Robust Emergency Planning and Response: Weaknesses and Key Lessons

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One of the key elements in any effective process safety management (PSM) program is the Emergency Preparedness plans and procedures. However, poor or inadequate emergency planning or response has been a recurring finding in the Process Industry. Establishment of a sound emergency response plan is vital in safeguarding not only employees and the community, but also in minimizing facility damage and environmental releases.

An emergency response plan should facilitate coordination between different departments or agencies and define what equipment is needed to control an onsite emergency. Likewise, it should also have plans for workers, and if necessary, the public, on what appropriate action (or actions) should be taken to minimize exposure to harm. The plan should also consider coordination with local authorities in cases of extreme emergencies, to ensure that the necessary emergency equipment is available onsite, that the workers and the public are properly instructed to know when and how to take protective action as well as communicates with off-site emergency response agencies.

The present paper focuses on the results from several PSM audits performed by ioMosaic between 2010 and 2016, at several different Chemical Process Industry (CPI) facilities. On the one hand, we have evaluated how well these facilities complied with the requirements of the OSHA PSM Standard (29 CFR 1910.119), a process-based program aiming at preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals. On the other hand, the data from the audit findings has been compiled and statistically processed in order to specifically assess the findings related to Emergency Planning and Response, one of the 14 elements of the OSHA PSM.

The audit findings were identified based on three different categories: Regulatory (non-compliant), Recognized And Generally Accepted Good Engineering Practices (RAGAGEP) and Local Attention.

Results show that the Emergency Planning and Response element, represents 7% of the regulatory findings, 9% of RAGAGEP, and 16% of the Local Attention, being the main contributing element for this latter category finding.

Emergency Planning and Response is a key weakness of many PSM programs. Understanding the nature of related findings helps identifying poor or inadequate Emergency Preparedness practices and provides an opportunity to address them to develop a sounder Emergency Planning process.

Keywords: RAGAGEP; disaster planning, emergency response, emergency planning, emergency preparedness, findings, OSHA PSM, incident, process safety, process safety management, audit, lessons learned

Introduction

Many major accidents have taken place in the chemical and petrochemical industry over the past 40 years (Table 1), which have been key driving forces for issuing new regulations (governments), publishing standards (industry groups), developing policies (companies), and ultimately for improving Loss Prevention strategies and Process Safety Management (PSM). In this context, a key standard is OSHA PSM (29 CFR 1910.119), a process-based program aiming at preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals.

Table 1 – Examples of major accidents in the chemical and petrochemical industry

Location	Date	Company	Process	Major Incident	Fatalities (F)/Injuries (I)
Flixborough (UK)	6/1/74	Nypro (UK) Ltd	Production of caprolactam	Cyclohexane vapour cloud explosion	F: 28 workers I: 36 on-site, 53 off-site
Seveso (Italy)	7/10/76	Industrie Chimiche Meda Societa Azionara (ICMESA)	Batch production of 2,4,5-trichlorophenol (TCP)	Toxic release of TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin)	F: 0 I: 477 people reported skin injuries (burns & chloracne)
Bhopal (India)	12/3/84	Union Carbide India Ltd	Production of Sevin	Toxic release of methyl isocyanate (MIC)	F: 3,787+ workers and near-by Residents
Piper Alpha (UK)	7/6/88	Occidental Petroleum (Caledonia) Ltd	Offshore oil and gas processing	Oil platform explosion and fire	F: 167 workers
Pasadena (USA)	10/23/89	Phillips 66	Polyethylene production	Polyethylene plant explosion and fire	F: 23 workers I: 130 to 300
Longford (Australia)	9/25/98	Esso Australia Resources Ltd	Gas and crude oil processing	Gas plant explosion and fire	F: 2 workers I: 8
Texas City (USA)	3/23/05	BP	Oil refinery	Vapour cloud explosion following a release from an atmospheric vent stack.	F: 15 workers I: 180

Source: Chemical Safety Board: https://www.csb.gov/

The US OSHA PSM is a performance-based management system regulation intended to prevent catastrophic releases of highly hazardous chemicals (HHC). This standard contains requirements for the safe management of hazards associated with processes using, storing, manufacturing, handling, or moving highly hazardous chemicals onsite. It emphasizes the management of hazards through an established comprehensive program that integrates technologies, procedures, and management practices. OSHA PSM consists of 14 elements (Fig.1) including Emergency Planning and Response (ER).

This paper presents a case study that compiles and analyses data from a sample of sixteen (16) PSM audits conducted by ioMosaic between 2010 and 2016. It assesses audit findings for Emergency Planning and Preparedness to understand whether there is any systematic system weakness in emergency planning.

Figure 1 – Fourteen Elements of the OSHA PSM Standard

Methodology for performing PSM Audits

The scope of the audits included all 14 PSM elements (Fig. 1), since they all work together and are interrelated (Fig. 2). They are all key in providing multiple layers of protection (Aziz, Shariff and Rusli, 2017). In addition, the audits' scope accounted for an evaluation of the applicability of the OSHA PSM standard based on the chemicals handled on each specific site.

The audits were conducted by experienced consultants who were impartial towards the facility or area being audited. All 14 OSHA PSM Elements were distributed among the members of the Audit Team.

Prior to arriving on site, a pre-audit questionnaire was requested to be completed and forwarded to the audit team. This pre-audit questionnaire included information regarding how PSM is implemented at the specific facility. Once on site, a kick off meeting was conducted to introduce the audit team, to identify the element champions, to review the plan and approach for conducting the audit, and to establish an agenda according to the team's availability. The audit was based on the following:

- Physical inspections of the facility;
- Examination of selected process safety administrative and operating records;
- Interviews and discussions with key facility management, staff, and contractors; and
- Verification activities to assess the facility's application of, and adherence to, the regulations and related facility policies and procedures

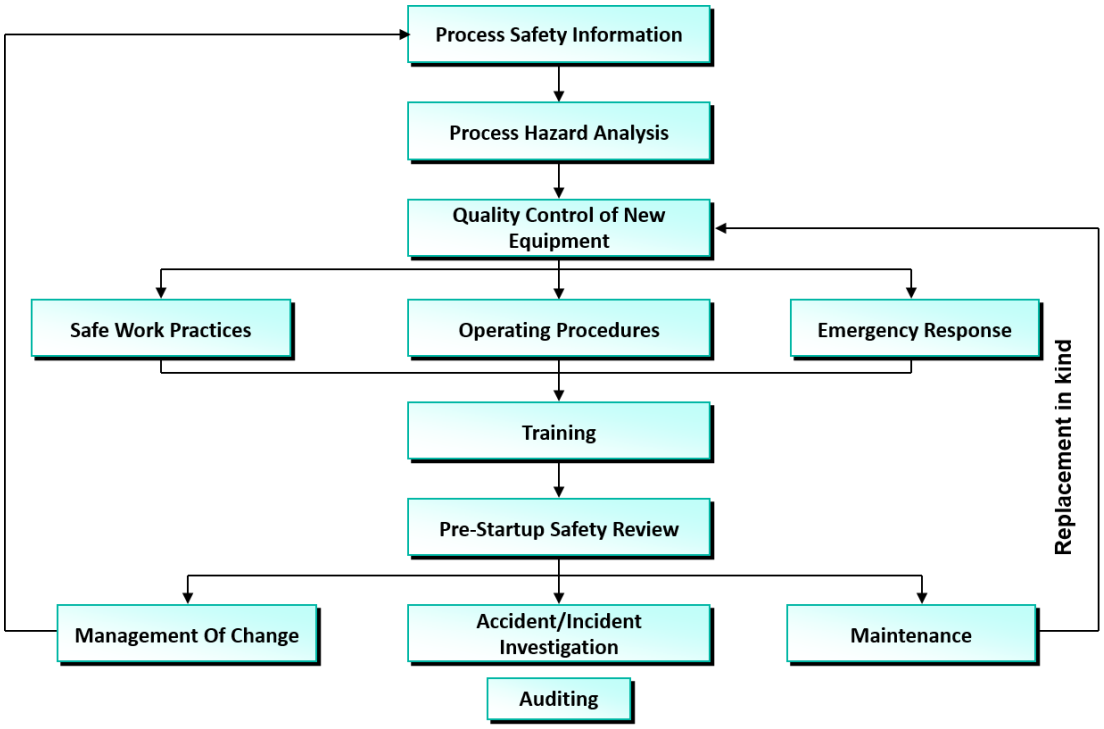

Figure 2 – Interrelations among the 14 Elements of the OSHA PSM Standard

An audit finding, citation or violation was defined as the identification of a part of the PSM program that does not meet regulatory requirements or industry/company standards. Likewise, an audit finding is a conclusion reached by the audit team based on data collected and analysed as to whether part of the PSM program does not meet regulatory requirements or industry standards. The audit findings were classified according to the following categories:

- Regulatory – finding related to the OSHA PSM Standard
- RAGAGEP – finding related to Recognized and Generally Accepted Good Engineering Practice (or best industry practice)
- Local attention item – finding of a relatively minor nature or not within the scope of the audit
- Compliant – no evidence of non-compliance

Daily debriefing meetings were held in order to communicate preliminary findings and observations made by the audit team to facility personnel. Likewise, a closeout meeting was also held to present all the regulatory, RAGAGEP and local attention findings on the last day of the PSM audit.

All covered facilities require compliance audits every three years. These audits serve as the ongoing quality assurance process for the process safety management systems.

Audit Findings: Statistical Analysis

ioMosaic has carried out many audits over the years, and a sample of sixteen (16) audits, from 2010 to 2016, was selected for conducting the analysis described in this paper. The sample of 16 audits covered chemical facilities, petroleum refineries and facilities handling explosives. The objective of the audits was to evaluate how well each facility complied with the requirements of OSHA PSM (OSHA 2012) as well as to specifically evaluate the audit findings for Emergency Planning and Preparedness to understand whether there is any systematic system weakness in emergency planning. All 14 elements were audited:

- Employee Participation (EP)
- Process Safety Information (PSI)
- Process Hazard Analysis (PHA)
- Operating Procedures (OP)
- Training
- Contractor Safety
- Pre-Startup Safety Review (PSSR)
- Mechanical Integrity (MI)
- Hot Work Program
- Management of Change (MOC)
- Incident Investigation
- Emergency Planning and Response (ER)
- Compliance Audits
- Trade Secrets

A statistical analysis of each of the 16 audits was conducted. The study identified a total of 1,108 findings, from which 626 were Regulatory (58%), 199 RAGAGEP (18%) and 261 local attention (24%). Figure 3 shows the distribution of the findings per audit conducted.

The study focussed on determining and analysing the contribution of each element and specifically the Emergency Planning and Response, to the three different finding's categories.

The first category to be analysed was the "Regulatory" findings, which are the ones related to the OSHA PSM Standard:

The total number of regulatory findings were 626. Emergency Planning and Response accounted for 7% of the regulatory findings with a total of 44 citations. The other main elements contributing to this category were: mechanical integrity (MI) with 104 findings, process safety information (PSI) with 78, operating procedures (OP) with 76 and 72 from hot work permit (HWP). These four elements accounted for almost 53% of all regulatory findings. Figure 4 depicts the total percentage of Regulatory findings per each of the 14 OSHA PSM elements.

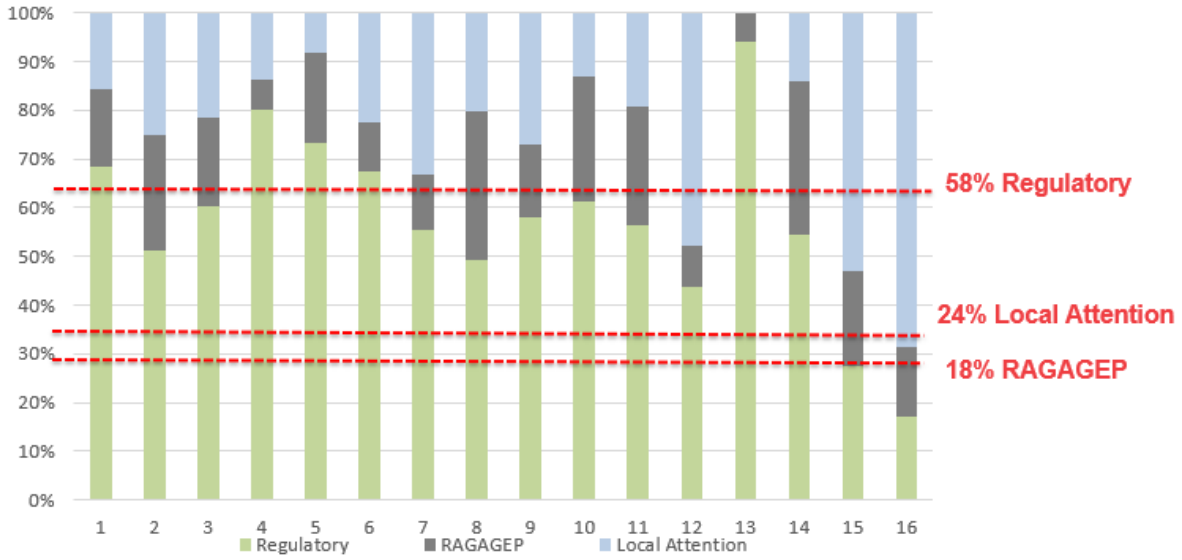

Figure 3 – Distribution of the findings per audit conducted

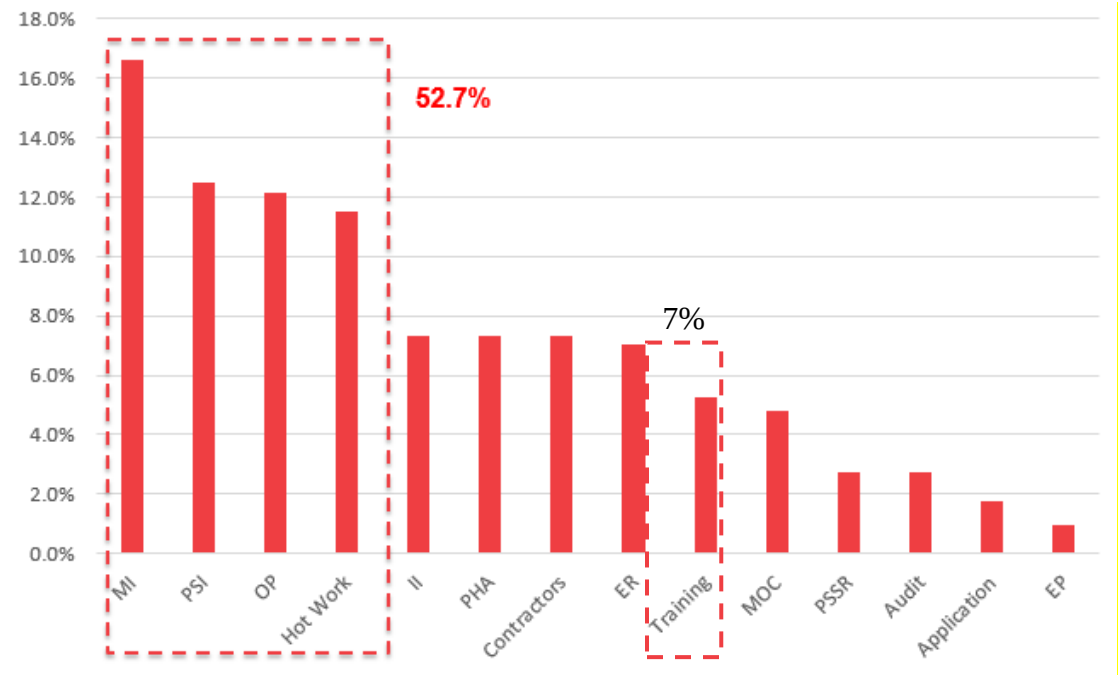

Figure 4 – Total percentage of Regulatory findings for each of the 14 OSHA PSM elements

The next category to be analysed is the findings related to Recognized and Generally Accepted Good Engineering Practice (RAGAGEP or best industry practice). OSHA PSM is performance based and does not specify how the standard should be implemented at each facility. Therefore, companies are sometimes not aware of industry best practices that can be followed, to ensure proper PSM implementation and it is the auditor's responsibility to properly explain the reason for RAGAGEP findings.

The total number of RAGAGEP findings were 199. Emergency Planning and Response accounted for 9% of the RAGAGEP findings with a total of 18 findings. The other main elements contributing to this category were: mechanical integrity (MI) with 31 findings, Incident Investigation (II) with 28, Process Hazard Analysis (PHA) with 21 and Operating Procedures (OP) with 20. These four elements accounted for almost 60% of all RAGAGEP findings. Figure 5 depicts the total percentage of RAGAGEP findings per each of the 14 OSHA PSM elements.

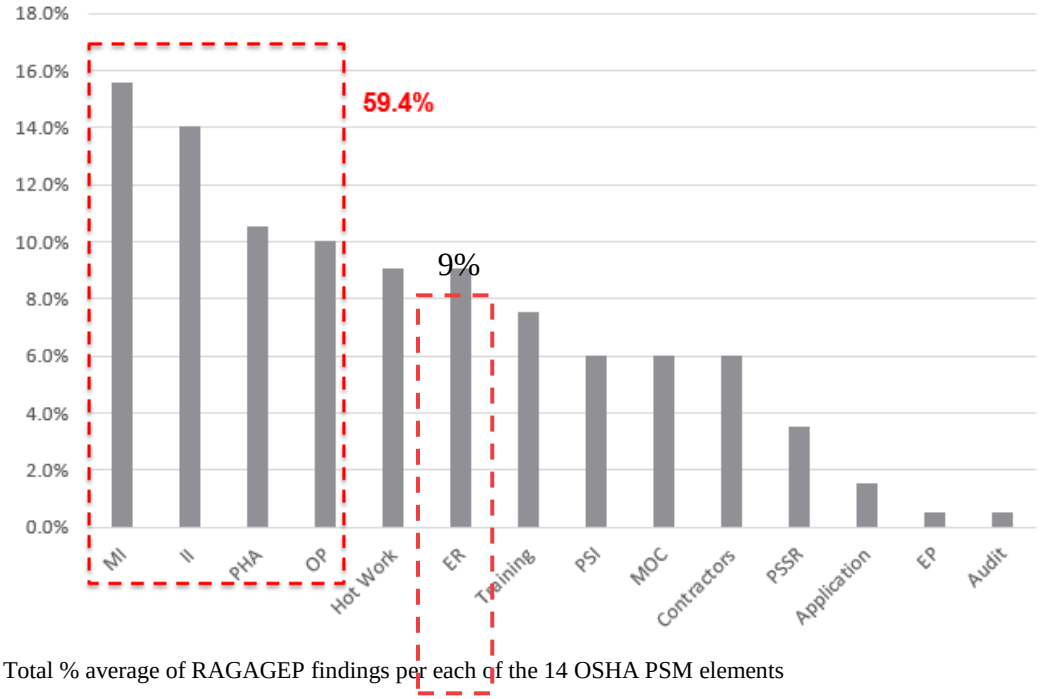

Figure 5 – Total % average of RAGAGEP findings per each of the 14 OSHA PSM elements

The last category to be analysed is Local Attention, i.e. findings of a relatively minor nature that do not represent a chronic PSM issue or a finding related to requirements not specifically listed in the PSM regulation.

Out of the 261 Local Attention findings, 42 relate to Emergency Planning and Response, the main element contributing to this category representing the 16% of all findings. Other important elements in this category are: Operating Procedures and Incident Investigation, both with 32 findings (12%) and 24 to Mechanical Integrity (9%). The total sum of these findings represents the 50% of all the Local Attention findings. Figure 6 presents the total percentage of Local Attention findings per each of the 14 OSHA PSM elements.

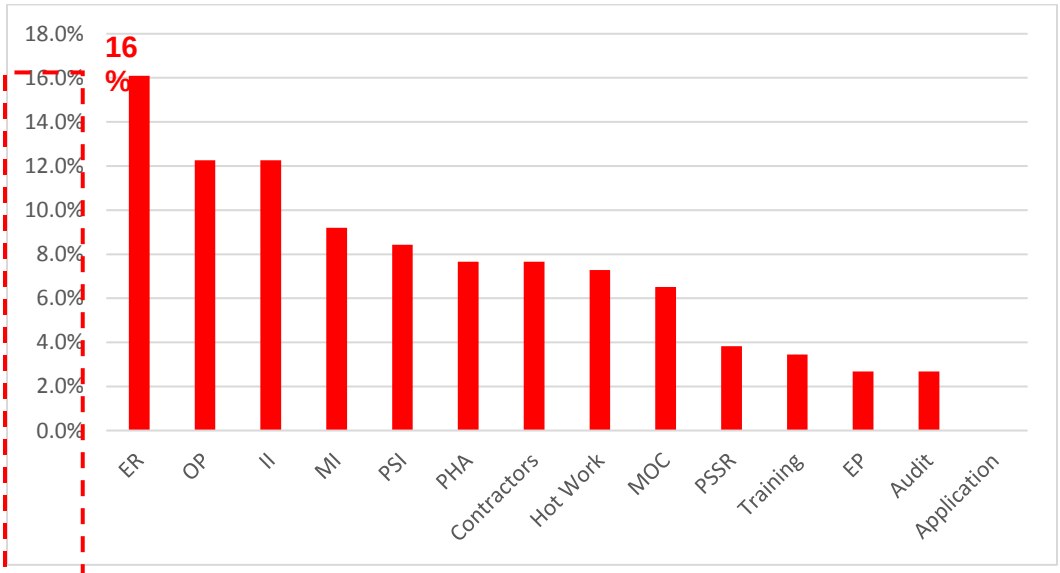

Figure 6 – Total % average of Local Attention findings per each of the 14 OSHA PSM element

The last statistical analysis focussed on identifying the contribution of each PSM element to the total audit findings, including Regulatory, Local Attention and RAGAGEP. Figure 7 shows the Distribution of all the findings per element.

Based on the results from ioMosaic audits, the following elements can be considered the most cited and correspond to almost 70% of all findings including all categories and all facilities:

- Mechanical integrity (15%)
- Operating procedures (12%)
- Process Safety information (10%)
- Hot Work (10%)
- Incident Investigation (10%)
- Emergency Planning and Response (10%)

Emergency Planning and Response represents 10% of the total findings, and therefore, together with MI, OP, PSI, HWP and II, is considered one of the main elements identified in the audits.

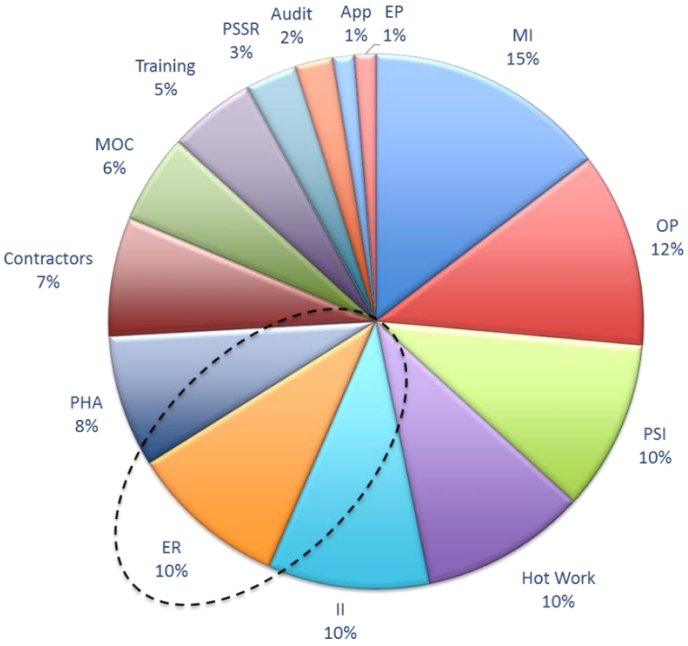

Figure 7 – Distribution of all the findings (Regulatory + RAGAGEP + Local Attention) per element

Emergency Planning and Response: a weakness of PSM programs

Emergency Preparedness is one of the key elements in any effective process safety management program. However, poor or inadequate emergency planning or response has been a recurring finding in the Process Industry, as presented in this study.

Some of the main ER findings identified are:

- The emergency plans don't include or refer to the corresponding procedures.
- There is no training plan for Emergency Response personnel.
- The responsibilities of Emergency Response personnel are not known or poorly defined.
- There is no formal written procedure for employees to review their roles in the Emergency Planning and Response Plan, when their responsibilities change.
- There is no emergency power backup system for the plant wide alarm system.
- Evacuation routes are not clearly marked.

Establishment of a sound emergency response plan is vital in safeguarding not only employees and the community, but also in minimizing facility damage and environmental releases.

An emergency response plan should facilitate coordination between different departments or agencies and define what equipment is needed to control an onsite emergency (Perry and Lindell, 2003). Likewise, it should also have plans for workers, and if necessary, the public, on what appropriate action (or actions) should be taken to minimize exposure to harm. The plan should also consider coordination with local authorities in cases of extreme emergencies, to ensure that the necessary emergency equipment is available onsite, that the workers and the public are properly instructed to know when and how to take protective action as well as communicates with off-site emergency response agencies (OSHA, 2001).

An Emergency response plan should address, at a minimum, the following items:

- Pre-emergency planning and coordination with outside parties
- Personnel roles, lines of authority, training and communication
- Emergency alerting and response procedures
- Safe distances and places of refuge
- Site security and control
- Evacuation routes and procedures
- PPE and emergency equipment
- Emergency medical treatment and first aid
- Decontamination
- Critique of response and follow-up
- Emergency recognition and prevention

General emergency response planning training is essential and must address the following:

- Individual roles and responsibilities
- Threats, hazards, and protective actions
- Notification, warning, and communications procedures
- Emergency response procedures
- Evacuation, shelter, and accountability procedures
- Location and use of common emergency equipment
- Emergency shutdown procedures
- Means for locating family members in an emergency

In addition to training, review and discussion of the Emergency Response Plan with all employees is considered good practice within the Process Industry (OSHA Training Material, 2019).

The following items should also be part of Emergency Response Planning:

- A description of the facility, layout and chemical inventory
- Training and drills to simulate realistic emergency situations
- Alarms including directional sirens, strobes or public announcement systems, and local annunciation systems
- Suitable back-up power for emergency response systems
- Written plans considering past incidents, near misses and credible emergency situations that could arise

Conclusions

Audit findings are a valued source of information for understanding current weaknesses and lessons learned and provide an opportunity to significantly improve any PSM system and minimize the consequences of any catastrophic incident. All audit findings should be seen as calls for action and should be addressed in a timely manner.

Results show that the Emergency Planning and Response represents 10% of overall audit findings, including 7% of regulatory findings, 9% of RAGAGEP and 16% of the Local Attention, being the main contributing element for this latter category finding. In general, our analysis suggests a pattern of repeat findings including lack of training, incomplete emergency planning, absent or poorly defined emergency roles and responsibilities.

We conclude that Emergency Planning and Response is a key weakness of many audited PSM programs. Understanding the nature of related findings and deficiencies helps identifying poor or inadequate practices and provides an opportunity to address these to develop a sounder Emergency Planning process. In this context, we believe that our analysis provides useful industry guidance, to help develop and improve emergency preparedness, planning and response.

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