# Safety Management in Industrial Corporation

Subjects: Management

Contributor: Bruno Fabiano

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.

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 96/82/EC [2], 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 [7], 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.

**Table 1.** Major accidents and main root causes.

| 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 | [21] [22] [23] |
| 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 | [31] |
| 20 April 2010 | Mexican Bay USA | Oil and gas | 11 | Lack of supervision | [32] |
| 17 April 2013 | West, Texas | Logistics | 15 | Lack of risk awareness | [33] |
| 12 August 2015 | Tianjin, China | Logistics | 173 | Failures in management system | [34] |

| Date | Location | Industry | Fatalities | Main/Root Causes | Ref. |
|---|---|---|---|---|---|
| 22 March 2018 | Kralupy, Czech Republic | Chemical Refinery | 6 | Human error and lack of supervision | [35] |
| 29 October 2018<br>10 March 2019 | Boeing 737<br>Indonesia<br>Ethiopia | Air traffic | 181<br>157 | Design errors<br>Production and profit pressure. Gaps in risk management | [36] |
| 4 August 2020 | Beirut port Lebanon | Storage | 204 | Lack of risk awareness<br>Poor process safety Management | [37] |

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 |

| No. | Impact Factors |
|---|---|
| 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. Well-established 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.

## References


1. EC Council Directive. 82/501/EEC of 24 June 1982 on the Major Accident Hazards of Certain Industrial Activities; Official Journal of the European Communities L230/25: Brussels, Belgium, 1982.
2. EC Council Directive. 96/82/EC of 9 December 1996 on the Control of Major-Accident Hazards Involving Dangerous Substances; Official Journal of the European Communities L10/13: Brussels, Belgium, 1997.
3. European Commission: European Parliament and Council Directive. 2012/18/EU of 4 July 2012 on Control of Major-Accident Hazards Involving Dangerous Substances, Amending and Subsequently Repealing Council Directive 96/82/EC; European Commission: European Parliament and Council Directive: Brussels, Belgium, 2012.
4. Laurent, A.; Pey, A.; Gurtel, P.; Fabiano, B. A critical perspective on the implementation of the EU Council Seveso Directives in Fran U.S. Chemical Safety and Hazard Investigation Board, Washington DC, USA ce, Germany, Italy and Spain. Process Saf. Environ. Prot. 2021, 148, 47–74.
5. Report of Deloitte Consulting Company “Leadership in the Fourth Industrial Revolution: Faces of Progress”, 2nd Edition. Available online: https://www2.deloitte.com/ru/en/pages/about-deloitte/press-releases/2019/types-of-leadership.html (accessed on 25 June 2021).
6. ISO: 31000. Risk Management—Principles and Guidelines; International Standards Organisation: Geneva, Switzerland, 2018.
7. ISO: 45001. Occupational Health and Safety Management Systems; International Standards Organisation: Geneva, Switzerland, 2018.
8. The Occupational Safety and Health Administration. 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals, Occupational Safety and Health Administration; U.S. Department of Labor: Washington, DC, USA, 2013.
9. ISO: 29001. Petroleum, Petrochemical and Natural Gas Industries—Sector-Specific Quality Management Systems—Requirements for Product and Service Supply Organizations; International Standards Organisation: Geneva, Switzerland, 2020.
10. Van Steen, J. Safety Performance Measurement; IChemE: Rugby, UK, 1996.

11. Demichela, M.; Piccinini, N.; Romano, A. Risk analysis as a basis for safety management system. J. Loss Prev. Process Ind. 2004, 17, 179–185.
12. Bragatto, P.A.; Ansaldi, S.M.; Agnello, P. Small enterprises and major hazards: How to develop an appropriate safety management system. J. Loss Prev. Process Ind. 2015, 33, 232–244.
13. Milazzo, F. On the importance of managerial and organisational variables in the Quantitative Risk Assessment. J. Appl. Eng. Sci. 2016, 14, 54–60.
14. Palazzi, E.; Currò, F.; Fabiano, B. Low-rate releases of hazardous light gases under semi-confined geometry: A consequence-based approach and case-study application. J. Loss Prev. Process Ind. 2020, 63, 104038.
15. Available online: http://www.factsonline.nl/ (accessed on 25 June 2021).
16. eMARS. Available online: https://emars.jrc.ec.europa.eu/en/emars/content (accessed on 7 January 2021).
17. Process Safety Incident Data PSID: Process Safety Incident Database. Available online: https://www.aiche.org/ccps/resources/psid-process-safety-incident-database (accessed on 25 June 2021).
18. Mannan, S.; Lees, F.P. Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment, and Control; Elsevier Butterworth-Heinemann: Oxford, UK, 2005.
19. Palazzi, E.; Caviglione, C.; Reverberi, A.P.; Fabiano, B. A short-cut analytical model of hydrocarbon pool fire of different geometries, with enhanced view factor evaluation. Process. Saf. Environ. Prot. 2017, 110, 89–101.
20. Fabiano, B.; Vianello, C.; Reverberi, A.P.; Lunghi, E.; Maschio, G. A perspective on Seveso accident based on cause-consequences analysis by three different methods. J. Loss Prev. Process Ind. 2017, 49, 18–35.
21. Goh, Y.M.; Tan, S.; Lai, K.C. Learning from the Bhopal disaster to improve process safety management in Singapore. Process Saf. Environ. Prot. 2015, 97, 102–108.
22. Palazzi, E.; Currò, F.; Fabiano, B. A critical approach to safety equipment and emergency time evaluation based on actual information from the Bhopal gas tragedy. Process Saf. Environ. Prot. 2015, 97, 37–48.
23. Di Nardo, M.; Madonna, M.; Murino, T.; Castagna, F. Modelling a Safety Management System Using System Dynamics at the Bhopal Incident. Appl. Sci. 2020, 10, 903.
24. INSAG-7. The Chernobyl Accident: Updating of INSAG-1, Report of IAEA; U.S. Chemical Safety and Hazard, Investigation Board: Washington DC, USA, 1992.
25. Wilkinson, J. The Challenger Space shuttle disaster. Loss Prev. Bull. 2016, 251, 26–31.

26. The BP, U.S. Refineries Independent Safety Review Panel, January. In CSB: Investigation Report for BP Texas City Refinery Explosion; The U.S. Chemical Safety Board: Washington, DC, USA, 2007.
27. Phillips Disaster of 1989. Available online: https://en.wikipedia.org/wiki/Phillips_disaster_of_1989 (accessed on 7 January 2021).
28. Enschede Fireworks Disaster. Available online: https://en.wikipedia.org/wiki/Enschede_fireworks_disaster (accessed on 7 January 2021).
29. Dechy, N.; Mouilleau, Y. Damages of the Toulose disaster 21st September 2001. In Proceedings of the 11th International Symposium Loss Prevention, Praha, Czech Republic, 31 May–3 June 2004; Czech Society of Chemical Engineering: Prague, Czech Republic, 2004; pp. 2353–2363.
30. Gyenes, Z. Risk and safety management of ammonium nitrate fertilizers: Keeping the memory of disasters alive. Loss Prev. Bull. 2016, 251, 32–36.
31. U.S. Chemical Safety and Hazard Investigation Board. Investigation Report, “Refinery Explosion and Fire,” Report No. 2005-04-I-TX; U.S. Chemical Safety and Hazard Investigation Board: Washington, DC, USA, 2007.
32. Roberts, R.; Flin, R.; Cleland, J. “Everything was fine”: An analysis of the drill crew’s situation awareness on Deepwater Horizon. J. Loss Prev. Process Ind. 2015, 38, 87–100.
33. Willey, R.J. West Fertilizer Company fire and explosion: A summary of the U.S. Chemical Safety and Hazard Investigation Board report. J. Loss Prev. Process Ind. 2017, 49, 132–138.
34. Chen, Q.; Wood, M.; Zhao, J. Case study of the Tianjin accident: Application of barrier and systems analysis to understand challenges to industry loss prevention in emerging economies. Process. Saf. Environ. Prot. 2019, 131, 178–188.
35. Available online: https://www.pap.pl/aktualnosci/news%2C1340746%2CCzechy-wybuch-w-instalacji-unipetrolu-szesc-osob-nie-zyje.html (accessed on 11 January 2021).
36. Boeing 737 MAX. Available online: https://titangrey.com/boeing-737-max/ (accessed on 20 February 2021).
37. Yu, G.; Wang, Y.; Zheng, L.; Huang, J.; Li, J.; Gong, L.; Chen, R.; Li, W.; Huang, J.; Duh, Y.-S. Comprehensive study on the catastrophic explosion of ammonium nitrate stored in the warehouse of Beirut port. Process. Saf. Environ. Prot. 2021, 152, 201–219.
38. Available online: http://www.bp.com/bakerpanelreport (accessed on 9 March 2021).
39. Hopkins, A. Failure to Learn: The BP Texas City Refinery Disaster; CCH Australia Limited: North Ryde, Australia, 2008; ISBN 9781921322440.

40. National Security Council. 10 Years after BP Texas City Explosion, CSB and OSHA Say More Must Be Done. 2015. Available online: https://www.safetyandhealthmagazine.com/articles/12077-years-after-bp-texas-city-explosion-csb-and-osha-say-more-must-be-done (accessed on 22 February 2021).
41. Markowski, A.S. The implementation of the Seveso II legislation in the Polish major hazard industry. J. Loss Prev. Process Ind. 2005, 18, 360–364.
42. Vaughen, B.K.; Klein, J.A.; Champion, J.W. Our Process Safety Journey Continues: Operational Discipline Today. Process. Saf. Prog. 2018, 37, 478–492.
43. OSHA's Top 10 Most-Cited Violations for Fiscal Year. 2017. Available online: https://www.safetyandhealthmagazine.com/articles/16362-oshas-top-10-most-cited-violations-for-2017 (accessed on 9 March 2021).