USING MEASURED PERFORMANCE AS A PROCESS SAFETY LEADING INDICATOR

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ABSTRACT

Periodic demands on layers of protection (i.e. pre-alarms, safety instrumented functions, relief devices, emergency response systems, etc.) are precursors to more serious incidents. Failure of one or more layers of protection are always part of an accident sequence. Documenting these demands when they occur and the associated consequences in a way to facilitate analysis provides a means to measure process safety management performance. While process safety metrics are still in their adolescence, this paper reviews experiences of development and implementation of a "Challenges to Safety Systems" process safety performance indicator. The paper includes a discussion of automating significant portions of the data collection process based on the technical work documented by the CCPS PERD (Process Equipment Reliability Database) initiative. The paper recommends various metrics that can be calculated and describes how the initial foundation developed to support improved process safety can be leveraged to achieve other benefits, such as design improvements, and improvements in the reliability, operation and maintenance of the facility.

Introduction

The chemical processing industry has long recognized the need for incident-free operations. Incident-free operations are the intent of process safety management. However, as the industry continues to improve and incident rates decrease, the public and stakeholders increase demands to eliminate incidents entirely.

Performance measurement is a business process that periodically quantifies and tracks selected indicators of an enterprise's performance, relative to its stated objectives. There are notably at least three reasons for measuring process safety performance:

- Benchmarking with other companies
- Communication with stakeholders
- Internal process improvement

This paper is intended to focus on one aspect of a performance management system: integrating the measurement system into other existing systems. Using the Center for Chemical

Process Safety's recommended indicator,[1] "Challenges to Safety Systems," this paper discusses options and lessons learned in data collection.

Performance Measurement

Establishing a performance measurement system is a process aimed at changing behavior, and ultimately culture. It is a process of continuous improvement (Figure 1). Because the performance measurement process is a culture modification tool, it is imperative that the entire measurement process be grounded on corporate environmental, health, and safety (EHS) objectives. Alignment with corporate goals supports corporate performance and helps assure that the measurement system will remain robust and viable in the long term.

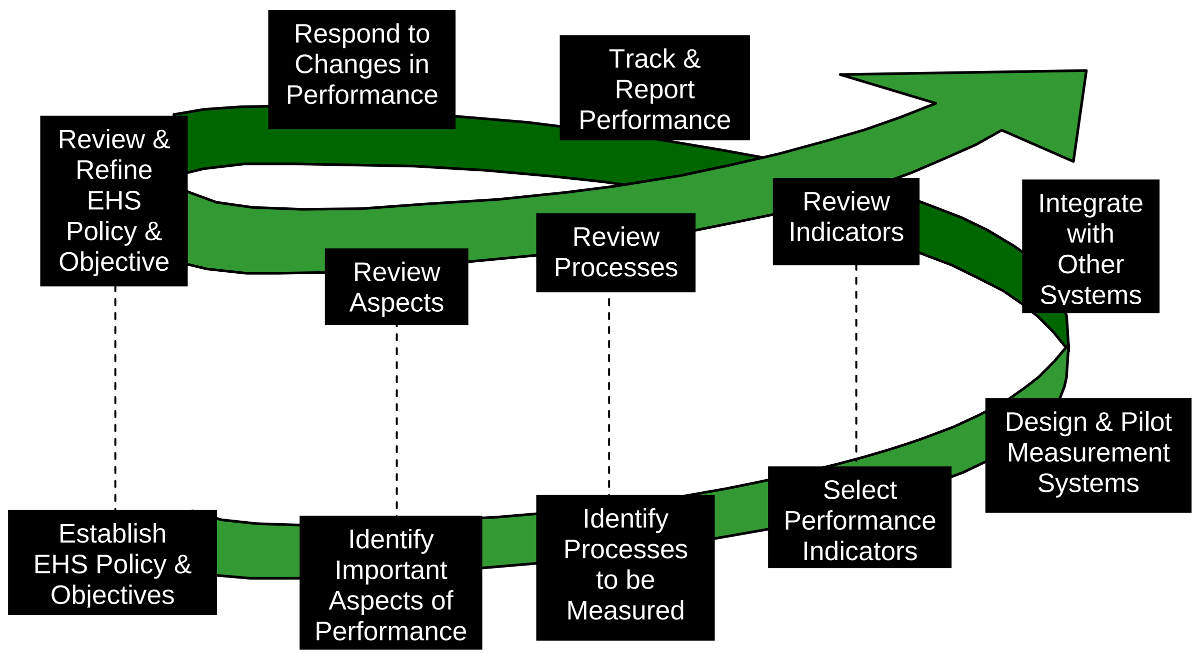


Figure 1 Performance Measurement Process

Corporate goals point to important aspects of performance that should be measured. These aspects are the behavior modifications sought. They can be very targeted or global in scope. However, aspect modification must support overall plant and corporate EHS objectives.

A performance indicator is a quantifiable attribute of an enterprise's activities that characterizes the potential contribution of these activities toward the enterprise's goals. A metric defines a specific means of measuring and tracking a performance indicator. Targets establish the desired behavior with respect to the chosen metric.

Table 1 presents example results from a performance measurement effort. Performance indicators and metrics not only vary from company to company, but vary from plant to plant and among the various levels within a company. The key issue in establishing a performance measurement system is to drive behavior modification around EHS goals and objectives.

Table 1 Example Performance Measurement Implementation

Aspect Modification	Performance Indicator	Metric	Target
Eliminate incidents	Process safety incidents	Process safety severity index	Zero
Reduce precursors to incidents	Process safety near miss	Number of losses of primary containment	Reduce the number by 10%
		Number of unplanned flames	Be in the top 10% among peer companies for lowest number
	Challenges to safety systems	Number of pressure relief device challenges	Reduce the number by 30%
		Number of safety instrumented system challenges	Reduce the number by 10%
		Number of process deviations or excursions	Reduce the number by 10% while maintaining production levels
Reduce the number of equipment failures	Completion of maintenance activities	Number of PMs past due	Reduce the number by 50%
		Number of corrective actions on MI equipment or systems past due	Reduce the number by 50%
	Maintenance of up-to-date procedures	Number of maintenance procedures past due scheduled review	Zero
Expeditiously address action items	Action items past due	Number of action items past due by month	No action item older than 3 years
		Number of action items past due	Reduce the number by 50%

Choosing Metrics for Performance Indicators

A key step in the performance measurement system is choosing metrics for performance indicators. Choosing metrics that are difficult to understand or difficult to implement will cause breakdown of the measurement process. Criteria for a good set of metrics are as follows:

- Relevant to strategic enterprise goals
- Effective for process improvement
- Support stakeholder communication
- Well-defined
- Cost-effective to implement
- Suitable for intra-industry comparison
- Consistent across sites and over time
- Few in number
- Appropriate normalization factors

CCPS[1] has proposed three metrics for the “Challenges to Safety Systems” performance indicator:

- Number of pressure relief device (PRD) challenges
- Number of safety instrumented system (SIS) challenges
- Number of process deviations or excursions

An effective measurement process must define each metric and determine data gathering methods.

A PRD challenge can be defined as any opening of a rupture disc, a pressure control valve to flare or atmosphere, or a pressure safety valve under any conditions, including an opening below the pre-determined set pressure. For PRDs under U.S. environmental regulatory influence, unplanned challenges may easily be defined and collected under emission event reports. In addition, counting bench test failures as PRD challenges can also be captured as part of testing documentation.

An SIS challenge can be defined as the activation of an automatic shutdown of any equipment or process based on a safety instrumented function due to a “process” variable going outside an acceptable range. SIS challenges are usually well-annunciated and noted by operators in logs.

A process deviation or excursion can be defined as whenever a process deviates or experiences an excursion outside its safe upper and lower operating limits as defined for the purpose of PSM compliance. Safe upper and lower operating limits are defined as part of process safety information. However, there may be no evidence of the excursion beyond an alarm at the time of occurrence.

Capturing events that may occur during off-shifts when no one is around other than the operators, may occur in one of two ways: proper operator reporting or automatic data logging. Proper operator reporting can work well, particularly where a positive, learning culture exists. In a trial with three plants over a three-month period, a total of 37 process deviations were noted through Immediate Incident Reports aimed at capturing operating parameter deviations. A review of data logging noted the equivalent events as reported by operators.

The success of this trial was attributed in part to the positive culture toward identification and solving process safety issues at the plants. This is not always the case at all companies or even at all plants within the same company.

Automated Data Collection

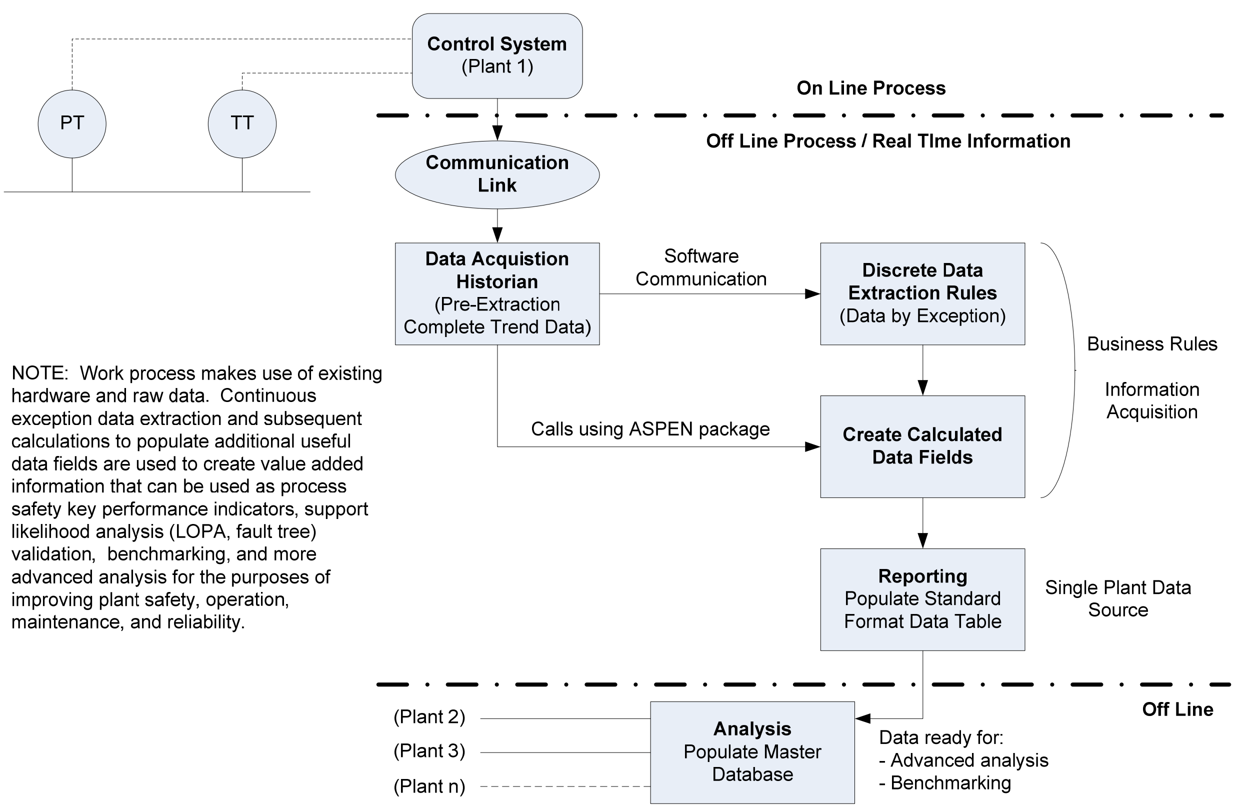
In process operating plants with distributed control systems and programmable electronic safety instrumented systems, a wealth of data is available as a result of discrete and analog inputs, as well as the intended output from the logic solver acting upon this information. While this paper focuses on analog inputs associated with potential significant hazardous events, much of the same thought process applies to discrete signals and especially to the topic of alarm management. However, that is beyond the scope of this paper.

As an example, assume a pressure vessel has three layers of protection: high pressure alarm, high pressure safety instrumented function (SIF) shutdown, and a relief valve. If a process upset resulting in high pressure were to occur, information transmitted by a pressure transmitter is often available to provide data as a function of pressure and time. This data is often stored in a historian for some period of time. What is useful to support KPI's however, is exception data that needs to be extracted, specifically in this example:

- Time and date when each layer of protection set point is reached
- Time and date when maximum pressure is reached
- Time and date when each layer of protection set point process should reset

Figure 2 shows the conceptual data flow for collection and processing, coupled with hardware and software that exists today. Data stored in the historian would periodically be batch-transferred to an offline database. The CCPS PERD software[2,5] was designed specifically with this type of activity in mind.

Figure 2
Automatic Data Collection/
Processing Flow diagram



Development Work Process

Making this concept work requires a multi-functional team representing engineering, operations/maintenance and process safety. Management must provide leadership so that adequate resources can be assembled to execute development of the application, implement and set up the work process for the long haul.

Steps in this process include:

- Define initial scope. Initial scope is suggested to be 1 or 2 plants with a limited number of safety instrumented functions as the foundation. As experience is gained and the value is more readily recognized, the scope can be expanded more cost effectively.
- Assemble multi functional project team.
- Establish off line database compatible with CCPS PERD taxonomies.[3,4] Ultimate goal would be to batch transfer data to PERD software directly.
- As part of establishing the off line database, document:
    - Standard leading indicator report content and interval for reporting
    - Standard analysis reliability parameters to report (i.e. mean time to specific application alarm, interlock, etc.
- Perform design configuration.
- Document Operation's support requirements and procedures.
- Implement configuration in selected plant(s).
- Begin operation / batch transfer data
- Generate standard reports for use as key performance indicators
- Use data to enhance management of process safety, improve the quality and credibility of internal hazard analysis and to assist risk decisions.

Resources Required

Table 2 lists typical resources required to establish automated data logging for process excursions.

Table 2 Typical Resources for Data Logging

Functional Discipline	Expected Responsibilities
Project Engineering	• Overall project management during design through startup
Process Safety	• Assist development of desired analysis and leading indicator reports • Person fully knowledgeable with CCPS PERD technical info • Ensure scope satisfies data requirements to support desired analysis and reports • Document off line database requirements • Peer review design to ensure data capture satisfies the requirements to support desired analysis and reports
Process Control – Design	• Perform configuration work to automate data capture in a way that permits efficient expansion to other plants

	• Participate in startup and troubleshooting
IT	• Work with Process Safety to establish off line database • Work with Process Controls to develop procedures and work process to update off line data base in a continuous batch manner • Manage the offline data base and work process for periodic updates
Process Control – Operations	• Maintain the hardware and software in the field associated with the application
Mechanical Integrity	• Peer review the scope • Work with Process Safety to develop internal plant benchmarking activities and to develop procedures that allow the data to help track performance of equipment in the mechanical integrity program

Technical Risk

Technical risk associated with connecting to operating DCSs and data manipulation should be minimal. The concept has been successfully demonstrated as part of a pilot exercise in a chemical plant, using transmitted process data (pressure, level, flow and temperature) associated with a distillation column.

Some important lessons were learned during the pilot. When configuring the software to excerpt the data, it is necessary to include checks to ensure the protection is actually in service and not being tested offline. A related issue is the potential for start-up bypasses for safety instrumented functions such as a low flow shutdown. In these cases, appropriate configuration is needed to ensure the data collected is relevant.

Automated Data Benefits

Successful implementation has the potential to lead to the following benefits if managed in an appropriate manner:

- Provide leading process safety indicators that can help reduce low frequency, high consequence events
- Automated source of proven in use data to:
  - Provide initiating event rates for use in layer of protection analysis (LOPA) or fault tree likelihood analysis
  - Validate multiple layers of protection within LOPA or fault tree likelihood analysis
  - Assist determination of equipment reliability parameters
  - Assist determination of human reliability expectations in particular circumstances
- Helps to identify failed layers of protection as part of mechanical integrity program

- Increase near miss reporting while decreasing the hours required by Operations to manually report
- Allows bench marking of specific plants versus aggregate of similar plants
- Improve efficiency and quality of incident investigations

Conclusion

From an overview of the performance measurement process, this paper focuses on the issues surrounding data collection to support the measurement process, specifically with metrics associated with "Challenges to Safety Systems." Plants with a history of positive safety culture have demonstrated that relying on human self-reporting can be an effective way to collect data.

Alternatively, ways exist to automatically measure the data for process safety metrics. The paper provides a proposed strategy, methodology and work process that utilizes existing hardware and software for the automated capture of demand data for the alarm, safety instrumented function (SIF) and pressure relief layers of protection. This in turn, allows calculation of demand rates that can be used as metrics. It also allows validation of layer of protection analysis performed within one's company and can help to provide insight as to where resources are best utilized to lower risk and improve reliability.

References

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