FACTORS THAT IMPACT SAFETY PERFORMANCE

How to Achieve & Sustain Excellent Performance

By James A. Klein

The primary goal of effective safety programs is excellent performance. This is accomplished through a strong and continued commitment by everyone in an organization to achieve zero injuries, zero significant harmful events and zero environmental harm.

Other program goals also come into play such as "no one gets hurt," positive rather than negative business impact, and employees striving to be good corporate citizens and community members. Sounds great, but how feasible is this? Many companies have achieved sustained excellent performance while some have not. Even good companies with strong safety programs sometimes have lapses. The reality is that people make mistakes and equipment can fail unexpectedly. Human error can be anticipated and prevented, or possible effects mitigated. Equipment can be designed appropriately and maintained correctly, and potential failures can be anticipated and safeguarded.

Ultimately, excellent safety performance requires continuous focus, dedication and perseverance by management and employees who take purposeful actions to implement, improve and sustain effective safety practices. But what factors most impact safety performance, and how can they be used to achieve and sustain excellent performance?

Safety Performance

Safety performance is sometimes summarized as "our injury and incident performance has been excellent," but there are two issues with this view. First, injury and incident statistics are lagging metrics, representing events that have already occurred rather than helping identify problems before they can lead to more serious injuries and incidents (i.e., leading metrics). Because serious injuries and incidents are infrequent, these indicators do not provide true measurement of how a safety program may be performing day to day. Are there problems that may be leading to higher risk of future injury? How would facility personnel know?

Second, while injury statistics are obviously important, they may not provide an adequate measurement of how well safety program requirements are being met. Part of the question is, performance of what? For example, injury statistics, such as lost-workday injuries, generally do not provide a clear view of process safety performance. In an investigation following a refinery fire and explosion (CSB, 2007), it was determined that "reliance on injury rates significantly hindered . . . perception of process risk" (BP U.S. Refineries Independent Safety Review Panel, 2007). This can be true for many aspects of safety programs. Is PPE worn correctly and at the right times? Are safe work practices (e.g., confined space entry, hot work, electrical lockout) followed and correctly completed every time? Are procedural shortcuts frequent? Injury and incident statistics do not reveal the whole picture, thus providing management with an incomplete view of safety program performance.

A better definition of performance relates to executing safety program requirements and systems with the intent of achieving program goals and objectives. Program goals should include 1. prevention of serious injuries and incidents; and 2. use of other leading and lagging indicators to measure the functioning and effectiveness of safety program activities to provide early warning of possible problems. Like medical professionals who routinely measure vital signs such as blood pressure and cholesterol for early warning of potential health problems, appropriate goals and metrics should be established, monitored and responded to by accountable facility personnel to monitor overall injury and safety program performance. For example, from a process safety perspective, failing to 1. document and assess changes to process equipment or 2. conduct equipment tests and inspections on the required schedules can greatly increase the risk of process-related injuries and incidents. Appropriate metrics should be provided to help ensure that management system requirements are being followed. While excellent performance can be demonstrated to some extent using lagging metrics such as past injury statistics, ultimately excellent future performance can typically only be pursued using appropriate goals and both leading and lagging metrics. For some safety professionals, a statement such as "we haven't had an injury for years" can be a red flag for possible complacency and future problems.

Key questions of safety performance include (Klein, 2020; Klein & Vaughen, 2017):

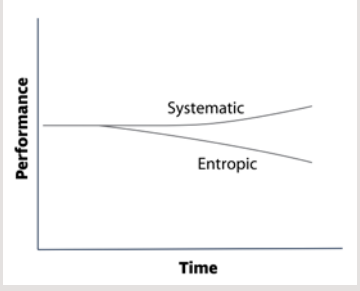
- What is the current level of performance?
- Is performance trending better, about the same or worse?
- How can performance be improved?

The answers to these questions are obviously highly specific to company or facility safety goals based on the hazards and risks that may be present as well as management priorities.

FIGURE 1

SAFETY PERFORMANCE OVER TIME

Safety performance is likely to slowly get worse with time unless specific systematic improvement activities are made per local needs.



Note. Adapted from "Sustaining Effective Process Safety Programs in CPI Facilities," by J.A. Klein, 2020, *Chemical Engineering*.

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While assessing current performance seems straightforward, serious injuries and incidents are (one hopes) rare, and therefore performance should also be assessed in terms of conformance to safety program requirements. But safety programs and needs differ, and what may be considered excellent performance at one company may not be at another, based on the goals and leading and lagging metrics that have been established. Some companies may also believe that they have excellent performance, but relative to industry standards and regulatory expectations, performance may not be as good as believed. Both internal and external measurements should be considered when evaluating process safety performance. Facilities must, at a minimum, be aware of industry standards and best practices for comparison and should benchmark operating results with other facilities and companies when possible.

Measuring current performance is the starting point on the performance axis shown in Figure 1. The status is important because if a company currently has excellent performance, its main goal is to maintain and improve on that high level. If a company has poor performance, it should set goals and provide resources for more significant improvement.

The second question regarding the direction of performance trend is more difficult. Several trends are possible, and unexpected events can lead to rapid change for better or worse (Klein, 2020). When continued attention to safety program performance is not maintained, slow degradation of performance is likely, as shown in Figure 1, and must be guarded against. Some causes may be:

- lack of a core value for safety (e.g., competing priorities degrade leadership priority for safety vs. financial and other factors)
- lack of a sense of vulnerability (e.g., complacency following a period without significant injuries)
- lack of awareness of degradation (e.g., inadequate monitoring through leading metrics or audits)

Conversely, improved performance over time (based on local facility needs) can be achieved by 1. systematic attention to safety performance or improvement with management leadership for effective safety programs; 2. goal setting with appropriate metrics; and 3. empowering personnel with the provision of appropriate resources. The rate of improvement will vary with both the initial starting point (is current performance good or bad?) and degree of focus on improvement, based on factors discussed in the next section.

Examination of the first two questions about safety performance is essential for considering the third question: How can performance be improved?

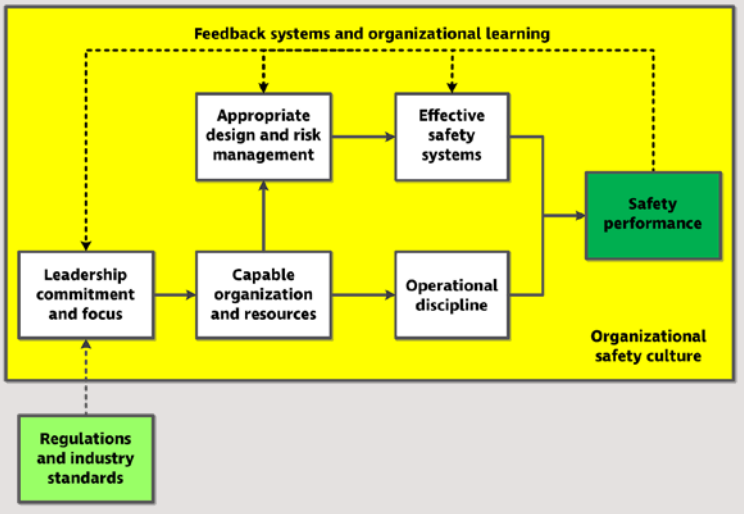
Improving Safety Performance

The performance model (Klein, 2020; Klein & Vaughen, 2017) shown in Figure 2 provides key safety program activities that impact performance and indicates how they interact. A model can be useful to help 1. ensure a more complete perspective on why safety performance may be good or bad, and why performance may be getting better or worse; and 2. serve as the basis for assessment of safety program performance to identify and prioritize improvement opportunities and help ensure that they are appropriately focused and comprehensive. Some possible improvement actions associated with each factor have been documented elsewhere (Klein, 2020), but ultimately depend on company and local organizational safety focus, goals and priorities.

- **Safety regulations and industry standards.** Companies must be aware of regulatory requirements, codes and standards, and industry best practices to support effective safety programs and implement internal requirements as needed. Knowledge of external information and activities is essential for 1. ensuring compliance with relevant regulations; 2. implementing effective systems; 3. developing and leveraging organizational capabilities; 4. ensuring proper equipment design and maintenance; and 5. promoting a learning culture.
- **Organizational safety culture.** A good definition of *safety culture* is "The normal way things are done at a facility, company or organization, reflecting expected organizational values, beliefs and behaviors that set the priority, commitment, and resource levels for safety programs and performance" (Klein & Vaughen, 2017). The effectiveness of safety programs and their ability to achieve excellent performance are strongly influenced by the safety culture, which can vary due to local and geographic differences, specific hazards and risk management needs, and conflicting priorities such as financial or production considerations. Characteristics describing the essential features of safety culture have

FIGURE 2
SAFETY PERFORMANCE MODEL

A practical model of safety performance helps ensure implementation and assessment of effective safety programs.



Note. Adapted from "Sustaining Effective Process Safety Programs in CPI Facilities," by J.A. Klein, 2020, *Chemical Engineering*, and *Process Safety: Key Concepts and Practical Approaches*, by J.A. Klein & B.K. Vaughen, 2017, CRC Press.

been defined (CCPS, 2007; 2018; Klein & Vaughen, 2017) and can be used to evaluate strengths and opportunities for improvement.

•Leadership commitment and focus. Leadership at a company or facility is influenced by the safety culture (e.g., in setting daily priorities for safety vs. production) and able to influence the culture (e.g., strengthen or weaken the culture over time; Klein & Vaughen, 2017). Leadership necessarily encompasses all levels of management from the board of directors to first-line supervision to all workers (BP U.S. Refineries Independent Safety Review Panel, 2007). If a shift supervisor is making decisions contrary to higher-level guidance, such as to complete certain work tasks in a less-safe manner, leadership credibility is challenged, and the safety culture can degrade. Leadership commitment and focus on safety as a core value are critical for ensuring that resources are provided for safety activities in terms of financial, personnel and time considerations. Safety program policies, goals, metrics and accountabilities must be established with appropriate resources provided to support excellent performance. Direct leadership involvement in safety activities is also essential for building trust and securing employee engagement through visibility and consistent action.

•Capable organization and resources. Leadership must provide sufficient resources for implementing and sustaining effective safety programs to support safe, reliable operations and meet program goals. This includes: 1. developing internally trained and capable safety professionals and others with expertise and knowledge of work activities, safety regulations, and relevant industry standards and guidance; and 2. using external resources when needed. Because it is increasingly difficult for everyone to know

TABLE 1

PERFORMANCE MODEL FINDINGS FROM 2005 REFINERY INCIDENT

Selected performance model findings for refinery fire and explosion incident and subsequent investigation.

Performance factor	Findings
External regulations/standards	•Corporate safety management system does not ensure timely implementation of external good engineering practices that support and could improve process safety performance.
Organizational safety culture	•Has not established a positive, trusting and open environment with effective lines of communication between management and the workforce at all refineries. •Has an incomplete picture of process safety performance because the process safety management system likely results in underreporting of incidents and near hits. •Personal safety was measured, rewarded and the primary focus of their safety efforts, but the same emphasis was not put on improving process safety performance. •Has not provided effective process safety leadership and has not adequately established process safety as a core value.
Leadership commitment and focus	•Has not provided effective leadership on or established appropriate operational expectations regarding process safety performance. •A lack of supervisory oversight and technically trained personnel during the startup, an especially hazardous period, was an omission contrary to refinery guidelines.
Capable organization and resources	•Good process safety performance requires adequate resources, including funding for inspecting, testing, maintaining and repairing or replacing equipment; resources for training and educating personnel; resources for keeping operating procedures up to date; and resources for implementing best or good industry practices. If a refinery is underresourced, maintenance may be deferred, inspections and testing may fall behind, old and obsolete equipment may not be replaced and process risks will inevitably increase. The company has not always ensured that the resources required for strong process safety performance at its refineries were identified and provided. •The company overloaded the U.S. refineries with a host of corporate initiatives. While these initiatives were well intentioned, they diverted attention from a greater focus on process safety issues because the company did not provide adequate resources or guidance for prioritization to the refineries.
Appropriate design and risk management	•The system (programs to analyze process hazards) does not ensure adequate identification and rigorous analysis of those hazards. Examination also indicates that the extent and recurring nature of this deficiency is not isolated, but systemic. •Corporate process safety management system does not effectively translate expectations into measurable criteria for management of process risk or define the appropriate role of qualitative and quantitative risk management criteria.
Effective process safety systems	•There were several deficiencies in the process safety knowledge and competence of, and training and education programs for, personnel and contractors. •Managers did not effectively implement their prestartup safety review policy to ensure that nonessential personnel were removed from areas in and around process units during startups and that the adequacy of all safety systems and equipment, including procedures and training, process safety information, alarms and equipment functionality, and instrument testing and calibration were verified. •The mechanical integrity program did not ensure that deficiencies were identified and repaired prior to failure, resulting in the "run to failure" of process equipment.
Operational discipline	•A lack of operating discipline, toleration of serious deviations from safe operating practices, and apparent complacency toward serious process safety risks existed at the refinery. •Management did not emphasize the importance of following procedures as evidenced by its lack of enforcement of the management of change policy, its acceptance of procedural deviations during past startups, and its failure to ensure that the procedures remained up-to-date and accurate, contributing to a work environment that encouraged operations personnel to deviate from procedures. •A check-the-box mentality was prevalent, where personnel completed paperwork and checked off on safety policy and procedural requirements even when those requirements had not been met, contributing to a culture of "casual compliance."
Feedback systems and organizational learning	•Significant deficiencies existed on site and corporate systems for measuring process safety performance, investigating incidents and near hits, auditing system performance, addressing previously identified process safety-related action items, and ensuring sufficient management and board oversight. •Reliance on lagging, after-the-fact indicators of process safety performance rather than leading, predictive measures, however, impaired the ability to measure, monitor and detect deteriorating or degraded process safety conditions •Did not create an effective reporting and learning culture; reporting bad news was not encouraged.

Note. Adapted from "Investigation Report: Refinery Explosion and Fire" [Report No. 2005-04-I-TX], by CSB, 2007, www.csb.gov/bp-america-refinery-explosion, and "The Report of the BP U.S. Refineries Independent Safety Review Panel," by BP U.S. Refineries Independent Safety Review Panel, 2007.

everything about all technical areas, appropriate policies and guidance should be documented, training conducted, and networking and mentoring opportunities provided, especially for new or less-experienced personnel so they know when to consult with safety personnel. Ultimately, safety must become part of everyone's job in terms of ensuring that safety program goals and requirements are met. A well-defined training strategy should be developed and implemented with refresher training at appropriate intervals to help ensure awareness and understanding of the hazards that may be present, and safety program requirements for managing these hazards.

•**Appropriate design and risk management.** Well-designed work activities and equipment are the starting point for safe and reliable operations and achieving excellent safety performance. Both should be based on identifying, evaluating and managing safety hazards and risks. Hazards must be evaluated using appropriate hazard evaluation methodologies, such as job safety analysis and process hazard analysis, to help ensure that hazards are identified, appropriate engineering and administrative safeguards are provided and, where possible, hazards are eliminated (Klein & Vaughen, 2017). These evaluations are also used to ensure that well-designed safety systems and procedures are implemented.

•**Effective safety systems.** Safety systems and procedures provide the detailed requirements based on risk management reviews, regulatory requirements and industry guidance to help ensure that safety risks are always successfully controlled as facility personnel complete their daily work activities. The effectiveness of safety systems is dependent on appropriate design, training and other factors (CCPS, 2007; Klein & Vaughen, 2017), as well as rigorous execution.

•**Operational discipline.** Safety systems only work as intended if personnel are following them; even highly trained people occasionally make mistakes. The reality is that human error should be anticipated, and appropriate systems and safeguards provided to help ensure that errors do not lead to serious injuries and other consequences, especially if work tasks include higher-risk activities. Operational discipline is used to describe human behavior in following required systems and procedures correctly, every time, to consistently achieve safer and more reliable operations. Developing an operational discipline program (CCPS, 2011; Klein, n.d.; 2019; Klein & Vaughen, 2017) intended to support day-to-day awareness and commitment by all company personnel can help 1. minimize the potential for human error; 2. ensure that safety program requirements are rigorously followed; and 3. support excellent safety performance.

•**Feedback systems and organizational learning.** Methods to monitor safety program effectiveness using both leading and lagging metrics are essential for achieving high performance (BP U.S. Refineries Independent Safety Review Panel, 2007; CCPS, 2007; Klein & Vaughen,

TABLE 2

SELECTED PERFORMANCE MODEL FINDINGS FROM AN INDUSTRIAL SAFETY ASSESSMENT

Performance factor	Findings
External regulations/standards	None noted
Organizational safety culture	• There is a perception of a strong production priority over safety at some facilities and with some supervision. • Safety programs are perceived as too reactive and often do not engage facility personnel in developing meaningful safety programs and corrective actions. • The system for reward and punishment was the lowest scoring safety culture survey question response, indicating that opportunity exists to improve safety recognition and disciplinary practices.
Leadership commitment and focus	Infrastructure problems at some facilities resulting from degradation over the past 5 or more years have led to poor housekeeping and reactive, overworked, stressed personnel, which has contributed to a poor working environment and low morale and may be contributing to higher incident rates.
Capable organization and resources	Management of employee turnover and employee hiring is an ongoing challenge. Many facilities have hiring needs and high turnover in some positions, contributing to fatigue and morale issues.
Appropriate design and risk management	Management practices for evaluating higher-level facility risks, such as use of process hazard analysis methodologies in project reviews, are not well defined.
Effective process safety systems	• Procedure and training practices are variable at different sites. Procedures are often not detailed, may not be kept current and, in some cases, may not be used routinely. Training on procedures is often informal, based on one-on-one mentoring with more senior personnel, potentially resulting in inconsistent learning. • While changes are not frequent, there is no effective management of change system. • The maintenance software program is not being used effectively to manage preventive maintenance and predictive reliability activities. • Incident investigation procedures in practice appear to relate primarily to injury investigations rather than other types of incidents and near hits. Many believe that investigations are "blaming" activities, leading to some reluctance on reporting of some near-hit events.
Operational discipline	Low operational discipline is broadly impacting safety performance, indicating individual sites should develop operational discipline improvement programs.
Feedback systems and organizational learning	Currently, very strong injury metrics and analysis are available, but leading safety metrics are not being used effectively to monitor and improve safety performance.

2017). Without appropriate program feedback, warning signs of problems may be missed, and learning opportunities for improving performance can be lost. Ensuring that the correct key indicators are measured and evaluated, based on safety program goals, provides information on the current performance level and trend. Metrics alone are of little use unless they are periodically reviewed and acted on, identifying strengths and weaknesses and initiating specific improvements or maintaining good practices. Learning from experience is a common safety theme, and using organizational learning approaches to collect, analyze, share and retain critical safety information and knowledge helps promote 1. sensitivity to ongoing operations; 2. a sense of vulnerability; and 3. knowledge of past problems and successes (CCPS, 2007; Klein & Vaughen, 2017).

Assessment of Safety Performance

As noted, a model can be useful for understanding factors that affect safety performance, either by assessing factors affecting current performance or by retrospectively investigating factors related to serious injuries or incidents. In both cases, a model may aid in identifying causes of poor performance and possible solutions for improvement that are appropriately focused and not narrowly based on preconceptions and other factors. Examples of each are discussed here.

Example 1: A 2005 refinery explosion and fire investigated by CSB (2007) resulted in 15 fatalities, 180 injuries and major facility damage. While CSB identified many causes, Table 1 (p. 50) highlights some of the performance model factors identified in its investigation of the incident and in a subsequent investigation (BP U.S. Refineries Independent Safety Review Panel, 2007) of several company refineries. The CSB investigation found that "a very low personal injury rate . . . gave [the company] a misleading indicator of process safety performance." The subsequent investigation found that "A substantial gulf appears to have existed, however, between the actual performance of [the company's] process safety management systems and the company's perception of that performance," and the "safety management system was not, however, effective in evaluating whether the actions taken were actually improving the company's process safety performance." The investigation indicated that all safety performance model factors were identified as causes of the incident, as shown in Table 1 (p. 50).

Ultimately, excellent safety performance requires active involvement and daily perseverance by management and all employees to implement, improve and sustain effective safety programs.

Example 2: A large multisite industrial company with above-average industry safety performance proactively commissioned an assessment to help identify any gaps and opportunities for improving the company's safety program and injury performance. The assessment consisted of a safety culture and operational discipline survey and visits to several facilities to observe facility conditions and practices, review safety program activities and performance, and interview personnel. The safety performance model was used to help 1. evaluate safety program requirements, implementation and performance; and 2. identify primary opportunities for improving safety program and injury performance. Findings were developed with the intent of sustainable improvement in safety performance with an emphasis on identifying the safety culture and safety program root causes underlying observed performance issues. Table 2 (p. 51) highlights some of the performance model findings where the model helped ensure that the assessment was comprehensive and appropriately focused on identifying the most important factors impacting performance.

Conclusion

The primary goal of effective safety programs is excellent performance leading to prevention of serious injuries, business interruption, environmental harm and achievement of other safety program goals. It is essential for companies to consider their current level of safety performance, whether performance is getting better or worse, and what can be done to improve and maintain excellent performance. Experience shows that sustained excellent safety performance is possible but also that past success does not ensure future success because competing priorities and other challenges are always present. A model of safety performance can be helpful in defining key factors that impact performance, which can be assessed to help identify and prioritize continuous improvement activities, or retroactively evaluate injuries or incidents when things went wrong. Ultimately, excellent safety performance requires active involvement and daily perseverance by management and all employees to implement, improve and sustain effective safety programs. A model assists this process by helping to ensure that safety program activities and improvement efforts are appropriately focused and comprehensive. **PSJ**

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