

## Existing Challenges in Incorporating Process Safety Management in Developing Countries and ways to Overcome

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The majority of the products that we consume in our daily life are produced in developing countries because of socio-economic factors. Most of these manufacturing companies are an important part of the international markets, providing products and raw material of desired specifications for other industries around the world. Demands from developed countries and their own local needs can only be met with safer productions. Various incidents that have occurred in these manufacturing industries indicate the lack of comprehensive process safety programs and regulations. Because of this weakness, the rigorous standards and regulations that the multinational companies promise to follow become less effective when implemented in developing nations. Most employees working in these industries are aware of the occupational hazards, but identifying and managing the process hazards requires proper safety management systems. Hence, developing countries need to create strategies to improve the safety management systems.

This paper presents the resulting root cause analyses for incidents that could be attributed to improper, inadequate and/or ineffective implementation of Process Safety Management in the developing countries, and compares their existing practice/regulations with OSHA PSM or EPA Risk Management Program. The key issues for incorporating good management systems are identified. Based on these identified challenges, recommendations for best practices are provided to improve the current situation with regard to process safety and risk management programs in developing countries.

Key Words: Process Safety Challenges; Developing Countries; Strategies to Improve Process Safety; Process Safety Regulations.

### Introduction

The American Institute of Chemical Engineers (AIChE) defines process safety as “a disciplined framework for managing the integrity of operating systems and processes handling hazardous substances by applying good design principles, engineering, and operating practices. It deals with the prevention and control of incidents that have the potential to release hazardous material or energy”(Center of Chemical Process Safety (CCPS)). In the United States, the Occupational Safety and Health Administration (OSHA) defines process safety management (PSM) as “the proactive identification, evaluation and mitigation or prevention of chemical releases that occur as a result of failures of process, procedures, or equipment” (Occupational Safety and Health Administration (OSHA) 1992). In the last 50 years, socio-economic development, along with scientific and technical progress, has brought an unprecedented amount of research and knowledge regarding risk management and process safety. This knowledge is practiced by many industries through their own internal standards or through standards and regulations imposed by law, but there are aspects that must be considered. Existing literature on process safety and the challenges of implementing it correctly shows that most of the research, conferences, and symposia are primarily about North American and European industry, putting aside the developing countries. Despite availability of information and resources regarding process safety management, adapting to these PSM standards and good engineering practices is slow for companies in developing regions where many process industries are growing at much higher rates due to the globalization of world economies. This has resulted in higher risk for the employees and for the environment in these developing nations (International Labour Office 2009).

Reports from the International Labour Office (ILO), International Association of Oil and Gas Producers (IOGP), and the Ibero-American Social Security Organization in the last decade conclude that process safety programs are not fully implemented or given a high priority in companies in developing countries due to socioeconomic factors (International Labour Office 2009, Ibero-American Social Security Organization 2012, International Association of Oil & Gas Producers 2015, International Labour Organization 2015). For example, IOGP published a report about fatal incidents around the world, from which information concerning regions with developing countries was extracted (International Association of Oil & Gas Producers 2015). It is important to note that this information comes from the reported incidents within the IOGP members, but according to the Economic Commission for Latin America and the Caribbean (ECLAC), South & Central American countries report only 25% of incidents at work and 5% of occupational diseases (CEPAL 2013), which means that the statistics do not necessarily reflect the reality of the situation. The study indicated by Renton *et al.* in 2012 estimated that in developing countries people are exposed to more than 80% of global hazards (Renton, Baker *et al.* 2012). The World Bank also conducted a study in 1995 which indicated that a manufacturing worker in a developing country (*e.g.*, Pakistan) is almost eight times more likely to die at work than a manufacturing worker in France. Similar differences have remained for many developing countries even today (World Bank 1995). This paper highlights ways to overcome the challenges in improving process safety in developing countries.

## Current Process Safety Status

The primary objective for companies is to maximize profit while making the process safer. This would require safety barriers which can often be costly. Without strong regulations that require companies to demonstrate a safer process, companies in developing countries could easily reduce the number of safety barriers to reduce the cost associated with the processes. Costs normally considered within the industry are those inherent in the production process and its management, while the social value of human life, health and environmental quality are considered external costs. Human life is not an effective expression in terms of monetary value; however, the relative comparison of human life between developing and developed countries is a topic that deserves more attention and often leads to higher risk operating conditions in developing countries. Furthermore, legal systems utilizing fines or sanctions are considered more stringent in developed countries as compared to developing countries, affecting the inherent issue of valuing life and the environment (Duijm, Fiévez *et al.* 2008).

It has been observed that the quantitative approach to risk analysis is not too evident in the process safety management of many industries in developing countries. Some adopt a management system based on static objectives, (*e.g.*, adherence to minimum legal requirements), where continuous improvement is not sought, demonstrating the continued need for work in the areas of education, collaboration, and commitment. The needed action to make a process safer is to reduce the process hazards in the plant, but this action will differ depending of the country and the company. According to the reports of the ILO, it is common in developing countries for the cost of compliance to fall heavily on the employees who are often not aware of the risk associated with their work (International Labour Office 2009).

Normally, the authorities impose two types of requirements on the industry. The first is prescriptive; these requirements are standards, norms, and criteria that the industry must meet to guarantee a minimum level of safety, but that do not contribute to the continuous improvement of the process. The second type is performance-based requirements, which include the use of tools for continuous improvement, best available techniques, as low as reasonably achievable/practicable (ALARA, ALARP) which can be costly. Thus, for many developing countries, only the first type of requirements is considered, while the second is viewed as optional and use will depend on the company. The company may want to implement it to meet the different markets that require it (Duijm, Fiévez *et al.* 2008).

## Standards and Regulations in Developing Countries

Literature shows that developing countries are looking for a broad and/or general treatment for safety issues. They are handling process safety within the framework of occupational safety and health (OSH), referring to the ILO (International Labour Office) policies; leaving the selection of PSM programs to the companies who want to embrace international practices and guidelines such as OSHA, EPA, and SEVESO. The OSH-related organizations that provide guidelines in some developing regions are the the Andean Community (CAN) and Southern Cone Common Market (MERCOSUR) in Latin America, and the Southern African Development Community (SADC) in Africa. But taking a look at the statistics of incidents in the industry, we can conclude that the measures taken have not been sufficient, and because of that, a more process safety focused framework is required (Ibero-American Social Security Organization 2012, Ghetta 2015).

Many developing countries are in the process of creating a framework or updating their national policies on process safety and occupational health. There are a number of cases in Latin America, Africa and Asia. Countries such as Dominican Republic, Costa Rica, Guatemala, and Nigeria are adopting new policies, others are improving the existing ones (Colombia) or creating new OSH institutes (Algeria and Serbia). Mali has recently requested assistance to initiate a national OSH policy and Sri Lanka has integrated it into their policies (International Labour Office 2009, International Labour Organization 2015, Ministry of Labor 2015).

## Factors Driving the Need of Change

In 2008, Joseph Louvar reviewed the CSB incident investigations, and reported that 50% of the incidents occurred in facilities covered by the PSM standard, and the other 50% occurred in small or mid-sized plants that were not covered by this standard. One clear conclusion from this review is that the OSHA PSM regulation and recommendations by CCPS, CSB, PSP, are not being used as detailed (Louvar 2008). For those countries where the regulations are weakly enforced, we can extrapolate that the number of incidents would be much higher. Large multinational companies are recognized for going beyond the minimum regulation requirements of the countries where they are active. These companies comply with the requirements that the larger markets demand. For mid-sized or small local companies in developing countries, this is not always the case, and often they take advantage of the socio-economic conditions and lack of law enforcement to continue operating without fear of being sanctioned.

To understand some of the shortcomings that can lead to PSM implementation problems in developing countries, the results of specific studies were used. In one of the study conducted in China in 2013 by Zhao *et al.* regarding the safety performance of small- and medium-sized enterprises, it was found that the management knowledge was one of the most common problems when implementing PSM (Zhao, Joas *et al.* 2013). Similarly, a survey was sent to owner/managers of SMEs in Ghana, with a response rate of 32%. The findings revealed that only a few of the SMEs adopted proactive health and safety practices such as; incident reporting procedures; incident investigation procedures; documentation of method statements; health and safety inductions, and use of health and safety posters.

In order to improve PSM implementation in developing countries, it is important to learn about the incidents that have occurred, and oftentimes it is difficult to obtain this information due to the lack of published data and records (Ghetta 2015). In depth reviews of situation of the different developing regions, found the following problems affect the development of good process safety programs.

- **Safety culture:** Perception and perspectives about the advantage of good process safety culture in developing countries are still struggling (Abu-Khader 2004, Louvar 2008, Khan 2013). Stakeholders and top management are not engaged unless there is a public outcry.
- **Laws and regulations:** Most countries have laws and regulations in safety standards to protect the workers and citizens, and the developing countries are no exception. However, in the developing countries these rules and regulations are not strongly enforced. As a result, owners do not feel the need to put many resources in training and workshops; therefore, the workers are not always aware of the hazardous scenarios, and even if they are, they might accept the risks because they are limited in employment opportunities (World Bank 1995, Iunes 2002).
- **Training:** Most developing countries are not capable of providing state-of-the-art training for their employees. These training facilities are often expensive to run or are not available locally. Employees may be sent to foreign countries for training which would increase their competency; however, this is considered expensive and is used minimally.
- **Contractors:** Contractors are an integral part of the process industries and play a significant role in managing the risk throughout the project lifecycle. One great challenge in developing countries is to find experienced local contractors to perform tasks. Inexperienced workers performing specialized tasks could lead to unsafe practices which could lead to incidents. Furthermore, if contractors are being brought in from other countries, it is often an expensive and lengthy process; long periods of time to hire contractors could lead to increased risk.
- **Mechanical Integrity:** PSM rules mandate training for process maintenance employees, written procedures for operation, and inspection and testing for process equipment. Not every company might have a competent workforce to perform these activities. These activities include inspection and testing of process equipment such as piping systems; pumps; devices relief and vent systems; pressure vessels and storage tanks; emergency shutdown systems; and controls such as monitoring sensors, alarms and interlocks. In addition, equipment used in the process industries has to meet certain design codes and standards. It should also be mentioned that for economic reasons, some companies overuse their equipment above their capabilities or service life.
- **Incident Investigation:** If a developing country does not have a well-established regulatory compliance structure, it could significantly affect the incident investigation. Furthermore, lax or non-stringent regulations set by the regulators would impact the number of investigations. In some countries, incident investigations are often avoided by management where weak management system could be blamed. The incidents which were not investigated often had similar root causes to incidents that occurred later. Hence, not doing an incident investigation or having a report would make it impossible for others to learn (International Labour Office 2009).
- **Compliance Audits:** Compliance audits depend upon the regulatory requirement. The biggest challenge in meeting the regulatory requirement is that auditors are more exposed to be bribed to keep industries running. The recent incident in Tianjin is an example where it was found that despite having some regulations the company had illegally built and operated freight-yard of hazardous materials with inadequate safety management. Local officials were deemed to have failed to enforce regulations (Lee 2016).
- **Process Hazards Analysis (PHA):** The PHA must address previous hazardous incidents, the hazards of the process, administrative and engineering controls that are in place and the consequence of the failure of the control measures. The main issues in implementing a PHA are that the regulations do not always define the set of criteria for conducting it. Also, it could be ignored as it requires significant number of personnel and expertise. When PHAs are conducted, recommendations that need to be addressed are made. If there are no strict regulations, these recommendations could be ignored easily as they could be costly.
- **Data management:** Poor data management of incident records and the lack of adequate programs to use them for lessons learned activities makes improvement of the PSM programs difficult (Louvar 2008, Khan 2013). Robust documentation systems cost money and industries are often reluctant in spending money without a business case.
- **Corruption:** Even with the well written laws and regulations, corruption can impinge on those responsible to perform the job honestly. Some organizations with a selfish agenda like to exploit this to save money (Khan 2013).
- **Poverty:** There are some regions with low standards of living in developing countries, where just having a decent paying job means a lot for a considerable amount of people. This can lead to exploitation of the work force by paying low salaries, working long hours and bad workplace conditions (Iunes 2002, Abu-Khader 2004).

### Path Forward in Implementing PSM in Developing Countries

To overcome the problems and challenges previously discussed, CCPS vision 2020 was used as a reference to build up the following recommendations (Center for Chemical Process Safety 2013).

- **Management committed to safety:** Leaders should be connected to the employees within the company, and have the capacity to involve them in the idea of "it can happen here too", and promote the commitment of senior executives showing the importance of safety. This commitment must be documented and shared with local people around the industries to promote safer actions and routines in accordance with the existing policies and procedures.
- **Basic but continuous education for all employees:** The objective is to continuously educate all employees with safety knowledge depending upon the safety critical roles. This helps employees to clearly understand the goals

and expectations of the company and its commitment for process safety. It thus enhances safety knowledge for all employees and creates a strong safety culture.

- **Development and pursuit of competency:** It does not matter how high the company's commitment is or how good the management systems are, competent personnel are needed to carry out safety critical tasks. It is necessary that all employees who have an impact on the process have the skills and knowledge to execute the technical and cultural requirements in safety that their position requires.
- **Willingness to adapt:** There should be constant evolution of the standards and best practices of safety through the use of excellent management of information that allows updating the equipment, the personnel and the procedures driven by the idea of learning from many sources.
- **Cooperative work:** Government regulatory bodies, labor organizations, industry association/consortium, research institutions, universities and industries should work together with the intent of sharing information on best practices and lessons learned to improve standards and regulations. These groups should produce guidelines for the safe design, maintenance and operation procedures of equipment, to harmonize them for the sake of a better understanding and implementation on a regional level. Governments should encourage industries to provide basic training and seminars, inviting employees to discuss regulatory issues and open a dialogue on how to work together for creating safer processes.
- **Systematic implementation of PSM programs:** As mentioned before, many developing countries do not have PSM systems that cover all companies. Large multinational companies comply with international standards while small ones do not have the resources or the technical knowledge to do the same. The use of a PDCA (Plan-Do-Check-Act) cycle implemented in a gradual and systematic way could be the start. Quantitative and qualitative indicators must be implemented as defined by the company. It is important to be able to evaluate the structure, process and outcome of the PSM system as they are aligned with and are part of the strategic platform. If companies do not have the resources to implement this new PSM system, a consortium can be built to share the cost and resources to create a platform that has the capabilities to provide service to these industries.

Companies should be granted a transition period to strengthen the PSM programs gradually and systematically. To make the transition to employers less stressful, labor organizations should be empowered to provide advice and technical assistance to affiliated companies and to submit quarterly reports of the progress made.

Developing countries, such as Colombia which is in the process of implementing a new occupational safety and health management system, have a transition period as follows:

1. 18 months to companies with less than 20 workers
  2. 24 months to companies with 21 to 100 workers
  3. 30 months to companies with 101 to 200 workers
  4. 36 months to companies with 201 or more workers
- **Academic support:** Another aspect that must be addressed is the importance of proper education and research in the process safety area. In developing countries, especially in Africa, most of OSH and PSM education is limited to inspectors and managers. However, efforts to make this education more inclusive are being made in countries such as India and Ecuador, where the subject has been included in their new draft of OSH policies, or Tobago and Trinidad, where OSH agency is currently working with the Ministry of Education to include OSH in the curriculum. Other countries like Bangladesh and Malaysia have started safety programs in some of their national leading institutions. Brazil is providing OSH courses within the framework of specialized studies for safety engineers and technicians, whereas OSH issues are included at all levels of the education system in Cuba, and Mexico. To what extent the PSM is being treated has yet to be seen (International Labour Office 2009).
  - The implication of this provision would create an environment to educate new and old generations of employees by providing education and training within their reach. The inclusion of PSM at all levels of education and training, including higher technical and professional education, is a way to produce an early familiarization with PSM knowledge and principles, and is the most effective way to ensure compliance, while increasing awareness among future employers and workers in hazard and risk reduction strategies. This way the changing industrial world and the new generation working population can be dealt with.
  - This also opens door for industries to reach out to academic institutions for any technical assistance they may need in solving major problems. Further, a state can allocate money to support such an institution, generate a research agenda, and promote cooperation between the industry and academia.

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