MONITORING OF PROCESS SAFETY PERFORMANCE

Doc 223/19

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Prepared by Safety Advisory Council, AHG-S.2 Process Safety

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1 Introduction

This publication is EIGAs first guidance on how to measure Process Safety (PS) performance. It is intended to help EIGA members to identify issues in PS and support them in improving their performance and assuring the integrity of their operations. It can also provide guidance for EIGA members in case of requests from authorities.

Process and plant safety performance can be evaluated through the use of key performance indicators (KPIs) that enable companies to identify trends and to take rapid corrective action if needed. Whilst the use of KPIs is common at individual company level, their application across industry is restricted because they are not harmonised in a universally shared management model for process safety. Reference: CEFIC booklet *Guidance for reporting on the ICC globally harmonized process safety metric* [1][1]

2 Scope and purpose

2.1 Scope

This publication refers to EIGA Doc 186 *Process Safety Management Framework – Guidance Document* and EIGA Doc 60*, Seveso Documents - Guidance on Applicability, Assessment and Legal Documents for Demonstrating Compliance of Industrial Gases Facilities with Seveso Directive(s)* [2,3].

This publication covers the selection, collection and validation of data. Multiple indicators are needed to monitor the different dimensions of process safety.

2.2 Purpose

The guidance in this publication is intended to contribute to developing process safety metrics, such that the number and the severity of process safety incidents can be reduced.

3 Definitions

For the purpose of this publication, the following definitions apply:

3.1 Publications terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May and need not

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Lagging indicators

A retrospective set of metrics which are based on incidents that meet a threshold of severity. [1]

3.2.2 Leading indicators

A forward-looking set of metrics which indicate the performance of the key work processes, operating discipline, or layers of protection that prevent incidents [1].

3.2.3 Process Safety Incident (PSI)

A release of energy or material in process involvement, with actual or potential consequences above a minimum reporting threshold.

3.2.4 Near Miss

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. This could for example be a loss of containment below a threshold or an unsafe condition which activated one or more layers of protection.

CCPS *Process Safety leading and lagging metrics*, January 2011 [4]

4 How to select KPIs for your process

Companies should select PS indicators according to their needs and processes. Some of them can be used over long periods for consistent observation. Others can be used for shorter periods. KPIs can be used on any level; for example, at the company or division or plant level of an organisation and can be freely chosen according to the needs or the organisation. When companies start to monitor PS performance it is important that they select only a few indicators in order not to overload the organisation as this can lead to poor quality data input, analysis and results. This publication contains basic and advanced KPIs but a company may choose any KPI to monitor their organization.

4.1 Guideline for good KPIs

In order to create KPIs they should follow some basic rules. They should:

- cover clear objectives and targets;
- be understandable and meaningful;
- be unambiguous;
- be measurable;
- be reviewed on regular basis; and
- lead to positive action.

In order to make KPIs effective, they should:

- have a process owner including for data collection and closing of actions;
- be distributed in the organisation to the relevant audience;
- be reviewed by the management.

In general, KPIs can be represented in percentages or in numbers, depending on the purpose of the metrics. For example, colour coding traffic light system or additional symbols can support the visibility of the KPIs.

5 KPI definitions

Key Performance Indicators are often split into lagging and leading ones. While there is consensus on the need to represent both, there are different and sometimes conflicting definitions on what is a leading and lagging indicator.

In this publication, leading indicators are generally thought of being precursors to a potential process safety incident or near miss or weakness in the process safety management system. Lagging indicators measure reactive metrics.

5.1 Lagging KPIs

Lagging indicators are parameters often revealing the defects or gaps in process safety protection layers. This can be demonstrated by using the Swiss cheese model. The Swiss cheese model illustrates in a simplified form the different barriers between a potential event and harm. No barrier is perfect and the holes in a barrier reflect the possible failure of a barrier. If holes of independent barriers are overlapping, an incident can occur. Lagging metrics count the number of events.

For this reason, they are used as reference and show either a need for improvement or a failure of safety programs. Root cause analysis of the event can then indicate where the system failed.

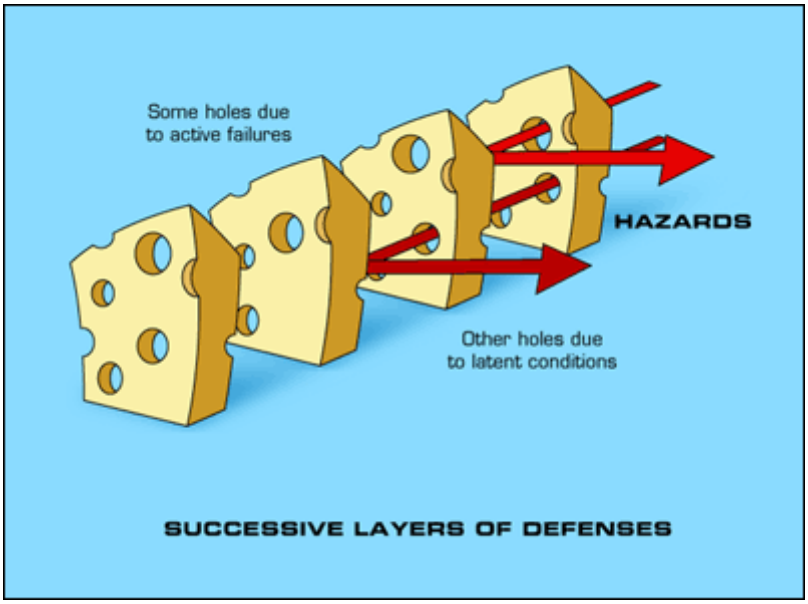

Figure 1 Swiss cheese model for a near miss

An example could be a lagging indicator showing a higher number of loss of containment incidents of carbon dioxide. Deeper analysis of the events could show that most releases have happened in pipeline systems and hazard analysis could show that maintenance, one of the protection layers in this example, had not been carried out properly for several years. The conclusion could be that there is a need for a maintenance plan for carbon dioxide pipelines. Typical lagging metrics examples are given in Table 1.

Table 1 Examples of typical lagging metrics

KPI definition	Objective	Comment
Number of PS incidents per year or per site	Track PS incidents to get indication of improvement	PS incidents could be classified by severity or consequence
Number of near misses per year	Track near misses to get indication of improvement	Categorization of near misses can help to identify root causes and trends

KPI definition	Objective	Comment
Number of plant safety trips and emergency stops	Track challenges on safety systems to minimise number of demands on safety systems	
Number of demands on safety critical devices	Same as above but the scope includes demand of other safety critical devices	Examples: pressure relief devices, high-level trip, etc.

5.2 Leading KPIs

Leading indicators are forward looking parameters. They also reveal defects or gaps in process safety protection layers often without an event happening. Using the Swiss cheese model, the holes in a barrier are detected during routine checks or by near miss analysis but with at least one layer of protection being intact. Figure 2 shows how leading and lagging indicators function.

Figure 2 Leading and lagging indicators

Since leading indicators cover non-happened events, good analysis of data is important indicating potential failures of barriers.

5.2.1 Competence and training of employees

Employee selection, training and competency is one of the elements in EIGA Doc.186 [2] and a fundamental safeguard in preventing worker injury events or potential accidents. Measurement of performance in this area is key to managing the expectations of leading process safety metrics and ensure safe operations. Performance indicators in competency can vary in their complexity and they depend on the maturity of the competency model of the company using them. Examples of KPIs for competence and training of employees are given in Table 2.

Table 2 Examples of KPIs for competence and training of employees

KPI definition	Objective	Comment
Percentage of competence profiles for employees/tasks	Ensure competence profiles for all employees/tasks are defined	
Percentage of employees trained in accordance to their profile	Ensure employees are trained and capable to fulfil their tasks	Competence profiles for jobs might change and regular update is needed, requiring adapted training
Percentage of employees assessed on competence	Ensure employee competency is regularly assessed against requirements of their assigned role and responsibilities, or is maintained via continuing professional development	Reassessment might be required on regular basis
Percentage of sites with a defined number of safety moments/activities per year	Raise awareness of employees by regular safety engagements	Different systems might be available in different companies (e.g. tool box talks, safety briefing)

5.2.2 Leadership

Assurance of the integrity of an organisation's operations requires visible leadership, commitment and accountability at all levels of the organisation. Examples are given in Table 3.

Table 3 Examples of leadership KPIs

KPI definition	Objective	Comment
Number of KPI review sessions per year	Help leadership to put corrective actions into place as result of KPI trends	
Number of recorded safety engagements/walks per Leader	Leadership involvement on corporate, cluster, site	Leaders should be trained on safety engagements
Number of sessions with incidents / incident analysis reviewed by management	Management involvement and awareness of root causes and learning from process safety events	This should apply to local and senior management

5.2.3 Risk assessment on site

Knowing all the risks associated with the production and auxiliary processes will help in adopting the correct and most effective preventive and mitigative measures, thus increasing process safety.

The measure of compliance between real plant and risk assessment, for example, maintenance implementation and management of safety layers, can be an important leading indicator. The maturity of risk assessment can also be a measure of process safety (leading KPI).

Table 4 gives examples of leading indicators proposed to evaluate the effectiveness of the risk analysis process.

Table 4 Examples of leading indicators

KPI definition	Objective	Comment
Percentage of sites with a Process Hazard Analysis (PHA) performed	Identify, document and address all hazards on a site	It is recommended to review process hazards periodically
Number of overdue actions from any risk assessment	Mitigate all identified risks	Percentage of compliance between plant and risk assessment (safety layers implemented) may complete this indicator.
Percentage of Pre- Start-up Safety Review (PSSR) completed before start-up	Ensure safety related actions, risks and processes are managed correctly before start-up of any site	

5.2.4 Emergency management

Emergency situations management is required to:

- minimize any adverse effects on people, damage to property or harm to the environment during and after an emergency;
- facilitate a prompt and effective emergency response and recovery;
- provide assistance to emergency and security services; and
- communicate adequate information to all relevant persons involved in the emergency (both internal and external stakeholders) with a minimum of delay.

Table 5 Examples of emergency management KPIs

KPI definition	Objective	Comment
Percentage of sites having a current emergency plan	Check if sites are prepared in case of emergency situations	
Percentage of sites having exercised emergency drills according to plan	Test the effectiveness of the emergency plan in place	Regular training of emergency drills is required for effectiveness. Emergency plan should cover all areas potentially impacted.
Percentage of drills where improvement plans after drills have been closed out	Ensure continuous improvement and implementation of lessons learned	

5.2.5 Operational control

The KPIs in Table 6 are examples proposed to ensure the organization is in control of their operating processes.

Table 6 Examples of operational control KPIs

KPI definition	Objective	Comment
Percentage or number of Management of Change (MOC) processes past due dates	Detect deviations on implementation, management and documentation (caused by organisation, resources, quality, competencies…)	MOC processes includes several dates related to approvals, documentation, training, close out, etc.
Percentage of key process safety documentation available and current	Measure management of key process documentation	Key process safety documents include e.g. process flow diagrams, process control system documentation and need to be defined by each company
Percentage of procedures reviewed as per schedule	Check if procedures that govern high-risk activities are kept up-to-date	Procedures should be kept up-to-date to ensure relevance as a safety barrier
Number of projects / plants where safety critical devices (SCD) have not been identified	Ensure all SCD are identified	Can be detected through project/facility assessments
Number of times that specific parameters are at limits of the normal operational range	Detect tendency to operate the process too close to the limits of normal and safe operating range	This tendency could be caused by aging of equipment, human error, failure of process control system, decision by operational management. This is an advanced KPI and parameters to follow are identified locally.

5.2.6 Mechanical Integrity

One of the potential failure mechanisms that can lead to a loss of containment and consequently to a PSI is a failure of mechanical integrity. The following leading KPIs can be used to foresee and identify such conditions.

5.2.6.1 Design and engineering

Failure to correctly design equipment or controls can lead to a PSI. An example of a KPI for design and engineering is given in Table 7.

Table 7 Example of a design and engineering KPI.

KPI definition	Objective	Comment
Number of MOC that required a risk analysis, but the risk analysis was omitted.	To ensure that changes to existing operations do not inadvertently introduce new hazards or unknowingly increase risks associated with existing hazards, minimizing unplanned adverse impacts on system integrity, safety, environmental compliance and reliability.	Can be detected through audits

5.2.6.2 Inspection and maintenance

Among the primary causes of failure of safety related controls or equipment, one of the most important can be wear and tear (aging plant). Plant inspection and maintenance is the key risk control system to prevent it and Table 8 gives examples of KPIs related to inspection and maintenance.

Table 8 Examples of inspection and maintenance KPIs

KPI definition	Objective	Comment
Percentage of incomplete inspection/maintenance as per plan on controls or equipment with potential to lead to a PSI	Ensure the organisation has a fully functional maintenance regime	This could include preventive maintenance, calibrations or inspections
Percentage of deficiencies detected of safety critical device during inspection	Minimize number of deficiencies of safety critical devices	Analysis of deficiencies should be performed to identify the cause (e.g. aging, improper design, etc)
Number of SCD maintenance actions overdue	Ensure short response time on maintenance of SCD	

5.2.7 Learning from incidents

Identifying the causes of process safety events will reduce the likelihood of reoccurrence. Preventive and corrective actions should be defined and shared throughout the organization. Examples of KPIs for learning from incidents are shown in Table 9.

Table 9 Examples of a KPI for learning from incidents

KPI definition	Objective	Comment
Percentage of process safety incidents reviewed	Ensure all learnings of PSI are covered	The subset of process safety incidents to be reviewed is selected by the organisation.
Percentage of PSI with root causes identified and corrective actions defined	Identify the real root causes of PSI and subsequent actions	Corrective actions should be applied for the appropriate level of the organisation (local, country and/or organisational level)
Percentage of actions closed out from PSI review and root cause analysis	Ensure findings from analysis are embedded	
Percentage of communication documents versus specific (chosen) process safety incidents	Communicate lessons learned tailored to relevant audience	Consider that more communication is not always the best solution. Chose various levels of importance and levels of detail.

5.2.8 Compliance

Compliance with legislation, regulation and internal standards is a fundamental requirement for organisations. Management shall ensure that the requirements are identified, understood and complied with, and examples of compliance of KPIs are shown in Table 10.

Table 10 Examples of compliance of KPIs

KPI definition	Objective	Comment
Percentage of actions from compliance audits overdue	Check the efficiency of audit systems related to PS	
Percentage of audits done against plan	Perform all required audits to identify possible gaps in protection layers	This is a basic KPI since audits are the source of information for other KPIs
Number of violations against mandatory country regulation	Track the conformity of sites	

5.2.9 Exposure of customer

Customers can be exposed to a PSI in case products or equipment do not comply with all safety requirements. The KPI in Table 11 can help to reduce the risk of exposure and uses an additional feedback loop helping to improve PS in the industry.

Table 11 Example of KPI for customer exposure

KPI definition	Objective	Comment
Number of process safety incidents at customers sites as a result of product delivery.	Ensure safety of our customers and understand the risks they are exposed to	

6 Data collection and validation

Reliable performance monitoring, electronic platforms for data collection and analysis are key. Typically, the following databases are available in most gas companies and can be used for analysis. The organisation should ensure that data is reliable and therefore put adequate procedures and resources into place.

- Audit:
  - audit planning;
  - audit date, participation, scope;
  - audit findings;
  - corrective action management.
- Competence and training:
  - on site level;
  - expert level;
  - leadership level.
- Plant production:
  - plant performance;
  - production reports;
  - alarms and trips;
  - product quality insurance.
- Plant maintenance:
  - scheduled maintenance;
  - mechanical integrity.
- Incident management:
  - date and information of event;
  - damage;
  - root cause analysis;
  - actions resulting and tracking.
- Customer non- conformity:
  - complaint management.

7 Data validation and communication

Review of data input should happen on regular basis on different levels of the organisation. To achieve good outcome of the data, review the following items should be considered:

- The quality of KPIs measured depends on the quality of data input. Therefore, the system should be easy to handle and easily accessible.
- Interpretation of KPIs depend on competence of personnel and the given scope.
- The results of the review should be verified for consistency. In many cases this gives an insight into the quality of the input data and the quality of the reporting in general.

Furthermore, it is best practice to

- Use standardised reports;
- Use a flexible reporting structure because of the number of different sites and processes;
- Share the results of data reviews with the relevant audience;
- Tailor the frequency of communication of results; and
- Tailor the results to the perspective of the various receivers.

KPIs are for the use of management, therefore leadership of a company should take ownership for them. Results and actions out of the analysis should be visible.

8 References

Unless otherwise specified, the latest edition shall apply.

[1] *Cefic Guidance for Reporting on the ICCA Globally Harmonized Process Safety Metric.* Responsible Care Leadership Group June 2016. www.cefic.org/Industry-support

[2] EIGA Doc.186 *Process Safety Management Framework Guidance Document*. www.eiga.eu

[3] EIGA Doc 60, *Seveso Documents - Guidance on Applicability, Assessment and Legal Documents for Demonstrating Compliance of Industrial Gases Facilities with Seveso Directive(s)*

[4] CCPS *Process Safety leading and lagging metrics, January 2011* www.aicheme.org

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