

28 YEARS AFTER BHOPAL – IMPORTANT THINGS THAT CATASTROPHIC EVENTS TEACH US

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It is well known that preventing process accidents requires vigilance. Those well experienced in process safety know that the passage of time without a process accident is not necessarily an indication that all is well, and therefore efforts must be made to avoid a dangerous and growing sense of complacency, leading to shortcuts, bypassing of safety systems, deviation from safe operating procedures, and deviation from good engineering practices. Even professionals and companies known to manage process safety well over time can experience such lapses if they don't pay attention to this phenomenon.

The problem is compounded significantly when professionals and companies have never gained this appreciation. Systems can be implemented haphazardly and rapidly deteriorate. Appreciation of safety systems' intended functions may not exist. Safety systems and controls can be implemented haphazardly and rapidly deteriorate. Lessons from past incidents may be unknown, or brushed aside. Deviations from safe operating procedures can be accepted as the norm. Under such conditions, people may never learn to be afraid. When systems and controls deteriorate, everything can come together in the worst possible way.

Developing countries in the Asia-Pacific (APAC) Region have been experiencing high economic growth, with the number of work sites with potential to cause major incidents increasing. In many cases, sites take built equipment directly from licensors and run it with only operating instructions without an appreciation for the hazards or needed process safety practices. Gaps include:

- General lack of awareness of potential hazards
- Failure to take preventive measures, particularly amongst the smaller companies
- Non-compliance with legal requirements, shortage of trained inspectors, or an absence of requirements
- Insufficient training at all levels
- Difficulty accessing, or unawareness of, necessary technical information

This paper will illustrate some of these issues in the APAC region and discuss efforts of CCPS to raise awareness in the region and to help through a collective process to overcome gaps in knowledge, practice, and management.

CCPS is a not-for-profit corporate membership organization that identifies and addresses process safety needs within the chemical, petroleum, pharmaceutical and related industries. CCPS brings together manufacturers, consultants, insurers, academics, and government agencies to lead the way in improving industrial process safety. CCPS was formed in early 1985 to provide a global response by the chemical engineering profession to prevent tragic accidents such as the massive explosion in Mexico City and toxic release in Bhopal, India in November–December, 1984. CCPS has been increasingly active in APAC since 2004 in order to help raise awareness of process safety in the region and to make tools available.

INTRODUCTION

Just after midnight local time in Bhopal, India, a long series of process safety system failures resulted in the release of highly toxic methyl isocyanate (MIC) gas and other toxic materials resulting from the decomposition of MIC. In the hours that followed, more than 2,000 people succumbed to toxic inhalation, while more than 100,000 were seriously injured. Even today, health effects from this tragedy linger.

Bhopal of course was not the first disastrous incident. Notable amongst its predecessors were the Texas City ammonium nitrate explosion in 1947 and the Flixborough vapor cloud explosion in 1974. Two things distinguish Texas City '47 and Flixborough from Bhopal and, to some degree, the explosion and annihilation of a Mexico City LPG plant only 3 weeks earlier. First, the former occurred in relatively developed economies and were caused by then-existing gaps of knowledge. Second, the latter occurred

in emerging economies where the knowledge existed but the culture of maintaining safety systems did not.

In the months that followed Bhopal and Mexico City, industry came together to begin to improve technologies and management systems used to prevent similar incidents from happening in the future. The American Institute of Chemical Engineers (AIChE) led with formation of the Center for Chemical Process Safety (CCPS) in March 1985 to serve the global chemical, petroleum, and related industries. Other collaborative efforts spawned by trade organizations and engineering societies followed. These new efforts differentiated themselves from previously existing technical organizations and working parties by their clear focus on bringing collective knowledge to bear on identifying improvement opportunities and advancing practice in these improvement areas.

Unfortunately, until only the past few years, these efforts had only marginal involvement of emerging economies. Even today, most efforts focus on training, conferences, and discussion groups, with only CCPS engaging engineers and companies in emerging economies in focusing collective knowledge on identifying and overcoming barriers to improvement. In the past 6 years of CCPS' engagement in the emerging economies of Asia-Pacific and Latin America, many process safety challenges similar to those in developed countries have been identified, but many differences and subtleties have been noted as well.

DISCUSSION

SENIOR LEVEL COMMITMENT

Since its early years, CCPS has emphasized that process safety performance starts at the top of the organization. This doesn't only mean the CEO; it means the top of any organization, including the leaders of the business unit, facility, unit, shift, or service group. While it would be unusual (though not impossible) in any part of the world to find a corporate leader that doesn't say and think that safety is important, it is more likely in emerging economies to find leaders in line management who are unable to set a compelling vision for process safety and communicate it and lead in ways that resonate culturally with their employees.

The reasons for this gap tend to be cultural. For example, some cultures are perceived to place lower value human life; some may be hierarchical, requiring more supervision than the leader can provide and preventing reporting of adverse conditions and some may dismiss human ability to change divine will. Furthermore, the facility or company may employ individuals from adjacent geographic regions or ethnic groups whose cultures differ or even clash. In these environments, leaders may believe they are powerless to change a deeply ingrained culture. Their path forward is to translate the objective – a corporate culture which values and adheres to good process safety management – into terms consistent with cultural norms. Effectively, leaders must build a common corporate culture which overlays the local cultures.

There is no standard solution. For example, in cultures which dismiss incidents as divine will, leaders could emphasize divine mercy and motivate employees to help their divinity act more mercifully to their coworkers, perhaps supplementing their efforts with reinforcement from local clergy. In every case, leaders must not assume that the approaches used in developed countries will be effective. After all, even amongst developed countries, there is no single culture or single best approach.

BASIC AND ADVANCED COMPETENCY

As the 28th anniversary of Bhopal approaches, with CCPS's 28th anniversary close behind, there is no basic or advanced principle of process safety which has not been well codified in a CCPS Guideline, nor is any principle suffering from a lack of other resources on the subject. This is not to say that our work is complete, as we continue to learn and discover new ways to advance the practice of process safety. However, the excuse of not knowing how to implement or improve process safety can no longer be supported. Indeed, very few incidents now occur that have not had similar precedents. Of these, very few could not have been anticipated and prevented through application of well-know basic principles.

The excuse of books being too expensive is also rapidly being invalidated. The cost of establishing a reasonable corporate library of the key books and other tools needed is relatively modest, and that library can be made electronic, enabling all employees to easily share the content of the library. Adding to this, a number of free resources exist, including the CCPS Process Safety Beacon and a large number of publications made available by US OSHA and CSB, UK HSE, and other governmental safety regulatory bodies around the world.

In emerging economies, which tend to be rapidly growing, a core of experienced and competent process safety experts can usually be found. The problem is that the manufacturing sectors in these countries are expanding so rapidly as to make it difficult to find sufficient expertise to support the ever-growing number of plants. Compounding the problem, once a person has developed expertise, he or she becomes valuable in the market and often is hired away by the competition.

Some argue that the solution is certification and other forms of credentialing. Unfortunately, this is a very quick way for a person who is book-smart, perhaps with a little experience, to be passed off as having the hands-on experience necessary to perform well in implementing the key challenges in process safety. Likewise, in some countries, large numbers of technically-minded students are being encouraged or directed into undergraduate and graduate degrees in safety engineering. This effectively accomplishes the same result as credentialing.

A more robust and long-term solution, applicable both in developing countries as well as in developed countries facing the wave of "baby-boomer" retirements, is to educate all chemical engineers (and other engineering disciplines practicing in the industry) in process safety along

with their degree programs as well as with their ongoing employee training activities. Basic education should start with both hazard recognition and sensitization to potentially hidden hazards, and progress to address hazards of all technologies a student is exposed to during his or her education.

In addition to the longer term benefits of this approach, considering process safety as part of the overall program of educating new chemical engineers will make our young engineers more holistic thinkers, and therefore better engineers overall.

Supporting this approach, it is critical for companies to identify core competencies in process safety necessary for every role in the company. CCPS is now developing a set of model competencies which companies may adapt to support their ongoing training programs.

INCREASING COMPLEXITY

As technology advances, there is a tendency towards more complex processes. This may happen, for example, by overlaying additional advanced control systems over existing processes to improve throughput or quality. Another example is implementing additional safety integrity levels (SILs) with the goal of improving process safety.

Since a greater level of capital investment is being made in emerging economies, it is more likely that newer technology, with its associated complexities, will be implemented in emerging economies. In view of the shortage of experienced process safety expertise, this places plants in these countries in greater risk of implementing a technology that adds complexity that cannot be supported and maintained satisfactorily.

In view of the competency gap discussed earlier, this may prove a difficult challenge to overcome in the short term. A potential solution is to maintain a larger staff than might otherwise be needed, focusing each person on a smaller specialty range. Over time, specialties can be rotated, to support competency development.

UNSOPHISTICATION

Often, growth takes place via the emergence of new small business. When this occurs in the chemical industry, the new business may have a core staff which understand the basic chemistry of the product but don't have experience in large scale production, including understanding how hazards are amplified on scale-up, and how to control these hazards. Sometimes, this leads to major accidents during the initial period of operation. Other times, these hazards can be controlled through the attention and focus of the core experts to maintain control over a narrow operating window on a daily basis.

However, once the business becomes established, the principals are often drawn away either by growth or by other pursuits, the company is left without either technical expertise on the shop floor to understand potential hazards or the discipline to maintain systems as necessary to prevent accidents.

This problem is difficult to solve, both in developed and emerging economies. The only solutions seem to be increased education and more robust regulation. Neither are short-term solutions, and a regulatory solution may be difficult to implement, as discussed below.

ROLE OF THE LICENSOR/ENGINEERING CONTRACTOR

Many new plants being built in developing economies are based on licensed technologies. As such, the plant is constructed by outside parties and then handed over to the company to operate. Licensed plants should come with sound designs for process safety as well as operating and maintenance procedures based on a deep level of experience; in this way, once the initial staff has been trained, the plant should operate well and safely from the beginning.

The problem arises over time. Workers move on and are replaced by new workers, changes are made in the plant which may not be reflected in drawings and other design documents, and ultimately drawings, documents may be lost. The original licensor may even cease to exist. If the company doesn't maintain the operating discipline, management of change, the operation and the safety of the plant can degrade with time.

Clearly, everyone wants a new plant based on licensed technology to work well from the beginning. The challenge is to establish and maintain a sense of vulnerability across the organization that helps managers and workers keep their focus on performing all the necessary aspects of process safety and maintaining the initial design as safe or safer than as built.

Licensors and contractors have a distinct role in this effort. While it is tempting for the licensor to walk away when the plant is handed over, it is in everyone's best interest for licensors to maintain contact with active plants using their technology. This includes sharing of safety lessons learned as well as periodic audits to ensure that as-built safety has not been compromised.

REGULATORY REQUIREMENTS

While there are countries without process safety regulations, the threshold for establishing regulations is relatively low. Countries implementing new regulations typically adapt existing regulations, such as UK COMAH and US PSM/RMP, to their needs, or follow the UN Environmental Programme's Flexible Framework.

Significantly more difficult is the implementation and enforcement of these regulations. Given the shortage of expertise discussed above as well as the rapid growth in the industry, it is difficult to train and maintain a corps of inspectors large enough to effectively enforce the regulations. Corruption also plays a factor in some places.

Even in developed economies, an incident can often do more damage to the financial health of a company than all but the worst regulatory penalties, which are typically reserved for egregious violations. This is not intended to

suggest that regulations are unnecessary; in fact, regulations are required in order to have a finding of egregious neglect. However, this does suggest that any new regulatory efforts should be paired with an aggressive and ongoing promotion of the benefits of process safety to the company and country as its industry grows.

CONCLUSION

Implementing a strong process safety program plays a key role in the expansion of the chemical and related industries in developing economies. Engineering contractors and licensees operating in this region have an expanded role to play in assuring new facilities are built and new facility personnel and management are trained to properly fulfill their roles related to process safety. Universities also play a critical role by including process safety in the curricula of chemical engineering, chemistry, and other technical disciplines related to the industry. Governments, technical organizations like CCPS, and trade organizations play a critical role in establishing regulatory and non-regulatory expectations related to process safety and to raising awareness and overall competency throughout industry. The industrialists and their senior staffs must adopt a personal commitment to process safety and find an appropriate way to communicate their values and expectations related to

the dedicated practice of process safety within their countries.

Everyone within this group, along with every worker in this growing industry, must play their part to prevent process safety incidents, both large and small. Small incidents may cast their effects only at the local level. But small incidents add up, and if we don't work together, globally, to prevent them, we invite another Mexico City, another Bhopal. To that we must collectively say, "Never again."

ABOUT CCPS

The Center for Chemical Process Safety (CCPS) was formed in 1985 as the chemical engineering profession's response to Bhopal and other tragic process safety incidents. From its start as a committee of 12 industry executives, CCPS membership has grown to 150 companies worldwide, with a growing staff in China, India, the Netherlands, and the United States. CCPS is committed to working with companies around the world to help eliminate all process safety incidents, wherever they can occur, in any industry which handles hazardous materials. Towards this end, CCPS seeks expertise wherever it can be found and facilitates sharing this expertise globally in order to synthesize the technical, management, educational, and cultural approaches that will be needed.