SAFETY MANAGEMENT

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PROCESS SAFETY MANAGEMENT

Improving Safety Performance Beyond the Chemical Industry

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PROCESS SAFETY MANAGEMENT (PSM) deals with the identification, understanding and control of process hazards to prevent process-related injuries and incidents (Amyotte et al., 2007). OSHA defines a "process" in 29 CFR 1910.119 as "any activity involving a highly hazardous chemical including any use, storage, manufacturing, handling, or the on-site movement of such chemicals, or combination of these activities." OSHA (2013a) goes on to define "highly hazardous chemical" to mean "a substance possessing toxic, reactive, flammable, or explosive properties and specified by (the regulation)," and the organization provides a full list of chemicals that fall into this category.

Because of the hazards associated with these chemicals and a string of major incidents, including the Bhopal incident in India that killed more than 3,800 people in 1984 (Broughton, 2005), OSHA promulgated 29 CFR 1910.119, commonly referred to as the PSM standard, in 1992 (Schmidt, 2012). This standard lays out a specific set of requirements that facilities under the standard must adhere to. These standards have largely been effective in reducing risk in PSM-covered facilities, although some subsections of this group have experienced more success in implementation and results than others (Behie et al., 2020). It is important to note that other regulatory frameworks and voluntary standards addressing PSM have been developed in other regions, including the European Union, U.K., India and China (Besserman & Mentzer, 2017) and by other standards organizations. In the context of this article, OSHA's PSM standard serves as the foundational framework for analysis of adaptation of PSM into other sectors.

Although OSHA focused PSM regulations on facilities using highly hazardous chemicals, many of the tools and techniques associated with PSM can be leveraged to improve safety and health in facilities in other sectors. This may be particularly true in facilities or sectors with high-risk environments that do not have enough of a covered chemical to meet the thresholds in OSHA's standard but have other hazards that may represent high safety and health risks to control, such as heat or pressure hazards. While many different sectors could likely benefit from the holistic approach PSM provides, mining, smelting and other non-PSM-covered manufacturing are some examples where the approach may have a significant impact.

The PSM standard establishes 14 individual elements. Some elements are easily transferrable and usable for non-process industries, while others might be more difficult to apply. Some represent opportunities for large impacts in other sectors, while others may already exist to some degree or may be less impactful. In this article, each element is discussed in detail as well as some potential methods for adapting them for use outside of the traditional process industries for which they were originally intended.

KEY TAKEAWAYS

- **Process safety management (PSM) techniques have been utilized by the traditional process industries (e.g., petrochemical, refinery, food manufacturing facilities) for decades. Many industries with highly hazardous chemicals have been required to use PSM techniques for more than 30 years per OSHA's PSM standard, which was promulgated in 1992. Tools such as process hazard analysis, prestartup safety reviews, and mechanical integrity programs are second nature for these companies and have helped drive improvements in safety metrics, as well as in other areas such as operational costs and quality performance.**
- **Outside of these industries, much of the focus has remained on personal or behavioral-based safety. The adoption of PSM-style techniques and holistic review of facility risk has largely been limited.**
- **The OSHA PSM standard establishes 14 separate elements of process safety management. Some of these elements used in process safety, such as mechanical integrity, could easily be applied to other sectors. Others such as process hazard analysis may require some adjustment. This article reviews each of the individual 14 PSM elements to discuss how each one might be applied outside the process industries and addresses why this approach is worth consideration.**

History of Process Safety Management

PSM has existed as long as people have been trying to protect themselves from getting hurt by the tools and substances (or energy) used in work. From a modern perspective, the roots lie in the industrial revolution. As processes were mechanized, new chemicals were being created and used, and higher energy levels came into play, there was more need to protect workers (and equipment) from the new hazards associated with them. Throughout the late 1800s and early 1900s, societal expectations surrounding safety and risk began to shift, driving further improvements. In the late 1950s and early 1960s, PSM started to become a field of its own, with independent studies, conferences and papers appearing on the subject (Hendershot, 2009). Some key techniques, such as process hazard analysis (PHA), were developed during this time. Because of the potential for high-consequence events affecting more than just a few onsite workers, many considered process safety more critical than functional safety from a risk perspective (Hendershot, 2009).

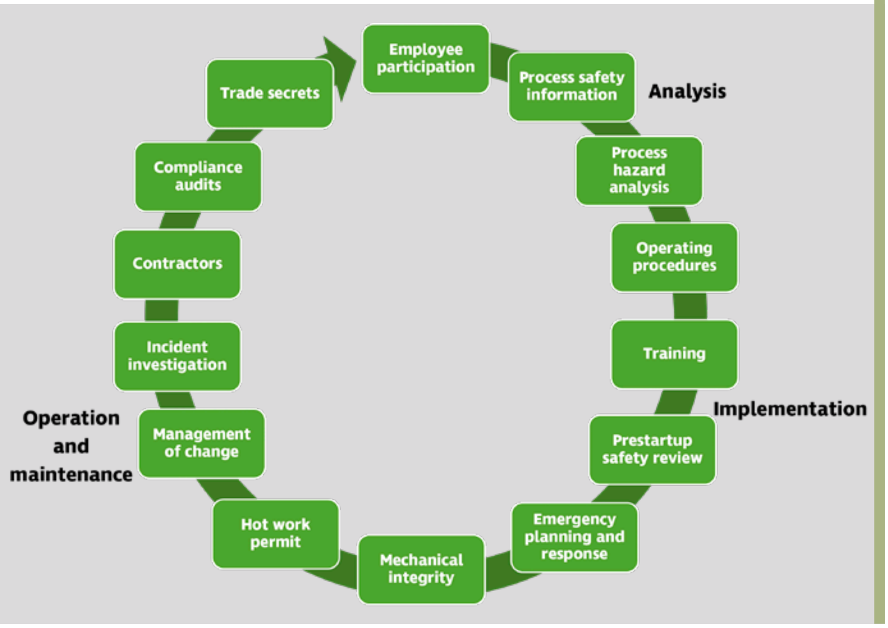
The focus on process safety increased exponentially in the 1980s with a string of disasters involving highly hazardous chemicals. Potentially the most influential was the incident at Union Carbide in Bhopal, India, where water entered a methyl isocyanate tank and began a series of events leading to a catastrophic release and more than 3,800 deaths and more than 100,000 injuries (Schmidt, 2012). In 1985, the Center for Chemical Process Safety (CCPS) was formed as part of the American Institute of Chemical Engineers by 17 charter companies and began work on *Guidelines for Hazard Evaluation Procedures* (Hendershot, 2009). This was the first step toward modern PSM as we know it today. In 1992, OSHA promulgated 29 CFR 1910.119, also known as the PSM standard. The requirements under this standard continue to serve as the framework for process safety for those industries that fall under the standard's jurisdiction in the U.S.

14 Elements of Process Safety Management

The OSHA standard lays out 14 elements that must be addressed by a PSM program to achieve compliance. Each element is shown in Figure 1 (p. 22).

Each element is an important part of the whole program and helps to guide employers through the three phases of the safety life cycle analysis, implementation and operation. The life cycle takes a cradle-grave-cradle approach, ensuring that process information—including limits and procedures—are documented and updated, process hazards have been evaluated, risks have been mitigated and protections continue to be validated. If changes are made, the life cycle starts again to ensure continuous protection, confirming that even incremental changes are addressed and new hazards are identified and mitigated. Most of the 14 elements of PSM correspond to the phases of the life cycle, as shown in Figure 1, although some may manifest themselves in multiple phases (Schmidt, 2012).

FIGURE 1
14 ELEMENTS OF OSHA PSM



It should be noted that not all elements are predicted to have the same level of impact on an organization's safety and health performance. Additional focus is provided on elements that would likely bring the most additional value, such as process hazard analysis and prestartup safety review. That is not to say that other elements are not critical; They are all interconnected, with each playing a key role in the success of others, but some (e.g., training, contractors, trade secrets) likely exist to some degree in most organizations or play a minor role in support of the others and would therefore be less likely to provide the same added value as other elements. This should not be interpreted as a reflection of their importance. As an example, incident investigation and emergency planning and response are critically important to successful safety and health programs, but those do not receive particular focus in this context as they are generally covered by other regulations or industry best practices. This article outlines a summary of each element and how they could be applied outside of the process industry. Generally, these are arranged in an order that aligns with the safety life cycle shown in this article, a sequence that could also serve as a step-by-step instructional guide to facilitate an orderly rollout for an organization wishing to implement a program based around these elements.

Employee Participation (Involvement)

Employee participation is included in the PSM standard to ensure that the employees working with the process (frontline operations and maintenance staff) are involved in the process safety program and understand the hazards and their roles in preventing harm from those hazards. OSHA requires a written plan to be in place and followed. It is easy to see that this requirement theoretically would not be difficult to implement in any industry if the other elements are in place for employees to participate in. Yet, a shift in culture may be required at some organizations to allow frontline employee involvement in some of these activities as well as to recognize the importance of that involvement and dedicate the time and resources to ensure that it is possible. While this element is unlikely to have a major impact on safety performance itself, it is listed first in this article given the criticality of open communication and 360° feedback from employees in the overall success of the other foundational elements. If the other elements are performed in a vacuum without the involvement of frontline staff, much if not all the effectiveness is lost.

Process Safety Information

The process safety information element requires employers to share information related to the hazards of the highly hazardous chemicals, technology and equipment in the process. This information is meant to help employees better understand the process and enable them to make safer decisions involving the operations and maintenance of the process. OSHA also requires that this information be kept up to date. Manufacturers outside the process industries may have a system in place to keep up with this type of information and share it with employees, but it is certainly done in many industries and is not particularly specific to process industries. For applications outside process industries, this information sharing would expand from process specific to include all equipment and materials that may create hazards for employees. OSHA's hazard communication standard already requires employers to provide safety data sheets that include the hazards of any chemicals that their workers may encounter. However, that alone would not meet the requirements of the PSM standard. Companies must go further to include information about the equipment and technology being used and how employees might be affected.

Many industries outside of PSM requirements have documentation and maintenance programs to ensure that technical specifications related to their operation are documented and kept current. If the employer has this type of system in place already, this requirement is likely relatively easy to comply with, assuming that the company is willing to share this information with employees in a way that helps them understand the hazards of their workplace. In cases where an employer does not have a robust system in place for this documentation, building an information repository could be a large undertaking. This information is also key in other aspects of business operations, as it can facilitate better operations and maintenance practices as well as help to reduce downtime and increase efficiency and quality over the long term. This information is critical for implementing other elements. It could even be considered a prerequisite for other elements that follow, hence the importance of an early focus on compliance in this area.

Trade Secrets

The trade secret element of PSM essentially states that companies cannot keep process details from employees by declaring them "trade secrets" (OSHA, 2013a). In the past, many companies would do this under the guise of protecting their competitive advantage. OSHA ruled that this reasoning is not appropriate in the case of companies working under the PSM standard, and it could easily be argued that it is never appropriate when those details could affect employee safety and health. This requirement is not difficult to implement but could require updated nondisclosure agreements with employees and a potential attitude shift for some executives. This element is listed early along with the process safety information element to highlight the importance of sharing complete information with employees, regardless of trade secret status, as this is critical to ensuring that the information employees receive to help them identify and mitigate hazards is complete. Implementation of this requirement would likely take the form of ensuring that information is not withheld unnecessarily as part of the employee involvement and process safety information elements.

Process Hazard Analysis

The process hazard analysis (PHA) element is one of the most technical elements of PSM and is likely to be one of the more difficult aspects for non-process-oriented facilities to implement. It is also likely the element with the most opportunity for impact when implemented correctly in a holistic manner. This element requires processes to be reviewed by someone familiar with the process's engineering design as well as someone familiar with the operation of the process. Due to employee involvement requirements from the first element discussed, this is normally a diverse team that includes frontline employees. The PHA element also requires that someone who is "knowledgeable in the specific process hazard methodology being used" participate in the process (OSHA, 2013a). The first two requirements for participants are likely not an issue for most employers other than the cost of the time these employees would dedicate

TABLE 1
HAZOP ALTERNATIVE DEVIATION EXAMPLE: CONVEYOR BELT

Deviation	Cause	Consequence	Safeguards	L	C	R
High flow	VFD failure; Wrong setpoint entered	Overwhelm downstream equipment, back up material leading to ergonomic strain or other minor injuries, equipment or product damage	Operator monitoring speed with Estop button to shut down belt, Setpoint limitation			
Low flow	WFD failure; Wrong setpoint entered	Loss of production-operational issue	Operator monitoring speed			
Misdirected flow	Guards failed on edges of belt; Guards not replaced after maintenance; Unevenly distributed material on belt causing spillage	Employee exposure to falling material; Exposure to moving parts; Trip hazard associated with spilling material; Fire hazard due to spilled material	Lockout/tagout procedure; Employee rounds to identify spills; preshift inspections			
No flow	VFD failure; Wrong setpoint entered; loss of power	Loss of production-operational issue	Operator monitoring speed			
Electrical deviation	Wiring short due to short in motor, animal or pest activity, vibration, etc.	Electrical shock	Weekly inspection documented by maintenance department; Preshift inspection by operator; Pest control measures; High-vibration alarm			
Machine guarding	Vibration leading to machine guarding failures; Guards not replaced after maintenance	See "misdirected flow"				
Human factors or ergonomics	Manual handling of material from end of the conveyor; Freeing stuck items or materials; Accessing head and tail pulleys for maintenance	Confined space and moving parts hazards (asphyxiation, exposure to harmful environments, moving parts, etc.); Ergonomic exposure due to bodily exertion, requirement for abnormal work angles; Repetitive motion	Permit-required confined space program, job safety analysis program to identify hazards associated with specific activities; Job rotation to limit repetitive motion exposures			

Note. L = a likelihood metric, C = consequence, and R = risk resulting from the stated likelihood and consequence

to the process. The last requirement could be met by utilizing a third-party consultant who is familiar with hazard identification and analysis or by having someone on site trained in relevant methodology.

One of the main issues non-process facilities may have in implementing this requirement is that the methodologies available to facilitate PHAs focus on finding hazards in a chemical processing plant. This means that they focus on process equipment such as vessels, tanks, piping, heat exchangers and pumps. The most popular, the hazard and operability (HazOp) study, uses deviations such as high and low pressure, temperature and flow to assist team members in identifying hazards by compelling them to review each deviation for each piece of equipment. An example of identifying a hazard using this technique in a non-process setting is a potential of no cutting fluid flowing during an operation, resulting in damage to equipment and potentially an operator injury. In this case, "no flow" could be the deviation. In the process industry, this technique and the traditional deviations generally provide a comprehensive review. However, many of these conventional deviations (e.g., high flow, low mixing, reverse direction) may not apply in many situations outside the process setting and would be less effective in identifying non-process-related hazards (e.g., those not related to temperature, pressure or flow).

While just having a diverse team set aside time to review a manufacturing facility for hazards is likely a worthwhile process, having a way to systematically review a facility and determine the risk associated with each cause-consequence pair is key to ensuring a reasonably holistic coverage of hazard assessment and risk mitigation across the board. While the existing tools may not translate completely across to other situations, some ways exist that a team could adapt the method to make it more broadly applicable.

One possible method would be to focus on consequences as a scenario development driver instead of causes. For example, instead of considering that high temperature could melt a gasket, cause a release of hot material and burn an operator (which would be the traditional train of thought in a HazOp), the team instead could ask how an operator could get burned in this situation (answer: by this piece of equipment or by deviations of normal operation associated with this piece of equipment) and work backward to achieve the same cause-consequence pair result. This approach is likely more ubiquitous, as consequences such as burns, struck-by, exposed-to and others can be caused by different types of equipment. Teams could also generate deviation keywords to focus on hazards outside of process causes (e.g., electricity, lifting or ergonomics) in addition to traditional guide words such as high flow or low flow. If a team selects guide words that are applicable from a prepopulated list before or during the review, a meaningful, comprehensive review could be facilitated. Table 1 (p. 23) provides an example of how a mixture of traditional and unconventional deviations or guide words could apply to a conveyor belt. Note that "L" is a placeholder for a likelihood metric, "C" is for consequence, and "R" is for the risk resulting from the stated likelihood and consequence. In a real-world risk review, these would be used to risk rank cause-consequence pairs.

Note that this is meant to be a representative sample of some traditional PSM guide words that could be used and the resulting cause-consequence pairs and safeguards. It is not meant to be a complete review of this piece of equipment. For this reason, the cause-consequence pairs are not risk ranked. To complete the review, a company would need to develop and utilize a risk tolerance criteria matrix and use it to risk rank each pair by estimating likelihood and consequence ratings and adjusting for safeguards. Once complete, a holistic view of risk for this piece of equipment has been generated. The key takeaway of this example is that tools such as HazOp can be adjusted to facilitate reviews on nonstandard PSM equipment.

These methods and other traditional PHA methods could also be paired with other hazard identification tools that are currently being used more frequently in other industries such as job safety or hazard analysis or pretask risk assessments to develop a comprehensive review of risk in a facility that is comparable to the thoroughness provided by a process facility's PHA. Opportunities exist to leverage artificial intelligence tools in conjunction with traditional tools and employee knowledge and experience to perform a holistic, risk-based review of a facility. While not the focus of this article, this technology is having profound impacts on the field of worker safety and there are many use cases for improving worker safety and health in the future (Fiegler-Rudol et al., 2025). The PHA process likely may not be easy for all industrial facilities to replicate but attempting to replicate the holistic view of risk that this type of hazard analysis can provide is a worthwhile endeavor.

Operating Procedures

Operating procedures (as well as maintenance and start-up procedures) should be an important part of every industrial facility's plan for safe operation. These should also be developed relatively early in the design of a process so staff can be trained as part of commissioning before operation commences. Some legal requirements exist for procedures (e.g., lockout/tagout, emergency response), but they are not seen as a legal necessity in many cases. Sometimes, this means that procedures are nonexistent, insufficient, or not updated to reflect current practices accurately. Procedures should include several elements, including PPE requirements, any operating and safe limits that may apply, a way to highlight critical steps, and enough detail to communicate steps clearly without unnecessary requirements. Procedures should be written not only for normal operations but also for emergency situations, start-ups, shutdowns and maintenance. The procedures should be reviewed at least annually and any time a change is made to equipment or practices. Employees should be trained on the procedures in their initial orientation and any time the procedures are updated. If procedures are not updated often, refresher training should be considered annually. Procedures should be audited on a regular basis to ensure continued accuracy.

Training

Workers should be trained on how to perform any task they are asked to complete and how to use any equipment they are asked to operate. The requirements for training parallel those for procedures and were discussed in the previous section. All training should be documented, and trainers should document qualifications in both the area of expertise and training methods. Training should also be audited on a regular basis. This would likely not be a new practice for most industries, although meeting the detailed expectations of the PSM standard may require an organization to improve in this key area.

Emergency Planning & Response

Emergency planning and response are particularly vital at sites handling highly hazardous chemicals, so it should come as no surprise that OSHA includes it as an element of the PSM standard. There are also requirements for emergency planning and response for facilities in general that should be followed regardless of PSM status or the presence of highly hazardous chemicals. This is an area in which most companies of a certain size should already have policies and procedures in place. If a company does not have these in place, it is likely behind and should do so as soon as possible.

Prestartup Safety Review

Prestartup safety reviews are required by the PSM standard for new and modified processes before the process is first put into service or returned to service. This process normally reviews the process for physical hazards that could not be identified during the design review (PHA) and ensures that the process has been built according to specifications with no new hazards introduced. It can also serve as an opportunity to confirm assumptions made during the design phase hazard review and ensure that staff are prepared to safely interact with the process through proper training on operating procedures. To be clear, the "start-up" in this instance is more akin to the commissioning process for non-process equipment, although there may also be some cases where it could also apply to the initial start-up of something like an oven or industrial furnace. However, it is not referring to every time a machine that is designed to be shut off frequently (e.g., a drill, hydraulic press) is restarted, although a mini version of a prestartup safety review could be considered in some of those cases.

Some manufacturing companies may have a version of prestartup safety reviews, but in many cases, it is not as robust as the expected standard in the process industries. Templates are available to help facilitate prestartup safety reviews. Much of the content could apply to industries outside the process industries as well as the process industries themselves, but they may need to be modified to fit specific circumstances. The overarching principles remain the same: to ensure that the equipment has been built as designed, to confirm that no new hazards were introduced as a result of the new construction or modification or new equipment, and to ensure that operators are prepared to operate the equipment in a safe and consistent manner. This element may require some extra work for non-process industries but should be relatively easily obtainable.

Contractors

The PSM standard's requirement for contractors mirrors some requirements for employees. The main point of emphasis is to ensure that the contractor understands the facility and job hazards and is properly trained to handle them. Many facilities have safety orientation processes for contractors that likely meet these requirements, even outside the process industries.

Mechanical Integrity

Mechanical integrity programs are vitally important to operating a facility in a safe and economical fashion. The PSM standard calls out specific equipment for which mechanical integrity programs are required such as pressure vessels, storage tanks, piping systems and ventilation systems. The PSM standard requires that documented inspection programs are required for these pieces of equipment with the expectation that any equipment that does not meet inspection requirements is repaired or replaced. Those conducting the inspections must be trained, and the guidelines that are used to perform inspections must follow "recognized and generally accepted good engineering practices" (OSHA, 2013a). This normally means finding an industry standard such as the American Society of Mechanical Engineers, American Petroleum Institute, National Fire Protection Association, or another nationally or internationally recognized standard. Internal standards can also be developed but require the same level of rigor as would be expected by a recognized standard.

Mechanical integrity programs are another element that likely exists in some form in most industrial facilities, often to comply with warranty requirements, insurance requirements or other industry best practices, but in many cases these programs are not developed to the extent required by PSM. This is another area where improvements can not only drive improved safety metrics, but also reduce downtime, increase efficiency and reduce overall operating expenses, particularly when leveraging a computerized maintenance management system to track activities and trend data. In many cases, mechanical integrity programs have been found to have a relatively high return on investment, but these programs require additional resources.

Hot Work Permit

Hot work permits require workers to fill out a written permit and take certain precautions before performing hot work such as welding. Hot work permits are common outside the process industry, so it is likely that other industries have already adapted a version of the hot work permit process. If they have not, examples and templates are available, and the permits can easily be incorporated into maintenance practices. It is important to keep records of hot work permits and to audit the permit system to ensure that employees are following the company's policy. It can also be helpful to consider whether hazards other than fire hazards could require a permit system. Examples might include toxic fumes, high or low temperatures, electrical or arc-flash exposure, working at height or crane lifts. A permit system for high-hazard work requires additional scrutiny, risk assessment and mitigation, and documentation such as hot work as well as other high-risk tasks is highly recommended for consideration. In addition, many countries already require permits for high-risk work, which is also starting to take hold in some companies in the U.S.

Management of Change

Management of change may be the most overlooked aspect of PSM. According to the PSM standard, the purpose of management of change is to manage changes to process chemicals, technology, equipment and procedures, as well as changes to facilities that affect a covered process and their impacts on safety and health. This generally means that these types of changes are reviewed for hazards, and all relevant documentation is updated appropriately. If implemented correctly, management of change can be a massive undertaking requiring many resources and constant vigilance in a facility where change frequently occurs. Whereas many of the other elements require a large amount of upfront work but relatively little effort to sustain, management of change requires a large amount of continuing focus and ongoing work. It also is a vital piece of the puzzle that helps ensure that all other elements are up to date, documentation is updated appropriately, and changes are reviewed to assess hazards so that new hazards are not introduced into the workplace without an opportunity for identification and risk mitigation.

The critical aspects in setting up a management of change program are defining what changes qualify for inclusion or review under the program and, once identified, what type of review or action is necessary to ensure that hazards associated with the change have been mitigated. While the OSHA standard is relatively clear regarding what changes are covered under the PSM standard, it may be less clear when building a program in other sectors. Ultimately, the definition of a change should be tailored to meet the intent of the program—identifying and mitigating new hazards associated with the change—but there are some standard items to consider including. New chemicals or substances (e.g., a new paint) being introduced into the workplace is a good place to start, as there are likely other requirements (such as hazard communication) within OSHA or other standards that must be met that can be managed through a management of change process. Other changes to consider can include material changes to equipment or new machinery, different modes of operation or human interfacing with equipment, changes to the work environment, or changes to procedures or tasks. Once a covered change has been defined, systems can be put in place within procurement, construction and maintenance processes to help facilitate hazard reviews or documentation updates in line with the hazards and risk of the change.

Management of change also brings both the tools and mindset to help make PSM more broadly applicable to processes, equipment and work practices that are highly dynamic. Templates or software that are specifically developed to pinpoint the hazards associated with a change versus starting from scratch with a full hazard review can help turn a burdensome process into something nimbler. A task-based example of this would be having baseline risk assessments or job safety analyses that outline normal risks associated with the task that are fairly static, in addition to dynamic risk assessments that focus on aspects of the job that may change given a specific situation (e.g., weather hazards, traffic hazards, unstable ground, insects). This approach allows workers to capture information over time in the base risk assessment document and benefit from that compilation of historical knowledge, and it ensures that they are engaged in the dynamic aspects of work that are likely to be impacted by circumstance. This principle could be more broadly applied in similar ways to address process or equipment-based hazards, focusing on aspects that do change.

Without a robust management of change, even the best PSM programs can fall apart over time. The keys to implementing management of change are to clearly identify what changes require action and what those actions are, and have a system (preferably software-based) that can handle tracking and sign-off. This piece of PSM is often the last to be done correctly. It requires intense dedication from management to implement and often requires substantial resources. Although management of change is difficult and time-consuming to implement, it can be seen as the keystone to the process of sustaining a PSM program. As with several other elements, this is not an insurmountable practice to apply to any facility. The challenge is threefold: first defining what changes must be managed in a way that is clear, consistent, reasonable and effective in preventing new hazards being created because of changes; second, providing the resources necessary to carry out this program (both tools and time); and third, driving the culture in the organization to embrace the mindset of continual evaluation of changes to identify and mitigate new hazards.

Incident Investigation

The PSM standard requires an investigation be performed for incidents that result in or could have resulted in a catastrophic highly hazardous chemical release. Incident investigation has become mainstream regardless of the industry and whether highly hazardous chemicals are in play. Many examples and guidelines exist for non-process industry companies to follow associated with incident investigation and root-cause analysis for those companies that do not already have a system in place. Incident investigation and, to take it one step further, near-miss investigation is critical to identifying root causes and gaps in current practices that can drive better safety performance in the future.

Compliance Audits

The compliance audit element of PSM reads, "Employers shall certify that they have evaluated compliance with the provisions of this section at least every three years to verify that the procedures and practices developed under the standard are adequate and are being followed" (OSHA, 2013a). This element is easy to understand and implement once a program is in place. The overarching goal is to ensure that the organization is following the other elements per its requirements and the requirements of the organization's own internal procedures. A third party is usually the most effective way to conduct a reliable audit, although it is not required. This element also requires employers to retain their two most recent audit reports at a minimum. This is a good practice in any industry, as there are other legal ramifications associated with not following internal policies and procedures.

Process Safety Management Justification

According to a study performed by CCPS, process safety provides benefits in four areas: corporate responsibility and business flexibility—which are qualitative—and risk reduction and sustained value—which are quantitative (Berger, 2012). The benefits associated with corporate responsibility include developing a good company image and reputation toward both the public and employees, which go toward building a reputable brand, and good relationships with stakeholders, which can create shareholder value. The benefits associated with business flexibility, or a company's freedom to operate, stem from the probable result of process safety: fewer incidents. This can lead to reduced regulatory scrutiny, fewer legal complications, less community discontent and happy shareholders.

Risk reduction is somewhat self-explanatory but also stems from fewer incidents in a more quantifiable way such as lives saved, reduced property damage and litigation costs, fewer business interruptions, protected market share, and fewer regulatory penalties. One company reduced injuries and fatalities resulting from major incidents by 50%, saving $5 million/year in losses and $3 million/year in worker's comp costs (Berger, 2012). Operational interruptions can cost much more. Sustained value metrics reported by companies in the CCPS study included 5% increases in productivity, 3% reduction in production costs, 5% reduction in maintenance costs, 1% reduction in capital budgets, and up to 20% reduction in insurance costs (Berger, 2012). Each of these areas provide strong motivation for the implementation of a PSM (or quasi-PSM program for non-process industries), but together they make a compelling case.

One might argue that existing safety management frameworks such as ISO 45001 already provide a structured approach to workplace safety, raising the question of why a PSM-based approach should also be considered. However, rather than viewing PSM as an alternative to comprehensive management systems such as ISO, it should be seen as a complementary set of tools and a lifecycle-based mindset that can be integrated within these frameworks to enhance their overall effectiveness. There are many aspects of workplace safety and health not addressed by PSM and, therefore, it should be part of a larger, more comprehensive framework.

Conclusion

Process safety management consists of many tools that have value in other industries. It is possible to create a program for non-process industries that resembles PSM. Many of the main elements of PSM can be easily transferred, while others may require adaptation. Implementation of such a program requires resources and support from management or executives, but multiple payoffs in the form of improved safety metrics, greater operational efficiency and lower operating costs are likely to result (Porter & Grubbe, 2018). **PSJ**

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