

Effectively Use Metrics as Part of Process Safety Feedback and Learning Systems To Monitor and Improve Performance¹

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Abstract

Without appropriate process safety program metrics and feedback systems, warning signs of problems may be missed and learning opportunities for improving performance can be lost. Ensuring the right things are measured and evaluated, based on process safety program goals, provides information on the current performance level and trends: is performance getting better or worse? Learning from experience, based on effective feedback systems and the use of organizational learning approaches to collect, analyze, share, and retain critical process safety information helps promote sensitivity to operations, a sense of vulnerability, and knowledge of past problems and successes to help maintain organizational memory and maintain or improve program performance.

KEYWORDS

process safety, metrics, feedback systems, learning organizations

1 INTRODUCTION

When working with a patient, health professionals measure vital signs, such as temperature and blood pressure, to help evaluate the health of the patient and to provide potential early warning of health problems. Similarly, vital signs – process safety metrics – are used to measure the health or effectiveness of process safety programs to provide early warning of potential performance problems. Are operating procedures being updated? Is training being completed on schedule? Are equipment inspections and tests being done at the right frequency? Are incident recommendations being tracked and completed? The answers to

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these and other questions reflect on the performance of the process safety program and, in particular, the feedback and learning systems that have been developed to monitor the program and maintain key information.¹

If performance is slipping, how would leadership know that the risk of process incidents might be increasing? What specific systems need to be improved? Is one plant or process area performing significantly better—or worse—than other plants or process areas? Obviously, an appropriate set of metrics is essential to understand if the process safety program is working as desired or if changes need to be made to make the program more effective. Trending of metrics over time to see if the results are getting better or worse, combined with periodic management review to identify strengths, problem areas, and improvement opportunities, is essential feedback to help ensure that process safety programs achieve performance goals and reduce the risks of potentially catastrophic incidents.

Without appropriate program feedback, many opportunities for learning can be lost. The result can also be worse performance as warning signs are missed and improvements that could have prevented serious incidents are not made. More incidents equals more injuries and higher costs. The success then, over time, of an effective process safety program is ensuring that the right things are measured, evaluated, and acted on to promote learning and help avoid complacency resulting from long periods of good performance:²

In the absence of bad outcomes, the best way—perhaps the only way—to sustain a state of intelligent and respectful wariness is to gather the right kinds of data. This means creating a safety information system that collects, analyzes, and disseminates information from incidents and near misses as well as from regular checks on the system’s vital signs. All of these activities can be said to make up an informed culture—one in which those who manage and operate the system have current knowledge about the human, technical, organizational, and environmental factors that determine the safety of the system as a whole.

Successful process safety feedback systems are sensitive to operations—understanding *what* is really happening—and focused on learning—understanding *why* something is happening. With this knowledge, appropriate actions can be taken both in response to information collected and in anticipation of larger potential performance issues to help prevent serious incidents and injuries.

2 FEEDBACK SYSTEMS

While all aspects of effective process safety programs are ultimately important, the performance model shown in Figure 1 provides the main program elements that impact

performance and indicates how they interact.^{1,3,4} In this paper, only the feedback and learning systems will be discussed.

Without appropriate program feedback, warning signs of problems may be missed and learning opportunities for improving performance can be lost.⁵ Ensuring the right things are measured and evaluated, based on process safety program goals, provides information on the current performance level and trends (i.e., getting better or worse as shown in Figure 2). Methods to monitor process safety program effectiveness using both leading and lagging metrics are essential for achieving high performance.^{1,6} Leading metrics proactively measure the performance of process safety system activities, such as completion of equipment inspections on the required schedule or conduct of compliance audits, to help determine if system requirements are being met. Lagging metrics retroactively measure the results of program outcomes, such as the number of incidents or injuries that have occurred. By evaluating current system performance, leading indicators help identify potential problems before more serious incidents occur.

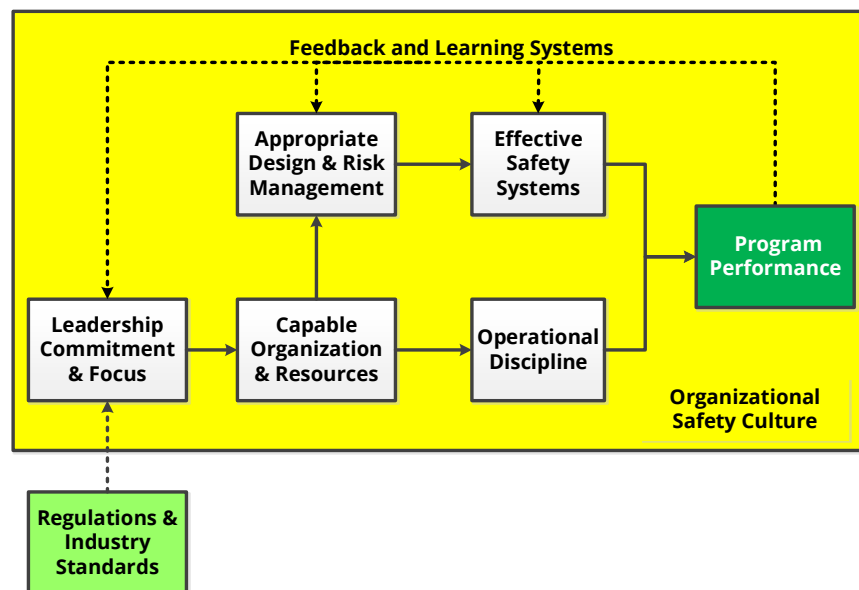


FIGURE 1 Process safety program performance is dependent on many factors, including effective feedback and learning systems³

Metrics by themselves are of little use unless they are acted on, identifying strengths and weaknesses, and initiating specific improvement opportunities as needed. Steps for establishing process safety feedback systems include:¹

- Provide resources and establish methods for implementing and maintaining feedback systems
- Identify the program activities and requirements that benefit from development of leading and lagging metrics, establish systems for collecting the required information, and set annual goals for expected performance
- Evaluate metrics and trends, based on appropriate frequencies and levels of review, and follow up as needed to support continuous improvement
- Utilize metrics information to support organizational learning.

Learning from experience is a common process safety theme, and the use of organizational learning approaches to collect, analyze, share, and retain critical process safety information helps promote sensitivity to operations, a sense of vulnerability, and knowledge of past problems and successes. Developing a process safety learning plan, based on learning goals, competency needs, information collection, and retention of knowledge can strengthen process safety programs and performance over time. Ultimately, effective feedback systems help identify: (1) what has happened in the past, (2) what is happening in the present, and (3) through trending, what may happen in the future.

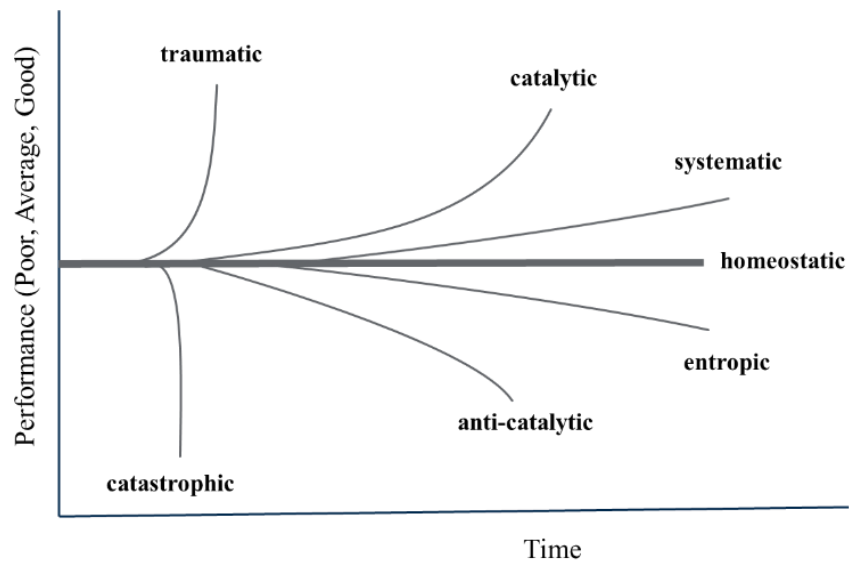


FIGURE 2 Trending of process safety metrics can help indicate if program performance is getting better or worse³

3 SENSITIVITY TO OPERATIONS

Sensitivity to operations is a current and continuing focus on the possible failure of hazardous processes as part of feedback systems.⁷ As such, key activities include anticipating potential problems, continuously monitoring operations, and appropriately responding to data as it is obtained. Data must be based on what is really occurring, rather than what people think may be occurring, so appropriate design of feedback systems can occur and the real meaning of the resulting data can be carefully reviewed and responded to. Doing these tasks effectively is difficult when people are distracted, do not really know what they are looking for, or misunderstand the significance of what they are seeing. Complacency, based on past successes, poor assumptions, overreliance on safety system design, and sometimes the potentially boring day-to-day routine of operations can also affect feedback system effectiveness. Sensitivity to operations therefore requires development of appropriate ongoing observation, measurement, communication, review, and response by trained resources.

Sensitivity to operations also requires recognition of “weak signals” that may not seem important, but when reviewed singularly or with other data can be warning signs of potential changes and problems.⁷ Sometimes weak signals may be readily apparent, such as near miss incidents that indicate bigger problems may result if not appropriately investigated or responded to. Sometimes weak signals may be more subtle, such as a slight process temperature trend over several months, possibly warning of condenser fouling or other problems, or small changes in cycle times, material loading, or even process noises. Sometimes, an observant person may simply feel that something is not quite right without really knowing what. The natural tendency is to minimize or ignore these feelings, but it will often make sense to trust these feelings and investigate further. Anticipation of possible problems, awareness of actual operations, and communication and review of both weak and obvious signals of potential issues are necessary to avoid complacency that may result from hopefully long term successful performance. Known operating problems and warning signs should be incorporated into training programs to raise and maintain awareness in personnel to provide for ongoing sensitivity to operations.

Without appropriate foresight and training, warning signs of larger problems can be missed, leading to major incidents and injuries.³ Warning signs may not be fully recognized, and they may even become accepted as normal. Both the Challenger and Columbia space shuttle explosions, for example, resulted from continuing operational problems that were well known from previous missions.⁸ Sometimes adaptations occur over time that slowly lead to a higher risk environment than intended.^{9,10} Sensitivity to operations therefore requires recognition, or at least a strong reporting environment, of differences from expected

operations allowing for additional review and interpretation. Learning from experience is an axiom of process safety and fundamental to development of an effective process safety program. Development of a learning organization, as discussed in the next section, overlaps and builds on sensitivity of operations and feedback efforts to maximize immediate learning from and response to potential warning signs and provides for continuing organizational learning and memory.

4 LEARNING SYSTEMS

Development of learning organizations has been a subject of interest for organizations focused on learning from experience and learning from others in order to improve or grow new capabilities that help maintain or develop competitive advantages for continuing success.¹¹ A learning organization has been defined as “an organization skilled at creating, acquiring, interpreting, transferring, and retaining knowledge, and at purposefully modifying its behavior to reflect new knowledge and insights.”¹² Some key aspects of learning organizations include:

- Collection of new ideas, information, and data
- Evaluation and interpretation of knowledge to understand significance and meaning
- Application and sharing of knowledge for organizational use
- Maintenance of learning in organizational memory as part of policies, procedures, and training.

Ultimately, learning results from experience – sometimes the hard way, based on serious incidents – which benefits from proactive development of appropriate metrics feedback and learning systems and awareness and learning based on the experiences of others. The development of a learning plan¹³ is discussed in the following section.

Sensitivity to operations and effective organizational learning are both related and overlapping parts of the feedback systems involving purposeful monitoring and improvement of process safety program performance that must occur if serious process incidents are to be prevented. Reflecting this focus, a questioning/learning environment is an essential characteristic of a strong safety culture.¹⁴ Weaknesses in this area, whether from failures to collect, evaluate, apply, or maintain information important to safe and reliable operations, as discussed earlier, can lead to catastrophic incidents.

In assessing the current learning plans and environment, many things will already be working well, some things may need improvement, and some new things will need to be implemented. A facility may have already developed several leading and lagging metrics to

measure process safety program performance. This system may be working well, or it may be found that some metrics are not really evaluated effectively or used to define and implement improvements. For example, current metrics may focus more on personal safety than process safety. Based on operating and safety performance and goals, new metrics may be needed. Better evaluation or more frequent evaluation of some metrics may be desired. Openness for reporting deviations from expectations may need improvement, related to the need for open and effective communication and other essential features of a strong safety culture. Some questions for evaluating the existence or quality of a learning organization include:¹²

- Does the organization have a defined learning agenda?
- Is the organization open to discordant information?
- Does the organization avoid repeated mistakes?
- Does the organization lose critical information when key people leave?
- Does the organization act on what it knows?

Several assessment protocols for evaluating learning organizations are available.^{13,15}

Some of the problems that can hinder development of effective learning organizations have already been discussed, but some additional learning issues may include:^{12,13}

- Biased information, based on blind spots, resulting from narrow or misdirected perspectives, inappropriate filtering of information, or ineffective information sharing practices
- Flawed interpretation of information, based on false connections or correlations, poor assumptions or stereotypes, extrapolation of past results, or information gaps
- Failure to accept new or external information as relevant
- Failure to act on information based on risk avoidance or organizational dynamics.

Many of these problems ultimately relate to the safety culture and leadership in a facility and are appropriately remedied by development of a learning plan. In addition, steps can be taken specifically to develop a supportive learning environment:¹²

- Recognize and accept differences in people and organizations, accepting that one method of learning may not always work effectively for everyone. Learning mechanisms, though, must ultimately ensure that differing methods of data collection and analysis can be combined and resolved in ways that do not lead to ineffective or divergent learning.

- Provide timely review and feedback, based on assessment of learning organization implementation and practices. Is the learning plan being followed? Are learning goals being met? Are there any examples of where important information was missed or not acted on?
- Stimulate new ideas from multiple sources and perspectives, ensuring that differing viewpoints from both inside and outside the organization are obtained and shared to challenge and improve current practices.
- Focus on sensitivity to operations to learn from inadvertent errors and mistakes and to encourage open communication and reporting to help develop improved approaches. Effective process safety programs should also include appropriate focus on operational discipline in following program requirements to help reduce human error.¹

Retention of learning and knowledge is a continuing challenge due to organization change. How much information is lost when a highly experienced worker transfers, resigns, or retires? Is important information lost when a knowledge management system fails or is replaced? How organizational memory is maintained is therefore an important part of learning organizations as well as effective process safety programs.^{16,17} As new knowledge is obtained, from targeted learning, from incidents, or from other sources, is it incorporated into improving process safety program policies, guidelines, and procedures? Are key learnings from incidents maintained in training materials, so workers know what has happened in the past and how to respond if it ever occurs again? Are process safety information and other technical documents updated to include new design, formulating, or operating learnings? Once information is updated, are there mechanisms for ensuring that it remains known or does it reside in a manual that is never looked at again?

5 LEARNING PLANS

A learning plan¹³ is a good place to start when working on building or improving feedback and learning systems. A learning plan consists of the thoughtful preparation of learning goals, analysis of competency needs, learning methods, and assessment needs. Focus areas include safety experience, technical experience, and operating experience. For process safety, a learning plan (several may be needed for different parts of the overall process safety program) should include what internal and external information is desired/needed, how it will be obtained, how it will be used, who will need training, and how often and by what means will its effectiveness be evaluated. How will a facility maintain sensitivity to operations, what metrics are needed, and how will they be collected, evaluated, shared, and used? What personnel and resources will be provided? Too often, incident investigations look backward

for warning signs, when earlier recognition of the warning signs could have prevented the incident. An effective feedback and learning plan can help avoid this failing.

6 CONCLUSION

Designing and implementing an effective feedback and learning system for monitoring process safety program effectiveness is essential for achieving high performance and prevention of serious incidents and injuries. Sensitivity to operations, based on use and trending of appropriate leading and lagging metrics and a strong learning culture can help provide a good view of what has been happening, what is really happening, and what may happen. Without appropriate feedback systems, warning signs of problems may be missed and opportunities for learning and continuous improvement may be lost. Developing a learning plan, based on learning goals, capability needs, information collection, and retention, sharing, and use of knowledge can be a useful tool for maintaining significant safety, technical, and operational learnings over time.

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