



**Guidance on Process Safety
Performance Indicators**





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Protection of people and the environment is the most important objective of chemical enterprises worldwide. An effective Process Safety Management System that enables the identification, elimination, reduction and mitigation of risks resulting from operations, is a pre-requisite.

Process and Plant Safety performance can be evaluated through the use of key performance indicators that measure and analyze Process Safety Incidents (PSI). Whilst the use of key performance indicators is common at individual company level, their application across industry is restricted because they are not harmonized into a universally shared management model for Process Safety.

This guide contributes to developing plant and process safety metrics to allow industry-wide cross reference via a common reporting system.

A recommended minimum data set with shared criteria and definitions is provided.

To ensure a consistent set of criteria for internal and external reporting of PSI, this guideline:

- Describes the need and benefit of implementing process safety performance indicators,
- Defines the constraints for an effective internal system to capture all incidents, and
- Provides criteria which characterize an incident as a process safety incident.

Objective

The objective of the guideline is to describe a globally applicable reporting system by:

- Defining harmonized criteria which qualify incidents as Process Safety Incidents (PSI),
- Giving guidance on methods for the development and use of Process Safety Indicators,
- Supporting their application by a set of questions and answers.

The aim is to provide a reporting system so that safety performance data at global, regional and country level is provided. This will allow senior management to recognize the actual level of performance and identify trends so that unplanned and undesired process incidents can be avoided, reduced or rectified.

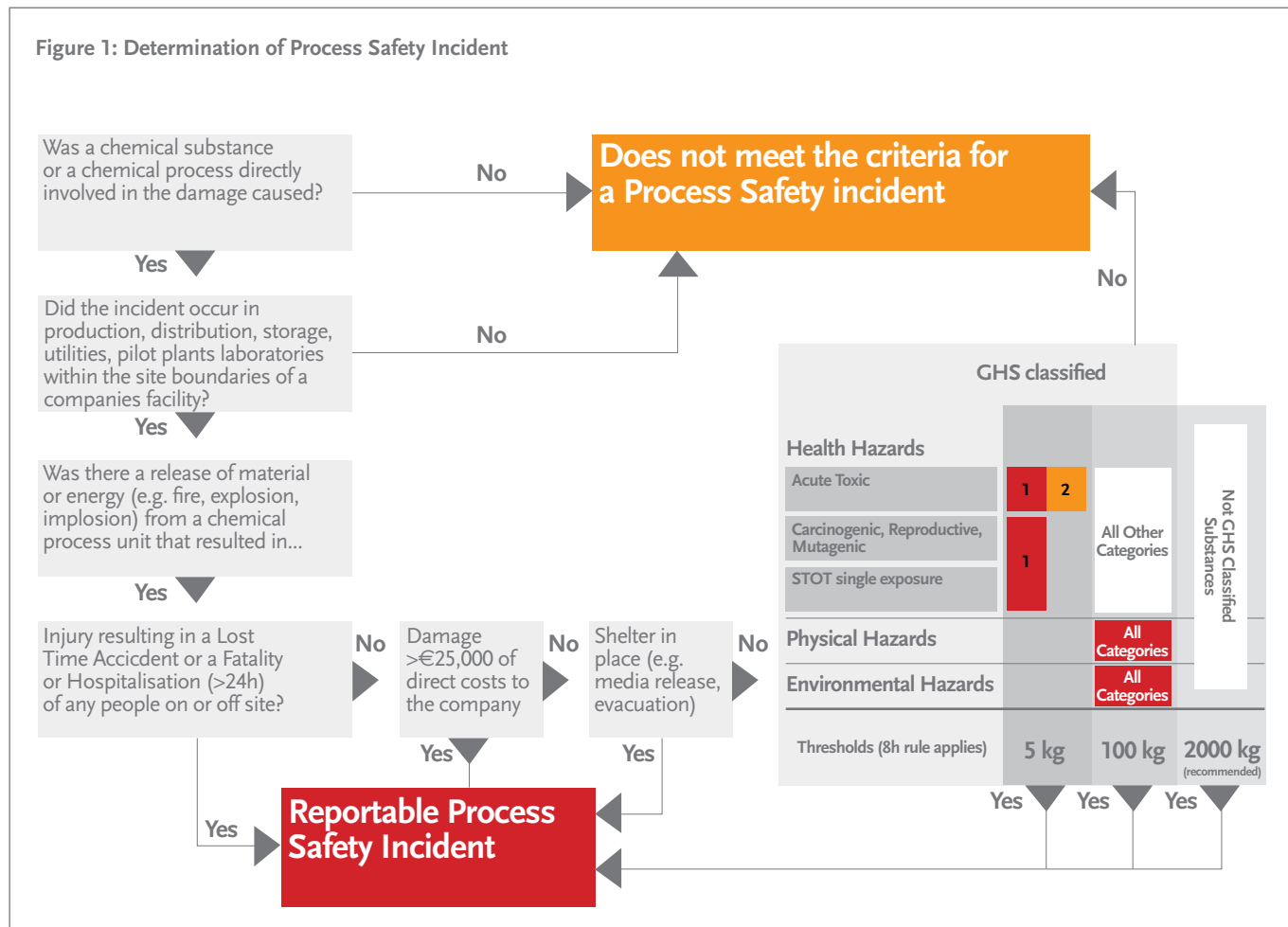
Scope

Short-term and long-term incidents are covered. Short-term Incidents have short-term consequences, such as release of an acute toxic substance. Long-term incidents have long-term consequences, such as the release of a substance with a carcinogenic potential or hazardous to the environment.

This guide focuses on measuring PSI as a lagging indicator for process safety performance. Lagging indicators follow behind overall activity and include lost time from injury frequency rate or severity rate. They are not site specific and can be adopted for a variety of situations so they are useful for benchmarking and trend analysis, enabling management to draw conclusions and drive continuous improvement. Leading indicators on the other hand, monitor prevention and control systems and the level of preparedness of the organization. They include near misses and the number of performed inspections in time. They are too site-specific for benchmarking or developing globally applicable criteria. Therefore, although crucial management tools, they are not covered in this guideline. It is company responsibility to adequately consider leading indicators in order to ensure effective process safety management.

Criteria

The flowchart below summarizes the process of determining whether an incident qualifies as a PSI.



A release of energy or material qualifies as a Process Safety Incident if it meets all three of the following criteria:

- 1. Chemical substance or chemical process involvement,**
- 2. Consequences above a minimum reporting threshold,**
- 3. Location.**

1. Chemical substance or chemical process involvement

A chemical substance process must have been directly involved in the damage caused. Term “process” is used broadly to include the equipment and technology needed for chemical production - including reactors, tanks, piping, boilers, cooling towers and refrigeration systems.

2. Consequences above a minimum reporting threshold

Such incidents qualify as PSI if one or more of the following criteria are fulfilled:

- Injury resulting in a Fatality, Hospitalization (>24h) or lost workday of any people on or off site,
- Release of energy (e.g. fire, explosion) that causes a damage with direct costs of > € 25,000,
- Release of chemical substances due to Loss of Primary Containment (LoPC) above certain thresholds,
- Shelter in place (e.g. media release evacuation).

Release of energy

In most cases the release of energy (e.g. fire, explosion) is detected rapidly after the incident has occurred. The release of a chemical substance can happen over an extended time period without being recognized, especially in areas that cannot be checked by regular inspections.

To support the decision whether a release of a chemical substance is qualified as a PSI, the thresholds for LoPC as defined above refer to a time period of 8 hours - approximately equivalent to a working shift.

A release to a flare or scrubber is still considered to be within the primary containment as long as the mitigation system (e.g. scrubber, flare) is operated under normal conditions without any release above the thresholds defined for normal operation.

A release to a secondary containment (e.g. waste water treatment or dike) will qualify as a PSI because the substance is leaving the primary process system.

Release of substances and mixtures

The thresholds should reflect the intrinsic hazard potential of the chemical substances. The Globally Harmonized System (GHS) is used to define thresholds for hazardous substances and mixtures as follows:

Substances:

- **LoPC > 5 kg:**
 - Cat 1 + 2 Acute Toxicity
 - Cat 1 Long Term Health Effects: Carcinogenicity (H350), Reproductive toxicity, Germ cell mutagenicity (H340)
 - STOT after single exposure and related to H370, category 1.
- **LoPC > 100 kg:**
 - All other GHS classified substances.
- **LoPC > 2000 kg:**
 - All other not GHS classified substances (recommended for internal reporting).

If the material under consideration is a hazardous material that does not have a GHS classification yet, use adequate/similar classification, for example the Hazard Classification from the UN.

Mixtures

Mixtures are treated as substances when classification according to GHS is available. The following principle should be applied:

Mixing rule: Calculate the fraction of threshold quantity release for each component. If the sum of the fractions is greater than 100%, the release is counted as a PSI. (This rule shall be applied conservatively.)

Figure 2 summarizes how thresholds for hazardous substances and mixtures are defined under GHS

3. Location

The incident occurs in production, distribution, storage, utilities, pilot plant or laboratory areas of company facilities. This includes tank farms, ancillary support areas (e.g. boiler houses and waste water treatment plants or warehouses), and distribution piping under responsibility of the company. Transportation incidents are not covered unless they occur during loading and unloading procedures when connected/transferred to the process.

Figure 2: GHS Thresholds

GHS classified			
Health Hazards			Not GHS Classified Substances
Acute Toxic	1	2	
Carcinogenic, Reproductive, Mutagenic	1	All Other Categories	
STOT single exposure			
Physical Hazards		All Categories	
Environmental Hazards		All Categories	
Thresholds (8h rule applies)	5 kg	100 kg	2000 kg (recommended)

NOTE: Agreed substance categorization is required for consistency of reporting. CLP: Classification, Labeling and Packaging of Substances and Mixtures regulation (EG 1272/2008) is used.

Data Reporting

Each company should implement a system to ensure that all information describing PSI is reported internally to a function responsible for the PS indicators.

The data to be reported should fulfill the following requirements:

- **Specific**
Data should be specific for the company, i.e. hazardous processes, organization.
- **Complete**
Data should fulfill internal and external requirements for the reporting of the process safety performance.
- **Comprehensible**
Data should enable the receptor to follow the course of the incident and the attributing factors.

To facilitate internal compliance and motivation to report Process Safety Incidents, the following aspects of data capture and reporting should also be considered:

- **Documentation**
The procedure for data capture should be easy to use so as to avoid unnecessary barriers to reporting incidents.
- **Quality**
The use of a template or spread sheet can enhance the quality of data provision by structuring the input of information and minimizing unstructured text which cannot be analyzed statistically.
- **Motivation**
An increasing demand for information may reduce the quality of the data provided as well as the willingness to provide it. Staff are more likely to report incidents in an open atmosphere.

Minimum Data Set

The minimum data set opposite is recommended to fulfill future external reporting requirements as well as those required under Responsible Care. Company specific information can be added to facilitate statistical evaluation where possible.

Additional information can be added in order to comply with the prospective standard of the American Petroleum Institute¹.

Recommended minimum data set

- Company identifier (BU, Department, etc.)
- Incident identifier (Incident title, No., Incident description)
- Date and time
- Location (Country, site, plant)
 - Type of incident
 - Fire (yes/no)
 - Explosion (yes/no)
 - Release of hazardous substances (yes/no)
 - Names
 - CAS Number
 - GHS classification
 - Optional UNDG Code
 - Amount
 - Physical state (gas, liquid, solid)
 - Release path (air, soil, water)
- Consequences
 - Human (employees, contractors, community members)
 - Fatalities (yes: number/no)
 - LTA (yes: number / no)
 - Hospitalization (yes: number/no)
 - Damage
 - Direct cost estimate
> € 25,000 to the company
- Mode of operation, i.e.
 - Normal operation
 - Startup
 - Shutdown
 - Maintenance
 - And others
- Off-site impact: An officially declared community evacuation or shelter-in-place (yes/no)
- Secondary containment in place (yes/no)
 - Loss of secondary containment (yes/no)

Additional information can be defined where necessary in order to meet the particular need of the company or industry association. Reporting thresholds can be adapted to the specific hazard portfolio of the company (e.g. lower reporting thresholds for explosives, LPG) to ensure that LoPC with minor consequences but high hazard potential are captured.

Process Safety Performance

PSI reporting is the first step to get an overview of the process safety performance of a chemical company. The information provided can only be compared within the same entity (e.g. country, site or plant) if the size of the respective entity has not changed significantly over the observed time period.

In order to facilitate a benchmark of different sites, companies or countries, the number of process safety incidents must be normalized to achieve a rate (Process Safety Event Rate: PSE). The value to be used for normalization should have an intrinsic and meaningful relationship to the probability of process safety incidents. As a first step the Number of PSI per 1 million working hours can be used.

To avoid inconsistencies, it is recommended that the same value is used for calculating LTAR (Lost Time Accident Rate) and PSE within a company.

The successful implementation of a PSI reporting system to evaluate safety performance within a company should include the following considerations:

- The reporting system is implemented top down from the management board to the operator,
- The benefit of reporting incidents is clearly communicated to the responsible management along the line down to the plant management,
- Misuse of the PSE should be avoided:
 - A small site within a company having only one PSI can have a much higher PSE than the medium value of a company. This does not reflect a poor performance of the small site automatically.
 - Senior management should be encouraged to communicate PSI, therefore the reporting of incidents should not jeopardize their job performance evaluation or bonus system.

Process safety incidents and work place accidents are caused, in most cases, by human error or deficiencies within the organization. Enabling the management and operators to improve the system requires an open atmosphere of reporting these deviations.

Conclusions

Process and plant safety can be significantly enhanced through the implementation of an effective Process Management System. At present however, a universally shared management model for process safety does not exist, partly because there are few if any harmonized key performance indicators that can measure process safety incidents across industry in order to provide benchmarking and trend analysis.

In order to fill this gap, this guide has provided:

- The basis to a common reporting system,
- A recommended minimum data set,
- Shared criteria and definitions.

It is hoped that this guide will facilitate industry-wide cross reference as a first step towards developing universally applicable process safety metrics.

Definitions

Loss of Primary Containment (LoPC)

LoPC is an unplanned or uncontrolled release of material or energy from primary containment. A tank, vessel, pipe, truck, rail car or equipment intended to serve as the primary container or used for processing or transfer of material.

Lost Time Accident Rate (LTAR)

Lost Time Accident Rate is the number of accidents causing an absence from work, with reference to a defined base (e.g. 1 million working hours, or 200,000 working hours). It is used in Occupational Health and Safety, and it is often linked to LTIR (Lost Time Injury Frequency Rate).

Release of energy

A release of energy (temperature, pressure) that results in:

- Fire (any combustion like smoldering, charring, smoking or an open fire). The presence of flame is not relevant for the combustion,
- Major pressure changes like a blast wave (e.g., detonations, deflagrations) or implosion.

Release of material

A release of chemical substances that reaches or exceeds the reporting threshold in eight hours or less.

- Releases via Pressure Relief Device (PRD) are reported as long as the release exceeds the threshold limits in this guide,
- Release to emission control device: Releases to a properly designed and operating emissions control device, such as a flare, scrubber, etc. do not have to be reported.

Secondary Containment (LoSC)

Any containment which serves as a barrier to limit the consequences due to the LoPC.

References

API:

RP 754 Process Safety Performance Indicators for the Refining and Petrochemical Industry

CCPS:

Process Safety –
Leading and lagging Metrics

HSE:

Developing Process Safety Indicators

EPSC:

EPSC Reports and Presentations

Abbreviations

API	American Petroleum Institute
CCPS	Center for Chemical Process Safety
GHS	Global Harmonized System
LOPC	Loss of Primary Containment
LTAR	Lost Time Accident Rate
PRD	Pressure Relief Device
PSE	Process Safety Event
PSI	Process Safety Incident
STOT	Specific Target Organic Toxicity

Acknowledgements:

Cefic Issue Team Process & Plant Safety



Cefic - The European Chemical Industry Council

Chemistry making a world of difference

Cefic is the Brussels-based organisation representing national chemical federations and chemical companies in Europe. Cefic represents, directly or indirectly, around 27,000 large, medium and small companies in Europe, which employ about 1.2 million people and account for more than 29% of world chemicals production.

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Dépot Légal D/3158/2011/1



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