Improving process safety culture: An audit checklist for effective first-line supervision based on common operations failure modes

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Abstract

The Abnormal Situation Management® (ASM®) Consortium funded a study to investigate common failure modes and root causes associated with operations practices. The study team analyzed 20 public and 12 private incidents across the refining, chemical and oil & gas industries for common operations practice failure modes including the BP Texas City Incident. A key finding from the analysis was that ineffective first-line supervision was one of the most frequent operations practice failures. Given the significant influence of first-line supervision on plant safety culture, this study provides the results of a detailed examination of the root causes of this particular failure mode. Specifically, a number of potential proactive indicators of weaknesses in operations practices were observed in the incident sample. An operations audit checklist is presented to enable plant personnel to assess their potential vulnerability to this common failure mode.

1. Introduction

Process industry plants involve operations of complex human-machine systems. The processes are large, complex, distributed, and dynamic. The sub-systems and equipment are often coupled, much is automated, data has varying levels of reliability, and a significant portion of the human-machine interaction is mediated by computers [1]. These systems are also social in that many plant operations function with a teamwork culture such that activities are managed by crews, shifts, and heterogeneous functional groups [2]. Team members have to cope with multiple information sources, conflicting information, rapidly changing scenarios, performance pressure and high workload [3].

Historically, the reporting of failures has tended to emphasize root causes associated with equipment reliability and less so on human reliability root causes [4]. Consequently, there is limited information available on the frequency and nature of operations failures pertaining to

human reliability. This tendency has limited the ability of process industry operations organizations to identify improvement opportunities associated with their management systems and operations practices.

In an effort to improve on the understanding of the impact of ineffective operations practices and management systems on safe plant operations, the ASM Consortium decided to conduct root cause analysis of existing major incident reports [5] across the refining, chemical and oil & gas industries. The study team analyzed 20 public and 12 private incidents for common operations practice failure modes. A key finding from the analysis was that ineffective first-line supervision was the 2nd most frequent operations practice failure (65 out of 539 observed operations practice failures), representing 12% of all failures.

Safety culture is a part of the overall culture of an organization that influences the members' attitudes and behaviors with respect to health and safety performance [6]. The findings from the BP Texas City incident highlight the importance of addressing process safety practices as well as personal safety [7]. Moreover, a review of the literature has shown that management is a key influence on an organization's safety culture as revealed in findings that employees' perceptions of management's attitudes and behaviors regarding safety practices are the most useful metric on safety climate [6]. In addition, a survey of offshore facilities has demonstrated that first-line supervision has a direct impact on safety performance [8].

The ASM Consortium root cause analysis study also revealed that ineffective first-line leadership is a significant contributor to process safety incidents [5]. By its very nature, the first-line supervisory role is management's primary interaction with operations personnel in communicating and enforcing their policies and practices for effective process safety performance. Moreover, we assert that an organization will be challenged to establish an effective process safety culture without effective first-line supervision.

To that end, this paper examines the root cause manifestations associated with the first-line supervision common failure mode to highlight potential indicators of weaknesses in this influence on process safety culture. An operations audit checklist is presented to enable organizations to assess their potential vulnerability to this common failure mode.

2. Incident Analysis

In general, the purpose of an incident analysis is to generate information to enable an understanding of why an incident occurred and identify corrective actions to address weaknesses in operations practices or management systems that contributed to its occurrence. In the ASM Consortium project, several incidents were analyzed to identify common failure operations practice failure modes to help member companies understand where they may have unacceptable risk to human reliability failures. The project team developed a new approach that goes beyond the typical root cause analysis methodology to identify systemic operations practice failures that are not indicated when looking at root causes alone. A detailed description of the methodology is available [5]. In this section, a high level description of the incident analysis methodology is provided with the findings related to the first-line supervision operations failure mode.

Figure 1 shows the eight-step incident analysis approach. In the second step of this methodology, all of the operations failures are clustered into common failure modes using the operational practice definitions from the ASM Consortium *Effective Operations Practices* guidelines document [9]. Since there are 52 operation practice guidelines, there were a total of 52 potential failure modes. A common failure mode represents a common problem across industry sites and characterizes 'What went wrong' across the incident sample. While this ASM guidelines document is not available to the general public, a process industry organization could develop a similar set of operational definitions based on their operations practice standards, policies and management systems.

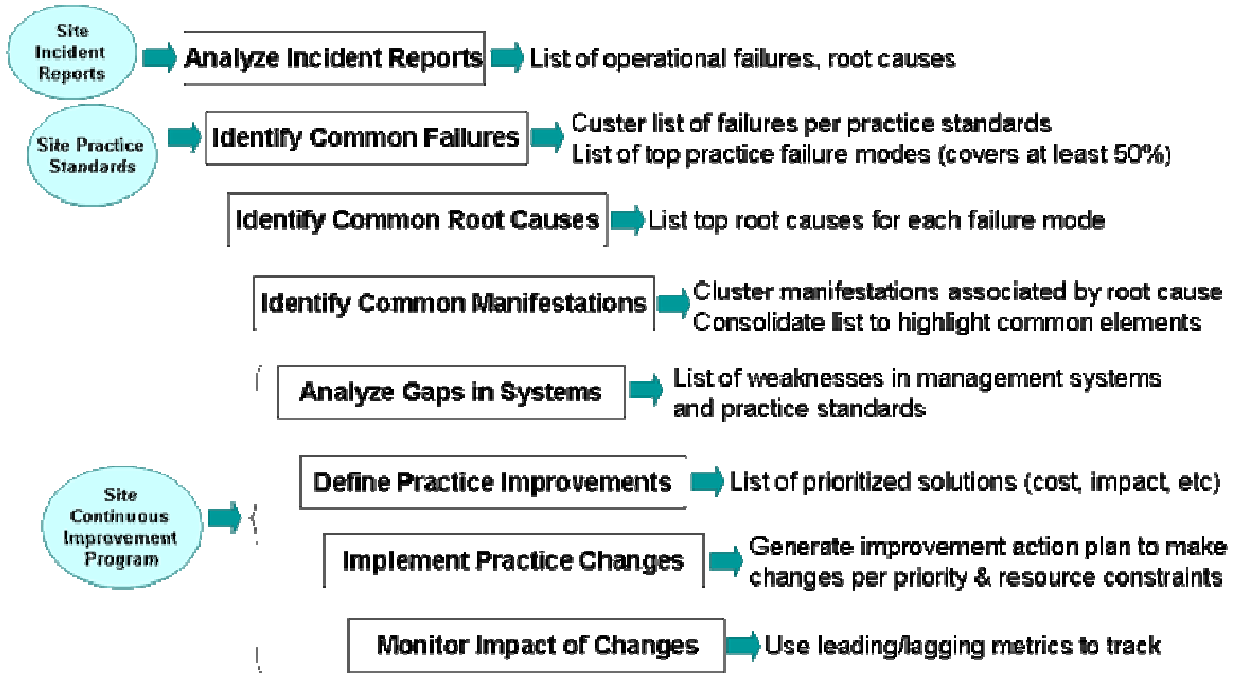


Figure 1. Summary of work process for incident analysis and continuous improvement.

The outcome of this second step in the analysis is the identification of the top ten failure modes (See **Error! Reference source not found.**).

The 10 most common failure modes accounted for 70% of the total number of failures across incidents. However, the top three failures accounted for 38% of the total and there was a clear drop in coverage between the top three failures and the rest (from 11% to 7%). Therefore, sites that are looking for critical areas to focus on should consider the following top three failures as most critical:

- Implement a comprehensive hazard analysis and communication program—15%
- Establish effective first line supervisor roles to direct personnel, enforce organizational policies, and achieve business objectives—12%
- Establish an effective and comprehensive program to continuously improve the impact of people, equipment, and materials on plant productivity and reliability—11%

To check for consistency of the findings, the sample was randomly split into two sub–samples to compare the distribution of failure modes. The comparison showed that the rank order of the failure modes was relatively consistent between the sub-samples, which suggested the overall sample of 32 incidents is relatively stable and the addition of more incidents would likely not dramatically alter the results. Therefore, the findings can be generalized across the process industry sectors represented by the incident reports.

Table 1. Top 10 common failure modes across all the incidents.

Common Failure Modes	**#**	**%**
Implement a comprehensive hazard analysis and communication program	79	15%
Establish effective first-line supervision roles to direct personnel, enforce organizational policies, and achieve business objectives	**65**	**12%**
Establish an effective and comprehensive program to continuously improve the impact of people, equipment, and materials on plant productivity and reliability	60	11%
Develop a strong safety culture[1]	36	7%
Establish initial and refresher training based on competency models that address roles and responsibilities for normal, abnormal, and emergency situations	30	6%
Establish effective protocol for task-oriented collaborative communications within operations	29	5%
Implement a comprehensive Management of Change (MOC) program that specifically includes changes in staffing levels, organizational structures, and job roles and responsibilities	28	5%
Establish good, periodic communication across plant functional responsibilities	23	4%
Ensure compliance with an explicit policy on the use of procedures in plant operations	15	3%
Use design guidelines and standards for consistent, appropriate implementation of process monitoring, control, and support applications	14	3%
Other failure modes (n=33)	160	30%
Total	539	100%

The focus of this paper is on the second most common failure mode*, Ineffective first-line supervision,* representing 12% (65 of 539) of the identified failures in the ASM approach. Focusing on the top failure modes is justified because they represent a significant portion of the total operations failures that were observed. To illustrate, if each potential failure mode had an equal probability of occurring, then one would expect on the average ~10 instances per failure

[1] A poor safety culture is reflected in a failure to follow many of the practices recommended by OSHA PSM. In general, we considered a failure to reflect a poor safety culture if many root causes were identified that would otherwise span multiple common failure modes. Based on the results in Table 8, these multiple failure modes tended to include use of procedures, management of change, and not having site standards, work processes, and standards or a failure to follow them.

mode for the 539 identified failures across the 52 potential operations practices defined in the ASM guidelines document. Hence, the observation of 65 instances of the ineffective first line leadership failure mode is much greater than one might expect by chance.

The third step in the incident analysis methodology examines the root causes associated with the common operations failure modes (See Figure 1). A root cause describes 'Why a failure occurred.' Table 2 shows the top root causes associated with the ineffective first-line supervision failure mode.

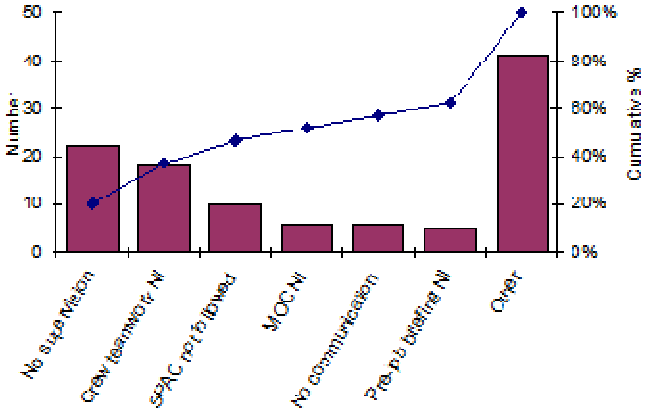
In the incident analysis approach, the value of the analysis of operations practice failure modes is that it establishes the context for understanding the root cause information. Most importantly, understanding the causes of failures establishes the opportunity to make improvements to mitigate the risk of plant incidents. Neither the aggregation across operations failures or root causes on their own provides sufficient detail to identify potential improvement opportunities.

Hence during the fourth step in the methodology (Figure 1), the team identified 'How' operational failure modes are expressed in real operations settings by examining the manner in which each root cause was manifested in the incident sample. The individual manifestations were clustered together around common themes indicating how the operations practice failed.

Table **3** below shows the result of the manifestation analysis for the two most frequent common root causes associated with *the Ineffective first-line supervision* failure mode.

Table 2. The top root cause profile associated with the Ineffective First-line Supervision operations practice failure mode.

Root Cause	**#**	**%**
No supervision	22	20%
Crew teamwork needs improvement (NI)	18	17%
SPAC[2] not followed	10	9%
Management of Change needs improvement (NI)	6	6%
No communication	6	6%
Pre-job briefing needs improvement (NI)	5	5%
Other	41	38%
Total	108	100%



[2] SPAC (Standards, policies, administrative controls)—standardized work processes, rules, and procedures.

Table 3. Common root cause manifestations for two common root causes associated with the *Ineffective first-line supervision* operations failure mode.

Root Causes	Common Manifestations
No Supervision	Not checking procedure progress for area of responsibility
	Not at job site and maintaining situation awareness
	Fail to identify and address risk to personnel
	Fail to monitor high risk activities for problems/issues
Crew Teamwork NI	Not enforcing violations of practices/procedures
	Not ensuring team members stays coordinated
	Not correcting or communicating known problems
	Team members not questioning when evidence of problems
	Not keeping track of big picture; losing sight of hazards

The examination of all common root cause manifestations for the first-line supervision failures revealed supervision problems, teamwork, and enforcing policy and work practices (i.e., MOC and pre-job briefings). A critical component to effective supervision is being at the work site to provide work direction. Teamwork issues were often due to team members failing to question improper readings, indications, or directions by the person-in-charge. Another critical role that leaders have is to communicate and enforce policy and work practices. Several failures occurred because leaders failed to ensure standards, policies, and administrative controls were used, adhered to, and followed correctly.

These findings illustrate that the detail in the common manifestations for each root cause profile provides:

- Specific reasons the failures occurred across incidents
- Manifestations are “indicators” of failures
- Potential candidates for leading indicators of incidents

Consequently, improvement opportunities are identified by extracting the root cause manifestations for each root cause profile for the top common failure modes. After collecting this information, the continuous improvement program is in a better position to analyze gaps in their management systems and operations practices and identify specific solutions to reduce vulnerability to systemic and repeating root causes. The ASM project team used the information from common root cause manifestations to develop an audit checklist. In fact, the audit checklist can serve as a gap analysis tool in step 5 of the incident analysis and continuous improvement work process (Figure 1).

3. Audit Checklist

The purpose of the checklist is to help plant and operations managers conduct audits to identify the presence of a common failure mode for significant process industry incidents. Also, the audit checklist can serve as a gap analysis tool as part of the plant continuous improvement work process. The manifestations or expression of the root causes associated with the *Ineffective first-line supervision* failure mode provide the basis for the audit items in this checklist. The audit checklist items are expressed in positive terms of the practice elements that the auditor is looking for in his/her observations of current site operations practice for first-line supervision.

ASM Operation Practice Guideline: Establish effective first-line supervision roles to direct personnel, enforce organizational policies, and achieve business objectives.

- The supervisor maintains a presence in the control room and field areas with face-to-face contact periodically throughout a shift to ensure good situation awareness of operations and maintenance activities.
- The supervisor is easily accessible via radio contact by any team member to answer questions and respond to problems.
- The supervisor assigns a stand-in responsibility when leaving the job site.
- The supervisor ensures that the behaviors of personnel are compliant with site policy and work practices, and does not allow individuals to operate in the presence of known hazards without taking adequate precautions.
- The supervisor ensures that team members stay coordinated with appropriate plant disciplines, each other and him or herself.
- The supervisor establishes an open communications culture, where there is two-way dialog and team members feel free to question each other when there is evidence of problems.
- The supervisor establishes effective mechanisms to communicate known problems to all shift team members and shift teams, and ensure that corrective actions are assigned and tracked for timely completion.
- The supervisor frequently monitors progress of procedural activities and ensures compliance with site policy on use of procedures; especially as a safety observer for high risk activities.
- The supervisor enforces clear guidelines on when and how to conduct pre-job briefings.
- The supervisor is involved in the review of safety issues and hazards during pre-job briefings; specifically in the comprehensive identification and mitigation of risk to personnel.

4. Conclusion

Ineffective first-line supervision was the 2nd most frequent operations practice failure identified in an analysis of 32 major process industry incidents [5]. Not surprising, first-line supervision had previously been identified as having a critical role in the management of safety [8]. Moreover, this previous HSE research found that the aspects of supervisor behavior that impacted on subordinate safety performance included:

- valuing subordinates
- visiting the worksite frequently
- work group participation in decision making
- effective safety communication

In the present study, an examination of the common manifestations of the supervision common failure mode identified a list of potential proactive indicators of weaknesses in operations supervision practices. The operations audit checklist has a similar theme in terms of the specific aspects of first-line supervisor behaviors that contributed to major process safety incidents.

By its very nature, the first-line supervisory role is management's primary interaction with operations personnel in communicating and enforcing their policies and practices for effective process safety performance. Any organization seeking to establish a strong safety culture needs to ensure that there is an effective first-line supervision practice. The operations audit checklist provides a set of leading indicators for assessing potential vulnerabilities associated with first-line supervision.

5. Acknowledgements

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