Safety Management in Industrial Corporation

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Safety management in industrial corporation's most relevant factors are related to leadership and high standard safety culture, as well as additional attributes, such as awareness and process risk assessment, knowledge and competencies, proper communication and information, effective decision-making, and resilience.

Keywords: corporation ; safety culture ; safety management ; Seveso establishment

1. Introduction

Recently, in many East European countries, large industrial corporations are bringing together many industrial plants with similar production processes. Under the pressure of an even more competitive marketplace, individual plants need to join their forces and create large industrial clusters, for producing positive economic effects related to integration and scale economy. However, the other side of the coin is the need to deal with organizational shortcomings, which include safety and risk management, and this facet can be particularly relevant in "Seveso" plants, where the evolution in regulatory thinking has progressively integrated traditional occupational safety with process safety. In Europe, since 1982, safety approaches were integrated into the EU legislation, with the so-called Seveso Directives (Directive 82/501/EEC ^[1], Directive 2012/18/EU ^[3]). Moreover, the business environment is becoming more and more dynamic and competitive, and frequent turnover in the staff ("job hopping") has deepened the problem.

Plant corporations are facing the conundrum of increasing production and, at the same time, achieving higher safety and environmental standards. Most of the corporations include Upper Tier Plants, under the umbrella of the last amendment of the European legislation focusing on prevention and control of major chemical incidents, known as Seveso 3 Directive, which means that safety policy standards are high. It must be mentioned that, for the first time since the first Seveso directive issued in 1982, Seveso III explicitly mentions specific procedures for safety performance indicators and/or other relevant indicators, to be utilized for monitoring the performance of safety management systems ^[4]. Consequently, leaders need to be well prepared to deliver high-level results within this topic ^[5].

2. Identification of Factors Necessary to Effectively Manage Process Safety in a Corporation

Ensuring safety in Upper Tier Plants requires robust roots in risk assessment and safety management systems. Such systems have been defined in different technical guidelines, e.g., ISO 31000 ^[6] and ISO 45001 ^[Z], or else OSHA ^[8] in USA. Additionally, it must be remarked that the concept of "risk-approach" is also integrated in the sector-specific quality management reference ISO 29001:2020 ^[9]. Safety management includes three main components based on the Deming management cycle:

- Designing the safety foundations of safety by delineating general, establishing safety principles and organizing the system by allocating authorizations and responsibilities.
- Delivering and mastering safety by developing and empowering appropriate management procedures.
- Checking and evaluating the system performance through audits and check-ups to double-check the attainment of goals adopted for the safety policy and introducing adjustments.

Management processes concern the so-called management components, which cover specific areas of industrial processes and safety management with strictly defined management procedures. The above-mentioned, normalized management systems have different structures when it comes to the type and number of elements. The PSM standard includes 12 components; the OSHA norm, 14 components; while some European companies covered by the Seveso Directive include 13–15 components ^[10].

The implementation and effectiveness of those processes are dependent on company resources, i.e., human resources, economic resources, knowledge and experience, other external circumstances, and regulations, as well as on multiple organizational factors. Several recent studies were performed on actual implementing and improving existing SMS. It seems well worth mentioning Demichela et al. ^[11] who evidenced that risk analysis (RA) provides sizing criteria for the whole SMS and helps to define the objective of the management system itself. Bragatto et al. ^[12] outlined a novel framework based on the bowtie model to improve the practical implementation of SMS in small-sized enterprises, while in ^[13] it is evidenced the relevant role of managerial and organizational factors in developing risk analysis studies addressing risk-based decisions.

The main method used to identify organizational and culture-related factors, which are principal causes of accidents, consists in using historical accident and incident-related data. The need of a historical accident analysis is increasingly recognized in the industrial sector, to understand the triggering causes ^[14], avoiding the repetition of the same mistakes noticing critical aspects of the process that often go unnoticed at the design stage.

Historical data on industrial accidents are available on several following databases, e.g., FACTS currently managed by the Unified Industrial & Harbour Fire Department in Rotterdam-Rozenburg ^[15], eMARS ^[16], Process Safety Incident Data PSID ^[17] and several surveys on selected accident scenarios were developed using, for instance, the Major Hazards Incident Data System (MHIDAS) ^[18], or FACTS database ^[19]. In the following, we do not provide a thorough accident synopsis, nor do we list all the learnings and changes that came from the selected incidents, but we highlight the key issues related to safety management items focusing on accidents resulting from leadership lack and evidencing the need to strengthen safety management systems. **Table 1** lists selected major accidents caused by safety management-related aspects.

Date	Location	Industry	Fatalities	Main/Root Causes	Ref.
10 July 1976	Seveso	Chemical	-	Human error, lack of process knowledge Emergency preparedness	[20]
2 December 1984	Bhopal	Chemical	8000 immediately 12,000 thereafter	Process safety and ageing management system Emergency preparedness	[<u>21][22]</u> [<u>23</u>]
26 April 1986	Chernobyl	Nuclear power plant	985,000	Human error in design Production pressure Absence of proof tests Leader error	[24]
28 January 1986	Challenger space shuttle	Space	7	Organization failure Pressure on success	[25]
6 July 1988	Piper Alpha Platform	Gas and oil	167	Management of change errors Production pressure	[26]
3 October 1989	Philips, Texas	Chemical	23	Human error	[27]
13 May 2000	Enschede, The Netherlands	Manufacturing	22	Lack of operational discipline	[28]
21 September 2001	Toulouse	Chemical	30	Lack of knowledge Poor hazard identification	[29][30]
23 March 2005	Texas City	Oil and gas	15	Failures in corporate management and culture	[<u>31]</u>
20 April 2010	Mexican Bay USA	Oil and gas	11	Lack of supervision	[<u>32]</u>
17 April 2013	West, Texas	Logistics	15	Lack of risk awareness	[33]
12 August 2015	Tianjin, China	Logistics	173	Failures in management system	[34]
22 March 2018	Kralupy, Czech Republic	Chemical Refinery	6	Human error and lack of supervision	[35]

Table 1. Major accidents and main root causes.

Date	Location	Industry	Fatalities	Main/Root Causes	Ref.
29 October 2018 10 March 2019	Boeing 737 Indonesia Ethiopia	Air traffic	181 157	Design errors Production and profit pressure. Gaps in risk management	<u>[36]</u>
4 August 2020	Beirut port Lebanon	Storage	204	Lack of risk awareness Poor process safety Management	[<u>37]</u>

Even if far from being complete, the above list suggests that, although over time new solutions in risk and safety management have become available, several issues, linked mainly with oversights and human errors in individual elements of safety management systems, constantly come back. Human errors are crucial, they happen in the design or operational stage and in some instances are connected only to organizational and management factors. Detailed knowledge and deep understandintg about the root causes related to organizational and cultural factors is not so common during the forensic investigations after an accident. Such knowledge is sometimes available for accidents that caused severe consequences and triggered strong public pressure. Forensic investigation of the Chernobyl disaster for the first time addressed the issue of negative safety culture as the root cause of the nuclear catastrophe ^[23].

The most relevant analyses were performed as a follow-up of the explosion in Texas City in 2005 ^[31]. **Table 2** summarizes the conclusions of the Baker Panel on corporate safety management ^[38], obtained after a thorough analysis of the accident immediate and root causes based also on detailed questionnaires.

Table 2. The Baker Panel conclusions on shortcomings in management factors.

No.	Impact Factors
1	Absent or poor leadership of the corporate management in safety
2	Shortcomings, or rather negative safety culture and climate (infringing procedures, inability to learn, cost cuts and a system of awards related with it, weaknesses in the safety assessment resulting from compliance assessment, not risk assessment)
3	Inadequate organizational structure and unspecified scope of management competence and responsibility in the area of safety
4	Insufficient knowledge and experience of leaders and no support to production managers
5	Underestimated need to assess safety
6	Absence of monitoring and Board's supervision over advances made in process safety
7	Attention paid mainly to occupational safety and safety indicators (IIR)

The above conclusions were confirmed by Hopkins ^[39] and are representative for some other process accidents, including an explosion in Tesoro Refinery (2010) and fire in Chevron Refinery in 2012 ^[40]. A research investigation performed on more than 30 high risk plants in Poland evidence similar issues, especially poor safety culture and lack of risk awareness ^[41].

In analyzing accidents statistics, there is no doubt that the leadership has a major impact on the effectiveness of safety and that PSM is recognized as the primary approach for establishing the level of safety in operations required to manage high-hazard processes and plants. Leadership requires many technical, social, and conceptual skills at the management level because it involves considering the corporation as a community that can ensure safety. Personal leadership skills supported with a solid system of communication and information are very helpful. Concerning the other aspects of safety culture, there are misgivings around the competences of new management staff, the ability to generate a self-learning environment that takes advantage of historical data, the issue of "cost cutting", which typically hinders safety measures and budgets allocated to training and learning in the first place.

Risk awareness at each level of installation development, from its design through exploitation up to the decommissioning, is another important aspect and one of the root causes of many accidents. DuPont believes that risk awareness is the key to ensuring operational discipline; the latter is defined as an engagement and commitment of each member of an organization in order to correctly comply with her/his duties at any moment of time ^[42].

At the same time, operational discipline is actually reinforced by positive safety culture and leadership functions related to the authority and professional position.

Another element that testifies to the importance of risk awareness and communication is the number of warnings and penalties imposed by the OSHA, which placed the issue at the top of its statistics for 2017 ^[43].

All the above-mentioned safety management factors can work properly only when the decision-making system as well as communication and information flow operate properly.

3. Conclusions

Historical data on serious accidents underline the central role of corporate management for safety performance. Wellestablished corporate safety management helps in building trust in a shared and communicative environment, inducing a collaborative workplace, supporting sustainable growth, financial stability, and business integrity of any industrial corporation. A vital role can and should be played by the management whose knowledge, experience, and leadership traits (charisma, engagement, and commitment) exert the biggest impact on financial success of an organization. Nowadays, special tasks in this field are related to digitalization of management processes, including the application of new process technologies moving towards Safety 4.0.

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