



## **ASM® Consortium White Paper**

# **CCPS Process Safety Metrics Review: Considerations from an ASM Perspective**

Last Revision Date: 23 May 2008

Version: 1.03

Filename: CCPS Review\_ASM Perspective\_White Paper\_v103.doc

Written by: Peter Bullemer and Doug Metzger  
ASM Consortium Metrics Work Group

[www.asmconsortium.com](http://www.asmconsortium.com)

**Paper Sponsored by the ASM Consortium**

## Introduction

The Abnormal Situation Management (ASM) Consortium has identified a gap in the capabilities of plant incident reporting systems<sup>1</sup>. Designed to support Process Safety Management (PSM) programs, current incident reporting systems do not support the plant's need to understand and control the bottom layers of the Safety Pyramid – those dealing with near misses, unsafe behaviors, and insufficient operating discipline. These have been areas of focus in ASM research. The ASM Consortium believes that changes are needed in the process industry's capability to identify, analyze and measure sources and impacts of abnormal situations in the plant. Moreover, advances in current practices are necessary for the successful integration of metric usage with daily work processes within the operations group to enhance operating team performance in anticipating and minimizing the impact of abnormal situations.

Because of this concern, the ASM Consortium has taken a keen interest in the recent developments of the CCPS to improve the industry's metrics on process safety. The ASM Consortium sees an opportunity to improve the process industries alignment on metrics for process safety and abnormal situation management, particularly in the area of leading indicators and near-miss lagging indicators.

### ***Perspective of the ASM Consortium***

The ASM Consortium is a long-running and active research and development consortium of 13 companies and universities concerned about the negative effects of industrial plant incidents. The ASM Consortium has focused on improving abnormal situation management with a focus on the role of the operations personnel. From this perspective, the ASM Consortium has studied challenges to successful abnormal situation management and collaborated on the development of effective solutions spanning operations culture, organizational structure, management systems and use of technology to mitigate those challenges.

An Abnormal Situation is a disturbance or series of disturbances that cause plant processes to deviate from their normal operating state. The nature of the abnormal situation may be of minor or catastrophic consequence. It is the job of the operations team to identify the cause of the situation and execute compensatory or corrective actions in a timely and efficient manner. A disturbance may cause a reduction in production; in more serious cases, the disturbance may lead to the loss of human life. Abnormal situations can extend, develop, and change over time in the dynamic process control environments increasing the complexity of the intervention requirements.

Abnormal situations are managed by **Prevention, Early Detection, and Mitigation**, in order to reduce unplanned outages and process variability that increase production, safety and environmental risk to plant employees and local communities. While we recognize that mechanical integrity is important to process safety, our focus on the operations team has led to an emphasis on operational integrity to reduce the likelihood of abnormal situations and ultimately improve process safety as well as plant performance. Hence, the perspective of the ASM Consortium on process safety metrics addresses the impact of operations practices on plant process safety.

---

<sup>1</sup> For more information on this concern, request Bullemer, P., Reising, D., and Barreth, R. (2008). *Why incident reporting systems do not help improve Abnormal Situation Management?* ASM Consortium White Paper.

## **Review Organization**

This white paper is organized around the three types of metrics discussed in the CCPS pamphlet, *Process Safety Leading and Lagging Metrics*:

- Common Industry Lagging Metrics
- Near-miss and Other Lagging Metrics
- Leading Metrics

For each type of metric, the review comments address our view of whether the metrics address concerns regarding process safety from an ASM perspective. Specific metric considerations are made with respect to leading and near-miss lagging metrics that improve the metrics alignment with abnormal situation management concerns that have the potential to lead to process safety incidents. For the sake of setting the context for the review comments, the CCPS definitions of the lagging and leading metrics are restated in each section in an abbreviated form.

## **Common Industry-wide Lagging Metrics**

The CCPS pamphlet defines three common industry-wide lagging metrics:

1. **Count of Process Safety Incidents (PSI)** — Any release of material or energy from a process unit resulting in injury, fire or explosion or chemical release from primary containment that exceed the defined threshold indicating significant process safety impact.
2. **Process Safety Incident Rate (PSR)** — a normalization of the PSI based on total plant work hours.
3. **Process Safety Severity Rate (PSSR)** — a weighting of the PSR based on the severity of each PSI.

From a process safety perspective, the three defined metrics are excellent choices for common lagging indicators. Moreover, the categories and severity levels are consistent with severity criteria commonly used in the industry for process hazard analysis. Hence, plant personnel will have experience in characterizing events on these dimensions.

From an abnormal situation management perspective, the proposed lagging metrics are appropriate and adequate for tracking process safety impacts. The definitions are quite clear and feasible to apply in practice. We agree with the intent to keep these metrics to a minimal set.

## **Near- miss and Other Lagging Metrics**

The conclusion of the CCPS committee was that a near-miss metric must have three essential elements based on the review of industry trends in near-miss event reporting:

- an event occurs, or the discovery of a potential unsafe situation
- the event or unsafe situation had a reasonable potential to escalate
- the potential escalation would have led to adverse impacts

Hence, the following definition is offered: “A near-miss is an undesired event that under slightly different circumstances could have resulted in harm to people, damage to property, equipment or environment or loss of process.”



The “normal” region in Figure 1 represents process deviations that the control system can manage. The “upset” region represents process deviations that require operator action to bring the process back to normal. It has been established in alarm management circles such as EEMUA and the ISA SP18 Committee that a situation calls for an alarm only if specific necessary operator action is required. If timely operator action is not required, other notification mechanisms may be used for operator communication (such as operator alerts and messages) – within the “normal” region; but they should not be classified as alarms, in order to avoid operator confusion of urgency. Hence, in an effectively rationalized alarm system, the count of alarms represents the count of transitions into the “upset” region.

It is true that alarms can be protecting the process from potential problems other than safety – such as (non-safety) environmental release, product quality, equipment life, and economic objectives. However, the mechanisms of control, loss of control, and recovery are essentially the same for all these potential problems. Hence it can be argued that any loss of control so detected “under slightly different circumstances” could result in a safety incident, and thus should be categorized as a near miss.

As with other metrics, alarm rate as a near-miss metric should be normalized in some way to enable comparison across control rooms and across plants. Our suggestion would be the average alarm rate is based on alarms associated with a console position over a specific time period such as 10 minutes. ASM research has established that a console operator can effectively respond to about 10 alarms in a 10 minute period<sup>3</sup>. The current industry defacto standard on alarm system configuration published by the Engineering Equipment and Materials Users Association (EEMUA, 2007) asserts that an average alarm rate of more than 1 alarm per minute is “very likely to be unacceptable”, that 1 alarm per 5 minutes is “manageable”, and that less than 1 alarm in 10 minutes is “very likely to be acceptable”. Since operators have other tasks besides alarms, and since operating philosophies differ between sites, the most important thing for a site to do is to establish reasonable goals that are consistent with their operating philosophy and to track to those goals on a regular basis.

For this approach of using alarm rates as a near-miss metric to be effective, a plant would need to have an alarm management system that includes an alarm rationalization methodology, resulting in an “effective” as opposed to an “ineffective” alarm system as shown in the Figure 1. In fact, the absence of an effective alarm system can be taken as a *leading indicator* of process safety risk – and perhaps should be considered in the Safety Culture evaluation under Leading Metrics.

In addition to the above near-miss and other lagging metrics, the CCPS suggests also capturing observations around Management System Failures such as:

- Discovery of Failed Safety System on testing
- Discovery of Defeated Safety System
- Errors of Omission and Commission
- Unexpected or Unplanned Equipment Conditions

---

<sup>3</sup> Reising, D. C., Downs, J. and Bayn, D. (2004). Human performance models for response to alarm notifications in the process industries: An industrial case study. In *Proceedings of the Human Factors and Ergonomics Society 48th Annual Meeting* (pp. 1189-1193). Santa Monica, CA: Human Factors and Ergonomics Society.

- Physical Damage to Containment Envelope

From an ASM perspective, we would agree with the need to measure Management System Failures. Presumably, the relevant management system failures to monitor would be those that could lead to PSIs. The examples given in the CCPS document are appropriate.

An observation on the CCPS pamphlet examples is that with the exception of the “Errors of Omission/Commission” category they tend to be equipment-centric, in that, (1) the examples tend to point out human error in the installation or maintenance of equipment and (2) the examples describe the problem in terms of the state of the equipment but not the work processes or operation of the equipment. Whereas, the CCPS focuses on the Process Safety Management System, the ASM Consortium perspective provides a slightly broader consideration of all Operations Management Systems that can impact operations ability to prevent and respond to abnormal situations. Thus, from a people-centric perspective, consideration should be given to failures of the procedure and training management systems as well.

### Leading Metrics

The objective of leading metrics is to capture early indication of deterioration in the effectiveness of the safety systems or Safety Management Systems and enable remedial actions to restore safeguards to prevent the occurrence of PSIs. The metrics proposed are based on the assessment of hazards inherent in operations, critical causal factors from major incidents and metrics in the CCPS risk-based safety book:

1. Maintenance of Mechanical Integrity
2. Action Items Follow-up
3. Management of Change (MOC)
4. Process Safety Training & Competency (& training competency)
5. Safety Culture

From an ASM perspective, there is strong overlap with the ASM Consortium recommendations for effective operations practices. The ASM Consortium has conducted research over the past 15 years to identify key practices that can improve operations ability to prevent and respond to abnormal situations. Most recently, the ASM Consortium conducted a research study to establish the relationship between root causes of major incidents and ASM effective practice recommendations<sup>4</sup>.

In the last column of Table 1, we present our assessment of the quality of coverage by the leading metrics defined in the CCPS pamphlet relative to the top 10 failure modes from the ASM Consortium root cause analysis study. Since we did not have a chance to review the Safety Culture survey, we were unable to characterize the coverage of issues identified in our study.

---

<sup>4</sup> These findings are based on 10 public and 4 confidential private incident reports that have occurred in the U.S. in the past 10 years. The Consortium is expanding the scope of the root cause analysis in 2008 to 30 incidents total including non-U.S. plants.

The assessment looked at four different aspects of the proposed metrics to characterize coverage of relevant aspects of the management system:

1. Scope of coverage
2. Timeliness and efficiency
3. Effectiveness
4. Compliance with stated policy/practice

**Table 1** The top 10 failure modes in rank order of impact in relation to coverage by the CCPS five critical causal factors.

ASM Failure Modes	CCPS Critical Causal Factors	Coverage Completeness
1. Effective 1st Line Leadership Roles	5. Safety Culture	Unknown
2. Comprehensive HAZOP & Communications	3. MOC	Partial
	2. Action Item Follow-up	Partial
3. Strong Safety Culture	5. Safety Culture	Unknown
4. Initial and Refresher Competency-based Training	4. PS Training	Partial
5. Corrective Actions for Reported Problems	2. Action Item Follow-up	Good
6. Formal Shift Handover Communications	None	None
7. Task-based Communications Protocol	None	None
8. Management of Change	3. MOC	Good
9. Periodic Cross-Functional Communications	None	None
10. Compliance with Risk-based Procedure Policy	4. PS Competency	Partial

A key finding was that there is significant overlap between the top 10 failure modes identified in the ASM Consortium study with the five leading metric categories proposed in the CCPS pamphlet. The one area not identified in our top ten was mechanical integrity. However, we would agree with the value of including the mechanical integrity metric category. A significant category not addressed in the leading metrics is communications as illustrated by three of the top 10 failure modes: 6. Formal Shift Handover Communications, Task-based Communications Protocol, and Periodic Cross-Functional Communications. These three failure modes reflect

breakdowns in communications between shift teams, within shift teams, and between operations, management and maintenance.

## The Metrics Dilemma

In recent news (Wall Street Journal, April 25, 2008) investigations allege that “FAA managers in the Dallas air-traffic-control facility intentionally misclassified controller mistakes to make them look like pilot errors”. These mistakes “allowed the planes to fly dangerously close together”. It was suggested that a contributing cause was that some controllers can qualify for bonuses based on low rates of errors. This illustrates an important dilemma that needs to be discussed openly and approached carefully based not only on the example from the aviation industry but also on our own observations of behaviors associated with safety incident reporting:

**It is difficult to incentivize people to reduce near misses and to improve unsafe behaviors or insufficient operating discipline, without also incentivizing them to hide or misrepresent the associated data.**

Metrics characterizing the lower layers of the Safety Pyramid are particularly susceptible to this problem since, unlike the upper layers, there is usually no physical evidence or specific occurrence that begs to be explained.

As the CCPS works to improve the process industry’s tracking and behavior with respect to these important lower layers, strategies to avoid this problem will need to be discussed and analyzed. For example, it may be useful to consider a policy statement that companies will not be penalized based on lower level metrics, while at the same time making the techniques and tools for tracking them very accessible.

## Conclusion

The ASM Consortium has a strong interest in the recent developments of the CCPS to improve the industry’s metrics on process safety. The ASM Consortium sees an opportunity to work together with CCPS to improve the process industries alignment on metrics for process safety and abnormal situation management, particularly in the area of leading indicators and near-miss lagging indicators.

The CCPS proposed near-miss process safety category of process deviation or excursion comprises the key linkage between abnormal situation management and process safety management. In fact, we propose that the plant alarm system may be an effective basis for capturing metrics related to critical process deviations or excursions.

The ASM Consortium has been studying operations management systems and practices to identify key challenges to effective prevention and response to abnormal situations – some of which may have the potential to escalate into process safety incidents. Our understanding enables us to offer some potential enhancements to the leading metrics that are currently based on process safety management systems.

Finally, from an abnormal situation management perspective, the proposed lagging metrics are appropriate and adequate for tracking process safety impacts. While it is important to have good metrics for measuring process safety incidents, the categories for causes are equally important to establish a common understanding of where continuous improvement is required. This is an area where we have witnessed significant variability between organizations. Moreover, there should

be some relationship between the causal categories and the leading metrics, if in fact; the leading metrics are indicating opportunities to reduce the risk of process safety incidents. Consequently, we suggest the CCPS also considers addressing some key root cause categories to help gain some consistency in understanding contributors to PSI occurrences.