21st Century Approach to Refrigeration Safety Replaces Emergency Control Boxes

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Four decades ago, fire chiefs in the Western U.S. completed and published the nation's first model fire prevention code, the Uniform Fire Code, culminating a multi-year effort to standardize fire-safety regulations over large geographic areas. The feat was somewhat remarkable, given that the new code was written on typewriters, and correspondence was circulated by U.S. mail. Modern technology used to develop today's codes, such as computers, fax machines, email and inexpensive long distance phone calls were many years away.

At the time, refrigeration systems were still operating in the days of analog. Skilled individuals used pressure gauges, hand valves and instinct to monitor and maintain proper operation. Modern technology used to safely operate systems today, such as programmable logic controllers, refrigerant gas detectors and other electronic sensing and control equipment had yet to be invented.

By today's standards, emergency response to hazardous materials incidents was also somewhat archaic. Emergency responders in the late-1960's received little, if any, training on hazardous materials or systems that used them. The focus was on fires and firefighting. Nevertheless, when a hazardous materials accident happened, the local fire department was the agency who got the call for help. While poorly equipped to deal with these types of incidents, they'd do their best to protect lives and property.

With all of this in mind, it is easy to appreciate how the concept of an emergency control box for ammonia refrigeration systems would have appealed to fire chiefs and fire marshals who wrote the new code. Imagine the thought of a refrigerated warehouse on fire, threatening a release of ammonia into the local community. But wait, firefighters arrive on the scene, open a special box and operate a magic valve. Miraculously, in a matter of minutes, the entire ammonia charge dumps into water, and firefighters have saved the day! Who wouldn't like that?

While those of us who specialize in refrigeration systems today recognize that a fire scenario wouldn't play out as described above, such knowledge would have been less common 40 years ago, and it would not have affected the development of the first model fire code. At the time, fire codes were developed with little input from industry.

Years later, the emergency control box requirement became a well entrenched code requirement, which became further legitimized when ASHRAE and IIAR standards added model figures to provide design and installation guidance for this equipment. Although the intent of including these figures was only to help designers when a box was required by local authorities, code officials latched on to the industry figures as confirmation of the control box's validity. After all, from the fire service's perspective, why would industry standards tell you how to design an emergency control box if the concept wasn't valid?

Charting a Course for Change

In 1999, the IIAR Board of Directors initiated a comprehensive program to review and update model code requirements related to ammonia refrigeration. Among many issues identified for study was a requirement in some codes

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The security required for the Fire Control Box has grown far beyond the traditional padlock due to growing concerns from the Drug Enforcement Administration and the Department of Homeland Security.

mandating installation of an emergency control box on new ammonia refrigeration systems.

Before discussing the merits, or lack thereof, of emergency control boxes, it must be stated that, as a matter of policy, safety is fundamental to IIAR. Accordingly, accepting a position that promoted removal of a device commonly thought to benefit emergency responders didn't come easy. However, after studying the issue, it became clear that emergency control boxes were neither an effective nor necessary safety feature.

Some of the considerations that led to this conclusion were:

1. Control boxes were only required in certain regions of the country under the old model code system, which divided the country up under three regional fire codes. Nevertheless, there was no evidence to suggest that areas of the country where emergency control boxes were not being provided suffered any adverse consequences based on the lack of this equipment.

2. Only ammonia systems associated with refrigeration processes were required by codes to have an emergency control box. Other uses of ammonia, such as industrial processes, water treatment, etc. did not require this equipment.

3. "Dump" valves in the box aren't really capable of evacuating a refrigeration system. Required valves basically add a small evaporator to each major vessel, and once compressors have been shut off, most liquid ammonia will remain in the system, as evaporation eventually equalizes ammonia in the system with atmospheric pressure.

4. Refrigerated warehouses built today are equipped with fire sprinkler systems, and machinery rooms are prohibited from containing combustible storage not associated with system operation. This represents a significant reduction in fire risk as compared to buildings built 40 years ago. Given the large volume of fire required to cause an ammonia vessel to vent, such a fire could only occur as a result of a sprinkler system failure, and in that case, ammonia will be released through emergency vents and will be consumed by the fire plume once the fire vents through the roof (which will happen quickly with today's lightweight construction techniques).

5. Computerized monitoring and control systems used today make a major system malfunction much less likely today than 40 years ago, when the emergency control box requirement was first added to the code. Times change, and codes need to change to keep up with benefits of improving technology.

6. An informal survey of fire officials found that the operation and capabilities of emergency control boxes were not well understood by emergency responders. In addition, the control valves were rarely, if ever, tested, exercised or used. Lacking training in the process of mechanical refrigeration, the function and operation of emergency control valves, and confidence in the reliability of equipment in control boxes, emergency responders were generally uncomfortable with the thought of using this equipment.

7. With the value of ammonia as an ingredient in explosive compounds and illegal drugs, placing a live valve box on the exterior of a building, where ammonia could be extracted from a refrigeration system, was deemed to present an unnecessary security threat.

Enhancements in refrigeration system control equipment associated with new technologies now make it possible to provide an automatic emergency control system to replace key functions of the traditional manual emergency control box, like the one shown above. Such automatic controls, now required by fire codes, have made manual emergency control boxes obsolete.

Changing Model Codes is No Easy Task

Even with a well-developed substantiation, citing many of the reasons listed above, the challenge of removing the emergency control box requirement from model codes proved to be a significant undertaking for several reasons, not the least of which was the fact that the requirement had a 40-year history in model codes. Many regulators involved in writing today's codes had literally grown up with the control box as a mainstay requirement for refrigeration safety, and changing the codes required an unprecedented outreach effort by the ammonia refrigeration industry to educate code officials on why emergency control boxes didn't do what they were thought to. To address this hurdle, IIAR produced a seminar aimed at educating code officials on the fundamentals of refrigeration, the properties of ammonia and the efficacy, or lack thereof, of emergency control boxes. This program has since been presented to more than 1,000 seminar attendees.

Although IIAR was ultimately successful in educating code officials to understand the limitations of emergency control boxes, many remained unwilling to support removal of the requirement from codes unless the industry volunteered a new and better approach. IIAR responded to this challenge by breaking down the capabilities of a control box into two categories. First, control boxes were provided with "cross-over" valves capable of internally relieving ammonia from high-side vessels to low-side vessels, keeping all of the ammonia within a system. Second, control boxes were provided with "dump" valves for the purpose of releasing ammonia into a water tank, diffuser or to atmosphere.

Birth of the "Emergency Pressure Control System"

Conceptually, industry experts working on IIAR's Code Committee agreed that providing a means to relieve ammonia across zones within a system was far less objectionable than providing a means to release ammonia from the system, and the point of compromise with fire officials was to eliminate "dump" valves and create an automated system to replace the manual "cross-over" valves in emergency control boxes. The new approach was dubbed an "emergency pressure control system," or EPCS.

The EPCS approach ultimately established common ground between the industry and fire code officials with respect to changing model codes to eliminate emergency control boxes and the "dump" valves that they housed. This level of agreement was a critical element of getting codes to change, and even industry experts who believed that emergency control boxes should just go away ultimately recognized that such an outcome wasn't plausible.

So, with the coming of the 2009 editions of the Uniform Fire Code, Uniform Mechanical Code, International Fire Code and International Mechanical Code, all references to emergency control boxes will disappear from model codes, replaced by requirements provide an EPCS. Shortly thereafter, new editions of IIAR 2 and ASHRAE 15 will drop provisions related to emergency control boxes as well, and IIAR 2 will provide comprehensive EPCS design guidance.

Key elements of the new EPCS approach

As mentioned above, an EPCS is basically a system that automates the "cross-over" function previously provided by manual valves in an emergency control box. The advantages of an EPCS over control boxes include taking away manual valves from possible access by untrained responders or thieves

Interior of an emergency control box for an ammonia refrigeration system.

and fully automating an additional layer of safety controls on refrigeration systems to reduce the risk of having an over-pressurized system operate emergency pressure relief valves.

Key elements of an EPCS include an overpressure sensing-shutoff system that is fully independent of and redundant to other systems, such as compressor cut-out controls or programmable logic controllers that normally manage system operation. In the event of a severe overpressure condition, where the pressure exceeds limits that should have been intercepted by other safety controls, EPCS sensors provide a last line of defense to stop compressors before ammonia is released from pressure relief valves. In addition, the EPCS includes a high-to-low cross-over valve that will immediately and automatically activate to begin dropping high-side pressure. Experimentation with the concept has shown that, left unattended, the system will eventually equalize across the valve at a pressure marginally above the starting low-side pressure.

Key aspects of requirements for EPCS components found in fire codes and the basis for these requirements are as follows:

Automatic crossover valves. Each high and intermediate pressure zone in a refrigeration system will be required to have a single automatic valve providing a crossover connection to a lower pressure zone. The requirement for a single crossover valve between systems was based on the traditional industry practice of providing a single manual crossover valve between each set of zones in an emergency control box.

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Overpressure limit set point. Automatic crossover valves will be required to automatically relieve excess system pressure to a lower pressure zone if the pressure in a high or intermediate pressure zone rises to within a predetermined set point for emergency pressure-relief devices. Initially, in the 2006 editions of model codes, the predetermined set point was 15 psi below the rating of pressure relief valves (PRV); however, that will be changed in the 2009 codes to be not less than 10 percent below PRV ratings. The 10-percent figure provides a wider safety margin to allow an EPCS to operate before a PRV, given that the pressure at which PRVs will unseat can vary significantly from rated pressures.

Manual operation. When required by a local code official, the emergency cross-over valves must be capable of manual operation, presumably by an approved switch or button. Although this was not regarded as necessary from a safety perspective, the manual operation reference was provided because it was recognized that some fire departments would be reluctant to completely give up manual controls.

Operation of an automatic crossover valve and system shutdown. Operation of an automatic crossover valve will be required to cause all compressors on the affected system to immediately stop. Dedicated pressure-sensing devices located immediately adjacent to crossover valves are permitted as a means for initiating operation of a valve. To ensure that the automatic crossover valve system provides a redundant means of stopping compressors in an overpressure condition, high-pressure cutout sensors associated with compressors are not permitted as a basis for triggering a crossover valve.

Overall, the intent of these provisions is for the emergency pressure control system to have a fully redundant means of stopping compressors. Although compressors are ordinarily provided with their own automatic high-pressure cutout controls, fire code requirements will not permit these controls to be used as a means of initiating the EPCS. An additional set of controls is considered necessary to serve as a back-up means of preventing a severe overpressure condition that could result in operation of a PRV.

Overpressure control for the lowest pressure zone. In lieu of a full EPCS, the lowest pressure zone in a refrigeration system will be required to have a dedicated means of determining a rise in system pressure approaching operation of PRVs serving that zone. The maximum initiating pressure will be limited as described in "Overpressure limit set point" above, and once a severe overpressure condition has been identified, compressors on the affected system must be stopped.

The approach to managing the lowest pressure zone is different because this zone cannot be arranged to bleed pressure to another system zone. Nevertheless, by providing a redundant emergency stop control to disengage the compressor, an overpressure condition in the lowest pressure zone should be automatically mitigated. The incident considered most likely to cause a low-side overpressure incident was a control valve stuck in the open position while transferring hot gas to defrost low-side components. In such a situation, stopping the compressor should disengage the pressure source for the defrost system.

Emergency pressure control systems reduce the likelihood that pressure relief devices will discharge flammable, toxic, or highly toxic refrigerants or ammonia to the atmosphere. This is accomplished through the use of an automatic cross-over valve, such as the one shown above, that internally relieves excess pressure from high-pressure equipment to other portions of a refrigeration system before an atmospheric release occurs. This photo illustrates a "crossover" valve arrangement interconnecting the high-side with the low-side after the pressure has essentially equalized.

Conclusion

Eliminating emergency control box requirements from model fire codes favorably resolves long-standing industry concerns regarding the potential for harm caused by an untrained person operating valves in an emergency control box, as well as concerns that such control boxes were not an effective investment in safety. IIAR advocates that there is no condition under which manual removal of refrigerant from a refrigeration system by the fire service is considered advisable. In contrast, automatic transfer of excess pressure to another zone of a system in conjunction with stopping the pressure source (compressors), through the use of an emergency pressure control system, provides an effective means to safely mitigate an overpressure condition that has not been intercepted by other safety controls.

It must be pointed out that elimination of the emergency control box based on the addition of an EPCS does not automatically eliminate other code requirements related to water diffusion tanks. Such tanks may still be requested or required in some cases by designers, owners or local authorities for the purpose of diffusing releases from overpressure relief devices.

IIAR is pleased to have had the opportunity to work cohesively with fire, building and mechanical officials from throughout the country who were willing to rethink more than 40 years of history to develop a modern-day approach to improving refrigeration safety. This exercise truly emphasizes the ability of industry experts and regulators to come together and craft effective solutions for the betterment of public safety.