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The disaster in Bhopal illustrated the need for safety management standards.

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Relief System Management Software: Helping Companies Achieve PSM Compliance

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On Nov. 15, 1990, the Occupational Safety and Health Administration (OSHA) made into law the standard for process safety management (PSM) of highly hazardous chemicals (29 CFR 1910.119), as well as section 304 of the Clean Air Act (CAA) amendments. The PSM standard and CAA changes were enacted in direct response to the Union Carbide India Ltd., Bhopal, India disaster that occurred on Dec. 2, 1984 and resulted in the deaths of 3,787 individuals. For the many valve and actuator users that operate processes involving hazardous materials, the changes mean analysis of PSM and creation of programs that should ensure a similar tragedy does not occur. Because pressure relief can be a last line of defense, PSM must address pressure relief systems.

Executive Summary

SUBJECT: The days of stashing binders on shelves as a means of having a process safety management system for pressure relief are long gone. Today's software offers many tools for better management.

KEY CONCEPTS:

- The Bhopal disaster and OSHA response
- What standards require
- Software considerations

TAKE-AWAY: Because pressure relief systems are the last line of defense, the best software tools are vital.

A TRAGEDY ANALYZED

Analysis of the Bhopal incident revealed a myriad of equipment and human failures. Outcry over the preventable tragedy promulgated a response by OSHA that culminated in passage of the PSM standard and CAA law. Since implementation, the PSM standard has been adopted in one form or another throughout the worldwide process community. While PSM programs vary from one geographic location to another, the basic tenets of an effective program are similar in nature.

The OSHA PSM standard is comprised of a number of individual program elements. Each of these elements, when combined into a whole, is designed to reduce the likelihood that a process will experience an unwanted hazardous chemical release. In the event that a release occurs, the standard also requires that plans be in place to mitigate the impact on the surrounding community. These program elements include process design, process safety information, process technology, process changes, operational and maintenance activities and procedures, non-routine activities and procedures, emergency preparedness plans and procedures, training programs and other elements that affect the process. Implementation of elements is done through a layered approach. A single element of the PSM program by itself would not prevent a catastrophic release, but in combination with all the program elements, the elements greatly reduce the risk that a single failure or even multiple failures would result in a catastrophic release.

PRESSURE MANAGEMENT

Pressure management systems are a significant part of the OSHA PSM process safety information (PSI) element of the standard, and they play a significant role in the implementation of that standard. In most cases, pressure management systems are the last line of defense in averting a release. They require considerable emphasis on design and maintenance to ensure availability when called upon.

Despite this critical nature, many operating companies historically considered pressure management a low priority engineering system. In fact, typically, a newly graduated engineer could expect to spend a brief stint as the resident "relief valve" expert until the next new engineer was hired to replace him or her. It was rare for a company to dedicate a senior staff engineer to fill this role. Pressure management programs languished under this mindset, and the processing industry was slow to respond even after the implementation of the PSM standard.

Experience performing sizing basis audits for numerous clients in a diversity of process industries highlights the disadvantages to this approach. These audits showed that after the PSM standard was implemented, there were instances where processors were generating pressure management system sizing basis documentation for the very first time. Audit findings show that when a client's existing sizing basis is properly scrutinized using American Petroleum Institute (API) recommended practices and American Society of Mechanical Engineers (ASME) Codes and Standards, between 25-50% of existing pressure protection systems are deficient and require some level of mitigation to bring them into compliance. The deficiencies range in severity from an incorrect relief valve mounting orientation to more serious infractions such as a system having inadequate relief capacity.

Another commonly discovered deficiency is a relief device that has set pressure greater than the maximum allowable working pressure of the equipment the relief device is protecting. The reality is pressure management systems are extremely complex, requiring a significant amount of knowledge and technical discipline to properly analyze and size for a given application. In many cases, individuals with pressure management system responsibilities are not properly equipped or trained.

Another aspect of pressure relief system management is the arduous task of performing relief system calculations and archiving these for documentation. Historically, the common scenario was that operators used spreadsheet formats to perform these calculations. In many cases, a single process change resulted in multiple spreadsheet input changes to fully evaluate and recalculate the sizing basis of a relief system. A physical paper file where copies of relevant equipment documentation were assembled to document the inputs for a given calculation is usually an element of this spreadsheet approach. Relief sizing basis calculations typically were assembled in three-inch-thick binders placed neatly on multiple shelves to document a given facility's sizing basis documentation. In more robust pressure management programs, sizing basis documentation was scanned into a PDF file placed on a shared drive so that everyone could access the information. These types of systems, while far superior to those they replaced, only captured a snapshot in time and were prone to input error.

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In today's environment of significant OSHA fines for each instance of non-compliance with the PSM standard, operators need better methods for documenting and maintaining pressure management sizing basis documentation. Modern PSM management is fortunate that specialized computer programs have been designed specifically to manage relief system calculations and the effects that changes to equipment and process variables will

have. Several vendor-supplied pressure management software platforms are now commercially available. The following paragraphs discuss considerations for purchasing and implementing any one of these state-of-the-art pressure management software platforms.

PROGRAM CONSIDERATIONS

A calculating platform should be comprised of a database that has the capacity to analyze the impact of a process change on the affected system and on any associated upstream or downstream pressure management systems. It should be able to flag those systems needing additional engineering review, informing the user of associated pressure management systems that will be impacted by a process change. Most importantly, it should tell a user if the process change will render the affected relief system inadequate.

Outdated technologies such as spreadsheet software systems are not capable of evaluating these interrelationships and are fully dependent on engineering judgment to make determinations. In many cases, because of the complexity of these systems and the subtle interactions between related systems, the effects of process changes on systems or equipment are missed or ignored.

Another factor to consider is that pressure management software should have an integrated thermodynamics modeling capability. This allows evaluation of physical properties from one set of thermodynamic conditions to the next layer of conditions. Output from models should be a direct input into calculation equations to avoid transcription errors. The thermodynamics package should also be able to support a diverse list of organic and inorganic compounds, including boiling point curves and custom compounds, and should be capable of supporting hydraulic calculations using standard single-phase flow, as well as more robust two-phase piping flow models.

Pressure management software should include the capability to evaluate complete relief device hydraulics from the protected system through the relief device's discharge piping, including collection header and disposal system piping. Although several excellent standalone software packages exist for evaluating header and disposal system piping hydraulics and capacity, incorporating the standalone packages into a real time or near real time assessment of process changes is not feasible. Because they depend on a large volume of data input, standalone header system packages are unwieldy and time consuming when evaluating multiple what-if strategies. Changes to the header or disposal system will invariably cause changes in the relief load, which in turn will demand changes in the header and disposal calculation. These standalone header and disposal system software packages are not capable of performing iterative calculations quickly and cost effectively.

MAINTENANCE ISSUES

A pressure management software system should have the capability to manage all maintenance aspects of a

pressure management system including scheduling relief devices for maintenance and flagging pressure relief devices for engineering review based on historical maintenance records. They also should be capable of showing as-found test results, recording and archiving relief device maintenance records and creating an interface between engineering and mechanical integrity disciplines as they relate to pressure relief devices. Maintenance documents should not only pertain to the relief device but also to the location in the process where that device was installed. It's important not to lose the maintenance history when replacing a worn-out pressure relief device or swapping a valve from a pool of spares.

The pressure management software system should be programmed such that calculations proceed through a strict adherence to API-recommended practices, ASME codes and standards, or other overarching regulatory requirements. Deviations from standard calculation methods should be readily observable with appropriate warnings and error messages brought to the attention of the reader. Additionally, pressure management software should be able to assess the impact that proposed or enacted regulatory changes will have on existing pressure relief systems. For example, if the definition of allowable inlet losses changes, the software should model how this change affects the overall state of compliance for existing relief systems in the facility.

From a documentation perspective, the software platform should include the capability to archive preceding revisions of calculations as process changes are made. Having the history of a given relief valve from the date of its first sizing basis to present time is invaluable to understanding the maintenance history of the pressure relief device and process change activities that impacted the sizing basis of the device. Additionally, the software platform should provide task management capability so that tasks can be assigned in support of calculation or maintenance activities. The software should also contain a project management tool that can assign work, assess workload assignments on individuals performing calculations, assess the progress of calculations and the volume of mitigation work needed to bring systems into compliance.

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A last major item the pressure management tool should contain is the capability to show that mitigation is required after a calculation has been performed. In addition, the tool should be able to clone the recent calculation while leaving the original calculation intact. This cloning function allows operators to modify existing pressure management system calculations using a what-if strategy to determine the most cost-effective solution for resolving the identified deficiency. It is imperative that any software tool be capable of maintaining documentation of the existing 'as-built' or 'as-installed' pressure management system because this is the existing sizing basis required per the PSM standard. The benefit of having a pressure management software tool that can manipulate a copy of the existing calculation is that operators can show regulatory authorities the plan of action to resolve identified deficiencies while fully complying with the PSI requirements associated with the PSM standard.

Once a mitigation strategy is selected, the modified clone is a pressure management system in waiting. Given the length of turnaround schedules today, it is entirely possible that a pressure management system deficiency might not be resolved for several years. When the mitigation pressure management system is implemented, it then becomes the system of record, showing the sizing basis of a given pressure management system. The previous system then becomes an historical archive and is retained for documentation purposes and reasons described above concerning maintenance. Identifying deficiencies and having corrective action plans in place using this type of an approach gives operators the best opportunity to demonstrate compliance should they become subject to a compliance audit by regulatory authorities.

Modern pressure relief system management is finally emerging after years of sub-optimal practice in legacy systems. Efforts to adhere to the PSM standard and create safe operating environments have been greatly aided by software technologies that are replacing fragmented and unrelated technology solutions. Processors now have to evaluate significant changes to industry codes and standards, and changes to process design with "evergreen" engineering practices and tools (those that are continually updated). This keeps pressure relief systems in compliance and functioning as intended when called upon to be the last line of defense. VM

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