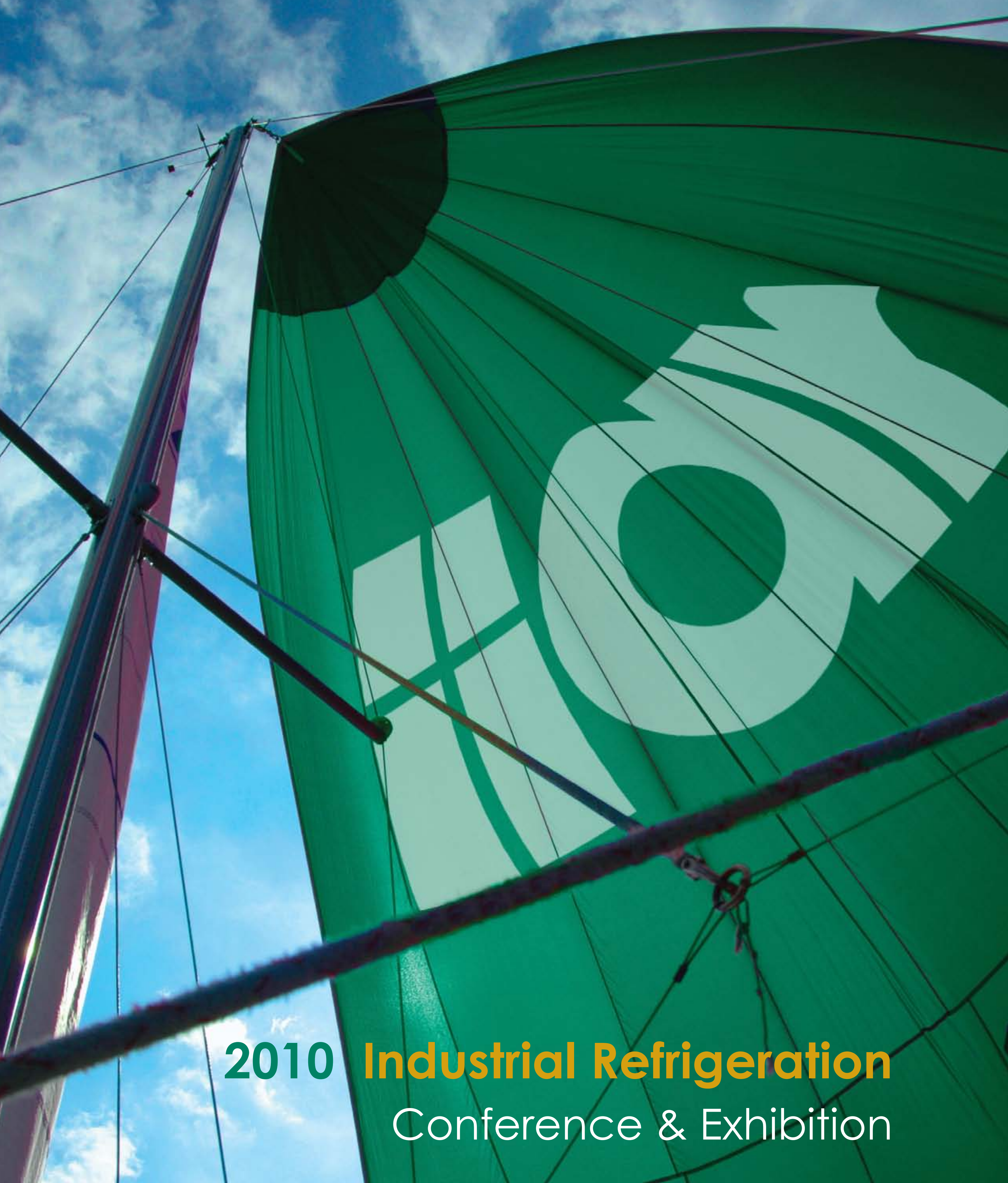

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These inspections included 100 static questions, which were published, and 15 dynamic questions, which were not published. Petroleum NEP inspections were very resource-intensive for the agency and took quite a long time to complete. The Chemical Facility NEP inspections are designed to be much quicker, but will reach a higher number of overall facilities.

By far, the most cited standard for violations under the Petroleum NEP was PSM. However, violations were also cited for issues such as lockout/tagout, hazardous waste operations and emergency response, guarding floor and wall openings and holes and permits required for confined spaces. One can anticipate that the majority of citations under the Chemical Facility NEP will also be in PSM, but facilities should be aware that CSHOs will issue citations for other violations that are identified during the inspection.

All members with PSM regulated facilities are strongly encouraged to update their PSM and RMP programs including proper documentation, training and emergency preparation. This is just good business, but will also help you make sure that you are in compliance with applicable regulations. If your company does not have a PSM specialist, you may want to consider using a consultant to review your PSM program and prepare for potential inspections.

IIAR and the Global Cold Chain Alliance (GCCA) are working with OSHA to better understand the NEP and how it will be implemented. A representative from OSHA gave a presentation on the NEP at the recent GCCA Assembly of Committees in Washington, DC and additional meetings with OSHA are planned.

In addition, GCCA is exploring the establishment of an alliance with OSHA that would enhance the communication between our industry and OSHA. By creating an alliance, GCCA will have a formal mechanism to work with OSHA to discuss regulatory programs and develop safety related information for the industry. In addition, GCCA will have more opportunities to provide technical expertise to OSHA on issues such as ammonia refrigeration systems and process safety management.

Watch for additional information in IIAR newsletters and the *Condenser* as these issues develop.

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Plant Operation and Refrigeration Capacity

Typically, the plant or refrigerated facility operators do not realize the impact of operational factors (personnel traffic, washing down, pressurization, types of doors, battery room location and cycle of change).

During plant operations it is quite common to observe that:

- Product process temperatures are outside of established parameters
- Doors are not shut tightly or are not shut at all and/or are the wrong type of doors
- Cold products and equipment pass through a humid environment
- Hot products and equipment pass through a cold environment
- Losses in insulation (walls and piping) occur due to compromised vapor barriers
- Room and equipment wash-down procedures occur while other process lines in other areas are still ongoing.
- Evaporators (cooling units) are out of adjustment (liquid feed or suction pressure out of adjustment)
- Condensers are fouled
- Compressors have capacity control issues. (Different suction pressures for the same stage of compression)
- Evaporators are defrosted in excess, not at all, or are not sequenced to maintain a balanced defrost load.
- Unbalanced pressurization of production spaces occurs, especially in sanitary environments

During different seasons of the year, the conduction and infiltration loads shift and there is a great deal of complexity added to the system adjustment. Also product lines change and the product load can become a major factor in the distribution of loads throughout the facility.

Energy Requirement Versus Energy Usage

These loads are often inconsistent and therefore require complete cooperation among operation, maintenance and refrigeration system personnel. Excellent cooperation results in the optimization of available resources which brings savings of energy and money and fewer shutdowns. Sustainability and carbon footprint are often discussed in the context of new technologies such as wind and solar power. However, we should not forget that optimizing existing refrigeration equipment can bring immediate savings. The end result is reduced energy use and a reduced impact on the environment.

Returning to the truck example, the driver and the mechanic need to agree on what the equipment is capable of. Shifting the gearbox at the right rpm to avoid unnecessary fuel consumption, and maintaining proper tire pressure can go a long way. Just as a vehicle runs more smoothly, inexpensively and dependably when it's tuned, your plant will run better when the mass and energy balance is achieved.

Meeting Industrial Refrigeration Market Potential in China

To meet demand, cold storage capacity in China is expected to increase by at least 800 percent with nearly 5 billion cubic feet (142 million cubic meters) in 2017. China's refrigerated truck fleet is expected to increase from approximately 30,000 to 365,000 vehicles during the next decade, according to A.T. Kearney Global Management Consultants.

That kind of growth potential led IIAR to reach out to China in the past five years by hosting delegations from the Chinese Association of Refrigeration at the annual IIAR Industrial Refrigeration Conference & Exhibition. IIAR representatives have also conducted workshops and seminars in several Chinese cities. Activities such as these were motivating factors in the IIAR decision to become a Core partner in the Global Cold Chain Alliance (GCCA).

China is still one of the top growth markets in the world and the GCCA is forging new links with China's businesses, trade groups and government leaders. The objectives of the GCCA's China Cold Chain Program are to:

- Work with local partners, such as the Guangdong Logistics Industry Association (GLI), to leverage local knowledge of China's priorities.
- Assist U.S. companies in establishing a greater presence in China by targeting areas of identified cold chain need.
- Present U.S. best practices and their impact on operational costs to the Chinese refrigerated warehouse owner-operators to educate owner-operators on how to improve their operations and expansion plans through applying U.S. technologies.

This October, the Global Cold Chain Alliance (GCCA) will be building on the previous successful efforts of United States Department of Agriculture Office of Capacity Building and Development (OCBD) and Foreign Service Department (USDA FAS) and Foreign Commercial Services (FCS) to develop the cold chain by tapping into China's market potential with a series of cold chain seminars sponsored by the United States Trade Development Agency (USTDA). Over the course of three days, (19-23 October 2009), leading U.S. firms will present the latest in refrigeration warehousing and transportation technologies and best practices in three different cities: Shanghai, Chengdu and Guangzhou. Up to 200 people are expected at each seminar. This will be in part due to the strong support of Agricultural Trade Office (ATO) in each of those cities.

GCCA has invited interested U.S. member companies to take advantage of this unique opportunity to present their products and services and to network with 600 potential customers and partners in China. With the 2010 Asian Games on the horizon, the demand for expertise to help ensure safe and efficient food storage and distribution systems is at an all-time high. The speakers include experts in refrigeration systems, product inventory management systems, product tracking using radio frequency identification (RFID) technology, facility design, product handling, food safety, microbiology, biotechnology, and cold chain management.

The GCCA seminars build on recent initiatives. In May 2008, GCCA hosted a dozen cold chain executives from China visiting the United States as part of the USDA Cochran Fellows program, which brings representatives from the cold storage industry from around the world to the United States to observe and tour cold storage facilities and learn best practices.

Last year, this commitment to the Chinese cold chain was reaffirmed by GCCA's first major event in China, the Global Cold Chain China Summit. The event, held in Shanghai, was the definitive cold chain event in China. While many events in China focus on local problems and address only immediate issues and needs, this Summit was first to address the global aspect of the cold chain industry and the future opportunities and challenges in China.

The participants represented a clear union of the private and public sectors, including international and local business leaders, government representatives, Chinese trade associations, and international trade associations, such as the International Institute of Ammonia Refrigeration.

They participated in a day and a half of educational programming, a trade show, networking and tours of local cold storage facilities. The Summit established a framework for developing the Chinese cold chain and food industry in the future. The key to GCCA's work is developing sustainable relationships, which means an ongoing commitment to invest time and resources to the work in China. Sustainability is also important to GCCA's cold chain development work in China. To learn more about how your company can participate in GCCA's China seminars, contact Richard Tracy at rtracy@gcca.org or +1 703 373 4300. iiar

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- VaCom Technologies of LaVerne, California, which worked with SDG&E to analyze the ideas for their potential return on investment and prepare an energy-efficiency report.
- Hamann Companies of El Cajon, California, which provided the architect, a certified LEED specialist, electrical expertise and a specialization in team-concept construction;
- SDG&E, which provided incentive funding and design support;
- SunPower Corporation of San Jose, California, which designed high-efficiency solar panels.

The solar panels generate up to 50% more power than conventional solar technologies and blend with the architecture of the building. Solar panels rest on the roof instead of penetrating the roof's surface to help prevent energy leakage. Pairing ammonia refrigeration with solar panels reduces CO_2 emissions and lowers energy costs at ICE-II.

Achieving LEED certification was an early objective. Once the project was underway, it was decided—in true Olympic fashion—to 'go for the gold' and add features that would enable the building to be considered for a gold rating, using the 69-point LEED guideline. A team approach guided the project all the way through the process with dozens of ideas considered and discarded.

Once the initial design was in place, each part was analyzed to see if it could be made more efficient and still have a reasonable payback. There was a review of the plans for energy efficiency that brought about several recommendations, which were implemented by the team. An analysis was performed against baseline and industry standards—the things that SDG&E would consider in calculating incentives. That enabled the selection of items for ICE-II that would maximize rebate money and energy savings. "It was informed, hard-nosed, financial decision-making," says Doug Scott, founder and president of VaCom.

Water issues also are a part of refrigeration, and the team that designed and built ICE-II went the extra mile to add water savings to the mix. Among the water-saving features:

- Evaporative cooling water from the condenser is treated using a chemical-less process. A portion of this water is stored in a 10,000-gallon tank for use in irrigation, saving an estimated 42,000 gallons of water per month.
- Xerophytic landscaping irrigated with drip irrigation is used throughout the grounds.
- Rainwater is collected, channeled to drainage areas, filtered and used by the evaporative condenser, saving more than 1 million gallons of city water based on average annual rainfall.
- Condensate water generated from defrosting the evaporator coils is collected in a storage tank in the office area and is used to flush low-volume two-stage tank toilets. Automatic faucets using potable water and waterless urinals are used in the restrooms.

"The water efficiencies are a key element in getting the LEED gold rating," Cassell said.

The completed building has a footprint of 132,000 square feet with a 114,300-square-foot freezer, a 13,200-square-foot dock, 5,000 square feet of office space and rooftop penthouses that extend to 72 feet high. It offers more storage capacity (6.5 million cubic feet) than ICE-I and uses less power.

Today, ICE-II is being used to store chicken, frozen Mexican food and other goods. The first ICE building is used to store 600,000 pounds of strawberries.

Looking ahead

Because ICE-II was the second cold storage building by Innovative Cold Storage Enterprises, the efficiency estimates derived from the standards set for it can be measured against the first building's performance and used as a guide for future construction. "We'll also apply LEED standards we met at ICE-II to existing buildings and maintenance efficiencies," Cassell said, "We're committed to that." iiar

Sandi Cain is a freelance journalist in Laguna Beach, California

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as agricultural and industrial storage tanks and tanks and equipment associated with bulk storage and production of ammonia, are permitted to terminate in outdoor air because code provisions governing ammonia in non-refrigeration applications don't include any special controls affecting relief valve termination.

It wasn't until the late-1990s that a more analytical approach to refrigeration system discharges began to take hold. Prior to completion of the first edition of the International Fire Code, IIAR sponsored a code modification that gained an allowance for alternative approaches to discharge termination when approved by the local code official. Then, IIAR successfully advocated three other code changes that brought us to where we are today: 1) A change permitting atmospheric termination of relief valves on a case-by-case basis, 2) A change that eliminated manual emergency control boxes in favor of emergency pressure control systems, and 3) A change that reduced the required tank size for cases where tanks are still required.

THE PRESENT

The most current edition of the IFC, dated 2009, contains the following requirements with respect to water tanks:

606.12.3 Ammonia refrigerant. Systems containing ammonia refrigerant shall discharge vapor to the atmosphere through an approved treatment system in accordance with Section 606.12.4, a flaring system in accordance with Section 606.12.5, or through an approved ammonia diffusion system in accordance with Section 606.12.6, or by other approved means.

Exceptions: 1. Ammonia/water absorption systems containing less than 22 pounds (10 kg) of ammonia and for which the ammonia circuit is located entirely outdoors. 2. When the fire code official determines, on review of an engineering analysis prepared in accordance with Section 104.7.2, that a fire, health or environmental hazard would not result from discharging ammonia directly to the atmosphere.

606.12.6 Ammonia diffusion systems. Ammonia diffusion systems shall include a tank containing 1 gallon of water for each pound of ammonia (4 L of water for each 1 kg of ammonia) that will be released in 1 hour from the largest relief device connected to the discharge pipe. The water shall be prevented from freezing. The discharge pipe from the pressure relief device shall distribute ammonia in the bottom of the tank, but no lower than 33 feet (10,058 mm) below the maximum liquid level. The tank shall contain the volume of water and ammonia without overflowing.

Note that there is no longer a requirement for manual emergency control boxes in the code, so only relief valve piping is currently required to discharge to a water diffusion tank. However, IFC Section 606.12.3, Exception 2 permits a performance-based analysis for specific installations to determine whether a tank is or isn't necessary. The analysis must consider three risk perspectives that might be associated with a leak: fire, health and environmental.

Given the propensity of ammonia to quickly dilute and dissipate in air, the prospect of igniting an uncontained outdoor release of ammonia vapor exiting a relief valve is essentially zero, largely because of ammonia's narrow range of flammability (commonly cited as 16-25% ammonia in air). With respect to environmental consequences, ammonia is a naturally occurring and biodegradable gas that does not contribute to global warming or erode the ozne layer, so environmental consequences aren't typically a concern. The only risk perspective that ordinarily requires complex analysis is health risk, and this can be evaluated with an incident analysis coupled with vapor dispersion modeling.

In the case of an ammonia refrigeration facility located in a highly populated area, it is possible that an analysis will show a safety benefit to preventing atmospheric discharge from a relief valve. However, given that Section 606.12.6 only requires enough water storage capacity to absorb ammonia released from the single largest relief valve over a one-hour discharge duration using a 1 gallon of water per pound of ammonia ratio, tanks required by today's code are far smaller than those required in years past. It's worth noting that the one-hour basis for the discharge duration calculation is based on an assumption is that an incident would either be mitigated within one hour, or if the incident involved an uncontrolled fire, the fire would grow so large after an hour that fugitive gas would be consumed by the fire plume.

So, here's the bottom line. The code now permits some ammonia refrigeration systems to be designed without water tanks, and when water tanks are considered necessary to capture discharges from relief valve piping, the required tank size is now a fraction of what was previously required by some codes.

THE FUTURE

IIAR has a longstanding strategic goal of getting water diffusion tank requirements altogether out of model codes, but given the incremental changes that have been accomplished in the past 10 years, which address many of the industry's concerns, the need for maintaining this goal into the future is no longer pressing.

IIAR members operating in Western states (the old Uniform code territory) mostly regard the current IFC provisions as far better than what the old Uniform codes required, and many seem willing to live with the current code provisions. On the other hand, IIAR members operating with Midwestern and Eastern states that used the old Building Officials and Code Administrators (BOCA) and Southern Building Code Congress International (SBCCI) codes express less enthusiasm in this regard. In the latter states, 24 of them, the IFC provisions for water tanks and ammonia diffusion came as entirely new requirements that many regard as unjustified.

It's worth noting that, several years ago, IIAR attempted to get ammonia diffusion and treatment requirements altogether deleted from the IFC, with what seemed to be sound justification, but the proposals were not accepted. Code officials at the time expressed an unwillingness to simply eliminate these requirements, citing particular concern for systems located in highly populated areas. I believe that the prospect for outright elimination of water tanks from the code remains less than promising today, and at this point, IIAR has no immediate plans to pursue additional code changes related to this issue. Accordingly, applicable code requirements, as described above, are expected to remain in place until at least 2015. iiar.

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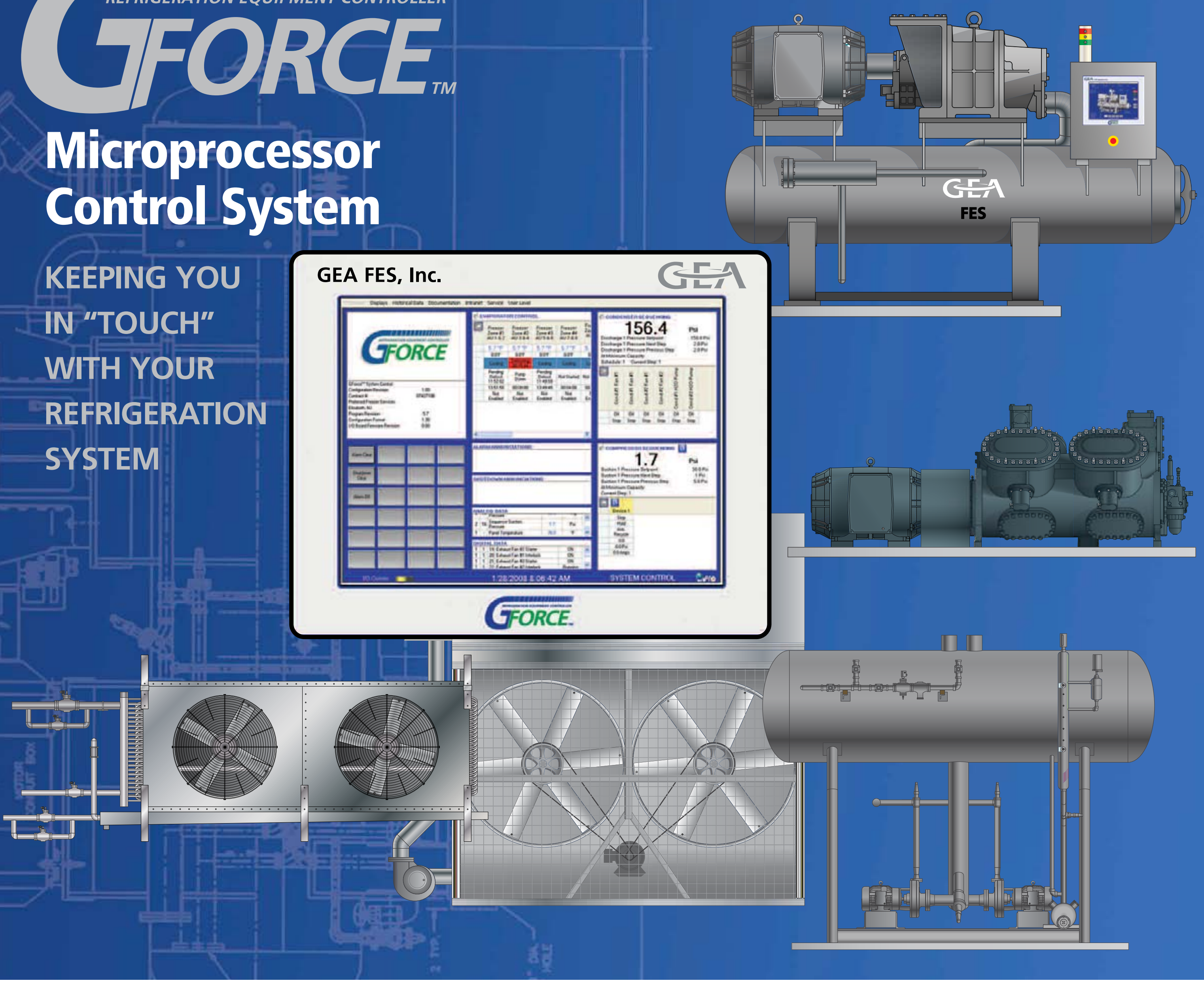

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