International Association of Oil & Gas Producers

REPORT 456 | MAY 2023

Process safety – Recommended practice on Key Performance Indicators

Acknowledgements

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About

The global oil and gas industry has expended considerable effort developing process safety procedures aimed at preventing major incidents. The upstream oil and gas industry, in response to major incidents, has developed improved process safety key performance indicators (KPIs) to learn from events with less serious outcomes and to manage system performance. Report 456 enables companies to establish effective leading and lagging indicators that assess the health of barriers that manage the risk of process safety events (PSEs), particularly those that could result in a major incident.

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Revision history

VERSION	DATE	AMENDMENTS
3.0	May 2023	General update; see introduction for summary
2.0	November 2018	Substantial revision; see Foreword for summary
1.1	December 2016	Tables in Appendix B updated
1.0	November 2011	First release

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Introduction

About the previous editions

The global oil and gas industry has expended considerable effort developing process safety procedures aimed at preventing major incidents. The upstream oil industry, in response to major incidents, has developed improved process safety key performance indicators (KPIs) to learn from events with less serious outcomes and to manage system performance.

Recommendations that reinforced the need for improved KPIs were provided by organizations such as the UK Health & Safety Executive (UK HSE), the US Chemical Safety and Hazard Investigation Board (US CSB), and the independent Baker Panel report.

Significant efforts were made by the American Petroleum Industry (API), the Center for Chemical Process Safety (CCPS) and others to develop and publish guidance on KPIs for companies to manage process plant risks and prevent unintended releases of hazardous materials.

IOGP released the first edition of Report 456 in November 2011. Several previous documents have informed the development of this report's previous version as well as its current, updated form. IOGP published Report 415 - *Asset integrity – the key to managing major incident risks*, in December 2008 to provide advice on how to implement an asset integrity management system for new and existing upstream assets. It included guidance on monitoring and review, including how to establish lagging and leading KPIs to strengthen barriers (risk controls), and reduce major incident risk. These KPIs can be analysed to improve preventive actions, such as management system revisions, procedural changes, training opportunities, and/or facility engineering improvements that aim to minimize and eliminate the potential for major incidents.

The American Petroleum Institute (API) published API Recommended Practice (RP) 754, *Process Safety Performance Indicators for the Refining and Petrochemical Industries* in April 2010. Report 456 supported API RP 754's applicability for upstream activities and recommended this standard to oil and gas companies worldwide.

Report 456 enabled companies to establish effective leading and lagging indicators that assess the health of barriers that manage the risk of process safety events (PSEs), particularly those that could result in a major incident. It was also based on guidelines on indicators published by UK HSE, CCPS, and the Organisation for Economic Co-operation and Development (OECD).

A second edition of Report 456 was published in 2018 to reflect changes made in the second edition of API RP 754, published in 2016, to incorporate guidance from other IOGP publications, give more detailed definitions and examples, and simplify the overall presentation.

About this revision

This third edition of Report 456 incorporates changes resulting from the latest edition of API RP 754. API published the third edition of API RP 754 in August 2021, proposing changes based on feedback from companies. Revisions in this third edition involve continuous improvement rather than fundamental modification.

This third revision of IOGP Report 456 maintains alignment with API RP 754 as per previous editions:

- Given the localized effects of corrosive loss of primary containments (LOPCs) compared to flammables and toxics, reduction of the material hazard classification for corrosive agents to better align with the other hazard classes
- Updated/new definitions of primary and secondary containment, direct cost, indoor release, and unsafe location, to provide additional clarity
- Consistency with the language of API RP 754

This third edition of Report 456 also:

- Updates and expands the list of process safety event tier classification examples
- Provides greater clarity on the classification of process safety events that are well operations related, as well as the classification system for Well Control Incidents (WCIs), helping IOGP members to report these events more consistently and get the Wells community more engaged
- Includes insights from the 2021 process safety leading indicators internal survey conducted among the IOGP Member Companies

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IOGP Report 544 - *Standardization of barrier definitions*

Part A - Establishing corporate and facility KPIs

Scope

Part A provides background on why the industry has put significant effort into process safety indicators and articulates the value KPIs can have for companies.

Why use process safety KPIs?

Preventing major incidents

Process safety failures can result in serious harm to people, the environment, property, reputation, and the financial stability of a company.

When process safety failures cause significant damage, companies naturally apply careful scrutiny to these events and their causes, seeking lessons that can be used to improve processes and training and prevent similar events from reoccurring. As these analyses are by nature retrospective and based on relatively infrequent events, companies cannot afford to rely on these lessons alone to prevent major incidents.

It is therefore necessary to broaden these analyses to learn from events with less serious outcomes and refine management system performance to strengthen the barriers that prevent major incidents.

Process safety KPIs generate a range of relevant data which can be analysed to improve preventive actions, such as management system revisions, procedural changes, training opportunities, or facility engineering improvements, that aim to eliminate or minimize the potential for major incidents.

Improving reliability

The quality and productivity of a company's operations are reflected in its future profitability. Actions to prevent major incidents go hand-in-hand with steps to make operations more reliable, feeding directly into financial performance.

Avoiding complacency

The Baker Panel Report, the product of an independent investigatory panel commissioned to examine process safety cultures, said the following:

"The passing of time without a process accident is not necessarily an indication that all is well and may contribute to a dangerous and growing sense of complacency."

Since major incidents are relatively rare events, it is easy to give priority to other lower consequence risks in the belief that "all is well".

Process safety KPIs provide a constant reminder of asset and operations integrity, the attention needed on process safety management systems, and the warnings from less severe process safety events.

Communicating performance

It is a constant challenge to communicate the importance of process safety to the workforce. KPIs provide reassuring evidence of management focus, transparency and progress which can, in turn, support process safety culture and behaviours.

The four-tier approach

A combination of measures is needed to monitor barrier performance within a process safety management system.

In alignment with API RP 754, IOGP recommends the **four-tier framework** of process safety KPIs.

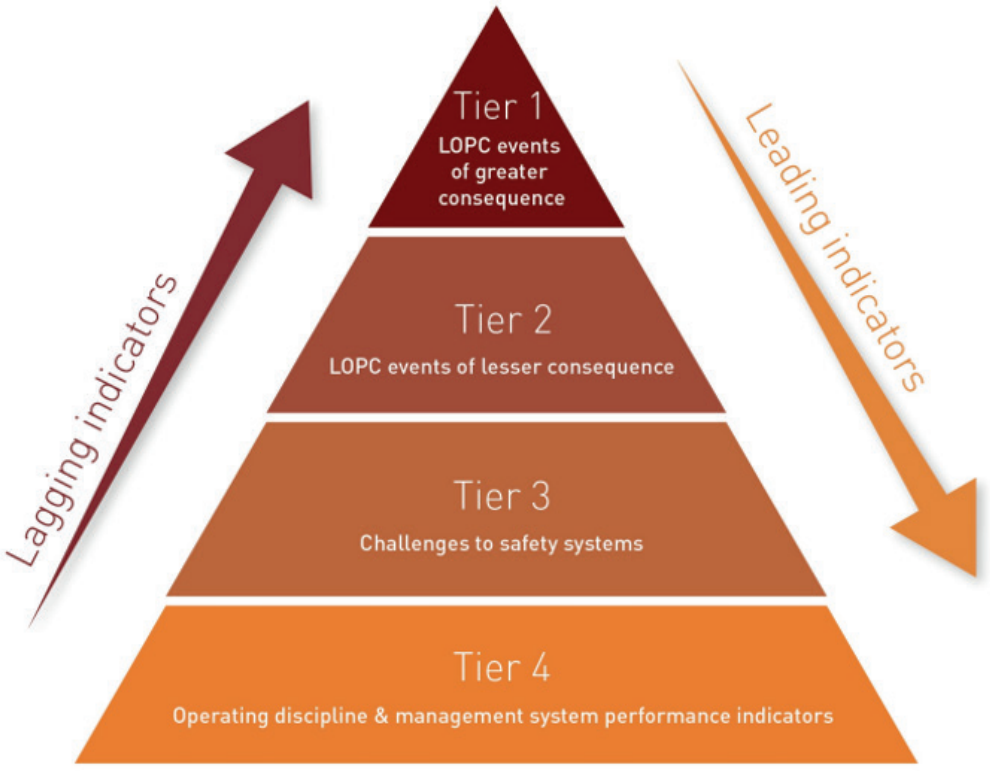

Figure A.1: Process safety indicator pyramid (from API RP 754): the triangle emphasizes that larger data sets are available from the KPIs at the lower tiers

Tiers 1 and 2 provide **lagging indicators** of process safety performance.

They cover major and less severe incidents. Loss of Primary Containment (LOPC) events are categorized as Tier 1 or 2, and typically indicate the failure of multiple barriers. Tier 1 covers incidents with greater consequence resulting from actual losses of containment. Tier 2 counts for process safety events represent LOPC events with a lesser consequence but may be predictive of future more significant incidents.

Tiers 3 and 4 provide **leading indicators** of process safety performance.

They are intended to be more specific to a company's own management system and often will be specific to an activity or to an individual asset, facility, or plant.

Tier 3 KPIs are used to monitor the performance of the barriers that prevent Tier 1 and 2 LOPC events. Events where the LOPC was below the Tier 2 thresholds, or when no LOPC has occurred, are Tier 3 KPIs provided one or more key barriers, or supporting systems, failed or did not function as expected. These represent challenges to safety systems. Tier 3 KPIs can provide an opportunity to recognize weak points within the safety barriers.

Tier 4 KPIs are used to monitor the implementation (operating discipline) and effectiveness (performance) of the management system elements that support the performance of key barriers. Tier 4 KPIs can provide an opportunity to identify management system areas of improvement for an effective and safe asset operating model.

The continuous improvement cycle

The concept of continuous improvement, whether at a corporate, business or facility level, is a fundamental process for any structured framework to address process safety.

There are many versions of the continuous improvement process including the 'Plan–Do–Check–Act' cycle, as applied within ISO guides and standards. This cycle places emphasis on improving the management system (including legal compliance, company standards, and local procedures) and minimising process safety risks by strengthening barriers that are implemented within operations.

The following three elements should underpin effective KPIs, particularly the more leading Tier 3 and 4 Indicators:

1) monitoring operational performance
2) internal and external reporting
3) reviewing outcomes to determine how to revise the management system and embed the continuous improvement.

Further guidance is provided in:

- IOGP Report 510 and IOGP Report 511, which relate to the development of Operating Management Systems
- IOGP Report 415, which describes how the Operating Management System is implemented to address process safety risks, barriers, and procedures for upstream operations.

Corporate versus facility KPIs

Process Safety KPIs are established to meet the following primary needs:

1) Internal monitoring and review of performance related to the management system and other actions to strengthen process safety barriers and reduce incidents.
2) Providing transparent disclosure of performance to stakeholders such as employees, local communities, investors, governmental and non-governmental organizations, and the general public. There are many opportunities for companies to communicate and engage with their stakeholders, but one important channel is through regular (typically annual) reports – often called sustainability or corporate citizenship reports. IOGP, API, and Ipieca collaborated on the joint publication *Oil and gas industry guidance on voluntary sustainability reporting*, which detailed and endorsed a process safety KPI framework for both upstream and downstream reporting.
3) Supporting employee engagement and promoting process safety management leadership behaviours that encourage a culture where there is constant vigilance, mindfulness, and sensitivity to signals such as changes in operating discipline or workforce concern and attitude.
4) Assessing whether the measured performance on process safety meets or exceeds industry norms by benchmarking KPI data against industry averages and by sharing lessons learned with other companies. See Part D of this report, IOGP data collection.

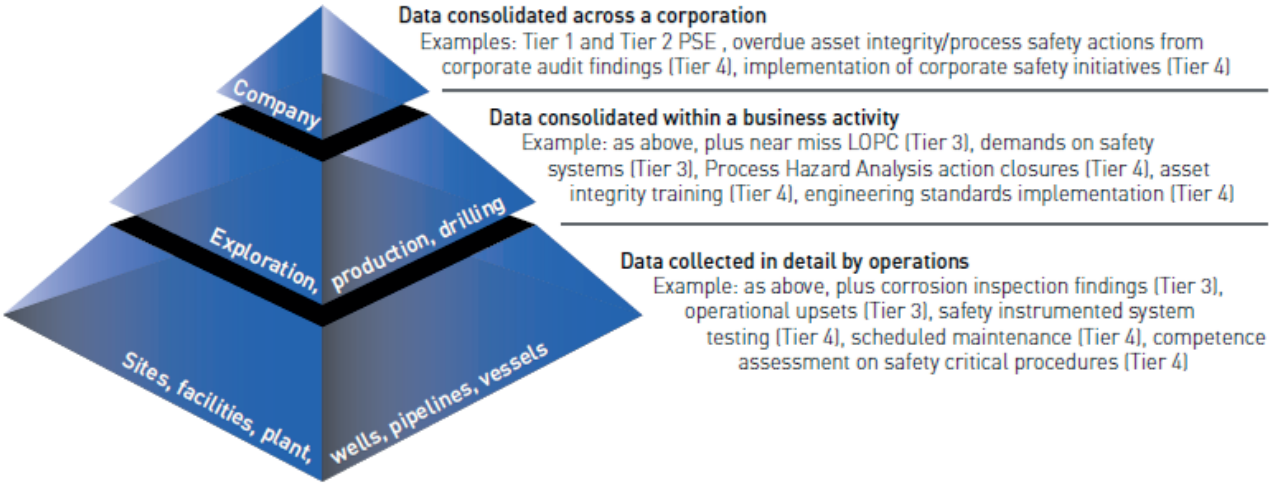

Figure A.2: Hierarchy of asset integrity KPIs

Process safety KPIs to meet these needs will vary across a company's organization from an individual facility up to the corporate level.

At the corporate level, data and other information should be selected carefully to be representative of the whole organization when compiled and consolidated to generate meaningful KPIs.

Tier 1 and 2 indicators are fully defined with the intent that these can be reported at the corporate level in both internal and external reports by any company. To achieve consistency and comparability, the indicator definitions have narrowly defined scopes and are threshold based. IOGP has retained consistency with API RP 754 to enable benchmarking.

Although some Tier 3 and 4 KPIs may be consolidated at a corporate level to test management systems implemented across the whole company, the greatest direct value of Tier 3 and 4 KPIs is generally at the local level because a company's assets will vary in terms of activities, equipment, and processes. Typically, this would mean that different additional Tier 3 and 4 KPIs are employed for activities such as production, well or pipeline operations, either offshore or onshore, and the KPIs would be focused on specific key barriers critical to those operations. Thus, as illustrated by Figure A.2, it is important that additional data is collected at lower levels of the organization so that performance can be analysed to address specific process safety risks for groups of operations with similar activities, equipment and environments.

Companies that decide to aggregate data from Tier 3 and 4 indicators should take care to ensure that similar facilities or activities form the basis of the aggregation, otherwise comparisons can lead to erroneous judgements. IOGP does not currently benchmark Tier 3 and 4 indicators but encourages sharing of company experience and good practice using these two tiers. While not all Tier 3 and 4 indicators can be aggregated, there is considerable value at the corporate level, or between companies, in bringing together the insights gained from asset level analysis.

Further discussion on KPI analysis and learning is included in Part I, Learning from KPIs.

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[1] 'BP Texas City Final Investigation Report'. US Chemical Safety and Hazard Investigation Board (US CSB), www.csb.gov/bp-america-refinery-explosion/ (Accessed 15 May 2023).

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[5] IOGP Report 511, June 2014 - *OMS in practice. A supplement to Report No. 510, Operating Management System Framework*

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Part B - Identifying Barriers and Selecting KPIs

Scope

Part B provides guidance on how to establish an effective process safety indicator program.

Introduction

When selecting KPIs, it is helpful to ask the following two questions: what is most relevant to the company's operations, and what reflects the company's performance in managing major incident risks?

To be able to answer these questions requires a well-developed knowledge and understanding of the major incident barriers, whether these are facility-specific, apply to groups of similar facilities, or even apply across the whole company.

Selecting effective indicators can be challenging, particularly leading Tier 3 and 4 KPIs, which aim to improve process safety at the facility level.

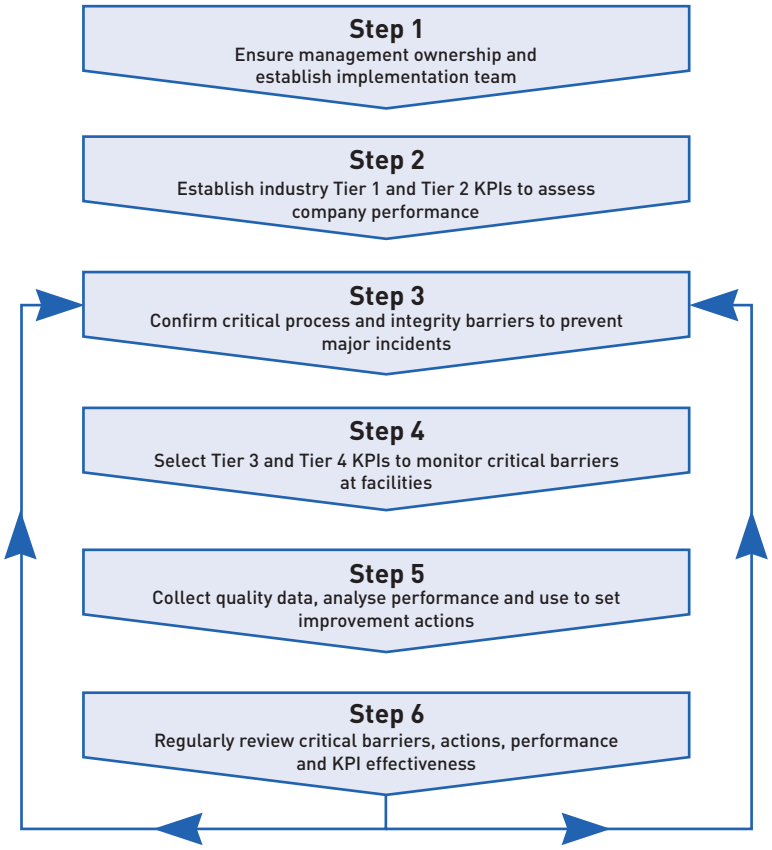


Figure B.1: Six-step approach for selecting process safety KPIs

Step 1 – Ensure management ownership

Ownership of the KPIs by senior management is essential to ensure that the data is reviewed at a level where continuous improvement actions can be agreed to and acted upon, including investment, prioritization, and resource deployment decisions.

Step 2 – Establish industry Tier 1 and 2 KPIs to assess company performance

The recommended Tier 1 and 2 KPIs provide consistent measures that provide baseline data on industry and company performance and facilitate trend analysis and benchmarking.

Tier 1 and 2 KPIs are typically established with the standardized industry definitions and retained year-on-year to provide a consistent record of a company's performance.

See Part C, *Tier 1 and Tier 2 Indicators.*

Step 3 – Confirm barriers to prevent major incidents

It is important to determine and annually confirm the barriers that are key to prevention of major incidents and to ensure that KPIs are in place to measure the performance of these key barriers.

Guidance on identifying barriers is provided in Report 415 and is summarized in Part G, *Tier 3 and Tier 4 Indicators.*

Step 4 – Select Tier 3 and 4 KPIs to monitor barriers

Selection and implementation of Tier 3 and 4 KPIs should ensure that the KPIs are specific to the barriers identified in Step 3 and that the KPIs are suitable for monitoring weaknesses in barriers and will provide **dual assurance**.

This is described in Part G, *Tier 3 and Tier 4 Indicators.*

Tier 3 KPIs reflect outcomes of unintended, unplanned or uncontrolled events, conditions, circumstances, or effects that represent impairment or failure of a barrier; therefore, targets for Tier 3 KPIs are typically set towards zero. While Tier 4 KPIs are a proactive measure of input (work, effort, investment) to maintain and improve the strength or quality of barriers and are typically driven to 100% conformance.

Step 5 – Collect quality data, analyse performance and set improvement actions

Collecting and analysing KPI data should be an integral part of the continuous improvement cycle, not about 'counting the score'.

Quality Assurance/Quality Control processes to verify the accuracy, consistency, and completeness of the collected data should be established. Trending, correlations, and other statistical analyses should consider the quality as well as the inherent reproducibility of the KPIs.

The performance data, highlighting meaningful change, should be transparently communicated to management for review resulting in improvement actions as input to the continuous improvement cycle.

See Part A, *Establishing corporate and facility KPIs*, and *Part I, Learning from KPIs.*

Step 6 – Regularly review barriers, actions, performance and KPI effectiveness

Process safety KPIs should remain focused on the barriers that prevent major incidents. While some KPIs, particularly the Tier 1 and 2 measures, are intended to be implemented and established for long-term review of performance, other KPIs may be used for a few years and then evolve to provide more detailed information on barrier health and performance.

Steps 3 and 4 should be revisited to ensure that process safety barriers and Tier 3 and Tier 4 KPIs are regularly reviewed, typically annually, as part of management's review of safety actions and performance. KPIs should be removed or replaced if they do not provide information that enables performance improvement or if they monitor a barrier which is no longer critical to address.

Guidance is provided in Part I, *Learning from KPIs.*

References

[1] IOGP Report 415 - *Asset integrity – the key to managing major incident risks.*

Part C - Tier 1 and Tier 2 Indicators

Scope

This section provides detailed instructions on how upstream companies should apply API RP 754 to their operations to identify and normalize Tier 1 and 2 process safety events.

Definitions

Tier 1 and 2 KPIs count Loss of Primary Containment (LOPC) incidents from a process. These are known as Process Safety Events (PSEs).

- Tier 1 PSEs are incidents with greater consequence and represent the most lagging performance indicator within the four-tier approach (see Figure A.1 in Part A)
- Tier 2 PSEs are incidents with lesser consequence.

When a Tier 1 or Tier 2 PSE occurs, it presents an opportunity for companies to identify weaknesses in their barrier systems and rectify those issues that lead to the event. Even those Tier 1 and 2 events that have been captured within secondary containment, contain lessons important to the prevention of future incidents of equal or greater consequence. When used in conjunction with lower tier indicators (see Part G), Tier 1 and Tier 2 KPIs contribute to a company's assessment of its process safety performance and can provide a company with opportunities for learning and improvement.

The Tier 1 and 2 KPI definitions below have been reproduced from API RP 754. They list the LOPC consequences which result in a PSE. Companies implementing the Tier 1 and 2 KPIs in this report should use API RP 754 as a source document for detailed definitions and guidance.

Tier 1 and 2 KPIs have been adopted by IOGP with the intent that these KPIs are applied across production and well operations for the oil and gas industry worldwide. Where practical to do so, companies should adhere closely to these definitions. Companies will commonly provide internal guidance, particularly to align definitions with existing company terminology and management systems.

Practical implementation of these KPIs can be challenging due to the complexity of applying the hierarchy of Tier 1 and 2 definitions and consequences. Section E provides a useful flow chart to help determine whether an LOPC is a Tier 1 or 2 PSE. The definitions refer to material release threshold quantities from Part E. Part F provides examples of upstream Tier 1 and Tier 2 process safety events with interpretation.

Part C provides guidance on applicability to upstream operations and activities.

Process safety event definitions, reproduced from API RP 754

Tier 1 Indicator Definition and Consequences

A Tier 1 PSE is an unplanned or uncontrolled release of any material (Loss of Primary Containment, or LOPC), including non-toxic and non-flammable materials (e.g., steam, hot water, nitrogen, compressed CO_2, or compressed air), from a process that results in one or more of the consequences listed below:

- An employee, contractor or subcontractor 'days away from work' injury and/or fatality
- A hospital admission and/or fatality of a third party
- An officially declared community evacuation or community shelter-in-place including precautionary community evacuation or community shelter-in-place
- A fire or explosion damage greater than or equal to $100,000 of direct cost
- An engineered pressure relief (e.g., use of a pressure relief device (PRD), safety instrumented system (SIS), or manually initiated emergency depressurization) discharge, of a quantity greater than or equal to the threshold quantities in Part E in any one-hour period, to atmosphere whether directly or via a downstream destructive device that results in one or more of the following four consequences. The threshold quantity determination is made at the discharge of the engineered PRD, while the consequence is determined when the material reaches atmosphere whether directly or via a downstream destructive device:
  - rainout
  - discharge to a potentially unsafe location
  - an onsite shelter-in-place or on-site evacuation, excluding precautionary on-site shelter-in-place or on-site evacuation
  - public protective measures (e.g., road closures) including precautionary public protective measures
- An upset emission from a permitted or regulated source, of a quantity greater than or equal to the threshold quantities in Part E in any one-hour period, that results in one or more of the following four consequences:
  - rainout
  - discharge to a potentially unsafe location
  - an on-site shelter-in-place or on-site evacuation, excluding precautionary on-site shelter-in-place or on-site evacuation
  - public protective measures (e.g., road closures) including precautionary public protective measures
- An unignited release of material greater than or equal to the threshold quantities described in Part E in any one-hour period, excluding engineered pressure-relief discharges and upset emissions from permitted or regulated sources.

Tier 2 Indicator Definition and Consequences

A Tier 2 Process Safety Event (PSE) is a LOPC with lesser consequence. A Tier 2 PSE is an unplanned or uncontrolled release of any material, including non-toxic and non-flammable materials (e.g., steam, hot water, nitrogen, compressed CO_2 or compressed air), from a process that results in one or more of the consequences listed below and is not reported as a Tier 1 PSE:

- An employee, contractor or subcontractor recordable injury
- A fire or explosion damage greater than or equal to $2,500 of direct cost to the company
- An engineered pressure relief (PRD, SIS, or manually initiated emergency depressurization) device discharge, of a quantity greater than or equal to the threshold quantities in Part E in any one-hour period, to atmosphere whether directly or via a downstream destructive device that results in one or more of the following four consequences. The threshold quantity determination is made at the discharge of the engineered PRD, while the consequence is determined when the material reaches atmosphere whether directly or via a downstream destructive device:
  - rainout
  - discharge to a potentially unsafe location
  - an on-site shelter-in-place or on-site evacuation, excluding precautionary on-site shelter-in-place or on-site evacuation
  - public protective measures (e.g., road closures) including precautionary public protective measures
- An upset emission from a permitted or regulated source, of a quantity greater than or equal to the threshold quantities in Part E in any one-hour period, that results in one or more of the following four consequences:
  - rainout
  - discharge to a potentially unsafe location
  - an on-site shelter-in-place or on-site evacuation, excluding precautionary on-site shelter-in-place or on-site evacuation
  - public protective measures (e.g., road closures) including precautionary public protective measures
- An unignited release of material greater than or equal to the threshold quantities described in Part E in any one-hour period, excluding engineered pressure-relief discharges and upset emissions from permitted or regulated sources.

Note 1: See the following sections for additional guidance on releases from a Pressure Relief Device (PRD), cold venting flare, shelter-in-place and public protective measures.

Note 2: Some non-toxic and non-flammable materials (e.g. steam, hot water or compressed air) have no threshold quantities and are only included in this definition as a result of their potential to result in one of the other consequences.

Note 3: An internal fire or explosion that causes an LOPC from a process triggers an evaluation of the consequences. The LOPC does not have to occur first.

Note 4: Engineered pressure-relief discharges and upset emissions from permitted or regulated sources are special-case LOPCs with their own criteria for classification as a Tier 1 PSE.

Note 5: In determining the Threshold Release Category, a company may choose to use either the properties of the released material based upon laboratory analysis at the time of the release, or the properties documented in the safety data sheet. Companies should be consistent in their approach for all LOPCs.

Note 6: Refer to API RP 754, Annex G (Application of Threshold Release Categories to Multicomponent Releases) for guidance on how to properly determine the threshold quantity for mixtures.

Note 7: Some companies, rather than performing a detailed estimate, use a simple rule-of-thumb to determine if the direct cost exceeded $2500: if the damage requires repair, then the direct cost is often at least $2500. This is not a requirement but may be considered as an approach to streamline PSE determination. It is always acceptable to perform a detailed analysis of the direct cost of a fire to confirm it is greater than $2500.

Tier 1 PSE Severity Weighting

API RP 754 presents an approach for severity weighting of Tier 1 PSEs, that in the 2021 3rd edition has become a reporting requirement.

It is recognized that severity weighting can provide additional insights about Tier 1 PSEs that may help drive performance improvement, even if there is no intended or implied value judgment that a Tier 1 PSE with a higher severity score is "worse" than another Tier 1 PSE with a lower severity score. Tier 1 PSE severity weighting is not part of the IOGP data collection process; however, companies can decide whether to individually apply API RP 754 Tier 1 PSE severity weighting, based on their own specific operational context and anticipated value from its adoption.

Consequence levels and material release thresholds

To determine whether an LOPC event is a Tier 1 or 2 PSE, it is necessary to collect and analyse data on the consequences of the release.

If the LOPC causes actual harm or damage – a fatality or injury, or a fire or explosion – then the level of consequence is relatively straightforward to determine. In the case of fatality or injury, the severity criteria are aligned with standard industry practice for reporting occupational safety performance in the oil and gas industry, including the annual data submission to IOGP. Most companies internally capture data on fire and explosion damage. It is important to capture these events because mitigation barriers have failed to prevent ignition of the LOPC. When an LOPC falls below the criteria for Tier 1 or 2, it is recommended that the event is reported for company internal monitoring using a Tier 3 KPI, see Part G for further guidance.

For guidelines determining the severity of a PSE, please see Part E.

When an LOPC event happens, but there is no harm to people or property, it is still important to examine the event in order to recognize that at least one barrier has failed. In these situations, there was a potential for serious consequences and the situation provides a learning opportunity. For this reason, an LOPC event is also reportable as a Tier 1 or 2 PSE, if the material is hazardous and the amount released is significant in terms of potential consequences.

To determine whether an LOPC is a PSE at either Tier 1 or 2, tables of release thresholds for different categories of material are included in API RP 754 and summarized in Part E.

Release from a Pressure Relief Device (PRD)

An engineered pressure relief device (e.g., pressure relief device (PRD), safety instrumented system (SIS) or manually initiated emergency depressurization) discharge (irrespective of downstream flaring or other destruction means) is a LOPC due to the unplanned nature of the release.

A release from a PRD is considered a PSE if the total amount of release exceeds a Tier 1 or 2 threshold (see Table E.3) and the release results in one of the following actual consequences:

- Rainout – in this case, the release quantity is the total release at the PRD, not the amount of liquid that was released as rainout

- discharge to a potentially unsafe location – per API RP 754, a discharge point that results in a potential hazard to personnel , whether present or not, due to the formation of flammable mixtures at ground level or on elevated work structures, presence of toxic or corrosive materials at ground level or on elevated work structures, or thermal radiation effects at ground level or on elevated work structures from ignition of relief streams at the point of emission as specified in API 521, Section 5.8.4.4. Excluded from the definition of an unsafe location are those ground level and elevated work structure locations that have a known potential for exposure of personnel to flammable mixtures, toxic substances, corrosive materials, or thermal radiation effects if access to those locations is controlled by virtue of authorized access or hard barriers with appropriate warning signs.
- onsite shelter-in-place or on-site evacuation, excluding precautionary on-site shelter-in-place or on-site evacuation.
- public protective measures (e.g., road closures) including precautionary public protective measures.

Note: The term "unsafe location" is used in the description of one of the four potential Tier 1 or Tier 2 consequences associated with an engineered pressure relief or an upset emission from a permitted or regulated source. The assumption is the discharge from the engineered pressure relief whether directly to atmosphere or via a downstream destructive device or the emission from a permitted or regulated source are engineered for safe dispersion of the release.

Release from a cold venting flare

A release to a lit flare will normally not be considered a Tier 1 or 2 PSE unless it results in rainout. An unlit or cold venting flare needs additional evaluation to determine if the release is a Tier 1 or 2 PSE.

- If a flare is designed to safely cold vent at the process conditions that occurred during the release, it should be evaluated in the same manner as a PRD, where it would not be a PSE unless one of the four additional consequences occurred.
- If the flare is not designed to safely cold vent at the process conditions that occurred or if the company does not have (at the time of the release) design information or studies confirming the flare can cold vent safely, the release of material greater than the threshold quantity would apply and no additional consequences would need to occur to qualify as a Tier 1 or 2 PSE.

Offshore mustering versus 'shelter-in-place'

Mustering on an offshore facility would only be considered 'shelter-in-place' if it was undertaken to separate people from a potentially hazardous atmosphere and if engineered protective features of the muster location were needed, in the event, to allow those mustering to shelter safely (see Part E for further guidance and Glossary).

Public protective measures

Community impact and the need for public protective measures applies to onshore facilities with public receptors that could potentially be exposed to impact from the release.

Concept of an acute release

Tier 1 and 2 PSEs relate to acute releases to differentiate a PSE from other LOPCs which occur over a prolonged period (such as fugitive emissions) and are unlikely to constitute a major incident risk.

An acute release of material is defined as an LOPC which exceeds the threshold for a Tier 1 or 2 PSE within any one-hour period during the release.

Acute releases include, but are not limited to, equipment and piping failures due to corrosion, overpressure, damage from mobile equipment, sabotage, etc.

Examples:

- valves being left open
- tanks being overfilled
- flare or relief systems not operating as intended
- process upsets or errors that result in process materials entering other process containment systems with no provisions or design considerations
- corrosion of a pipe or a gasket failure where the release over an hour exceeds thresholds.

Part E reports Tier 1 and Tier 2 threshold release quantities organized by Threshold Release Categories (TRCs).

For each material involved in a LOPC, a Company will determine the TRC and the corresponding threshold release quantity using Toxic Inhalation Hazard (TIH), DOT version of the United Nations Dangerous Goods (UNDG) hazard classifications language. When using this material hazard classification to determine the TRC, a company should first use the toxic, flammable, or corrosive characteristic of the material.

If the TRC cannot be determined from these characteristics, then and only then is the packing group descriptor used. When a single component has multiple hazards (e.g., toxic and flammable), the TRC category that gives the most severe tier rating should be used. API RP 754 Annex F (Listing of Chemicals Sorted by Threshold Quantity (based on UNDG Hazard Class or Grouping)) describes the process for assigning packing groups and TIH zones based upon flammability and toxicity information.

While these classifications differ from some of the other hazardous material classifications used by the petroleum industry in some countries, the UNDG lists represent a common international basis for use in this material hazard classification.

The UNDG lists are comprehensive in terms of pure chemicals. However, for hydrocarbon mixtures, such as crude oil or fuels, the UNDG classifies flammable liquids in terms of their physical properties. Whenever possible, when determining whether an LOPC is Tier 1 or 2, the hydrocarbons released should be classified based on boiling point and flash point. Only use the UNDG Packing Group if the hazard of the material is not expressed by those simple characteristics (e.g., reacts violently with water).

In determining the TRC, a Company may choose to use either the properties of the released material based upon laboratory analysis at the time of release, or the properties documented in the Safety Data Sheet (SDS).

To promote consistency and for convenience, the tables in Part E have been supplemented with examples of hazardous materials common in production and well operations for each of the API RP 754 material categories.

Refer to API RP 754 Annex G (Application of Threshold Release Categories to Multicomponent Releases) for guidance on how to properly determine the threshold quantity for mixtures. API RP 754, in the third edition, presents the Globally Harmonized System for Classification and Labelling of Chemicals (GHS) language as an option to the UNDG hazard classifications language. It is recognized that in some business context GHS may provide help in the hazardous material classification process, nonetheless in this IOGP document the GHS is not considered as an option to the UNDG language.

Normalizations

Both Tier 1 and 2 PSEs can be reported as normalized rates to aid comparability over time and between facilities or companies.

As there is no uniformly applicable normalization factor for process safety indicators based on facility configuration, IOGP has reached a consensus to use **worker exposure hours** (as used for personal injury rates), as a convenient, easily obtained factor for both KPIs.

This factor enables IOGP to calculate a **Tier 1 and 2 Process Safety Event Rate (PSER)** for annual upstream benchmarking and ultimately to benchmark across the entire petroleum industry with API and other associations.

The rates are calculated as:

$$\textbf{Tier 1 PSER} = \frac{\textbf{Total Tier 1 PSE Count}}{\textbf{Applicable Hours Worked}} \times 1{,}000{,}000$$

$$\textbf{Tier 2 PSER} = \frac{\textbf{Total Tier 2 PSE Count}}{\textbf{Applicable Hours Worked}} \times 1{,}000{,}000$$

Applicable hours worked includes employees and contractors for applicable company functions within the scope of reporting (refer to IOGP Safety Data Reporting User Guide for further details on scope and definitions). Companies may choose to use additional normalization factors such as mechanical units or production volumes.

Because the frequency of PSEs is likely to be low, care should be taken when assessing Tier 1 and 2 PSER because the rates are likely to be statistically valid for comparisons at an oil and gas industry or company level rather than at facility level, where trending analysis of these KPIs is more valuable.

Applicability to upstream operations

The Tier 1 and 2 PSEs are applicable to well and production operations because of the inherent potential for LOPC consequences (see Part E).

In this 3rd edition of the Report 456, the term well operations is used instead of drilling because, although the definition of drilling is wider, the use of this term may create confusion and potential missed reporting of non-drilling process safety events, such as during wireline interventions, etc.

The following list describes those activities that are considered well and production operations for the purpose of reporting.

Well operations include all activities related to well construction (e.g., exploration, appraisal and development drilling and completions), well testing, surveillance, interventions, and workovers (e.g. wireline, stimulation, coiled tubing), and abandonment (including downhole plugging and temporary abandonment).

Any LOPCs from a well that occur during well operation PSEs and meet Tier 1 and 2 thresholds are reportable to IOGP. Well operations PSEs may occur when connected to a well with a work unit (e.g., drilling rig, workover rig, rigless unit, etc.) including during riserless operations. It includes any LOPC from the well.

For well operations, Tier 1 and 2 PSEs are excluded for:

- equipment staging
- loss of circulation, loss of drilling mud, well kick, or underground blowout where there has not been an associated LOPC of material (e.g., gas, oil, other fluids, or mud) released above ground or above seabed or onto the rig floor

  It is good practice for companies to report such events using Tier 3 KPIs, Well Control Incident Levels 2 or 3, and – in particular – to identify, investigate, and learn from any such events that had high potential for a major incident. Generally, well operations PSE should also be assessed for its potential WCI classification - Refer to Part J for more information on Well Control Incidents.

Production operations, for this guidance, covers petroleum and natural gas production activities, including administrative and engineering aspects, repairs, maintenance and servicing, materials supply, and transportation of personnel and equipment. It covers all mainstream production operations, including:

- work on production and injection wells under pressure related to the well head and associated components (e.g., piping, valves, instrumentation, fittings)
- oil (including condensates) and gas extraction and separation (primary production)
- heavy oil production where it is inseparable from upstream (i.e., steam assisted gravity drainage, oil sands extraction) production
- primary oil processing (water separation, stabilisation)
- primary gas processing (dehydration, liquids separation, sweetening, CO_2 removal)
- Floating Storage Units (FSUs) and subsea storage units

- gas processing activities with the primary intent of producing gas liquids for sale:
  - secondary liquid separation (i.e., Natural Gas Liquids (NGL) extraction using refrigeration processing)
  - Liquefied Natural Gas (LNG) and Gas to Liquids (GTL) operations
- flowlines between wells and pipelines between facilities associated with field production operations
- oil and gas loading facilities, including land or marine vessels (trucks and ships) when connected to an oil or gas production process
- pipeline operations (including booster stations) operated by company oil and gas business.

Production excludes:

- well operations
- mining processes associated with oil sands extraction up to the point where the ore becomes a slurry
- tailings processes associated with oil sands extraction
- secondary heavy oil processing (upgrading)
- refineries (see API RP 754)

IOGP does not request Tier 1 and 2 PSEs to be reported for exploration (except during well operations, as noted above), construction, and other unspecified activities as listed in the IOGP *Safety data reporting user guide*.

At joint venture sites, the company should encourage the joint venture to consider applying Tier 1 and 2 PSE KPIs, as well as to adopt a process safety indicators framework and management system as described in this Report

All activities related to well and production operations are applicable to Tier 1 and 2 PSE reporting, including related facility start-up or shutdown operations, related brownfield construction activities, or decommissioning operations, and events resulting from sabotage, terrorism, extreme weather, earthquakes, or other indirect causes.

In addition to the above-mentioned exclusions, events associated with the following activities fall outside the scope and are **not** to be included in data collection or reporting efforts, per API RP 754:

a) marine transport operations, except when the vessel is connected or in the process of connecting or disconnecting to the process

The boundary between marine transport operations and connecting to or disconnecting from the process is the first/last step in loading/unloading procedure (e.g., first line ashore, last line removed, etc.).

b) truck or rail operations, except when the truck or rail car is connected or in the process of connecting or disconnecting to the process, or when the truck or rail car is being used for on site storage

Active staging is not part of connecting or disconnecting to the process. Active staging is not considered on-site storage. Active staging is considered part of transportation.

The boundary between truck or rail transport operations connecting to or disconnecting from the process is the first/last step in loading/unloading procedure (e.g., wheel chocks, set air brakes, disconnect master switch, etc.).

c) vacuum truck operations, except on site truck loading or discharging operations, or use of the vacuum truck transfer pump

d) routine emissions from permitted or regulated sources

Upset emissions from permitted or regulated sources are potentially Tier 1 or 2 PSEs (see section 1).

e) office, shop, warehouse, or camp/compound building activities (e.g., resulting in office fires, spills, personnel injury or illness, etc.)

f) activities leading to personal safety incidents (e.g., slips, trips, falls) that are not directly associated with on site response or exposure to a LOPC

g) activities resulting in a LOPC from ancillary equipment not connected to the process (e.g., small sample containers). The exclusion includes fuel/oil leaks involving trucks or other vehicles or other mobile equipment not considered part of the process

h) Quality Assurance (QA), Quality Control (QC) and Research and Development (R&D) laboratory activities (except pilot plant activities, which are within scope for PSE reporting)

i) new construction that is positively isolated (e.g., blinded or air gapped) from a process prior to commissioning and prior to the introduction of any process fluids, and that has never been part of a process

j) on site fuelling operations of mobile and stationary equipment (e.g., pick-up trucks, diesel generators, and heavy equipment).

References

[1] 'ANSI/API RP 754 - Process Safety Performance Indicators for the Refining and Petrochemical Industries. 3rd Edition'. American Petroleum Institute, August 2021, https://www.api.org/oil-and-natural-gas/health-and-safety/refinery-and-plant-safety/process-safety/process-safety-standards/rp-754 (Accessed 15 May 2023)

[2] 'API Std 521 - Pressure-Relieving and Depressuring Systems. 7th Edition'. *American Petroleum Institute*, 2020, API Std 521 | API Standards Store, https://www.api.org/products-and-services/standards/important-standards-announcements/standard521 (Accessed 15 May 2023).

[3] ECE/TRANS/300, Vol. I and II ("ADR 2021"). 'European Agreement Concerning the International Carriage of Dangerous Goods by Road'. United Nations Economic Commission for Europe (UNECE), 2020, ADR 2021 (files) | UNECE (Accessed 15 May 2023)

[4] United Nation's Globally Harmonized System of Classification and Labelling of Chemicals (GHS), 9th editon, New York and Geneva, 2021. https://unece.org/transport/standards/transport/dangerous-goods/ghs-rev9-2021 (Accessed 15 May 2023)

[5] IOGP - *Safety data reporting user guide – Scope and definitions*. Note: Published annually

Part D - IOGP data collection

Scope

Part D describes IOGP's annual benchmarking data collection.

About IOGP's annual benchmarking

The annual IOGP benchmarking collection of health and safety data includes Tier 1 and 2 PSEs, which are aligned with API RP 754.

IOGP recognizes the need for companies to adopt leading indicators and the use of Tier 3 and Tier 4 KPIs.

Numerical Tier 3 or 4 data is not currently requested by IOGP. These KPIs will typically be specific to a particular company's process safety controls and management system, and thus are less likely to be directly comparable to those of a different company.

Collection of process safety KPI data is integrated with IOGP's existing safety data collection process. Collection of offshore and onshore Tier 1 and 2 PSE data commenced in 2011 (for 2010 data). It is published annually.

Process safety data collection is based on the numbers of Tier 1 and 2 PSEs recorded by companies. Production and well operations activities are reported separately and are subdivided into offshore and onshore data.

Further details of the data collection process, including instructions, definitions and templates, are available in the annually published IOGP Safety data reporting user guide.

More help

Determining whether an event is reportable as a Tier 1 or 2 PSE can be complex and definitions are open to interpretation. IOGP has developed a list of example events with interpretation as Part F of this report.

References

[1] 'ANSI/API RP 754 - Process Safety Performance Indicators for the Refining and Petrochemical Industries. 3rd Edition'. American Petroleum Institute, August 2021, https://www.api.org/oil-and-natural-gas/health-and-safety/refinery-and-plant-safety/process-safety/process-safety-standards/rp-754 (Accessed 15 May 2023)

[2] IOGP - *Safety data reporting user guide – Scope and definitions*. Note: Published annually

Part E - Determining Tier 1 and 2 Process Safety Events

Scope

Part E provides a method to determine whether a Loss of Primary Containment (LOPC), Pressure Relief Device (PRD) activation or upset emission from a permitted or regulated source is a Tier 1 or Tier 2 Process Safety Event.

Instructions

Use the flow chart (Figure 1) to determine if a Loss of Primary Containment (LOPC), Pressure Relief Device (PRD) activation, or upset emission from a permitted or regulated source is a Tier 1 or Tier 2 Process Safety Event.

Use the six tables that summarize the hierarchy of LOPC, PRD discharge and upset emission consequences and thresholds:

Table E.1:

LOPC events involving consequences related to harm to personnel or property.

Tables E.2 and E.3:

LOPC, PRD discharge, or upset emission events, which exceeded material release thresholds, but did not result in harm to people or damage to property.

Tables E.4, E.5 and E.6:

LOPC Tier 1 and 2 PSE thresholds for example materials commonly found in upstream operations.

If an event results in multiple exceeded thresholds, record the PSE at the highest tier applicable to any one of the exceeded thresholds.

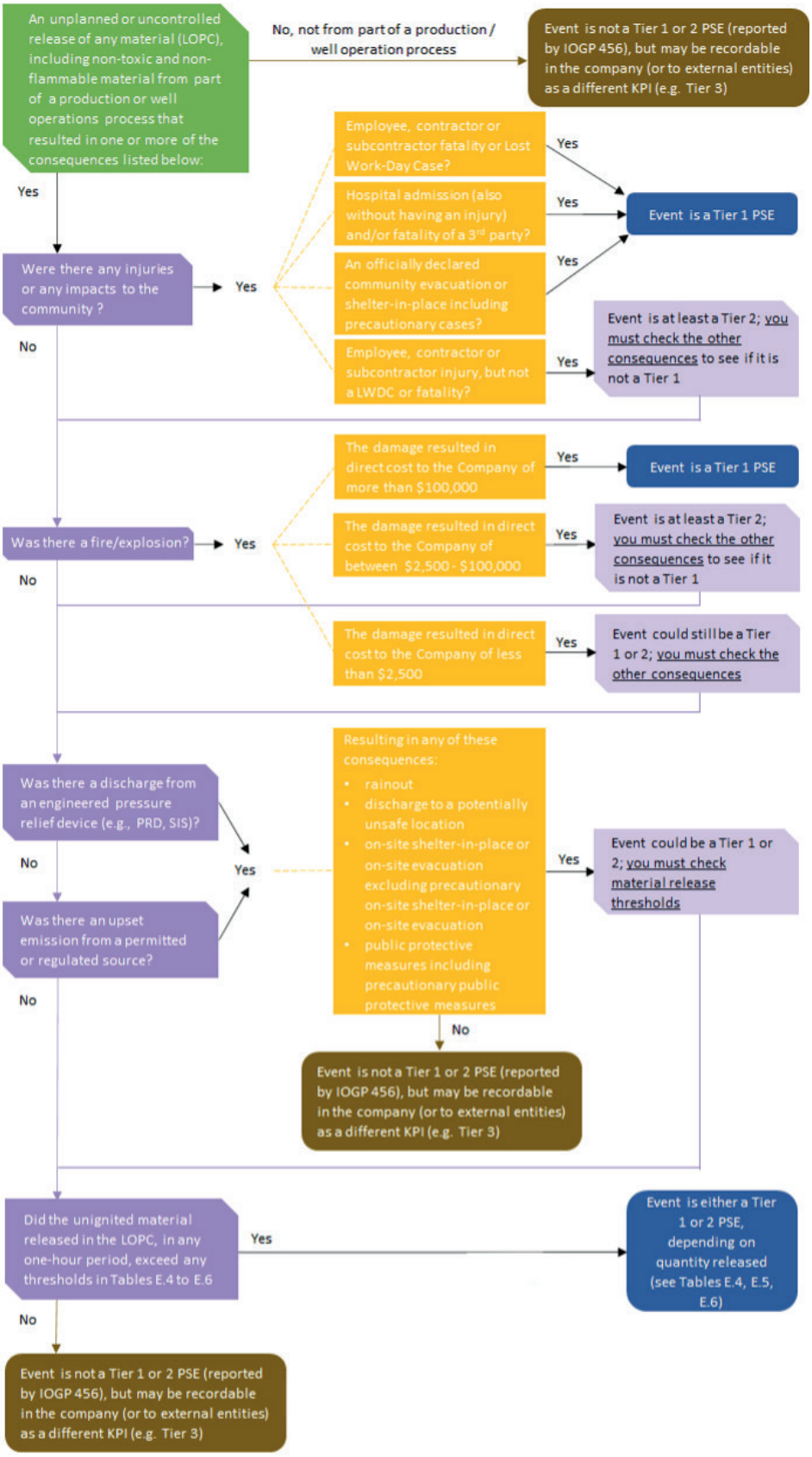


Figure E.1: Determining a Tier 1 & 2 Process Safety Event (PSE)

Table E.1: Thresholds for LOPC resulting in actual harm or damage

A LOPC, including PRD discharge and upset emission from a permitted or regulated source, is a Tier 1 or 2 PSE when it results in one or more of the consequences, irrespective of the amount of material released.

Consequence	PSE Level	
	Tier 1	Tier 2
Injury to employee or contractor	Fatality and/or Lost Workday Case ('days away from work' or 'lost time injury')	Recordable occupational injury (restricted work case or medical treatment case)
Injury to third party	Fatality, or injury/illness that results in a hospital admission	None
Impact to the community [a]	Officially declared community evacuation or community shelter-in-place including precautionary community evacuation or community shelter-in-place	None
Fire or explosion [b]	Fire or Explosion resulting in greater than or equal to $100,000 of direct cost to the Company	Fire or Explosion resulting in greater than or equal to $2,500 of direct cost to the Company

a Community evacuation/shelter-in-place would apply only to onshore facilities with public receptors that could potentially be exposed to impact from the release.

b For a fire or explosion, the classification should be done on the fire or explosion direct cost not the release rate. Fire or Explosion takes precedence over release rate in this case.

Table E.2: Thresholds for LOPC material releases

A LOPC is a Tier 1 or 2 PSE, even when no serious harm or damage results, if the amount of material released exceeds specified thresholds.

	PSE level	
	Tier 1	Tier 2
A LOPC release of a gas or liquid exceeds the material release threshold quantities in any one-hour period	See Tables E.4, 5 or 6 for Tier 1 threshold quantities	See Tables E.4, 5 or 6 for Tier 2 threshold quantities

These thresholds for the amount of material released are based on Tier 1 and 2 categories from API RP 754, which are in turn based on the international UN Recommendations on the Transportation of Dangerous Goods (UNDG).

Table E.3: Thresholds for PRD discharges and upset emissions

An engineered pressure relief (pressure relief device (PRD), safety instrumented system (SIS) or manually initiated emergency depressurization) device discharge event, or an upset emission from a permitted or regulated source, is a Tier 1 or 2 PSE if it results in serious harm or damage per Table E.1, or it exceeds the material release threshold quantities per Tables E.4, 5 or 6 and results in any of the listed criteria in Table E.3.

	PSE level	
	Tier 1	**Tier 2**
An engineered pressure relief (PRD, SIS or manually initiated emergency depressurization) device or an upset emission from a permitted or regulated source discharge, either directly to atmosphere or to a destructive device (e.g., flare, scrubber)	Event is a Tier 1 PSE if it resulted in the consequences listed in Table E.1, regardless of the quantity released, or Event results in a: 1. rainout, or 2. discharge to a potentially hazardous location, or 3. on-site shelter-in-place[a] or on-site evacuation, excluding precautionary on-site shelter-in-place or on-site evacuation, or 4. public protective measures including precautionary public protective measures **and** the quantity discharged equals or exceeds any Tier 1 threshold in Tables E.4, 5 or 6	Event is a Tier 2 PSE if it resulted in the consequences listed in Table E.1, regardless of the quantity released, or Event results in a: 1. rainout, or 2. discharge to a potentially hazardous location, or 3. on-site shelter-in-place[a] or on-site evacuation, excluding precautionary on-site shelter-in-place or on-site evacuation, or 4. public protective measures including precautionary public protective measures **and** quantity discharged equals or exceeds any Tier 2 threshold in Tables E.4, 5 or 6

These thresholds for the amount of material released are based on Tier 1 and 2 categories from API RP 754, which are in turn based on international UNDG Packing Groups.

a Mustering offshore would be considered 'shelter-in-place' only if it was undertaken to separate people from a potentially hazardous atmosphere and if engineered protective features of the muster location were needed, in the event, to allow those mustering to shelter safely.

Table E.4: Non-toxic material release threshold quantities for LOPC

A LOPC is a Tier 1 or 2 PSE only when release is 'acute', i.e., exceeds a threshold quantity in any one-hour period. PSE Tier is highest of all that apply. Categories (e.g. TRC 5) refer to API RP 754 Threshold Release Categories (TRC).

Material hazard classification (with example materials)	**Tier 1**		**Tier 2**	
	Outdoor release	**Indoor release**	**Outdoor release**	**Indoor release**
Flammable Gases, e.g. • hydrogen • methane, ethane, propane, butane • natural gas • ethyl mercaptan	≥500 kg (1,100 lbs) (TRC 5)	≥50 kg (110 lbs) (TRC 5)	≥50 kg (110 lbs) (TRC 5)	≥25 kg (55 lbs) (TRC 5)
Flammable Liquids with Boiling Point ≤35 °C (95 °F) and Flash Point <23 °C (73 °F) – e.g. • liquefied petroleum gas (LPG) • liquefied natural gas (LNG) • isopentane	≥500 kg (1,100 lbs) (TRC 5)	≥50 kg (110 lbs) (TRC 5)	≥50 kg (110 lbs) (TRC 5)	≥25 kg (55 lbs) (TRC 5)
Flammable Liquids with Boiling Point >35 °C (95 °F) and Flash Point <23 °C (73 °F), e.g. • gasoline/petrol, toluene, xylene • condensate • methanol • >15 API Gravity crude oils (unless actual flashpoint available)	≥1,000 kg (2,200 lbs) or ≥7 bbl (TRC 6)	≥100 kg (220 lbs) or ≥0.7 bbl (TRC 6)	≥100 kg (220 lbs) or ≥0.7 bbl (TRC 6)	≥50 kg (110 lbs) or ≥0.35 bbl (TRC 6)
Combustible Liquids with Flash Point ≥23 °C (73 °F) and ≤60 °C (140 °F), e.g. • diesel, most kerosenes • <15 API Gravity crude oils (unless actual flashpoint available)	≥2,000 kg (4,400 lbs) or ≥14 bbl (TRC 7)	≥200 kg (440 lbs) or ≥1.4 bbl (TRC 7)	≥200 kg (440 lbs) or ≥1.4 bbl (TRC 7)	≥100 kg (220 lbs) or ≥0.7 bbl (TRC 7)
Liquids with Flash Point >60 °C (140 °F) released at a temperature at or above its flash point, e.g. • asphalts, molten sulphur • ethylene glycol, propylene glycol • lubricating oil • drilling mud	≥2,000 kg (4,400 lbs) or ≥14 bbl (TRC 7)	≥200 kg (440 lbs) or ≥1.4 bbl (TRC 7)	≥200 kg (440 lbs) or ≥1.4 bbl (TRC 7)	≥100 kg (220 lbs) or ≥0.7 bbl (TRC 7)
Liquids with Flash Point >60 °C (140 °F) and ≤ 93°C (200°F) released at a temperature below its flash point, e.g. • some drilling muds • some marine diesel	Not applicable	Not applicable	≥1,000 kg (2,200 lbs) or ≥7 bbl (TRC 8)	≥500 kg (1,100 lbs) or ≥3.5 bbl (TRC 8)

Note 1: Companies may need to provide more detailed guidance on hydrocarbon mixtures or other gases or liquids specific to their operations. Refer to API RP 754, Annex G (Application of Threshold Release Categories to Multicomponent Releases) for guidance on how to properly determine the threshold quantity for mixtures.

Note 2: It is recognized that threshold quantities given in kg or lbs and bbl are not exactly equivalent. Companies should select one of the pair and use it consistently for all recordkeeping activities.

Table E.5: Toxic material release threshold quantities for LOPC

A LOPC is a Tier 1 or 2 PSE only when release is 'acute', i.e., exceeds a threshold quantity in any one-hour period. PSE Tier is highest of all that apply. Categories (e.g. TRC 1) refer to API RP 754 Threshold Release Categories (TRC).

Material hazard classification (with example materials)	**Tier 1**		**Tier 2**	
	Outdoor release	**Indoor release**	**Outdoor release**	**Indoor release**
Toxic Inhalation Hazard (TIH) Hazard Zone A materials – includes: • acrolein (stabilized) • bromine	⩾5 kg (11 lbs) (TRC 1)	⩾0.5 kg (1.1 lbs) (TRC 1)	⩾0.5 kg (1.1 lbs) (TRC 1)	⩾0.25 kg (0.55 lbs) (TRC 1)
Toxic Inhalation Hazard (TIH) Hazard Zone B materials – includes: • hydrogen sulphide (H_2S) • chlorine (Cl_2)	⩾25 kg (55 lbs) (TRC 2)	⩾2.5 kg (5.5 lbs) (TRC 2)	⩾2.5 kg (5.5 lbs) (TRC 2)	⩾1.25 kg (2.75 lbs) (TRC 2)
Toxic Inhalation Hazard (TIH) Hazard Zone C materials – includes: • sulphur dioxide (SO_2) • hydrogen chloride (HCl)	⩾100 kg (220 lbs) (TRC 3)	⩾10 kg (22 lbs) (TRC 3)	⩾10 kg (22 lbs) (TRC 3)	⩾5 kg (11 lbs) (TRC 3)
Toxic Inhalation Hazard (TIH) Hazard Zone D materials – includes: • ammonia (NH_3) • carbon monoxide (CO)	⩾200 kg (440 lbs) (TRC 4)	⩾20 kg (44 lbs) (TRC 4)	⩾20 kg (44 lbs) (TRC 4)	⩾10 kg (22 lbs) (TRC 4)
Other Packing Group I Materials (excluding acids/bases) – includes: • aluminum alkyls • some liquid amines • sodium cyanide • sodium peroxide • hydrofluoric acid (>60% solution)	⩾500 kg (1,100 lbs) (TRC 5)	⩾50 kg (110 lbs) (TRC 5)	⩾50 kg (110 lbs) (TRC 5)	⩾25 kg (55 lbs) (TRC 5)
Other Packing Group II Materials (excluding acids/bases) – includes: • aluminum chloride • phenol • calcium carbide • carbon tetrachloride • some organic peroxides • hydrofluoric acid (<60% solution)	⩾1,000 kg (2,200 lbs) or ⩾7 bbl (TRC 6)	⩾100 kg (220 lbs) or ⩾0.7 bbl (TRC 6)	⩾100 kg (220 lbs) or ⩾0.7 bbl (TRC 6)	⩾50 kg (110 lbs) or ⩾0.35 bbl (TRC 6)

Note 1: Companies may need to provide more detailed guidance on hydrocarbon mixtures or other gases or liquids specific to their operations. Refer to API RP 754, Annex G (Application of Threshold Release Categories to Multicomponent Releases) for guidance on how to properly determine the threshold quantity for mixtures.

Note 2: It is recognized that threshold quantities given in kg or lbs and bbl are not exactly equivalent. Companies should select one of the pair and use it consistently for all recordkeeping activities.

Table E.6: Other material release threshold quantities for LOPC

A LOPC is a Tier 1 or 2 PSE only when release is 'acute', i.e., exceeds a threshold quantity in any one-hour period. PSE Tier is highest of all that apply. Categories (e.g. TRC 7) refer to API RP 754 Threshold Release Categories (TRC).

Material hazard classification (with example materials)	**Tier 1**		**Tier 2**	
	Outdoor release	**Indoor release**	**Outdoor release**	**Indoor release**
Other Packing Group III materials – includes: • lean amine • calcium oxide • activated carbon • chloroform • some organic peroxides • sodium fluoride • sodium nitrate	⩾2,000 kg (4,400 lbs) or ⩾14 bbl (TRC 7)	⩾200 kg (440 lbs) or ⩾1.4 bbl (TRC 7)	⩾200 kg (440 lbs) or ⩾1.4 bbl (TRC 7)	⩾100 kg (220 lbs) or ⩾0.7 bbl (TRC 7)
UNDG Class 2.2 non-flammable, non-toxic gas excluding air (CO_2, O_2)	⩾2,000 kg (4,400 lbs) or ⩾14 bbl (TRC 7)	⩾200 kg (440 lbs) or ⩾1.4 bbl (TRC 7)	⩾200 kg (440 lbs) or ⩾1.4 bbl (TRC 7)	⩾100 kg (220 lbs) or ⩾0.7 bbl (TRC 7)
Strong Acids or Bases [a] – includes: • sulphuric acid, hydrochloric acid • sodium hydroxide (caustic) • calcium hydroxide (lime)	Not applicable	Not applicable	⩾1,000 kg (2,200 lbs) or ⩾7 bbl (TRC 8)	⩾500 kg (1,100 lbs) or ⩾3.5 bbl (TRC 8)

Note 1: Companies may need to provide more detailed guidance on hydrocarbon mixtures or other gases or liquids specific to their operations. Refer to API RP 754, Annex G (Application of Threshold Release Categories to Multicomponent Releases) for guidance on how to properly determine the threshold quantity for mixtures

Note 2: It is recognized that threshold quantities given in kg or lbs and bbl are not exactly equivalent. Companies should select one of the pair and use it consistently for all recordkeeping activities.

Note 3: Packing Group III materials that do not pose a process safety hazard cannot be a Tier 1 or Tier 2 PSE (e.g., Hazard Class 9 materials) based on the quantity of material released and are only included in this definition as a result of their potential to result in one of the other consequences.

a LOPC of strong acids or bases cannot be a Tier 1 PSE based upon quantity released, no matter the volume

References

[1] 'ANSI/API RP 754 - Process Safety Performance Indicators for the Refining and Petrochemical Industries. 3rd Edition'. American Petroleum Institute, August 2021, https://www.api.org/oil-and-natural-gas/health-and-safety/refinery-and-plant-safety/process-safety/process-safety-standards/rp-754 (Accessed 15 May 2023)

[2] "United Nation's Globally Harmonized System of Classification and Labelling of Chemicals (GHS), 9th editon, New York and Geneva, 2021. https://unece.org/transport/standards/transport/dangerous-goods/ghs-rev9-2021 (Accessed 15 May 2023)

[3] 'Process Safety Metrics Guide for Leading and Lagging Indicators. 4.1 version'. AIChE CCPS, June 2022, CCPS Process Safety Metrics - V4.1 2022.2 (aiche.org) (Accessed 15 May 2023)

Part F - Examples of process safety event tier classification

Scope

Part F contains 112 examples of upstream events and their classification as PSEs (or otherwise) using the guidance of this Report.

They are adapted for upstream operations from API RP 754 and from reporting from IOGP member companies.

Injury or fatality

	Example	Reporting
1	An operator walks through a process unit and slips and falls to the ground and suffers in an occupational injury, which is a lost work day case (LWDC). The slip/fall is due to weather conditions, 'chronic' oily floors, and slippery shoes. This is not a Tier 1 or Tier 2 PSE. Personal safety 'slip/trip/fall' incidents that are not directly associated with evacuating from or responding to a LOPC are specifically excluded.	LWDC but not a PSE (Part D)
	Same as above, except that the operator slips and falls while responding to a small spill of liquid with a flash point <23 °C (73 °F) quantity less than 7 barrels in 1 hour, resulting in a recordable LWDC incident. This would also be recorded as a Tier 1 PSE since the operator is responding to an LOPC, even though the LOPC is below the Tier 1 threshold quantity in Table E.4.	Tier 1 PSE and a LWDC
	Same as above, except that the operator slips and falls several hours after the incident has concluded. This is a recordable LWDC incident but would not be a reported as a PSE. Occupational safety events that are not directly associated with onsite response to a LOPC are excluded. A slip or fall after the LOPC has concluded (such as 'after-the-fact' clean-up and remediation) is not directly associated with onsite response.	LWDC but not a PSE (Part D)
2	A scaffolding contractor is injured after falling from a scaffold ladder while evacuating from a LOPC on nearby equipment. The contractor is absent from work for 5 days and the injury is recorded as a recordable LWDC incident and the LOPC is then classified as a Tier 1 PSE, whether or not the release exceeded the Table E.1 Threshold quantities.	Tier 1 PSE and a LWDC
3	An operator walks past a steam trap that discharges to an unsafe location. The steam trap releases and the operator's ankle is burned by the steam, resulting in an occupational injury which needed medical treatment and his work is restricted for 3 days. This incident is a Tier 2 PSE, because even though the LOPC event was steam (vs. hydrocarbon or chemical), the physical state of the material was such that the unintended release caused a recordable injury. Non-toxic and non-flammable materials are within the PSE scope when a recordable injury results from LOPC.	Tier 2 PSE and recordable injury (restricted work day case)
	If this incident had not resulted in an occupational injury it would not be a PSE because the physical state of the material does not mandate a Tier 1 or Tier 2 classification without the associated recordable injury.	Not a Tier 1 or Tier 2 PSE
4	A separator chamber or other vessel has been intentionally purged with nitrogen. A contractor bypasses safety controls, enters the enclosure and dies. This is not a PSE because there is no unplanned or uncontrolled LOPCs, but it would be a recordable occupational injury and classified as a contractor employee fatality.	Fatality but not a Tier 1 or Tier 2 PSE
	If nitrogen had inadvertently leaked into the enclosure, this would be a Tier 1 PSE because there was a fatality associated with an unplanned or uncontrolled LOPC.	Tier 1 PSE and a fatality

	Example	Reporting
5	A maintenance technician is turning a bolt on a flange on a gas pipe with a wrench. Due to improper body positioning, the wrench slips and hits the employee in the mouth, requiring dental surgery. This incident is a recordable occupational injury (medical treatment case) but not a PSE, because there is no unplanned or uncontrolled LOPC involved with the injury.	Recordable injury but not a Tier 1 or Tier 2 PSE
6	A maintenance contractor opens a process valve and gets sprayed with less than the Tier 2 Threshold Quantity of sulfuric acid resulting in severe burn and days away from work injury. This is a Tier 1 PSE because it is an unplanned or uncontrolled LOPC that results in a lost work day case (LWDC). If this incident had resulted in a recordable injury which was not a LWDC or fatality (i.e., a restricted work day case or a medical treatment case), it would be a Tier 2 PSE.	Tier 1 PSE (Table E.1) and a LWDC Tier 2 PSE (Table E.1) and a recordable injury
7	During the draining of a produced water line, the drain valve failed to open, resulting in a significant release. While responding to the event the operator fell down a flight of stairs injuring his ankle. The injury resulted in 8 days away from work. This is a Tier 1 PSE because an unplanned or uncontrolled LOPC resulted in a lost work day case (LWDC).	Tier 1 PSE (Table E.1) and a LWDC

Fire or Explosion

	Example	Reporting
8	Over-pressurisation in a process vessel causes equipment damage greater than $100,000, but there was no loss of primary containment. While this is a serious process event and should be investigated as such, it does not meet the definition of a Tier 1 or 2 PSE because there was no LOPC involved. It is good practice to report, classify, and investigate other types of asset integrity or process events with actual or potentially serious consequences using the internal reporting mechanisms of the company and its facilities. This would include locally defined possible Tier 3 PSE KPIs.	Not a Tier 1 or Tier 2 PSE (Possible Tier 3 KPI)
9	A scaffold board is placed near a high-pressure steam pipe and subsequently begins to burn, but is quickly extinguished with no further damage. The investigation finds that the board had been contaminated by oil, but there is no indication of an oil leak in the area. This is not a PSE since there was no unplanned or uncontrolled LOPC, but may be a reportable incident under other company or facility KPIs.	Not a Tier 1 or Tier 2 PSE
10	An electrical fire impacts the operation of the process resulting in an acute release outdoors of 3,300 lbs. (1500 kg or about 10 bbl) of light crude oil (API Gravity ca. 40, flash point <23 °C). The released crude oil is not ignited. This is a Tier 1 PSE since the released crude oil did not ignite and the LOPC exceeds the reporting threshold quantity of 2,200 lbs. (1000 kg, 7bbl) for a flammable liquid. *NOTE: If the crude oil had ignited, the amount of the release would no longer be relevant and only the direct damage cost of the crude oil fire would have been used to determine the Tier level.*	Tier 1 PSE (Tables E.2 & E.4)
11	An electrical fire results in a sudden loss of power that causes an emergency shutdown and incidental equipment damage greater than $100,000 to the oily water separator due to inadequate shutdown. Since the event did not result in LOPC of a material, it is not a PSE, but is likely to be reportable based on other KPIs of the company or facility.	Not a Tier 1 or Tier 2 PSE
12	A pump lube oil system fire from a leak causes damage greater than $75,000 and the soil remediation and other cleanup costs are $50,000, but does not cause a fatality or serious injury. This is a Tier 1 PSE since the direct costs to the company because of the fire was greater than $100,000. *Note: If the material released ignites, the fire/explosion direct cost damage represents the LOPC's full potential for harm; therefore, only the direct cost from the fire/explosion is used to determine the Tier classification of the event.*	Tier 1 PSE (Table E.1)
13	A forklift truck moving materials inside a process unit knocks off a bleeder valve leading to the release of condensate and a subsequent vapour cloud explosion with asset damage and clean-up costs greater than $100,000. This is a Tier 1 PSE since an unplanned or uncontrolled LOPC resulted in a fire or explosion causing greater than $100,000 direct costs to the company.	Tier 1 PSE (Table E.1)
14	There is a boiler fire at the main office complex, and direct cost damages totaled $150,000. The incident is not a PSE since office, shop, warehouse, and camp/compound building events are specifically excluded, but is likely to be reportable based on other KPIs of the company or facility.	Not a Tier 1 or Tier 2 PSE

	Example	Reporting
15	Hydrocarbon fumes migrate into the QA/QC laboratory located within the facility and results in a fire with $5,000 damage. The source of the hydrocarbon fumes is the oily water sewer system. This event is a Tier 2 PSE since the LOPC was from the process and resulted in a Tier 2 consequence (a fire which results in a direct cost greater than $2,500).	Tier 2 PSE (Table E.1)
16	A pump seal fails and the resultant loss of containment catches on fire. The fire is put out quickly with no personnel injuries. However, the fire resulted in the need to repair some damaged instrumentation and replace some insulation. The cost of inspection to determine the extent of the damage and the necessary repairs totaled $8,500. The cost of the repairs, replacement, and cleanup totaled $20,000. Is this a Tier 1 or Tier 2 PSE? This is a Tier 2 PSE since the direct costs from the fire damage exceeded the Tier 2 threshold of $2,500 but was less than the Tier 1 threshold of $100,000. It should be noted the cost of replacing the seal is not included in the direct cost calculation—only the costs for repair and replacement of the equipment damaged by the fire, not the cost to repair the equipment failure that led to the fire. Also excluded from the direct cost calculation is the cost for engineering or inspection assessments to determine the extent of damage or necessary repairs.	Tier 2 PSE (Table E.1)
17	There is a loss of burner flame in a fired heater, resulting in a fuel rich environment and subsequent explosion with greater than $100,000 in damages to the interior of the heater. There was no release outside of the fire box. After the flameout the continuing flow of fuel gas results in an uncontrolled release; however, because the explosion resulted in direct cost greater than $100,000, the amount of the release need not be considered. The intent is for combustion of the fuel gas at the burner and not for fuel gas to be contained in the fire box. This is an LOPC and due to the amount of direct cost would be a Tier 1 PSE.	Tier 1 PSE (Table E.1)
	If this same incident had resulted in less than $100,000 but over $2,500 in damages, it would be a Tier 2 PSE.	Tier 2 PSE (Table E.1)
18	A tube rupture in a fired heater causes a fire (contained in the heater) resulting in greater than $100,000 in damages to the heater interior. The tube failure is a loss of primary containment of the process fluid and combined with the direct costs greater than $100,000, makes this a Tier 1 PSE.	Tier 1 PSE (Table E.1)
	Same as above, except the operator detects the tube cracking with only a small flame from the tube and subsequently shuts down the heater with no resultant damage from the tube flame. If the estimated amount of material released is below the threshold quantities in Table E.4, E.5, or E.6, this would not be a Tier 1 or 2 PSE. However, this event could be reported within the Tier 3 PSE KPI of the company or facility.	Possible Tier 3 PSE KPI
19	A steam injection well fails with an explosion resulting in release of 10 tonnes of fluids (a mixture of hydrocarbons and water). The direct cost of replacing and repairing damaged equipment was estimated at $300,000 and a worker was injured, needing medical treatment. The failure is a Tier 1 Process Safety Event, because it is an LOPC that resulted in an explosion causing over $100,000 of damages.	Tier 1 PSE (Table E.1) and a recordable injury (well operations were not being conducted at the time of explosion; this is not a WCI)
	As above, but without the explosion. The recordable injury resulting from the LOPC would require at least a Tier 2 PSE be reported.	Tier 1 PSE (Tables E.2 & E.4) or Tier 2 PSE (Table E.1) and a recordable injury
	Note: If the amount of hydrocarbon released met or exceeded any Tier 1 threshold in Table E.4, then a Tier 1 PSE will still be reported. The estimate of material released should exclude the amount of water as there is no threshold quantity for water.	
20	A line catastrophically fails due to vibration induced fatigue. The release ignites resulting in a jet fire. The jet fire impinges on a crane parked nearby destroying the crane but does not cause any significant damage to process equipment. The cost to replace the crane is $350,000. This is a Tier 1 PSE since the direct cost fire damage from the LOPC exceeded the Tier 1 PSE threshold of $100,000. By definition, direct cost fire/explosion damage includes the cost to repair or replace process and non-process equipment and tangible public or private property.	Tier 1 PSE (Table E.1)

	Example	Reporting
21	A corrosion related leak results in a large fire that damaged piping and an out-of-service vessel (abandoned in place). The company spends $15,000 in engineering and inspection costs to determine the extent of the fire damage, $95,000 to replace the damaged pipework with an upgraded metallurgy resistant to the corrosion damage mechanism, and $50,000 to make the out-of-service vessel safe to remain in place. To replace the pipework with in-kind metallurgy would have cost $45,000. To restore the functionality of the out-of-service (abandoned in place) vessel would have cost $125,000. This is a Tier 2 PSE. The definition of direct cost excludes the cost of engineering or inspection assessments to determine the extent of damage or necessary repairs, and it also excludes the cost of opportunity upgrades to materials or technology. The definition of direct cost does include the cost to restore equipment to pre-event condition whether or not the repairs are made. In this example the out-of-service vessel has been abandoned in place (i.e. no expectation of future functionality); therefore, only the post fire cost to make the equipment safe is included in the direct cost calculation. This is a Tier 2 PSE based upon $50,000 to make the vessel safe and $45,000 for the in-kind metallurgy piping replacement for a total direct cost of $95,000.	Tier 2 PSE (Table E.1)
22	A portable diesel-driven pump was being used to transfer material from one tank to another. The hot exhaust of the diesel engine ignited a fire in the soundproofing exhaust housing and burned through a radiator hose releasing engine coolant. The fire damage to the pump exceeded $2500.	Not a Tier 1 or Tier 2 PSE
	This is not a Tier 2 PSE. While the temporary portable pump and its diesel-driven engine is part of the process while it is connected to the process, the fire was caused by the hot exhaust and not a LOPC, therefore, the fire damage is excluded from the Tier 2 determination. Additionally, the fire induced LOPC of engine coolant did not result in any of the Tier 2 consequences. A company may choose to record this event as a Tier 3 PSE KPI fire.	Possible Tier 3 PSE KPI
23	A crude oil liquid carryover to the flare resulted in a fire at the base of the flare and the unignited crude oil contaminated the soil surrounding the flare. The liquid carryover quantity released in any one hour was minimal and below Tier 1 and Tier 2 thresholds and the fire did not result in any equipment damage that required repair. However, the cost to remediate the contaminated soil was $3,800.	Tier 2 PSE (Table E.1)
	This is a Tier 2 PSE since the direct cost to the company associated with the flare carryover fire was >$2,500 because the soil remediation clean-up cost is included in the fire direct cost calculation.	

Loss of primary containment

	Example	Reporting
24	Ten barrels of flammable condensate (1,400 kg, 3,100 lbs) leak from piping onto concrete and the hydrocarbons do not reach soil or water. Site personnel estimate that the leak occurred within one hour. This is a Tier 1 PSE because there was a LOPC of 7 bbl (1,000 kg, 2,200 lbs.) or more of flammable liquid with a flash point <23 °C (73 °F) in any one-hour period.	Tier 1 PSE (Tables E.2 & E.4)
	If the spill had been less than 1,000kg/2,200 lbs., but equal to or greater than 220 lbs (0.7 bbl), it would be a Tier 2 PSE.	Tier 2 PSE (Tables E.2 & E.4)
25	A faulty tank gauge results in the overfilling of a product tank containing liquid with a normal boiling point > 35 °C (95 °F) and a flash point < 23 °C (73 °F). Approximately 50 barrels (7,000 kg/15,500 lbs.) of liquid overflows into the tank's diked area within minutes. This event is a Tier 1 PSE since it is a release of 2,200 lbs. (1000 kg/7 bbl) or more within any one-hour period, regardless of secondary containment.	Tier 1 PSE (Tables E.2 & E.4)
	If the spill had been less than 2,200 lbs. (1000 kg/7 bbl), but equal to or greater than 220 lbs. (100 kg/0.7 bbl), it would be a Tier 2 PSE.	Tier 2 PSE (Tables E.2 & E.4)
26	A process vessel low level cutout fails to close a valve, releasing 1200 lbs. of flammable gas, causing minor damage to a tank and a gas release to the atmosphere. This was an LOPC from the vessel and because the amount exceeds the 1100 lbs. threshold quantity for flammable gas, this is a Tier 1 PSE.	Tier 1 PSE (Tables E.2 & E.4)
27	An operator opens a quality control sample point to collect a routine sample of crude oil and material splashes on him. The operator runs to a safety shower leaving the sample point open and a Tier 2 threshold quantity is released. This is a Tier 2 PSE since the release of a threshold quantity was unplanned or uncontrolled.	Tier 2 PSE (Tables E.2 & E.4)
	Same as above, however, the operator catches the sample, blocks in the sample point, and later drops and breaks the sample container resulting in exposure and injury from the sample contents. This is not a PSE because the LOPC is from a piece of ancillary equipment not connected to a process.	Not a Tier 1 or Tier 2 PSE

	Example	Reporting
28	A bleeder valve is left open after a plant turnaround. On startup, an estimated 15 bbl of lubricating oil with a flashpoint of 195 °C (383 °F), is released at 38 °C (100 °F) onto the ground within an hour and into the plant's drainage system before the bleeder is found and closed. This is not a Tier 1 or Tier 2 because the flash point is higher than 93 °C and it is released at a temperature below its flash point. It can be reported as Tier 3 PSE KPI.	Possible Tier 3 PSE KPI (Tables E.2 & E.4)
	Same as above, except that the release temperature is above the flashpoint; thus, it would be a Tier 1 PSE.	Tier 1 PSE (Tables E.2 & E.4)
29	An operator is draining water off a crude oil tank with a flash point of 60 °C (140 °F) or less (or an API Gravity of <15) into a drainage system designed for that purpose. The operator leaves the site and forgets to close the valve. Twenty barrels of crude oil are released into the drainage system within an hour. This would be a Tier 1 PSE because the release of crude oil is unplanned or uncontrolled and it is greater than the release criteria of 14 barrels.	Tier 1 PSE (Tables E.2 & E.4)
	If the drainage system is a closed system and goes to an API separator and the oil is recovered (secondary containment), this would not be a Tier 1 event because the crude oil did not leave primary containment. If the closed drainage system is breached, ineffective, or overwhelmed, then the amount of oil lost from the closed system would be evaluated for a possible Tier 1 or Tier 2 event.	
	In the example above, if a crude oil with a flash point above 60 °C (140 °F) and less than 93 °C (200 °F) is released at a temperature below the flash point, it would be a Tier 2 PSE.	Tier 2 PSE (Tables E.2 & E.4)
30	An operator purposely drains 20 bbl of material with a flash point >60 °C (140 °F) ⩽ 93°C (200 °F) at a temperature below its flash point into an open oily water collection system within one hour as part of a vessel cleaning operation. Since the drainage is planned and controlled and the collection system is designed for such service, this is not a reportable Tier 1 or 2 PSE.	Not a Tier 1 or Tier 2 PSE
	If the material released had been unplanned or uncontrolled and flowed to an open drain, sewer or other collection system, it would be a reportable Tier 2 PSE based on the threshold quantity and material below its flash point.	Tier 2 PSE (Table E.2 & E.4)
31	A valve leak occurred in a gas turbine acoustic enclosure (or a valve box) which is accessible to the workforce. The quantity of natural gas released was 40 kg within 1 hour. This is a Tier 2 PSE, because the LOPC exceeds the threshold quantity for an indoor release of flammable gas. If equipment or a work area is enclosed (apart from louvers and/or air intakes) then the indoor release threshold quantities should be used for determining whether an LOPC occurring in any one-hour period is a Tier 1 or Tier 2 PSE.	Tier 2 PSE (Tables E.2 & E.4)
32	An operator finds a leaking natural gas pipeline while making his normal rounds. It takes him 15 minutes to isolate the pipeline. During the 15 minutes it takes to isolate the pipeline, 20 kg (44 lbs.) of natural gas is released. Then it takes 90 minutes to depressurize the pipeline through the leak point (there was no other means to blowdown the pipeline). The maximum amount released in any 1 hour period during isolation and blowdown is 60 kg. The blowdown of the line is included in the LOPC threshold quantity. This is a Tier 2 PSE because the release rate exceeds the threshold quantity of 50 kg (110 lbs.) in any 1 hour period.	Tier 2 PSE (Tables E.2 & E.4)
	Same as above but, the natural gas release rate does not exceed 50 kg (110 lbs.) in any given 1 hour time period during isolation and blowdown. Not a Tier 1 or Tier 2 PSE	Possible Tier 3 PSE KPI
33	A process upset leads to gross crude oil contamination of the produced water stream that is being discharged to sea. The contamination lasts for several hours and the largest quantity of oil released to sea in any one hour is 4000kg. In addition, determination of a PSE is not dependent on the environment into which the LOPC occurs. The acute discharge quantity exceeds the Tier 1 PSE release threshold for this crude oil which has flash point <60 °C (140 °F).	Tier 1 PSE (Tables E.2 & E.4)
34	A process overpressure leads to a pipeline failure causing LOPC from three different points. The released material is a flammable liquid with boiling point ⩽35 °C and flash point <23 °C. It takes 90 minutes to stop the leak and the maximum released amount in any hour for each point is: 26 kg from the first release point which is a hole of 0.5 mm diameter, 101 kg from the second point which is a hole of 1 mm diameter, and lastly 406 kg from a flange joint. This is a single Tier 1 LOPC as there are multiple releases caused by a single initiating event and total released amount is 533 kg which is higher than Tier 1 threshold (500 kg for outdoor release). Although the first release is below the Tier 2 threshold and the second/third releases below the Tier 1 threshold, the PSE classification is based on the total released amount from all release points combined, which is 533 kg.	Tier 1 PSE (Tables E.2 & E.4)

	Example	Reporting
35	While doing routine well checks on a Normally Unmanned Installation (NUI), operator comes across a spill. The fluid was a flammable liquid with boiling point >35 °C and flash point <23 °C that was coming from a dust cap of a stuffing box. The maximum release rate was 384 kg in any hour. This is a Tier 2 PSE as the maximum released quantity in an hour is above the Tier 2 threshold for this material (100 kg for outdoor release). NUI is part of the process and consequently the releases from NUI are included in the scope of PSE reporting.	Tier 2 PSE (Tables E.2 & E.4)
36	An outdoor two-phase LOPC happened in production separation area. The two-phase release was released over a one hour period and was composed of: • 17 kg of natural gas, and • 89 kg of light crude oil, with Boiling Point >35 °C (95 °F) and Flash Point <23 °C (73 °F) To determine if this is a PSE the following analysis is made: • Flammable Gas (natural gas) released quantity (17 kg) is only 34% of the Tier 2 outdoor threshold ⩾50 kg (110 lbs)), whereas • Flammable liquid (light crude oil) released quantity (89 kg) is only 89% of the Tier 2 outdoor threshold ⩾100 kg (220 lbs). Applying the API RP 754 mixture principle for event classification, then 89% + 34 % = 123 % and thus the event is a Tier 2 PSE. Alternatively, another way to look at this case is to consider that there is a release of 106 kg of flammable gas/liquid mixture, which is greater than both Tier 2 threshold quantity for flammable gas and flammable liquid, and thus the event is a Tier 2 PSE.	Tier 2 PSE (Tables E.2 & E.4)
37	In an offshore platform a generator diesel pump began leaking after it was put in service. The generator provides electricity to run the production process, so it is considered "part of the process" for PSE determination. The calculated outdoor released quantity in an one hour period was 15 bbl of diesel with flash point less than 60°C (140°F). This event is classified as a Tier 1 PSE because the quantity released exceeded the Tier 1 outdoor threshold (14 bbl).	Tier 1 PSE (Tables E.2 & E.4)
	The same as above but, the diesel has a flash point > 60°C (140 °F) and ⩽ 93°C (200°F) and it is released at a temperature below its flash point. In this case the event is classified as a Tier 2 PSE because the quantity released exceed the Tier 2 outdoor threshold (7 bbl).	Tier 2 PSE (Tables E.2 & E.4)
38	An oily water leak occurred from an API Separator on an onshore well pad. The leak was caused by a hole on the feed line due to corrosion issues. The oily water released was a mixture of water (quantity of 850 kg) and hydrocarbons (quantity of 150 kg) with Boiling Point >35 °C (95 °F) and Flash Point <23 °C (73 °F)). The release was stopped in less than one hour. If the amount of hydrocarbon released met or exceeded any Tier 1 and Tier 2 thresholds in Table E.4, then a Tier 1 or Tier 2 PSE to be reported. The estimate of material released should exclude the amount of water, as there is no threshold quantity for water. In this case the hydrocarbons quantity exceeds the Tier 2 outdoor threshold and so the event is a Tier 2 PSE.	Tier 2 PSE (Tables E.2 and E.4)
	As above, but with the quantity of water of 980 kg and the quantity of hydrocarbons of 20 kg. In this case the hydrocarbons quantity does not exceed the Tier 2 outdoor threshold and so the event can be recorded as possible Tier 3 PSE KPI.	Possible Tier 3 PSE KPI
39	Heat Exchanger Tube Leak Examples:	
	There is a crude oil (15< API Gravity) leak into a cooling water system which is >2 bbl in a one hour period. This is considered an LOPC. The severity of the LOPC is considered the same as a release directly to the atmosphere. This would be a Tier 2 PSE since the release rate is above the outdoor release threshold rate.	Tier 2 PSE (Tables E.2 & E.4)
	A vessel contains two phases—aqueous and non-aqueous. The aqueous phase overfilled the vessel, resulting in a carryover of corrosive material (>12.5 pH) into equipment that was not intended for that purpose. The overfill occurred for 30 minutes and a total of 1200 kg or 2400 lbs was released into the downstream equipment. The corrosive material carried over to equipment that was not designed to handle the material; therefore, this would be considered an LOPC. This would be a Tier 2 PSE since the material that carried over would be considered a strong base.	Tier 2 PSE (Tables E.2 & E.4)

	Example	Reporting
	Acute release (within any one hour period)	
40	There is a 10 bbl spill of condensate that steadily leaks from piping outdoor onto soil over a two-week time period. Simple calculations show the spill rate was approximately 0.03 bbl per hour. This is not a Tier 1 or Tier 2 PSE since the spill event did not exceed the threshold quantity in any one-hour period. However, this event can be reported within the Tier 3 KPIs of the company or facility.	Possible Tier 3 PSE KPI
	Same example as above, except that the 10 bbl leak was estimated to have spilled at a steady rate over a period of 1 hour and 30 minutes. Simple calculations show that the spill rate was 6.7 bbl per hour. The spill rate was less than the reporting threshold of 7 bbl within 1 hour for a Tier 1 PSE but it does meet the threshold of 0.7 bbl within 1 hour, thus it is a Tier 2 PSE.	Tier 2 PSE (Tables E.2 & E.4)
41	An operator discovers an approximate 10 bbl liquid spill of light crude oil (flash point <23 °C, API Gravity >15) near a process exchanger that was not there during their last inspection round two hours earlier. Since the actual release duration is unknown, a best estimate should be used to determine if the Threshold Quantity rate has been exceeded (it is preferred to err on the side of inclusion rather than exclusion). This incident is a Tier 1 PSE because the crude oil involved is a flammable liquid and the threshold quantity of 7 barrels is exceeded if the time period is estimated to be less than one hour.	Tier 1 PSE (Table E.2 & E.4)
42	Infrared scans identified that a separator floatation treater was leaking 10,000 SCFD (approximately 8 kg per hour) of gas from the agitator seals. The separator continued to operate for 10 days until the treater was taken out of service and its seals replaced. This LOPC is not a PSE because the leakage rate was less than the Tier 2 release threshold for flammable gas 50 kg (110 lbs) in one hour.	Not a Tier 1 or Tier 2 PSE (see 'Concept of an Acute Release', Part D)
43	While troubleshooting an abnormally high natural gas flow rate, operating personnel find a safety valve on the natural gas line that did not reseat properly and was releasing to the atmospheric vent stack through a knock-out drum. Upon further investigation, it is determined that a total of 1 million lbs of natural gas was released at a steady rate over a 6-month period. This is an LOPC which does not meet the criteria for a Tier 1 or Tier 2 PSE and could be reported as a Tier 3 KPI by the company. Although the release rate is about 100 kg per hour and exceeds the threshold quantity of Tier 2, it does not result in one of the defined adverse consequences.	Possible Tier 3 PSE KPI Not a Tier 1 or Tier 2 PSE
44	A pipe containing CO_2 and 10,000 vppm H_2S (1% by volume) leaks and 7,000 kg (15,400 lbs) of the gas is released within an hour. Calculations show that the release involved about 55 kg (120 lbs) of H_2S (TIH Zone B toxic hazardous material). The release is a Tier 1 PSE because it exceeded the threshold quantity.	Tier 1 PSE (Tables E.2 & E.5)
	If the H_2S concentration were 50 vppm, then the calculated release quantity would be 0.3 kg of H_2S. The release would not be a Tier 1 or Tier 2 PSE since this amount is below the 25 kg (55 lbs) and 2.5 kg (5 lbs) thresholds for H_2S. However, this LOPC event could be reported within the Tier 3 PSE KPIs of the company or facility.	Possible Tier 3 PSE KPI
45	There is an outdoor release of 4000 kg of Molten Sulphur below its flash point. Molten Sulphur is a Packing Group III, Hazard Class 9 material. This is not a Tier 1 or 2 PSE as Packing Group III materials that do not pose a process safety hazard (e.g., Hazard Class 9 materials) cannot be a Tier 1 or Tier 2 PSE based on the quantity of material released. However, this LOPC event could be reported within the Tier 3 KPIs of the company or facility.	Possible Tier 3 PSE KPI (Table E.6 Note)
46	A portion of methanol piping is being prepared for maintenance. The line is drained and isolation is verified. At some point prior to the first flange break, the line accumulated liquid due to a leaking valve. The volume of material that leaked back into the isolated line is greater than the Tier 2 threshold quantity in any one-hour period. Since there was no LOPC, this is not a Tier 2 PSE. The material remained within the piping designed to contain it.	Not a Tier 1 or Tier 2 PSE
	If the flanges were opened by a pipefitter and 300 lbs methanol immediately leaked out of the pipe, it would be a Tier 2 PSE.	Tier 2 PSE (Tables E.2 & E.4)
47	If an internal or external floating roof partially sinks and material gets above it, but remains within the tank, is this a LOPC? Material on top of the floating roof is an LOPC. Material stored within a floating roof tank is expected to be inside the tank walls and beneath the floating roof. Depending upon the volume of material released, this may be a Tier 1 or Tier 2 PSE.	Tier 1 or Tier 2 PSE Classify using Table E.2 & appropriate threshold quantity table (E.4, 5 or 6)

	Example	Reporting
48	A flash fire occurred during top loading crude oil l into a third-party carrier truck. The driver sitting on top of the truck compartment at the manhole per loading procedures suffered burns requiring hospitalization. No liquid spilled from the truck, and there was no significant damage to equipment. The fire may have started due to static ignition and/or switch loading. Vapors are expected to be present in normal top loading operations. This is a Tier 1 PSE. When the ignition occurred, the flame front inside the vessel expanded the gases in the vapor space causing them to exit the manway at a much faster rate (and much hotter) than what would be considered "normal operation", and therefore it was an unplanned and uncontrolled release resulting in a 3rd party hospitalization. Also, top loading operations qualify as being connected to the process for the purpose of loading.	Tier 1 PSE (Table E.1 LWDC)
49	A pipe containing CO_2 and 10,000 vppm H_2S (1 % by volume) leaks and 7000 kg (15,400 lbs) of the gas is released within an hour. Calculations show that the release involved about 55 kg (121 lbs) of H_2S, a TIH Zone B chemical, and 6945 kg (15,279 lbs) of CO_2, a UNDG Class 2, Division 2.2 non-flammable, non-toxic gas. The release is a Tier 1 PSE because it exceeds the Tier 1 threshold quantity for both Release Category 2 and 7. Alternate Scenario: If the H_2S concentration is 50 vppm, then the calculated release quantity would be 0.3 kg (0.66 lbs) of H_2S and 6999 kg (15,398 lbs) of CO_2. The release would still be a Tier 1 PSE since this Release Category 7 threshold quantity is exceeded even though the Release Category 2 quantity falls below the Tier 1 and Tier 2 thresholds for H_2S.	Tier 1 PSE (TableE.2 & E.5 & E.6)
50	During a turnaround, a Tier 2 threshold quantity of crude oil was spilled from a frac tank that had been used for equipment draining. At the time of the spill, the frac tank was in the process area awaiting transport to the disposal facility but was not connected to the process. Is this a Tier 2 PSE? This is not a Tier 2 PSE. The frac tank was not connected to the process but was instead awaiting transport for disposal or recycle. The frac tank had transitioned from being part of the process (while connected) to being in transportation mode. This example is analogous to the use of a vacuum truck to transport material that was not actively loading, discharging, or using its transfer pump. A company may choose to record this as a transportation event.	Not a Tier 1 or Tier 2 PSE
	Instead of awaiting transport to a disposal facility, the frac tank was awaiting transport to a crude tank where the material could be recycled back into the process after the turnaround. In this situation, the frac tank would be considered on-site storage even though it was not connected to the process, and the LOPC would qualify as a Tier 2 PSE for the refinery.	Tier 2 PSE (Table E.2 & E.4)

Pressure relief device

51	There is a unit upset and the PRD opens to an atmospheric vent, resulting in a release of 300 lbs. of propane to the atmosphere with no adverse consequences. Is this a PSE? This is not a Tier 1 or Tier 2 PSE. Although the release volume exceeded the Tier 2 threshold quantity for propane, the PRD release did not result in one of the defined negative consequences, and it is not a Tier 2 PSE. A company may choose to count this as a Tier 3 demand on a safety system.	Possible Tier 3 PSE KPI (See Tier 3 PSE example in Part G)
	Alternate Scenario: Same as above, but there was a non-precautionary site shelter-in-place. This is a Tier 2 PSE because it exceeded the Tier 2 threshold quantity for propane and resulted in one of the defined PRD negative consequence.	Tier 2 PSE (Table E.3 & E.4)
52	A sour gas scrubber has a PRD that was identified in a recent Process Hazard Analysis (PHA) to be undersized. During normal operations, the scrubber becomes over-pressurized. A release of 60 pounds of H_2S gas (TIH Zone B material) occurs through this PRD and is directed to the flare system over a period of 25 minutes. This would not be a Tier 1 or Tier 2 PSE, regardless of the PHA finding, so long as it did not result in a rainout, on-site shelter in place, public protective measure, or other indication of discharge to a potentially unsafe location (Table E.3). A company using a Tier 3 KPI to track demands on safety systems could report this event as an activation of a PRD resulting in a release to atmosphere via a destructive device.	Possible Tier 3 PSE KPI (See Tier 3 PSE example in Part G)
53	A relief valve operates and vents 250 kg of flammable gas directly to the atmosphere with a small rainout estimated at 10 kg of hydrocarbon. This is a Tier 2 PSE because there was a rainout and because the total mass released exceeds the threshold quantity (i.e., not just the mass of the liquid or the mass of the gas) and major component of the material is flammable gas.	Tier 2 PSE (Tables E.3 & E.4)

	Example	Reporting
54	There is a unit upset and the PRD fails to open, resulting in over-pressurization of the equipment and a 10-minute release of 2200 lbs/1000 kg of C3-C5 hydrocarbons from a leaking flange before it can be blocked in. This is a Tier 1 PSE.	Tier 1 PSE (Tables E.2 & E.4)
55	The failure of a vapour recovery unit (single initiating event) results in over-pressurization of three tanks, which is relieved through the PRDs located on top of each tank. The release quantity from Tank #1 is 172kg of methane, from Tank #2 is 31 kg of H2S, and from Tank #3 is 404 kg of methane. None of the four consequences related to PRD discharges occurred for the releases from Tanks #1 and #2. The release from Tank #3 was to a potentially unsafe location. This is a Tier 2 LOPC incident as the discharge from Tank #3 exceeds the Tier 2 threshold and the release was to a potentially unsafe location. The material released from Tank #1 and #2 is not included in the overall release quantity used to categorize the event because the PRD discharge on those two tanks did not result in any of the four consequences.	Tier 2 PSE (Tables E.2 & E.4)
56	A process upset causes an atmospheric tank to vent 27 kg of H_2S to atmosphere via a low-pressure vacuum relief valve. The vent occurs immediately adjacent to an elevated platform on top of the tank. The site has an administrative procedure, including a swing gate, and a restricted access sign at the bottom of the tank. Dispersion modelling indicates there is no concern of harmful H_2S concentrations at grade. This is a Tier 1 LOPC incident as the discharge quantity exceeds the Tier 1 threshold and the release is to a potentially unsafe location. No credit is taken for administrative controls when determining whether-or-not a release is to a potentially unsafe location.	Tier 1 PSE (Tables E.2 & E.5)
	Same as above, except the barrier at the bottom of the stairs is controlled by a lock and key, thus preventing access to the platform. This is a Tier 3 KPI incident as none of the four consequences are applicable. In this example, the platform is not considered a potentially unsafe location as inadvertent access has been controlled by the use of a lock and key. This control is similar to car-sealing-open a block valve in the relief path of a PRD to ensure the relief path is not obstructed.	Possible Tier 3 PSE KPI
	Same as above, except the dispersion modelling shows that there is the potential for H_2S concentrations above acceptable levels at grade. This is a Tier 1 LOPC incident as the discharge quantity exceeds the Tier 1 threshold and the release is to a potentially unsafe location. In this case, the potentially unsafe location is grade and not the platform on the tank.	Tier 1 PSE (Tables E.2 & E.5)
57	If a PRD activates/opens at 30 % of its set point due to a frozen pilot and the release is greater than the TRC for a Tier 1 event, is this a Tier 1 PSE event since the PRD failed to perform as designed?	Not a Tier 1 or Tier 2 PSE
	The Tier 1 criteria for PRD releases is independent of whether the PRD opened at, above or below its set point or any other factors associated with design and installation. Releases from PRDs are only classified at Tier 1 or Tier 2 PSEs if one or more of the listed consequences occurs (i.e. rainout, discharge to a potentially unsafe location; an on-site shelter-in-place; public protective measures) and the release volume at the PRD discharge exceeds the Table 1 threshold quantity. None of those negative consequences is identified in the question; therefore, this event is not a Tier 1 PSE.	Possible Tier 3 PSE KPI
58	An atmospheric relief device lifts and discharges greater than a Tier 1 threshold quantity of material. Dispersion modelling conducted as part of the relief device design indicates that a flammable mixture could impact an elevated work platform on an adjacent tower. Knowing that the platform could be impacted, the company controls access to the platform via their authorization system. At the time of the release, the wind was blowing in the direction of the elevated work platform, but no one is on the elevated platform. Is this a Tier 1 PSE?	Not a Tier 1 or Tier 2 PSE
	This is not a Tier 1 PSE. Although the relief volume exceeded the Tier 1 threshold quantity, the discharge did not result in one of the four defined consequences. One of those consequences is release to a potentially unsafe location. The definition of unsafe location specifically excludes ground level and elevated work structure locations that have a known potential for exposure of personnel to flammable mixtures, toxic substances, corrosive materials, or thermal radiation effects if that location is a controlled by virtue of authorized access or hard barriers with appropriate warning signs.	
	Alternate Scenario 1	
	A worker was present on the platform in accordance with the site authorization requirements. The worker was able to escape unharmed. This is not a Tier 1 PSE. Even though a worker was present, by definition the work platform is not an unsafe location under the exclusion for controlled access. If the worker had been injured, then the event would be a Tier 1 or Tier 2 PSE dependent upon the severity of the injury.	Not a Tier 1 or Tier 2 PSE

	Example	Reporting
	Alternate Scenario 2	
	The company did not control access to the platform via their authorization system or hard barriers and signage. This is a Tier 1 PSE, since the elevated work platform was impacted by the discharge and the exclusion for controlled access did not apply. The definition of unsafe location is independent of whether or not personnel are actually present at the time of the relief device discharge.	Tier 1 PSE (Table E.3 & E.4.5 or 6)
	Alternate Scenario 3	
	The company did not control access to the platform via their authorization system or hard barriers and signage. A worker was present on the elevated work platform at the time of the relief device discharge, but the wind direction was away from the platform. This is not a Tier 1 PSE. Since the work platform was not actually impacted at the time of release, it did not qualify as an unsafe location. The assessment of a LOPC for Tier 1 or Tier 2 categorization is based upon actual conditions and results at the time of release and not on alternate what-if conditions.	Not a Tier 1 or Tier 2 PSE
59	A heat exchanger with natural gas on the tube side and water on the shell. There is a safety valve on the shell which is designed to protect the shell from over pressuring in the event of a tube rupture. The safety valve discharge is routed to the atmosphere via a high discharge point, such that dispersion modeling indicates that it is a "safe location". A tube ruptures and the valve relieves. The natural gas is dispersed and none of following four consequences occur: 1. Rainout 2. Discharge to a potentially unsafe location 3. An on-site shelter in place or on-site evacuation, excluding on-site shelter in place or site evacuation 4. Public protective measures (e.g., road closure) including precautionary public protective measures However, water is carried along with the natural gas and the water "rains out". The water is cool/ambient and there is no risk of thermal burns to personnel. The material which "rains out" as a result of a relief system discharge is non-hazardous (water in this scenario). The release and subsequent rainout of the cool water would not be a classified as a PSE 1 or PSE 2 because there is no process safety issue related to this release since there is no Threshold Quantity for cool water. The 4 consequences for release from a pressure relief valve must be considered and consequences 2 through 4 clearly do not apply. Rainout is intended to apply to a material with the potential to cause harm which would not apply to cool water. If this logic were not applied then any release through a downstream destructive device or directly to the atmosphere containing any water, including water vapor, would eventually "rain out" the water making the exemption meaningless. If the water that was raining down was hot (>55 °C or 130 °F), then it would be considered rainout of a material with the potential to cause harm.	Not a Tier 1 or Tier 2 PSE (Possible Tier 3 PSE KPI)

Pipelines and flowlines

60	A pipeline operated by the company leaks and releases 2,200 lbs/1000 kg of flammable gas above ground within one hour; however, the release occurred in a remote location and not on a facility. This is a reportable Tier 1 PSE since 'remoteness' is not a consideration and the release exceeded a Tier 1 threshold quantity.	Tier 1 PSE (Tables E.2 & E.4)
61	A pipeline leaks and releases 2,200 lbs/1000 kg of flammable gas above ground within 1 hour. A public road bisects the main facility and its marine docks. This pipeline originates in the facility and goes to the docks. The leak site happens to be off the site's property in the short segment of piping that runs over the public road. Although the leak technically occurs off-site, this is a Tier 1 PSE since the facility owns and operates the entire segment of pipeline.	Tier 1 PSE (Tables E.2 & E.4)
62	A third-party truck loaded with a flammable liquid is traveling on Company premises and experiences a leak and subsequent fire and property damages of $125,000 (direct costs). The incident would not be a Tier 1 or Tier 2 PSE because truck incidents are excluded, except when they are connected to the process for the purposes of feedstock or product transfer.	Not a Tier 1 or Tier 2 PSE (See Part C)
	Same as above except, the third-party truck is parked and being used for temporary onsite storage. This would be a Tier 1 PSE since the applicability exclusion does not include the use of trucks or railcars for onsite storage.	Tier 1 PSE (Table E.2 & E.4)

	Example	Reporting
63	There is a 200 bbl spill from a flowline containing light crude with a flash point <23 °C (73 °F). The spill ignites and results in damages to other equipment, a toxic gas release above the reporting threshold, along with three LWDC injuries and one fatality. This is a Tier 1 PSE. The site would record a single PSE with multiple consequences (e.g., one fatality, three day away from work injuries, fire, and threshold quantity of liquid with a flash point <23 °C (73 °F) and toxic gas).	Tier 1 PSE Tables E.1, E.2, E.4 and E.5)
64	An underground pipeline operated by the facility leaks and releases 1,000 bbl of heavy crude oil with flash point > 60 °C (140 °F) and ≤ 93 °C (200 °F) at a temperature below its flash point within the facility over a period of three days (13.9 bbl/hr). The spill results in contaminated soil that is subsequently remediated. This is a Tier 2 PSE since the leak rate was greater than the Tier 2 threshold quantity; note that there is no Tier 1 threshold quantity for this material.	Tier 2 (Tables E.2 & E.4)
65	A pipeline that is owned, operated and maintained by Company A crosses through Company B's property. The pipeline has a 1500 lbs release within an hour from primary containment of flammable gas and causes a fire resulting in greater than $100,000 damage to Company A's equipment. This is not a PSE for Company B since the pipeline is not owned, operated or maintained by Company B. This would be a Tier 1 PSE incident for Company A.	Tier 1 PSE (Tables E.1, E.2 & E.4)
66	Failure of a subsea pipeline during leak testing results in a rapid methanol release of 550 kg into the sea. The subsea line is part of the process and the release is unplanned and uncontrolled. The release quantity exceeds the Tier 2 threshold for outdoor release of flammable liquids with boiling point >35 °C and flash point <23 °C. Although in this case there was no potential for the release to ignite, determination of a PSE is not dependent on the environment into which the LOPC occurs.	Tier 2 (Tables E.2 & E.4)

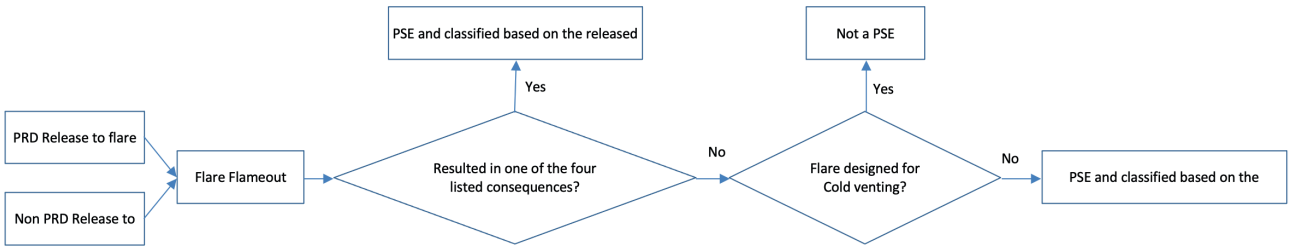
Marine and land transport

67	A Company-operated Marine Transport Vessel that had just disconnected from an offshore rig has an onboard spill of 14 bbl Of drilling fluids with a flash point > 93 °C (200 °F) released at a temperature below its flash point. The event is not a PSE because Marine Transport Vessel incidents are specifically excluded, except when the vessel is connected to the process for the purposes of feedstock or product transfer. This is likely to be a reportable spill to the environment within other KPIs of the Company.	Not a Tier 1 or Tier 2 PSE (See Part C)
	If the marine transport vessel were still connected to the rig when the spill occurred, it would be a possible Tier 3 KPI since the flash point of this drilling mud is higher than upper limit (93 °C) and it is released at a temperature below its flash point (Table E.4).	Possible Tier 3 PSE KPI (Tables E.2 & E.4)
68	A third-party barge is being pushed by a tug and hits the Company dock. A barge compartment is breached and releases 50 bbl of diesel to the water. This LOPC event is not a PSE since the barge was not connected to the process for the purpose of feedstock or product transfer.	Not a Tier 1 or Tier 2 PSE (See Part C)
69	A marine survey boat is pulling a tube screen for seismic survey and a shark bites into the tube releasing 7 bbl of hydraulic fluid into the water. This LOPC event may be a reportable spill to the environment but not a PSE because exploration activities are not within scope for PSE KPIs.	Not a Tier 1 or Tier 2 PSE (See Part C)
70	A Company railcar derails and spills more than 7 bbl of gasoline while in transit. The LOPC event is not a PSE since it is not connected to the process for the purpose of feedstock or product transfer, but this is likely to be a reportable spill to the environment within other KPIs of the Company.	Not a Tier 1 or Tier 2 PSE (See Part C)
71	A third-party truck/trailer on Company premises connected to the process has a spill of condensate greater than 7 bbl in less than an hour while loading. The event is a Tier 1 PSE since the truck is considered part of the process while it is connected or in the process of connecting/disconnecting from the process for the purpose of feedstock or product transfer.	Tier 1 PSE (Tables E.2 & E.4)
72	A truck enters a well pad, parks and is connected to the crude tank load line. After loading the product, the truck disconnects and leaves the well pad and an accident occurs leading to a LOPC on the well pad lease road. Is this a PSE? This would not be a PSE per API 754; the truck was not connected nor in the process of disconnecting from the process; therefore, the subsequent LOPC should be counted as a transportation event. Even though it is not a PSE per API 754, it should be investigated and corrective action taken to prevent a recurrence.	Not a Tier 1 or Tier 2 PSE (See Part C)

	Example	Reporting
	Alternate Scenario	
	A truck enters the well pad and parks with other trucks waiting to be loaded. The truck contains several hundred gallons of product from the previous load. The truck develops a leak resulting in a LOPC of product in excess of the Tier 1 threshold quantity. Is this a Tier 1 PSE? This is not a Tier 1 PSE since the truck was not connected to the process nor in the process of connecting/disconnecting from the process. Similarly, the truck would not qualify as 'active staging' since by definition active staging only applies to truck/rail waiting to be unloaded. Therefore, the LOPC should be counted as a transportation event.	Not a Tier 1 or Tier 2 PSE (See Part C)

Destructive devices

In case of a release to flare system while the flare is flameout, the flow chart below indicates the process to follow for event classification.



73	The flare system is not functioning properly due to inactive pilots on the flare tip. During this time, flammable gas is sent to the flare due to overpressure in a process unit. The volume of the unlit vapour released to the atmosphere through the flare is greater than the Tier 1 threshold. The flare is not designed for cold venting. This would be classified as a Tier 1 PSE since the downstream destructive device which was not designed for cold venting did not function correctly and an unplanned/uncontrolled discharge (LOPC) exceeded a threshold release quantity.	Tier 1 PSE (Tables E.3 & E.4)
74	100 bbl of crude oil are inadvertently routed to the flare system through a PRD. The flare knockout drum contains most of the release; however, there is minimal liquid phase hydrocarbon rainout. This is a Tier 1 PSE since the volume released from the PRD to a downstream destructive device exceeds the threshold quantity in Table E.4 and resulted in one of the four listed consequences (i.e., rainout).	Tier 1 PSE (Tables E.3 & E.4)
75	A PRD release of sour gas less than Tier 1 but more than a Tier 2 threshold quantity is routed to a flare which exposes two personnel to toxic SO_2/SO_3 vapours resulting in a lost work day case (LWDC) incident. This is a Tier 1 PSE since the PRD discharge resulted in a days-away-from-work injury.	Tier 1 PSE and a LWDC (Table E.1)
	Same as above, except the toxic material was observed or detected, without injury, at an unrestricted elevated work structure. This is a Tier 2 PSE since the release quantity from a PRD to a downstream destructive device exceeds a Tier 2 threshold quantity and results in an unsafe release (discharge to a potentially unsafe location) as specified in the list of Tier 2 consequences. If the elevated platform was restricted, then this is not a Tier 1 or Tier 2 PSE and a company may choose to include this event in their Tier 3 indicators.	Tier 2 PSE (Table E.3 & E.5)
76	A propane tank releases through a PRD to the flare system. The pilots on the flare system are not working properly, and the flare does not combust the vapours. The event occurs over a period of 45 minutes. The volume of propane release was estimated to be 1300 pounds (ca. 600 kg) and the release generated an explosive atmosphere above grade without being ignited. The amount of PRD discharge and resultant unintended propane release from the flare exceeded the Tier 1 threshold quantity. This is a Tier 1 PSE since the flare did not function correctly and a LOPC resulted in one of the four consequences (discharge to a potentially unsafe location) with a release amount above Tier 1 thresholds.	Tier 1 PSE (Tables E.3 & E.4)
	If the flare was designed for cold venting and the LOPC resulted in none of the four consequences, a Company using a Tier 3 KPI to track demands on safety systems would report this event as an activation of a PRD resulting in a release to atmosphere via a downstream destructive device.	Possible Tier 3 PSE KPI

	Example	Reporting
77	An upset causes a PRD to open and release fuel gas to the facility flare system. The flare system works properly and combusts the vapour release which came from the PRD. This is not a Tier 1 or Tier 2 PSE because the PRD release was routed to a downstream destructive device that functioned as intended (i.e., did not cause one of the four listed consequences). A company may record this as a Tier 3 challenge to the safety system. Alternate Scenario: An upset causes a PRD to open and release a two-phase mixture exceeding a Tier 1 or 2 threshold quantity. The liquid is carried over to the flare drum knockout, but no release to atmosphere in the form of rainout occurs. Is this a Tier 1 or Tier 2 PSE? This is not a Tier 1 or Tier 2 PSE since the PRD release was routed to a downstream destructive device that functioned as intended (i.e., did not cause one of the four listed consequences). A company may record this as a Tier 3 challenge to the safety system	Possible Tier 3 PSE KPI Possible Tier 3 PSE KPI
78	There is hydrocarbon rainout on a flare when a compressor is started. Investigation finds that natural gas condensate had collected in a low point in the flare line over many days and had been 'blown' to the flare when the compressor started and caused the rainout. The calculated volume of condensate in the low point is 1.5 bbl. This is an upset emission from a permitted or regulated source. Although discharge to flare during compressor start-up would not normally be consider an LOPC, given that the activity/release is considered unplanned/uncontrolled and the downstream destructive device malfunctioned (or otherwise failed to destroy the liquid), resulting in liquid rainout, the event would be considered a PSE of Tier based on the total quantity of hydrocarbons released into the relief system (i.e. not just the quantity of hydrocarbon liquids released as the 'rainout'). Since the released amount is more than Tier 2 threshold for condensate (1 bbl), the incident would be classified as a Tier 2 PSE.	Tier 2 PSE (Tables E.3 & E.4)
79	The flare system is not functioning properly due to inactive pilots on the flare tip. During this time, flammable gas is sent to the flare due to an overpressure in a process unit. The volume of the flammable gas through the PRD is greater than the Tier 1 threshold and it results in the formation of a flammable mixture at grade. This would be classified as a Tier 1 PSE since the PRD discharge is greater than the Tier 1 threshold quantity and resulted in a discharge to a potentially unsafe location. Same as above except, the flare is designed for cold venting which results in the flammable gas being dispersed into the atmosphere without creating any one of the four listed consequences. This is not a Tier 1 or Tier 2 PSE. A company may count this as a Tier 3 PSE KPI.	Tier 1 PSE (Tables E.3 & E.4) Possible Tier 3 PSE KPI

Vacuum truck operations

80	After collecting a load from an adjacent unit, a vacuum truck is parked at the wastewater treatment facility awaiting operator approval to connect to the process and discharge its load. While waiting the vacuum truck malfunctions and vents process material to the atmosphere. This is not a PSE since vacuum truck operations are excluded unless loading, discharging or using the truck's transfer pump.	Not a Tier 1 or Tier 2 PSE (See Part C)
81	A vacuum truck outfitted with a carbon canister on the vent is loading a spill of hydrocarbons. The carbon canister catches fire which escalates to the point of creating more than $10,000 in damage to the vacuum truck. This is a Tier 2 PSE because the original spill of hydrocarbons constitutes the LOPC and the response to the LOPC results in one of the Tier 2 consequences. Same as above, except the vacuum truck is connected to the process. This is a Tier 2 PSE since the direct costs from the fire damage exceeded $2,500. The excess of hydrocarbon vapours absorbed by the carbon canister is the uncontrolled LOPC.	Tier 2 PSE (Table E.1) Tier 2 PSE (Table E.1)
82	A vacuum truck was being used to remove sludge and crude oil from a separator that is inside a building to allow for mechanical inspection. The vacuum truck driver accidentally reversed the flow of the vacuum truck's transfer pump and caused crude oil to flow back into the separator and 1 bbl of crude flowed out of the separator through the manway which had been removed onto the building's floor. As described, the vacuum truck would be considered part of the process since the vacuum truck transfer pump was being used. This event would be classified as a Tier 2 PSE since there was an LOPC out of the manway that exceeded the indoor release threshold quantity for this type of crude.	Tier 2 PSE (Table E.2 & E.4)

	Example	Reporting
	Evacuation or shelter-in-place	
83	A small quantity (less than Tier 2 threshold quantity amount) of very odorous material (e.g. methyl mercaptan for odorizing natural gas) inadvertently enters a cooling water system via an exchanger tube leak. The material is dispersed into the atmosphere at the cooling tower. An elementary school teacher decides not to conduct recess outside due to a noticeable odor even though officials deemed no shelter-in-place was necessary. Is this a Tier 1 or Tier 2 PSE? This is not a Tier 1 or Tier 2 PSE. The school teacher acting from an abundance of caution and deciding not to conduct recess outside does not constitute an officially declared shelter-in-place or evacuation. The facility may choose to capture this event as a Tier 3 other LOPC.	Possible Tier 3 PSE KPI
84	A pressure relief device (PRD) discharges to a scrubber that vents to atmosphere. The scrubber is overwhelmed by a flow rate greater than its design resulting in a discharge that is detected by fence-line monitoring and a public shelter-in-place order is issued. The PRD release quantity is estimated to be less than the Tier 1 thresholds. This is a PSE with a Tier 1 consequence regardless of the quantity released exceeding a threshold quantity because of the officially declared community shelter-in-place.	Tier 1 PSE (Table E.1)
85	A pressure relief device (PRD) activates on an offshore platform, resulting in a substantial release exceeding Tier 1 thresholds, causing precautionary partial evacuation or platform abandonment (some or the entire workforce). This is equivalent to an onshore situation resulting in an 'onsite shelter in place' and would be a Tier 1 PSE. Mustering offshore to a safe location on the platform is not considered a sufficient consequence to trigger reporting a Tier 1 or 2 PSE. The partial evacuation of an onshore gas plant to a safe muster point, onsite or offsite, is also considered a 'shelter-in-place' consequence, which would result in a Tier 1 or Tier 2 PSE following LOPC which meets or exceeds the threshold quantities in Table E.4.	Tier 1 PSE (Tables E.3 & E.4)
86	Less than 1 pound (0.45 kg) of H_2S gas is released while loading a molten sulfur car. The release is detected by a local analyser and triggers a unit response alarm. An off-duty police officer living in a nearby home advises his neighbors to evacuate because "an alarm like that means there's a problem at the plant." This is not an officially declared evacuation or shelter-in-place because in this situation the officer is acting as a private citizen suggesting a precautionary measure; therefore, this is not a Tier 1 or Tier 2 PSE. The site may choose to capture this event as a Tier 3 PSE KPI .	Possible Tier 3 PSE KPI
	PSE Reporting Responsible Party	
87	Regarding LOPC events associated with marine transport, truck and rail operations: A company has 1) met the requirement of "connected to the process for the purposes of feedstock or product transfer," and 2) exceeded either a Tier 1 or Tier 2 threshold quantity. When classifying the event, is ownership or operation of the transport additional criteria? If the transport (vessel, barge, truck, or rail car) was owned or operated by a third-party, would it still be a PSE? The ownership of the transport equipment involved in marine transport, truck and rail operations has no bearing on what constitutes a PSE, nor does the involvement of contract workers. Where a facility is a joint venture operated by others, the PSE is reported by the responsible party.	Tier 1 or Tier 2 PSE
88	The facility experienced a Tier 1 PSE. The facility is owned by Company A, but is operated by Company B. Who is the responsible party, who should count the PSE? The answer depends on the nature of the contract between the two parties. As the contract operator, does Company B also have responsibility for the performance of the facility (i.e. In this case would they be expected to perform the investigation and identify and implement corrective action?). If 'yes', Company B is the responsible party and they would record the PSE. If 'no' and Company B is simply acting upon the instructions of Company A, then the Company A is the responsible party and they would record the PSE.	Tier 1 PSE

	Example	Reporting
89	A 3rd party tank truck operator begins filling his tanker at an unstaffed loading rack. The belly valve of the tanker truck was left open and when the operator disconnected the loading hose, a Tier 1 quantity of flammable liquid was spilled. Is this a Tier 1 PSE? This is a Tier 1 PSE since the LOPC occurred while disconnecting from the process (i.e., the loading rack). Although the 3rd party tank truck operator has an obligation to follow the operating procedures (i.e. close the belly valve before disconnecting the loading hose), he is not the operator of the facility and therefore he is not the responsible party. The Company that owns or operates the loading rack is the responsible party. The Company establishes the operating procedures, installs prevention measures, authorizes 3rd parties to use the facility, etc.	Tier 1 PSE
90	A contractor performing work overpressured the contractor supplied tank which is connected to a process. The tank roof blew off and traveled 45 ft where it landed on the cab of the contractor's CO_2 supply truck causing $15,000 in damage. Since this was a turn-key job by the contractor, the Company had no contractual liability for the event or the damage. Is this a PSE? Although the contractor is performing a turn-key job on behalf of the Company, the Company is still the responsible party (i.e. the party responsible for delivering safe, compliant and reliable operations) and the Company should record this event as a Tier 2 PSE.	Tier 2 PSE
91	The custody transfer meter for a refined products pipeline that is owned, operated, and maintained by a pipeline company is physically located inside the fence line of a refinery. On a quarterly basis, the pipeline company checks and calibrates the meter. During the proving operation, a lineup error results in a Tier 1 threshold quantity release of a flammable liquid. Is this a Tier 1 PSE for the pipeline company or the refinery? This is a Tier 1 PSE for the pipeline company. Even though the LOPC occurred inside the fence line of the refinery, the Tier 1 PSE is recorded by the pipeline company since they own, operate, and maintain the custody transfer meter and the portable meter proving station. The pipeline company is the responsible party.	Tier 1 PSE
92	Company A owns a pipeline that has been out of service for 2 years. The pipeline runs from Company A's facility to a marine terminal owned by the government. Company A is in the process of cleaning up and decommissioning the line for removal via a pigging operation. During the course of this operation, 23 bbls of a Threshold Release Category 8 material (60°C < FP < 93 °C, released < FP) is released in an hour due to a failure of a piping component. The failure does not occur on Company A's property but on the government's property. The entire release is contained in a concrete bunker on the government's property. Since this line has been out of service for a number of years, is no longer connected to the process, and the spill did not occur on Company A's property, is this a PSE? This is a Tier 2 PSE for Company A. There was an unplanned or uncontrolled release of TRC-8 material from a process that exceeded the Table E.4 threshold quantity in a 1-hour period. Even though the line was out of service and had been for several years and was no longer connected to the process it is still process equipment. Also, Company A is the responsible party; it doesn't matter that the release occurred on government property.	Tier 2 PSE
93	Two pipeline companies share a common right of way. The pipelines are independently owned and operated. Company A's pipeline experiences a LOPC leading to a Tier 1 fire and explosion that subsequently causes Company B's pipeline to also have a Tier 1 LOPC. Is this one or two Tier 1 PSEs, and who reports the PSEs? In this case, there are two responsible parties. Each pipeline company is the responsible party for their own line. Each pipeline company experienced a LOPC that resulted in a Tier 1 consequence. Each company would report a Tier 1 PSE. The fact that Company A's LOPC and fire was the initiating cause for Company B's LOPC does not make the Company B LOPC a continuation of the first event.	Tier 1 PSE
	In the case that both pipelines were owned by the same company and the two LOPCs impact the same population or equipment, there is only one responsible party and only one Tier 1 process safety event is recorded.	Tier 1 PSE

	Example	Reporting
	Well Operations	
94	A drilling subsurface blowout comes to surface (along the casing or along another path to the surface) resulting in a gas release of over 45 tonnes of flammable gas to atmosphere over a period of 72 hrs. This LOPC is a PSE and would be classified as Tier 1 because the average leak rate over the period of 1 hour exceeds the threshold quantities. This event is also a Level 1 WCI because well operations, i.e. drilling, were being conducted at the time and all well barrier envelopes failed resulting in the uncontrolled gas flow. Part J – Well Control Incidents	Tier 1 PSE (Tables E.3 & E.4) Level 1 WCI
95	During an extended well test at 10,000 Barrel Per Day rate with 1250 gas-to-oil ratio, a slug of liquid extinguished the flare flame, resulting in a release of uncombusted natural gas at 520,000 SCF per hour until the flare was reignited 10 minutes later. This is a Tier 1 PSE because the flare failed to operate as designed (it was not designed for cold venting) when it flamed out resulting in an unplanned and uncontrolled release (LOPC) of flammable gas significantly exceeding the Tier 1 release quantity of 1100 lbs (500 kg) within one hour. This is not a WCI as there was no failure or degradation of the defined well barrier envelope(s).	Tier 1 PSE (Tables E.2 & E.4) This is not a WCI
96	While drilling a well, there is a loss of hydrostatic overbalance resulting in a kick. Standard well control procedures are followed to reestablish full control, resulting in the planned and controlled venting of the gas kick through the mud gas separator (MGS) vent. This was a planned release consistent with procedures and therefore not a Tier 1 or Tier 2 PSE, even though the gas release may have exceeded the release quantity thresholds for the PSE KPI. Companies may report this within their Tier 3 KPIs because this is a demand on a safety system.	Possible Tier 3 PSE KPI
	Same as above, except the rig is a Mobile Offshore Drilling Unit with an enclosed shaker house. While routing through the MGS, the liquid leg is lost sending hydrocarbons to the shaker room. The gas released to the shaker room is calculated to be 34 kg. This release was unplanned and uncontrolled so categorized as a PSE. The volume is above 25 kg, the Indoor Tier 2 threshold for methane, so this release would be categorized as a Tier 2. One well barrier, the hydrostatic overbalance, failed so this would also be categorized as a Level 3 WCI	Tier 2 PSE (Tables E.2 & E.4) Level 3 WCI
97	While drilling a well, a shallow gas pocket is struck, causing a loss of well control. Mud, cuttings and 100 barrels of oil are released to the environment, and 1.8 MMSCF of gas (about 64,000 kg) are discharged through the diverter valve to the atmosphere. The release continued for two days at an average of 900,000 SCFD. This meets the criteria for a Tier 1 PSE because of the flammable gas LOPC. It is also a reportable spill (over 1 barrel) to the environment under company's environmental reporting requirements. No well barrier envelopes existed allowing the release to continue for two days. This would be classified as a Level 1 WCI.	Tier 1 PSE (Tables E.2 & E.4) and a reportable oil spill to the environment. Level 1 WCI
98	100 kg (220 lbs) of diesel fuel spills within an enclosed area during a period of 30 minutes while transferring fuel to a drilling platform while running casing in-hole. A LOPC, while connected to a platform when well operations are being conducted, is reported as a process safety event. This would be a Tier 2 PSE because the fuel system on a platform is considered part of the process, and the spill exceeds the 50 kg indoor threshold quantity for Tier 2 for flammable liquids. If the spill occurred during transfer of fuel to a MODU (e.g., jack-up or drill ship) contracted to carry out drilling operations at a company well site, this would also be included as a PSE, as above. However, if the spill occurred when the MODU under contract was moving between well sites then no well related operations are taking place and would not be considered 'connected to the process' and would not be a PSE.	Tier 2 PSE (Tables E.2 & E.4) This is not a WCI
99	During the completion with the drilling rig, the derrick man was asked to mix a KCl brine pill in the slug pit. The derrick man forgot to close the transfer valve, the slug pit quickly overflowed and approximately 10 bbls of 7% KCl of brine with 112 kg of KCl (261 lbs) was lost to the ground. The pits are considered part of the process during well operations and the release was unplanned. KCL brine is not classified as a hazardous solution and does not fall within the material hazard classifications (e.g. toxicity, flammability, corrosivity) associated with an upper threshold release quantity. This incident would be classified as a PSE Tier 3 Release.	Possible Tier 3 PSE KPI
	As above except 10 bbls of Diesel-based Oil Based Mud overflows. If the diesel-based drilling mud has a flash point below 93 °C and so 10 bbls is over the Tier 2 threshold. It is important to verify the flash point and the release temperature of the mud.	PSE Tier 2 (Table E.4) This is not a WCI

	Example	Reporting
100	During drilling operations, 1.5 bbl of diesel with flash point less than 60°C (140°F) are released from a fuel tank indoor in a period of 90 minutes. The diesel was contained in the secondary containment and there was no fire. The LOPC occurred while Well Operation were being conducted and since the released amount in one hour is about 1 bbl. and more than Tier 2 indoor threshold (0.7 bbl), the event is a Tier 2 PSE.	Tier 2 PSE (Tables E.2 & E.4)
	Same as above but the release is outdoor, it is not a Tier 2 PSE since the released amount is less than the outdoor threshold (1.4 bbl); possible Tier 3 PSE KPI.	Possible Tier 3 PSE KPI This is not a WCI.
101	During a deep-water offshore drilling operation, a leak of oil-based mud (OBM) is noted from the slip joint at the top of the marine riser. The flash point of the OBM is less than 93 °C and the total volume released to the sea is estimated as 8 bbls over a 1-hour period. The riser system is part of the process. As the OBM flash point is between 60 °C and 93 °C and it was released at a temperature lower than its flash point, it is classified as a Tier 2 event.	Tier 2 PSE (Tables E.2 & E.4)
	As above, but the 8bbls were released over a 4-hour period. In this case, the maximum release rate was less than the 7bbl/hr threshold, so this is not a Tier 2 event but is a possible Tier 3 KPI based on the company's reporting criteria.	Possible Tier 3 PSE KPI
	There has been no well barrier envelope failure however there may have been the potential for the leak to escalate to an extent that the hydrostatic overbalance in the well was reduced. This is a possible Level 4 WCI.	Possible Level 4 WCI.
102	During normal drilling operations, as part of routine maintenance, rig personnel changed a generator's (Generator A) oil filter and restarted it. Shortly after restarting generator A, a second generator (Generator B) caught fire. It was determined that generator A's oil had leaked from the oil filter and sprayed onto generator B, causing the fire. Cost to repair the fire damage was $25,000. The rig was conducting well operations, so the generator is part of the process. The Operator is responsible for reporting this PSE, not the Drilling contractor, as the Operator is the responsible party.	Tier 2 PSE (Table E.1) This is not a WCI.
103	While executing a workover, performing a remedial cement squeeze with a pulling unit, the cement unit was being refueled. While refueling the fuel tank overflowed and 3 bbls of diesel was discharged to the ground. well operations were being conducted and since the cement unit is connected to the well, it is considered part of the process. Therefore, this is a PSE; the volume is ≥1.4 bbls making this a Tier 2 PSE.	Tier 2 PSE (Table E.4) This is not a WCI.
	As above, but with secondary containment installed below the fuel tank so the spill did not reach the ground/environment. In this case the spill is still considered a PSE as it was an unplanned loss of primary containment (LOPC).	
104	While performing a wireline perforation job on a horizontal well on land, pumps were used to pump down the wireline tools. The wireline BOP and lubricator were supported by a crane. The lubricator disconnected from the wellhead crown valve when the quick-connect malfunctioned and 160 bbls of brackish water was discharged to the ground. The well was isolated by the wireline operator closing a remotely operated shear seal valve integral to the X-tree. As the lubricator is connected to the well it is part of the process. As brackish water is non-hazardous, there is no Tier 2 or 1 threshold exceeded, a company may count this as a Tier 3 KPI.	Possible Tier 3 PSE KPI
	Same as above but the fluid used was a gel containing 8 bbls of strong bases. The material released exceeds the Tier 2 threshold for strong Acids or Bases (> 7 bbls), so this is a Tier 2 PSE.	Tier 2 PSE (Table E.6)
	Note that a LOPC of strong acids or bases cannot be Tier 1 PSE based upon quantity released, no matter the volume. If the fluid used was a gel containing moderate bases (alkali), this would be also a possible Tier 3 event. It is not a Tier 1 or 2 PSE as the moderate acids or bases are classified as non-hazardous and does not have threshold volumes.	Possible Tier 3 PSE KPI
	One well barrier envelope was lost when the lubricator disconnected from the wellhead. A remaining barrier envelope functioned as designed. This is a Level 3 WCI.	Level 3 WCI.

	Example	Reporting
105	While performing a frac-pack stimulation treatment offshore the treating pressure started to increase quickly due to a potential screen out, the engineered pressure relief valve (PRV) activated as designed and discharged 44 bbls of frac fluid to a catchment tank on the frac vessel. The frac tanks and associated pipework is connected to the well and hence considered to be part of the process. The fluid was KCL brine with additives used for friction reducer, the volume was estimated at 20 bbls of brine and polymer. the activation of the relief valve is considered a demand on a safety system so this is a process safety event. However, as the fluid was contained within the tank, this would not be a Tier 1 or Tier 2 PSE. The discharge was to a safe location as designed without any consequences listed in Table E.3, i.e. the volumes do not matter. A company using a Tier 3 PSE KPI to track demands on safety systems could report this event as an activation of a PRD. If the fluid overflowed the catchment tank on the frac vessel, this would also be a possible Tier 3 PSE. It is not a Tier 1 or 2 PSE as the fluid is not hazardous and does not have threshold volumes. The well barrier envelopes have not failed nor been degraded by the activation of the PRV. This is not a WCI.	Possible Tier 3 PSE KPI (Table E.3) This is not a WCI
106	A Hydraulic Work-Over unit was involved in abandonment operations of a live well, the work string was being snubbed into the well. Just after a joint of pipe was made up and lowered into the well, flow was observed coming from the top of the pipe indicating that the back-pressure valves in the string had failed. The pipe was lowered to the work basket level and a fully opening safety valve was stabbed and closed to stem the flow. It was subsequently determined that 65 kg (143 lbs) of methane gas was released. This is a Tier 2 PSE because there was a LOPC of 50 kg (110 lbs) or more of flammable gas in any one-hour period. Failure of the back-pressure valves has compromised the primary barrier envelope. This is a Level 3 WCI.	Tier 2 PSE (Tables E.2 & E.4) Level 3 WCI.
107	A Coiled Tubing Unit was involved in a tubing clean-out activity pumping acid. During the process of pumping a strong acid downhole, fluid was observed to be spraying from between the wraps of coil left on the drum. Pumping was halted and the leak stopped indicating the downhole check valves were fully functional. calculations established that 0.8 bbl (115 kg/253 lbs) was released. No further fluid was seen leaking from the coil and preparations were made to pull out of hole. This is not a Tier 1 or Tier 2 PSE since the spill event did not exceed the threshold quantity of ≥1000 kg (2200 lbs) of strong acid in any one-hour period. However, this event can be reported within the Tier 3 KPIs of the company or facility.	Possible Tier 3 PSE KPI
	Same as above, except the Coiled Tubing operator was sprayed in the face with acid when he went to investigate the leak. If this incident had resulted in a recordable injury which was not a LWDC or fatality (i.e., a restricted workday case or a medical treatment case), it would be a Tier 2 PSE.	Tier 2 PSE (Table E.1) and a recordable injury
	The primary well barrier, including the downhole check valves, and the secondary well barrier, including the BOP shear / seal rams, remain effective. This is not a WCI.	This is not a WCI.
108	A well test was being conducted on an onshore exploration well, flowing to a burner pit via a test separator package. A leak occurred in the pipework connecting the Pressure Relief Device to the separator vessel. The process operator initiated an Emergency Shutdown (ESD), and the well was successfully closed-in. The liquids in the test package were blown-down to the burner pit at a safe distance from the test package. Based on the vessel pressure and the hole size a process calculation determined that 21 kg (46 lbs) methane was released to atmosphere. The well test package is connected to the well and considered to be part of the process. This is not a Tier 1 or Tier 2 PSE since the spill event did not exceed the threshold quantity in any one-hour period. However, this event can be reported within the Tier 3 KPIs of the company or facility.	Possible Tier 3 PSE KPI
	Same as above, except the gas released ignited and the fire from a leak causes damage greater than $15,000 but does not create a LOPC greater than the threshold quantity or cause a fatality or serious injury. This is a Tier 2 PSE since the damage was greater than $2,500.	Tier 2 PSE (Table E.1)
	The well barrier envelopes have remained effective. This is not a WCI.	This is not a WCI

	Example	Reporting
109	During a rig-supported electric line perforating operation during the completion of a production well, a methane gas release is experienced from the quick disconnect in the lubricator. The rig is winterized, and the drill floor is fully enclosed. Following an initial delay to stem the release, the wireline BOP was closed around the wireline and after 15 minutes the leak has ceased. During this time a total of 30 kg (66 lbs) of methane has been released above the drill floor. The LOPC occurred while the lubricator was connected to the well and the release amount exceeds the 'indoor' threshold for a Tier 2 PSE (25 kg or 55 lbs) and since the released amount occurred in less than one hour, the event is a Tier 2 PSE.	Tier 2 PSE (Table E.4)
	A similar leak during a stand-alone wireline operation (outdoor) would not be recognized as a Tier PSE as the applicable threshold for a Tier 2 PSE would be >50 kg or 66 lbs, however the WCI classification will still apply. Possible Tier 3 PSE KPI.	Possible Tier 3 PSE KPI
	One of the well barrier envelopes failed when there was a leak at the quick connect hence this is at least a Level 3 WCI. The secondary barrier envelope, including the wireline BOP, was effective however the delay in stemming the leak may be indicative of complications hence this is possibly a Level 2 WCI.	Possible Level 3 or Level 2 WCI
110	During a deep-water offshore intervention operation, a subsea leak is found by the ROV from an Intervention Riser System deployed from a light well intervention vessel performing wireline operations on a producing well. An estimated 4 bbls of condensate were released into the sea before the tree valves were closed (duration < 1 hr). The riser system is part of the process, and the release quantity and fluid type exceed the Tier 1 threshold for outdoor release of flammable liquids. The determination of a PSE is not dependent on the environment into which the LOPC occurs (e.g. to ground or in the water column). The leak in the intervention riser system is a failure of a well barrier envelope. This is a Level 3 WCI.	Tier 1 (Tables E.2 & E.4) Level 3 WCI.
111	A wellhead maintenance contractor started to remove the vent cap from a grease injection fitting on an annulus valve. The well had sustained casing pressure in that annulus. He used one wrench rather than two and so unscrewed the entire fitting. The corroded fitting ejected causing a continuous release of gas to the atmosphere in the open wellbay until the annulus gate valve was manually closed. An estimated 75 kg of gas was released. The wellhead is part of the process, and the release was unplanned and uncontrolled. The release quantity exceeds the Tier 1 threshold for outdoor release of flammable gases.	Tier 1 PSE (Table E.2 and E.4)
	As above with a release volume less than the Tier 2 threshold, but the technician is hit and injured by the ejected fitting and results in a Lost Workday Case. In this case, although the volume does not exceed the release threshold, the injury associated with the release classifies this as a Tier 1.	Tier 1 PSE (Table E.1) and a LWDC
	The wellhead maintenance was being conducted on a producing well, not during well operations. This is not a WCI.	This is not a WCI.
112	During a wireline activity running in hole with the tool string on slick line, a minor release of gas is observed from the stuffing box. The hydraulic pressure on the stuffing box is slightly increased within the operating envelope of the control equipment and the leak ceases, so operations continue. Minor releases from the stuffing box are inherent with the process and controlled procedurally. This event is therefore not considered an LOPC if the release is timely addressed and managed by adjusting the stuffing box in accordance with the operating procedures for the equipment. This event has potential to escalate so is a Level 4 WCI.	Not a Tier 1 or Tier 2 PSE Level 4 WCI
	As above, but now it is not possible to stem the release by manipulation of the hydraulic pressure within the operating limits as the stuffing box elements have worn down and will not provide an adequate seal anymore. The wireline BOP is closed, and the packing element was replaced before continuing operations. Now the release of 15 kg of methane is considered a LOPC as the equipment has failed to maintain the containment. As the released volume was below the threshold for an outdoor methane release, it is not a Tier 2 PSE but a possible Tier 3 KPI.	Possible Tier 3 PSE KPI, possible WCI (lost barrier)
	A well barrier envelope has failed but there is a remaining well barrier envelope operating as expected. This is a Level 3 WCI.	Level 3 WCI

References

[1] 'ANSI/API RP 754 - Process Safety Performance Indicators for the Refining and Petrochemical Industries. 3rd Edition'. American Petroleum Institute, August 2021, https://www.api.org/oil-and-natural-gas/health-and-safety/refinery-and-plant-safety/process-safety/process-safety-standards/rp-754 (Accessed 15 May 2023)

Part G - Tier 3 and Tier 4 Indicators

Scope

Tier 3 and 4 indicators are primarily designed for monitoring and review of barriers and the management systems that support their performance, especially at the operational level.

These indicators are often considered leading because they are implemented as predictive measures compared to the lagging Tier 1 and 2 indicators.

This part explains the difference between Tier 3 and 4 indicators and provides guidance on how to select effective Tier 3 and 4 indicators to monitor critical barriers.

Barrier thinking

A barrier is designed to either prevent an event caused by release of a hazard (a prevention barrier) or to mitigate an event's potential consequences (a mitigation barrier).

Multiple barriers are normally deployed in combination to address each type of threat or cause of an event and its consequences.

See the glossary for the definition of barrier and related terms.

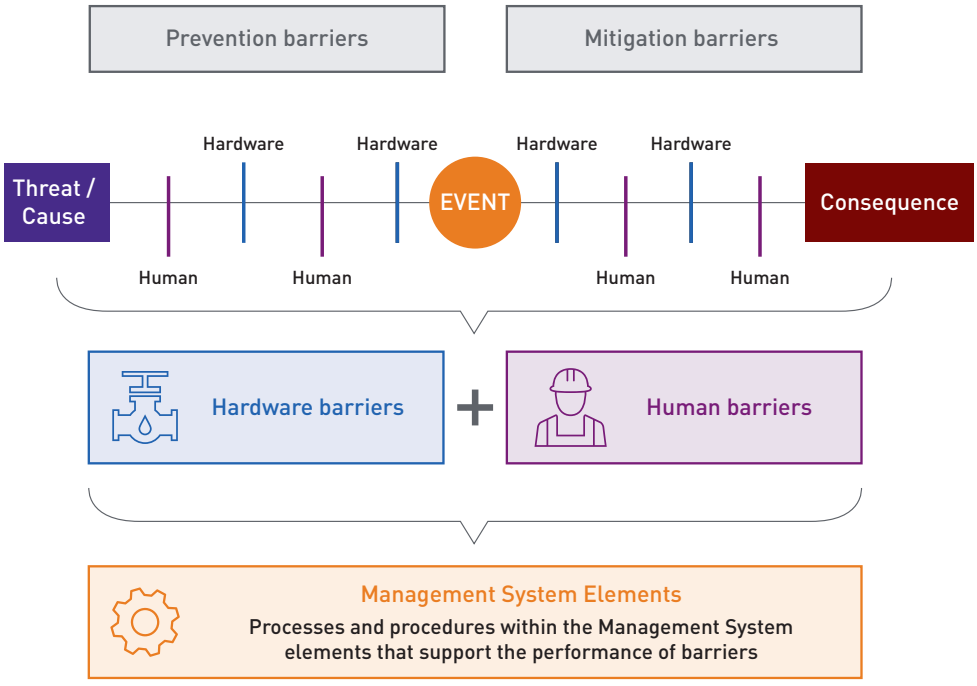


Figure G.1: Barriers can be either hardware barriers or human barriers. They are supported by Management System Elements

Hardware barriers

Hardware barriers are primary containment, process equipment, and engineered systems designed and managed to prevent and mitigate process safety events. These barriers are checked and maintained by people.

Human barriers

Human barriers rely on the actions of people capable of carrying out activities designed to respond and act to manage the potential cause or threat of an event.

Guidance on the IOGP standardized barrier model is provided in Report 415 and Report 544.

Management System Elements

The elements of an asset's management system provide the necessary support processes, policies, and practices to ensure the barriers are effective throughout the asset's life.

The distinction between barriers and Management System Elements is important because focusing on the barrier identifies what went wrong. Any corresponding shortfall in the management system contributing to or causing barrier lapses can highlight systemic weaknesses.

For more examples of barriers and management systems, see IOGP Report 544 - *Standardization of barrier definitions*.

When identifying barriers and management systems, consider the following inputs:

- **Proactive input** relies upon identification of hazards and risks which could lead to a major incident. Information can be drawn from recent Process Hazard Analysis (PHA) and other risk assessments related to process safety, which will include the barriers identified to manage the risks. Proactive input confirms which barriers are in place to control the most important process safety risks and the management system elements to maintain and improve those barriers.
- **Reactive input** is based upon root cause investigation of major incidents and high potential events or demands on safety systems that could, in other circumstances, have resulted in an actual incident. The review of root causes should be mapped against both hardware and human barriers as well as management system elements to identify those that are most critical to future incident prevention based on past incidents, or to identify the need for new barriers where gaps exist. Such a review can also be supported by evidence from process safety and occupational safety audit findings. At a more detailed level, reactive input identifies weaknesses in barriers.
- **External input** takes account of experience and best practice barriers shared in the oil and gas or other industries, often as a result of past major incidents. Learning from others can highlight key barriers and often suggests KPIs which can be considered in Step 4 of the Six-step approach for selecting process safety KPIs (Part B, *Selecting process safety KPIs*).

Indicators should be in place to measure the performance of key barriers. Establishing indicators for all barriers is not feasible and could overwhelm operators and management. When selecting barriers and management systems for establishing indicators, organisations should consider the importance of the barrier in terms of mitigating the risk of a major process safety incident (as specified in the risk studies) and the current performance of the barrier.

Barriers can be assessed using a combination of leading and lagging KPIs.

- Tier 4 KPIs are leading and monitor operational activity to maintain or strengthen a barrier or management system
- Tier 3 KPIs are more lagging and record the number of failures of a barrier
- In this context, Tier 3 indicators are also considered leading when used as predictive KPIs with respect to more severe consequences characterized by Tier 1 and 2 PSEs. In general, Tier 3 indicators are selected such that targets are set towards 0 in the long term, while Tier 4 indicators are selected such that targets are set towards 100% conformance in the long term.

Tier 3 KPIs

A Tier 3 indicator records an operational situation which has challenged the safety system by progressing through one or more barrier weaknesses to result in an event or condition with:

- release thresholds or consequences that do not meet the criteria for Tier 1 or 2 PSEs, or
- no actual consequences but the recognition that, in other circumstances, further barriers could have been breached and a Tier 1 or 2 PSE could have happened.

Tier 3 KPIs reflect outcomes of unintended, unplanned or uncontrolled events, conditions, circumstances, or effects that represent impairment or failure of a barrier; therefore, targets for Tier 3 KPIs are typically set towards zero. Hazards alone – e.g., as recorded in a Risk Assessment – are not Tier 3 KPIs.

In early stages of collecting this data, organisations may need to encourage a culture of accurate recognition and reporting of Tier 3 events. Over time, Tier 3 KPIs mature resulting in consistent reporting practices, and the organisation can learn from and correct the weaknesses that caused the Tier 3 events. As those learnings are shared and implemented, the Tier 3 KPIs should reduce toward zero. Addressing the weaknesses in barriers and management systems that resulted in a Tier 3 KPI event or condition can help prevent incidents of a more serious consequence.

Types of KPIs implemented at Tier 3 could include numerical data or other parameters related to:

- LOPC below Tier 2 thresholds
- demands on safety systems, e.g., pressure relief devices (Tier 3 example 1)
- safe operating limit excursions (Tier 3 example 2)
- impaired or bypassed safety systems
- safety systems failing on demand or in test
- primary containment inspection or testing results outside acceptable limits.

LOPC below Tier 2 thresholds is the most lagging indicator among the Tier 3 indicators proposed. This indicator can help to develop a stronger process safety culture in an organization, recognizing the importance of reporting and analysing more minor PSE events (i.e., those that are expected to be more frequent than Tier 1 and 2 PSEs), which could, in other circumstances, have realistically resulted in more severe consequences.

This KPI is also relevant for well operations activities and further guidance on well operations Tier 3 events can be found in Part J.

The following two Tier 3 examples are brief descriptions of Tier 3 KPIs provided in API RP 754, which should be consulted for the complete text.

Tier 3 indicators are intended primarily for internal company use at the facility, business or corporate level, but may occasionally support external reporting. Tier 3 indicators are specific to particular facilities or company systems, and so they are not generally suitable for company-to-company or asset-to-asset benchmarking, whereas their trending analysis can provide value in proactively identifying barriers weaknesses at facility level.

Tier 3 example 1: Demands on safety systems

This KPI monitors demands on safety systems designed to prevent an LOPC or to mitigate the consequences of an LOPC. A system can include sensors, logic solvers, actuators, and final control devices designed to prevent an LOPC, or it can include a Pressure Relief Device (PRD) and flare or scrubber that function together to mitigate the consequences of an LOPC.

All of these elements function together as a system and when a demand is placed on the system, a single event is counted, regardless of the number of devices that must function within the system.

A Demand on a Safety System is counted, regardless of the phase of operation (e.g., start-up, shutdown, normal, temporary, emergency) when one of the following occurs:

- activation of a safety instrumented system
- activation of a mechanical shutdown system
- activation of a PRD not counted as Tier 1 or 2, with release of material directly to atmosphere
- activation of a PRD not counted as Tier 1 or 2, with release of material to atmosphere via a destructive device (e.g., flare or scrubber).

The KPI count is typically segregated by the four types of demand above. Some companies find that a rate of demands per safety system type provides a more useful indicator than a simple count.

A demand resulting from intentional activation of the safety system during periodic device testing, or manual activation as a part of the normal shutdown process is excluded. A PRD is considered to have been activated when the system pressure reaches the device set point whether or not the PRD performs as designed. Activation of PRDs includes safety valve lifts above the set point, rupture disc or pin replacement (except preventive maintenance) and deflagration vent re-seats but excludes pressure/vacuum vents (e.g., on tanks) unless the vent fails to function as intended or the release is an upset emission from a permitted or regulated source.

Tier 3 example 2: Safe Operating Limit (SOL) excursion

This KPI monitors process parameter deviations that exceed the Safe Operating Limit (SOL) applicable to specific operations at a facility. This includes different operating phases including start-up, shutdown, and normal operation which may have different SOLs for the same equipment.

Figure G.2 shows the relationship between Normal Operating Limit, High/Low Alarm Limits, and the SOL (or equivalent High-High Level Shut Down) system. Reaching the SOL represents the point beyond which troubleshooting ends and pre-determined action occurs to return the process to a known safe state. The pre-determined action can range from manually executed operating procedures to a fully automated instrument based control system.

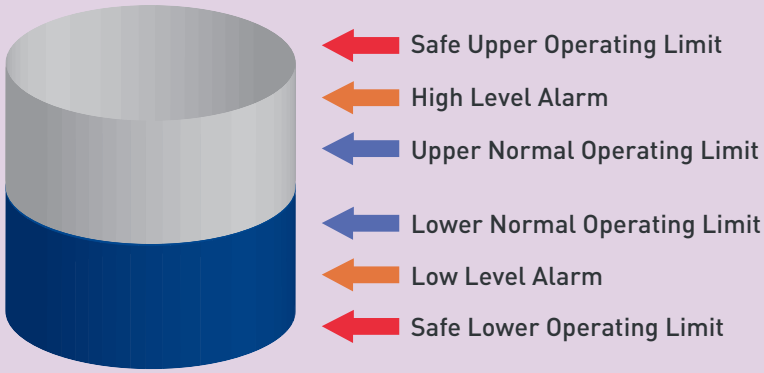


Figure G.2: Storage tank example of safe operating limit KPI [From API RP 754]

The Tier 3 KPI counts each event or condition resulting in a SOL excursion (i.e., a recorded exceedance of the SOL in a specified time period). A Company may want to record specific data or information about individual SOL excursions, including operational phase, excursion duration, material in the tank and, following investigation, root causes of the SOL. A single initiating process event or condition can result in a number of SOL excursions for different equipment (e.g., site-wide failure of a utility) and each excursion should be counted separately. A process condition that hovers near the SOL value for one piece of equipment results in multiple excursions that should be counted as a single event or condition.

Tier 4 KPIs

Tier 4 indicators proactively measure the asset-specific efforts to maintain and improve the completeness, integrity, strength, or quality of barriers and supporting Management System Elements.

Tier 4 indicators support understanding of the effort required to reduce barrier weaknesses to an appropriate level in terms of risk management and the maturity of any existing performance indicators.

Measures can be focused on:

- equipment maintenance, inspection and testing
- process hazard and major incident risk assessments
- quality of, and adherence to, operating procedures
- facility management of change
- contractor capability and management
- audit improvement actions
- process safety initiatives
- workforce and management training and development
- technical competence assessment and assurance.

Tier 4 indicators are more effective when applied in combination with lagging indicator information. This would include correlation with Tier 1, 2, and 3 data, and particularly when root cause analysis provides specific indications of barrier weaknesses related to the effective implementation (operating discipline) or effectiveness (performance) of management system requirements.

Tier 4 indicators are intended primarily for use by operators, first-line supervisors, engineers and managers at the facility or business level where awareness of specific hazards, detailed understanding of the plant and local ownership of risk management is most critical.

However, a few Tier 4 KPIs can be rolled up to business or corporate level to assess management system barriers which are highly standardized across a company. Because of specificity to facilities or company systems, Tier 4 indicators are not generally suitable for company-to-company benchmarking, whereas their trending analysis can provide value in anticipating Management Systems Elements weaknesses situations at facility level.

Dual assurance – Tier 3 and 4 in combination

The role of Tier 3 KPIs is to proactively track and identify the weaknesses of barriers and then eliminate or minimize these defects.

The role of Tier 4 KPIs, in contrast, is to use indicators to measure targeted management system assurance or check processes to assess whether specific barriers are being maintained as intended.

The concept of using Tier 3 and 4 in combination is called **dual assurance**, introduced in UK Health and Safety Executive's Report 254 - *Developing process safety indicators: A step-by-step guide for chemical and major hazard industries*. Dual assurance is related to the correlation between the extent of weaknesses in a barrier and level of proactive activity (effort and investment) to maintain a barrier's integrity.

For each key barrier (those of highest concern to the company or facility), a good practice is to identify one leading KPI at Tier 4 level and one lagging KPI from a higher tier. These two 'matched' KPIs can then be used in combination to assess the performance of the selected barrier.

Whereas Tier 1 and 2 yield knowledge on barrier failures, dual assurance aims to be preventative in terms of future events by providing remedial or special measures focused on key barriers.

Note that Tier 3, in this instance, is considered lagging relative to Tier 4. This approach differentiates Tiers 1 to 3 that measure outcomes (i.e., unintended events or effects) versus Tier 4 KPIs that measure inputs that sustain barriers including the implementation and continuous improvement of Management System Elements.

A simple example of dual assurance would be a leading Tier 4 KPI to monitor the number of completed tests of a company's alarm system against the number of planned tests of that system, linked with a lagging Tier 3 KPI which monitors the number of alarm system failures, either actual or during testing. Combined, these two KPIs provide data to assess whether the ongoing maintenance and testing regime of safety critical alarms is sufficiently effective to ensure that any weaknesses in the barrier are monitored and minimized to an acceptable level.

Over time, in parallel with improvement actions to strengthen the barriers, analysis of the KPIs is used to correlate Tier 3 and 4 indicators and determine whether the actions are resulting in the desired improvement of the two key barriers. Typically, this correlation is the subject of annual review when Tier 3 and 4 results are analysed comparatively to determine if better barrier performance can be verified, i.e., a sustainable reduction in Tier 3 has been achieved due to corresponding improvements in operating practices and processes.

When establishing a process safety indicator program, companies often implement the Tier 3 KPIs described in section 2 without 'matching' Tier 4 KPIs. As the program matures, the established Tier 3 KPIs may or may not be 'matched' with a Tier 4 KPI to support the concept of dual assurance.

An annual review of process safety KPIs should assess the value of continuing to measure all existing Tier 3 and 4 KPIs, recommend changes to the suite of KPIs and determine where dual assurance would provide additional insight into the performance of key barriers.

Selection of Tier 3 and 4 KPIs

Choose Tier 3 and 4 KPIs which operators and engineers recognize as meaningful and applicable to the specific barrier systems in place at the facility. The indicators selected should provide actionable information which directs activities to further improve barrier strength and address identified weaknesses.

Facilities should determine which barriers are key for management of major incident risk then select suitable leading and lagging KPIs for each key barrier.

Take care to avoid overwhelming staff with too many indicators – be selective and focus KPIs on barriers which are important in terms of managing major risk or address known weaknesses.

It is not necessary to monitor every constituent part of a key barrier to assess performance. A single, well-selected KPI will often provide notice of performance changes that signal the need for further investigation (analogous to a doctor measuring blood pressure before undertaking further tests).

Consider the following factors for each key barrier:

- Which activities or operations must be undertaken correctly on every occasion?
- What aspects of the barrier's hardware, human factors or processes are liable to deteriorate over time?
- Which activities are undertaken less frequently?

From these factors, identify an aspect of the barrier functionality that is essential to delivering the barrier's desired outcome. There can be an acceptable tolerance of deviations which is applicable when setting the KPIs.

The KPIs should then directly measure:

- Tier 3 – the number of recorded occasions (or other quantifiable measure) that indicates the barrier has not delivered its planned outcome
- Tier 4 – the amount of input activity (e.g., effort, investment) related to an essential aspect of maintaining or improving the barrier's intended performance.

Further guidance

The Center for Chemical Process Safety (CCPS) has provided a comprehensive selection of possible KPIs for each of 20 management system elements (see CCPS *Process Safety Metrics Guide for Lagging and Leading Indicators*).

In API RP 754, Annex J, API has suggested 10 Tier 4 KPIs and UK HSE 254 has illustrated their dual assurance concept by providing a selection of possible leading and lagging indicators for nine common barriers.

Example indicators are also discussed in Part H, *Examples of leading process safety Key Performance Indicators.*

References

[1] IOGP Report 415 - *Asset integrity – the key to managing major incident risks.*

[2] IOGP Report 544 - *Standardization of barrier definitions.*

[3] 'ANSI/API RP 754 - Process Safety Performance Indicators for the Refining and Petrochemical Industries. 3rd Edition'. American Petroleum Institute, August 2021, https://www.api.org/oil-and-natural-gas/health-and-safety/refinery-and-plant-safety/process-safety/process-safety-standards/rp-754 (Accessed 15 May 2023)

[4] 'HSG254. Developing process safety indicators: A step-by-step guide for chemical and major hazard industries'. *UK Health and Safety Executive (HSE)*, 2006, www.hse.gov.uk/pubns/books/hsg254.htm (Accessed 15 May 2023)

[5] 'Guidelines for Risk Based Process Safety.' *Center for Chemical Process Safety (CCPS) - American Institution of Chemical Engineers*, 2007, Guidelines for Risk Based Process Safety | AIChE (Accessed 15 May 2023)

[6] 'Process Safety Metrics Guide for Leading and Lagging Indicators. 4.1 version'. AIChE CCPS, June 2022, CCPS Process Safety Metrics - V4.1 2022.2 (aiche.org) (Accessed 15 May 2023)

Part H - Examples of leading process safety Key Performance Indicators

Scope

Part H provides examples that illustrate the application of dual assurance using Tier 3 and 4 KPIs to assess the performance of both prevention and mitigation barriers.

It shares good practice based on recent company experience or significant past events in our industry.

It provides **four generic groups of leading indicators**:

- **Groups A and B** focus on **lower consequence events**

  These KPIs recognize the learning that can be gained through analysis of more frequent events broadly categorized either as **Minor spills and releases** (LOPC below Tier 2), and **Challenges to safety systems** (threats to the final layers of protection)
- **Groups C and D** focus on individual barriers

  Group C covers **Hardware barrier weakness**

  Group D covers **Human barrier impairment**

Many of the examples are set in the context of past incidents to demonstrate the value of setting leading indicators to prevent recurrence of barrier failures by proactively identifying and eliminating their weaknesses.

Leading indicators are not intended to be limited to barriers that failed in past incidents. To prevent future events, it is important to proactively and continually seek evidence of other barrier weaknesses and deploy appropriate indicators to address these deficiencies before new incidents occur.

Group A – Minor spills and releases

This type of KPI is arguably more lagging than other Tier 3 indicators. It is important because it provides additional information on the Process Containment hardware barrier. It may also provide information on the *Operating in accordance* with procedures barrier.

Because Tier 1 and 2 PSEs are likely to be infrequent at the asset level, there is value in collecting and analysing data on LOPCs that fall below the Tier 1 and 2 thresholds, and categorising these as Tier 3 events. Good practice at the asset level is to use the company-wide data collection system to classify and quantify all LOPCs, irrespective of the amount or type of substance released or activity involved.

The key is to have a workforce culture that understands that any unintended spill or release needs to be 'recorded' and that this is recognized positively by management. Once recorded, events can then be classified to generate Tier 3 KPI data.

Example – Spill and Release Data

Today most companies have sophisticated computer systems to record, collate, and analyse event and incident data in support of an operating management system. The system may also be used to record data that it not event based, e.g., continuous emissions or discharges.

Such data systems can be set up with categories to enable classification of all spills and release data that has been recorded by the workforce, no matter how 'minor' the event, and irrespective of definitions such as primary containment or even process safety.

After events are recorded by the workforce, a second step involves a supervisor/manager/administrator trained in use of the data system and KPIs reviewing the data to ensure its completeness and accuracy, as well ensuring the data is classified properly against the company's KPI definitions.

At a basic level, the system can be configured to automatically enter data, allow for repeat entries, or use drop down lists to ensure information can be recorded easily and quickly.

Basic information should include:

- time, date, and organisation details
- substances involved and estimate of quantity and duration of release
- type of energy release, if involved (e.g., pressure or temperature/fire)
- exposure of any person to the substance
- location – on-site, off-site, mobile or fixed plant, name of unit/facility
- was substance released into secondary containment or released directly into the environment (air, ground or water). If secondary containment, was it breached?
- brief description of the event.

Assets may consider this phase as 'recording' of spill and release data, rather than 'reporting' of KPIs. The reported KPIs in scorecards and to corporate level are then the result of classifying the data in the system. By making the event 'reportable', it means that certain thresholds and criteria have been met, namely a) confirmation the spill or release was from primary containment and b) the event was associated with a process.

It can be necessary to ask additional questions, such as:

- Did the quantity exceed company or regulatory threshold criteria for oil spills? Or Tier 1 or 2 PSE thresholds?
- What were the actual and potential consequences of the event, including injuries, illness, or damage?
- What standard barriers failed or were impaired?
- What was the cause of the event (a standard list of causes helps)?

The advantage of recording all LOPCs initially in the data system, and then classifying afterwards, is that different assets can then determine their reportable KPIs from the basic recorded data, and that this determination can evolve over time.

For example, a Tier 3 'Minor LOPC KPI' could be easily established from a subset of the data based on thresholds that are a fraction (e.g., 10%, or 1%) of the Tier 2 thresholds to increase the available data to test specific barriers.

Group B – Challenges to safety systems

These KPIs can provide considerable insight into systematic weaknesses and improvement opportunities for hardware barriers, particularly Process Containment, and human barriers, particularly *Response to process alarm and upset conditions*; see IOGP Report 544.

For each of these barriers:

a) An unintended or undesirable condition (excessive temperature or pressure, change in fluid gas composition, corrosion, overfill or other circumstances) causes the hazard (i.e., hydrocarbon liquid or gas) to create an effect that places stress (a 'challenge') on the barriers.

b) The challenge is detected (e.g., by sensors or other means) and acted upon through hardware controls, such as relief systems or through human intervention.

c) Because the challenge was not intended, it provides evidence that the overall system of barriers is weak or is impaired.

d) The number of challenges and their characteristics are recorded so that the data can be classified for reporting as Tier 3 KPIs.

e) The data has greatest value when the characteristics are analysed to confirm the initial and root causes of the challenges and determine how barriers have been compromised to allow such challenges to occur.

f) Depending on the maturity and type of the plant, the safety systems may be fully automated multi-layered barriers with no requirement for human action or intervention.

At the asset level, the safety systems generally provide data streams automatically and the key is to select and extract the most appropriate data for the KPI and to confirm the causes and modes of barrier failure. Most often the barriers in combination are effective and LOPCs do not occur, but Tier 3 events demonstrate that at least one barrier was ineffective.

Examples of these Challenges to safety systems Tier 3 KPIs include:

a) safe operating limit (SOL) excursions

b) demands on Safety Systems (DOS), which can be defined with greater specificity to monitor:
   - activation of Mechanical Shutdown System
   - activation of Pressure Relief Device (PRD)
   - well control upsets/kicks
   - activation of a safety instrumented system (SIS)

c) safety systems that failed on demand, which could separately monitor:
   - prevention systems, such as pressure relief and isolation
   - mitigation systems, such as alarm, ignition control, and suppression

d) average (and/or maximum) Alarm Rate, which could include the human response by adding:
   - number of alarms per control panel operator above target threshold
   - number of console operator shifts exceeding an alarms/hour threshold.

The identification of appropriate Tier 4 KPIs should be based on the causes and modes of barrier weakness. The Tier 4 KPIs related to the examples above will often be based on confirmation of the effective implementation of processes that support management system elements, such as maintenance or competence/training.

Examples include completion of:

- inspections of equipment designed to prevent LOPC
- leak detection and repair programme completed on time
- fatigue risk education/awareness
- training for process safety critical positions
- competency assessments.

The Alarm Floods example is based on two major accidents and highlights the importance of setting KPIs that strengthen the prevention barriers on **Process Containment** and **Response to process alarm and upset conditions**.

Example – Alarm Floods

Response to process alarm and upset conditions is an important human barrier and can be effective for both prevention and mitigation of events. The reaction to alarms is important when the potential event is a hydrocarbon release. Detection systems, ignition controls, and efficient shutdown mechanisms can eliminate or greatly reduce the potential consequences of a major LOPC. Past failures have shown that a rapid response to cut off the supply of hydrocarbon to the release point, even if ignition has occurred, could have substantially reduced the impact of an LOPC event. Equally, when the release is an oil spill, a controlled and effective shutdown could greatly reduce the impact on the surrounding environment.

The partial nuclear meltdown in one of two Three Mile Island reactors in 1979 was the worst accident in US commercial nuclear power plant history. A factor in this example was alarm management, which can be critical for control room operators in complex facilities overloaded with information, including alarms. In the Three Mile Island case, operators initially ignored both alarms and temperature and pressure readouts that indicated a loss of coolant.

The catastrophic fire at the Longford Gas Plant in 1998 provides a further example of alarm floods, where operators were expected to deal with 300–500 alarms per day, and, on one investigated incident, 8500 alarms during a 12-hour shift were recorded.

KPIs can be deployed to proactively address alarm flood or other identified weaknesses in the *Response to process alarm and upset conditions* barrier. Example KPIs used in the industry include monitoring the number of operators shifts where the maximum alarm rate is exceeded, which is a Tier 3 KPI. At the Tier 4 level, another company has tracked to completion an alarm prioritisation and review programme. Tier 3 and 4 indicators may also be set to assess the sufficiency and quality of competence assurance of shift teams and/or individuals whose roles support the barrier's performance.

Group C – Addressing weaknesses in other hardware barriers

Failed hardware barriers, such as Structural Integrity or Process Containment caused by, for example corrosion or valve/seal failures, are frequently found to be weakened through physical deficiencies. Data to assess a particular cause and its barriers often already exists through management system processes such as:

a) maintenance

b) inspections and tests

c) safety observations

d) Process Hazard Analysis (PHAs) or HAZOPs

e) audits

f) Process Safety Event or incident investigations.

The aim here is to identify relevant barrier-specific evidence through these scheduled processes. Example Tier 3 KPIs include 'Number of non-conformances on safety critical equipment identified through inspection/ maintenance'. Tier 3 KPIs are often focused on a key barrier (e.g., ignition control) which has been identified as weak through PSE investigations or Process Safety audits.

Corresponding Tier 4 KPIs (for dual assurance) may initially focus on ensuring that the processes that identify and eliminate deficiencies are effectively implemented (sufficiently resourced, on schedule, with actions tracked to closure).

Three examples based on past events are provided here to illustrate the importance of setting KPIs on hardware barriers:

- Maintenance of critical equipment is based on a major UK accident that highlights the value of setting KPIs that strengthen the management system processes that support the Process Containment barrier.
- Certification of electrical equipment and ignition source isolation are important protection measures in the event of leak detection within classified areas.
- Functionality of deluge systems needs to be ensured by regular maintenance and testing as part of an asset's Protection Systems to mitigate the potential consequences of LOPC.

Example – Critical equipment maintenance

In IOGP/Ipieca Report 510 - *Operating Management System Framework for controlling risk and delivering high performances in the oil and gas industry*, Expectation E6.5 within Element 6, Asset design and integrity seeks to ensure that:

> "There are processes to maintain, replace, test, inspect, calibrate, certify and verify performance of assets, facilities, and equipment. These activities are performed at frequencies appropriate to the level of risk, and deviations from specified criteria are managed."

This management system expectation directly supports the Process containment standard barrier in IOGP Report 544.

An example of this barrier failing due to weak implementation of OMS Expectation E6.5 is illustrated by one of the immediate causes of the Buncefield explosion in 2005. An automatic tank gauge became stuck, causing the gauge to 'flatline'. This was a known problem, with 14 previous instances, that were rectified temporarily by operators or through contract engineers without identifying the underlying cause of the malfunctioning gauge. The failure to log the fault and the lack of an effective maintenance regime were management system weaknesses that allowed the threat of overfilling to breach the process containment barrier.

Tier 3 indicators could be used by an asset to ensure that deficiencies of critical equipment such as gauges are logged when observed. Tier 4 indicators would track inspections, testing and maintenance to ensure that these processes were completed, including action closure, with appropriate verification. If significant levels of deficiencies continue to be tracked at Tier 3, review should raise the question regarding the frequency and quality of the inspections, testing and maintenance processes.

Example – Deluge Systems Functionality

Setting Tier 3 and 4 KPIs on protection systems provides additional assurance that can minimize or avoid loss in the event of LOPC. Whether offshore or onshore, the deluge system needs to be fit-for-purpose and well maintained.

In this example, a facility produces significant quantities of liquefied propane and butane for onward transportation by rail and truck. At the truck loading stations, each bay is protected from fire by a manually initiated deluge system comprised of twelve elevated spray nozzles fed from a firewater distribution system via a deluge valve. During a review, the deluge system was activated to demonstrate the functionality of the system. All nozzles were supposed to deliver their design water capacity; however, during the exercise, approximately 20% of nozzles were found to be blocked due to rust scale accumulation in the piping system and nozzles. A system's inability to function as required on demand is a Tier 3 indicator event, whereas the overdue (incomplete) periodic maintenance of the nozzles suggests the need for a Tier 4 indicator.

Group D – Improving performance of other human barriers

Failure of human barriers can result from inadequacy of processes and procedures but, more commonly, are through lack of effective implementation during preparation or execution. Therefore, human barriers typically rely on competence assurance in combination with other supporting management system processes.

Generally, deficiencies result from factors such as insufficient resources (including personnel and time), training, operating discipline and verification. The human barriers Permit to Work (PTW), isolation of equipment, overrides and inhibits of safety systems, shift handover, and acceptance of handover or restart of facilities or equipment are also often impacted by non-routine variations from standard work management practices.

Dual assurance Tier 3 and 4 KPIs that focus on potentially impaired human barriers can provide proactive vigilance of the associated risk and improve barrier performance.

Example Tier 3 KPIs include:

a) non-conformances within operating procedures, Permit to Work (PTW), or related processes

b) temporary modifications continuing longer than planned

c) changes implemented without Management of Change (MOC) or Pre-Start-up Safety Review (PSSR).

At the Tier 4 level, KPIs will vary depending on the affected barriers, but could include:

a) completion of specific training or competency testing

b) completion of audits or other checking processes of Permit to Work (PTW) or Management of Change (MOC)

c) completion of toolbox talks/task risk assessments

d) monitoring over-time and extended shifts

e) ensuring adequate manpower is in place for all shifts.

The industry example here is drawn from the Piper Alpha disaster and highlights the risk of failing to learn lessons from previous incidents. The communication of leading indicator results on key human barriers can heighten awareness within the workforce of a facility's recognition of weaknesses and the need to improve systems, such as PTW and handover.

Example – Failure to learn

A primary cause of the LOPC that resulted in the loss of Piper Alpha in 1988 was the failure of the Permit to Work (PTW) system and a lack of communication during a shift change resulting in lack of awareness that staff should not use a pump that was out of service with its Pressure Safety Valve (PSV) removed. The PTW system had failed just one year before, when a worker was killed in an accident that was the result of a breakdown of communications in the PTW system and an error in the shift handovers.

Evidence of significant weaknesses in key barriers should provide impetus for sustainable learning and improvement actions. One of the processes that could help maintain management and staff focus on PTW and handover improvement is to set and communicate targeted Tier 4 KPIs to confirm progress on the specific improvement actions and corresponding measures that aim to identify and manage remaining weaknesses.

For example, completion of audits of a planned proportion of permits and shift handovers can be monitored as a Tier 4 indicator, as well as tracking completion of PTW and handover refresher training. Corresponding Tier 3 KPIs could be recording of non-conformances of the PTW system and handover procedures identified through audits or PSEs, and the number of staff failing on test of PTW and handover understanding within one month of refresher training. When a barrier is known to be weak, the Tier 3 KPIs should be revealing a significant number of non-conformances and there should be Tier 4 gaps, otherwise the indicators are not sufficiently effective and must be improved to increase insightfulness.

References

[1] IOGP Report 544 - *Standardization of barrier definitions*

[2] IOGP Report 510 - *Operating Management System Framework for controlling risk and delivering high performances in the oil and gas industry*

Part I - Learning from KPIs

Scope

Part I provides high level guidance on consistency in KPI data collection systems, data communication, and review of barrier performance and KPI effectiveness.

Data collection

The aim of process safety KPIs is to help prevent major incidents that are generally the result of multiple, simultaneous barrier failures.

Major incidents do not occur very frequently so it can take a long time to gather statistically relevant data on major incidents alone.

Therefore, systems need to be implemented for consistent collection and analysis of data and related information on more than just major incidents.

Companies should consider the following for each KPI:

- **Engage all parties** who will be involved in the data collection and review process to ensure that there is common understanding of the importance and value of the data, and commitment to regularly checking data accuracy (e.g., the tier classifications of PSEs) and submitting a complete set of data.
- **Establish a clear boundary for the facility, business, or company which lists all discrete assets for which data will be collected**. IOGP/Ipieca/API have provided guidance on developing a reporting boundary, and recommends applying the 'operational approach' for collection of Tier 1 and 2 data. This approach is based on collecting data from 'reporting units' which are assets operated by the company (irrespective of the company's ownership in the company or joint venture). Companies should clarify whether any assets operated by a contractor on the company's behalf are to be included.
- **Clarify the scope of the KPI**. The scope should clarify which activities are included for reporting. Further information is provided on the upstream activities included for Tier 1 and 2 reporting in Part C, *Tier 1 and Tier 2 Indicators*. Companies may decide to widen the scope of a KPI but should ensure that the data system can isolate those data beyond the guidance of Part C to preserve consistency for benchmarking purposes.
- **Ensure that the definition of the KPI is clearly understood and unambiguous**. For a new KPI, a period of pilot testing may be necessary. There can be debate about inclusion of data and therefore a mechanism should exist to provide additional guidance, when required. The set of examples included in Part F, *Examples of process safety event tier classification* provide a useful reference on determining whether an event should be reported based on the definitions in Part C.
- **Consider automating data collection** from the source systems via a central data warehouse to reduce resource burden and ensure that data is available when needed to generate the KPIs.

Example of a KPI specification

Systems should be implemented for consistent collection and analysis of data and related information required to generate the KPIs.

Consider defining KPIs using a specification similar to the example in Figure I.1.

Performance Indicator Specification

KPI Functional Definition			
KPI Name	*[E.g. tier 1 PSEs]*		
KPI Type	*[E.g. lagging or leading]*		
Specified By	*[E.g. site, location]*	Owned By	*[E.g. governance body]*
Objective			
[Describe the objective of the KPI. E.g. To report the number of loss of primary containment events that exceeded the IOGP 456 Tier 1 threshold in order to indicate whether preventative controls were not present or had failed and either detective/mitigative controls failed to initiate in order to promptly isolate the loss of containment. This KPI provides a lagging indication of failed or insufficient controls with potential root causes relating to inadequate management of SCEs or a lack of operational discipline in SCE overrides]			
Definition			
[Provide a specific definition of the KPI, including any calculations required. E.g. This KPI is the sum of the total number of Tier 1 lagging events in the reporting period: *Total number of loss of containment events exceeding IOGP456 Tier 1 thresholds in the reproting period*			
Data Capture Frequency	*[E.g. Weekly]*	Default Granularity	*[E.g. Quarterly]*
Data Capture Method	*[manual/automated]*	Calculated or Provided	*[E.g. Provided]*
Data Source			
[Description of the data source e.g. manual report or a provided set of data. Provide a description of how the KPI is calculated from this data using actual data item names in source data]			
Data Aggregation Requirements			
[Describe any specific data aggregation requirements for the KPI. E.g., if the KPI is a rolling-period percentage, aggregation will not be required if the last calculated daily/weekly/etc. KPI value in the reporting period is sufficient to represent the period. Alternatively, if the KPI is a sum over the reporting period, specify how the data will be summed, e.g. sum of data in reporting period 1 (January – March) for reporting in April]			

KPI Targets and Tolerances					
Out of Tolerance	Tolerance	Target	Best Practice	Zero for Zero	Effective From
KPI Data Recording					
[Where data for the KPI is provided from an external system, this section includes details on the forms, screens, etc. in the source system which provide the data from which the KPI is reported/calculated].					

KPI Authorisation			
Approved By		Date Approved	
Authorised By		Date Authorised	
Reviewed By		Date Reviewed	
Next Review Date			

Figure I.1: Example KPI specification

Communicating the data

Communicating the data is important. If the data is communicated well, it will quickly highlight relevant trends and changes to promote management review and action; if communicated poorly, the presentation of the data may obscure critical performance information or even misdirect management attention.

Regular reporting typically includes a combination of graphical output to show trends, tabulated data and interpretative text.

A **dashboard** can be effective, especially when automatically populated from an electronic database or plant control system. Typically, a dashboard combines and highlights process safety together with related operational data to quickly show change using 'traffic lights', 'dials', or other icons.

Larger organisations might communicate the data to various levels of management by consolidating data in different views and degrees of detail.

Figure I.2 illustrates how different dashboards may be 'stacked' in a data system to serve the various needs of an organisation.

Corporate

Greatest emphasis on purely lagging performance (Tier 1 and 2) across all Business Units (with extensive data aggregation, i.e. no facility-level detail) and including Business Unit leadership commentary on interpretation of KPIs.

Business Unit

Emphasis in trends and correlations in lagging indicators (Tier 1, 2 and 3) across all facilities in the Business Unit (with aggregation of data per facility) and including facility management commentary on interpretation of KPIs.

Facility

Emphasis on trends and correlations in more-leading (Tier 3 and 4) across functions and operations at a facility. Including emphasis on purely leading indicators (Tier 4) linked to operational parameters.

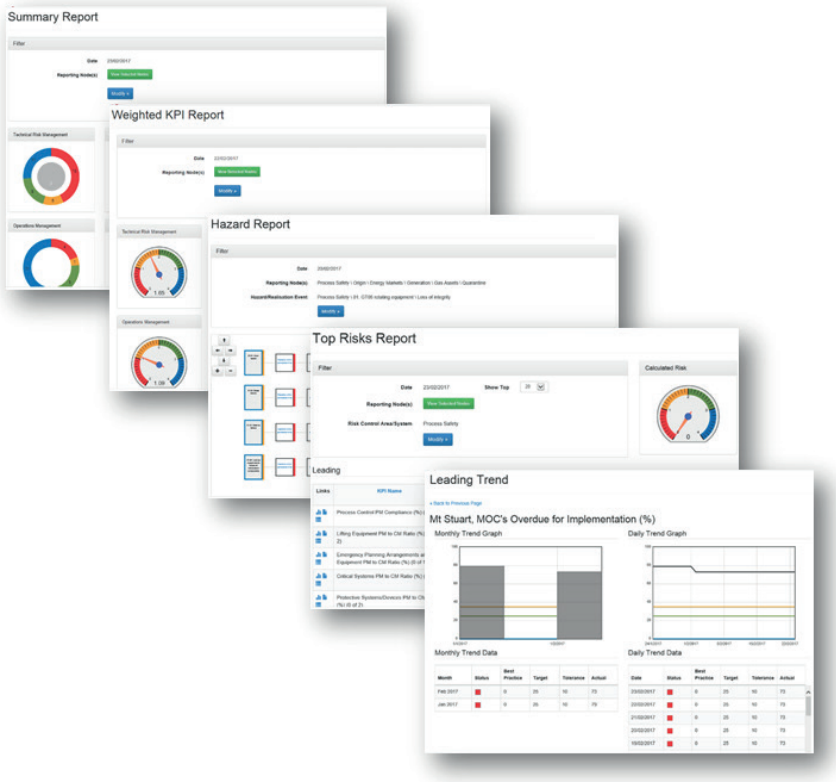


Figure I.2: Use of dashboards at various levels of an organisation

Review barrier performance and KPI effectiveness

Having collected and communicated the process safety KPI data in a timely manner to the right audience, the most important step is to put the data to work and strengthen the barriers and the elements of the management system that support the barriers.

For the KPI data to contribute to the continuous improvement cycle, regular review of the data is required. This typically includes a full annual review and regular interim progress reviews. There is little value from collecting KPI data without regular review to understand whether the facility's current set of KPIs are effective, i.e., delivering the intended outcomes.

Actions should be taken to improve KPIs that are trending in the wrong direction or which reveal intolerable performance. If the KPI does not respond to the actions, then it becomes clear that alternative action needs to be defined and implemented.

The reviews can help assess whether resources to maintain or strengthen a particular barrier are sufficient or excessive in terms of the process safety assurance and improvements achieved. The reviews should also consider if the resources directed at implementing and maintaining Tier 3 and 4 KPIs are appropriate. It is not usually realistic to expect perfect, weakness-free barriers, and therefore the review needs to be risk-based with the aim of reducing key barrier weaknesses to a tolerable level.

In addition to KPI data, other inputs to the reviews can include:

- high-level management systems or specific process safety audit findings
- summaries of investigation outcomes and implementation of lessons learned from Tier 1 and 2 incidents and high potential events
- responses to major incidents elsewhere in the industry
- overviews of plant reliability and correlation with process safety KPIs
- changes to staffing levels, safety critical competencies, training, demographics
- impacts of major start-ups/shutdowns, new developments or acquisitions
- safety culture surveys or behaviour-based safety findings
- benchmarking data from IOGP or other associations
- proposals for new, modified, or eliminated KPIs.

While not all of these inputs may be relevant, it is nevertheless important to use sources of existing data and information to support interpretation and decisions based on the process safety KPIs.

The annual review should also link to the other data needs of the company which will normally include external/public reporting to stakeholders or regulators and also submission of data to enable benchmarking against industry performance norms or comparison with peers.

Tier 1 and 2 PSEs are important when assessing overall performance at the corporate level, including performance relative to peer companies through benchmarking. Individually, each event should be considered an opportunity in terms of learning. Tier 1 and 2 PSE investigations can provide more detail on specific barrier weaknesses that can either confirm existing Tier 3 and 4 KPIs are focused on the most important barriers or can indicate that different barriers may need more attention or that a different focus is needed. There is also value in recognising those barriers that mitigated potential consequences of a Tier 1 or 2 PSE, to ensure that these barriers remain effective in the future.

Leading KPIs at the facility (or company) level need to continually evolve and improve.

For example, a dashboard showing a large Tier 4 gap (e.g., a KPI value of 70% versus a target of 100% for maintenance inspections) versus a smaller Tier 3 gap (e.g., 10% versus 0% target on a corresponding component defects KPI) is a positive scenario as it provides opportunity through better maintenance to close the gap on defects. In contrast, if there is a large Tier 3 gap (e.g., KPI shows an unacceptable level of defects) with a corresponding small or zero Tier 4 gap (e.g.,

95–100 % consistently achieved on the maintenance KPI) then a more challenging Tier 4 measure is probably required to monitor and drive better performance (on maintenance or another system element) and reduce defects.

The specificity of Tier 3 and 4 KPIs to an asset's activities, equipment or processes will generally present challenges in comparing leading indicator data between assets, even within one company. Often it is difficult to normalize Tier 3 or 4 KPI data and this can give rise to complexity in determining completeness of 'denominator' data. These challenges constrain the value of external intra-company benchmarking by aggregating Tier 3 and 4 KPI data. However, there is considerable value at the corporate level, or between companies, in bringing together the insights gained from asset level analysis. This is particularly important at the corporate level as good analysis and presentation of findings is an essential part of engaging senior management in review of process safety performance. Leading KPIs also provide useful catalysts for intra-company sharing of experiences, successes and technical practices on barrier assessment and improvement. These opportunities are facilitated by adopting standard barrier terminology and KPI processes.

Questions to ask during the annual review of KPIs

Incorporation of 'barrier thinking'

- What actions have been taken over the past year to improve barriers as a result of KPI findings?
- Have any additional key barriers emerged that require monitoring using Tier 3 and Tier 4 KPIs?
- Should any current KPIs become more detailed or focused to achieve improvement in one particular aspect of a key barrier?
- Do the current KPIs adequately address the root causes of barrier failure that resulted in any Tier 1 or Tier 2 incidents, or other related high potential events that occurred during the past year? If not, what actions are in place to identify appropriate KPIs?

Effectiveness of KPIs for performance management

- What questions and comments have been raised to understand performance based on Tier 3 and Tier 4 KPIs?
- Is there correlation between improvements in Tier 4 KPIs and a corresponding reduction in Tier 3 events for specific barriers? If not, should any KPIs be modified?
- Should any KPIs be retired because a Tier 4 improvement objective (e.g., inspections in date) has been achieved as planned, with a corresponding reduction in related Tier 3 events?
- Is the number of KPIs appropriate to provide sufficient indication that barriers are being sustained and improved? Equally, is the number of KPIs excessive to the extent that no additional insight results, or data overload obscures understanding, or the reporting burden dilutes operating effort to strengthen barriers?

Improvement of KPIs

- For new KPIs, is the data now sufficiently mature and stable for reliable trending and analysis? If not, is any action required?
- Are there any challenges in definitions, data collection methods or resources that are impacting the effectiveness of the KPIs?
- Are there any good practices shared by other assets, or from external sources, that should be considered?

References

[1] IOGP 544 - *Standardization of barrier definitions.*

Part J - Well Control Incidents

Scope

In addition to process safety events, IOGP defines and collects data for Well Control Incidents (WCI).

Part J provides guidance for a classification system for the WCI KPI.

The guidance is applicable to well operations[1] which includes rig and rig-less activities related to well construction (e.g., exploration, appraisal, development well drilling and completions), interventions and workovers (e.g. wireline, stimulation, coiled tubing) and abandonment. It is not applicable to injection and production operations.

A WCI that results in an unplanned release from the well should also be assessed for its potential PSE Tier classification.

For definitions of well barrier element and well barrier envelope see Glossary.

WELL CONTROL INCIDENTS

Definition of a well control incident

A well control incident (WCI) occurs when there is a failure or degradation of the defined well barrier envelope(s) that are designed and managed to keep fluids in the well or the reservoir.

The WCI levels are a measure of deviation from the general principle of operating with two well barrier envelopes whenever there is the potential for flow.

The robustness of process safety in well operations[1] can be assessed by recording the number and classification level of WCIs.

A Level 1 WCI reflects a failure or degradation of the well barrier envelopes and consequently there is uncontrolled flow:

- at surface into the atmosphere in a surface well blowout, or
- at the mudline for subsea wells, or
- into another downhole formation resulting in an underground blowout

[1] Well operations: All well activities related to well construction (e.g., exploration, appraisal, injection, production drilling and completions), well testing, surveillance, interventions and workovers (e.g., wireline, stimulation, coiled tubing), and abandonment (including downhole plugging and temporary abandonment).

Classification system for Well Control Incidents (WCIs)

WCI Level 1 – Loss of well control

A failure of the well barrier envelopes resulted in uncontrolled flow from the well to surface, seabed, or, via underground communication, to another formation or well.

WCI Level 2 – Complicated well control

One or more well barrier envelopes failed. The remaining well barrier envelope still had pressure integrity but may have been degraded, operated outside its design capacity, or complications resulted in escalation of the response.

Any flow period from the well was temporary, i.e., the well flowed only while planned procedures were immediately implemented.

WCI Level 3 – Routine well control

One or more well barrier envelopes failed. A single planned and tested barrier envelope remained. The remaining well barrier envelope operated within its design capacity and has operated as expected.

Any flow period from the well was temporary, i.e., the well flowed only while planned procedures were immediately implemented.

WCI Level 4 – Near miss or potential well control incident

An incident, including a near miss, that had the potential to escalate and/or could have resulted in the failure of a well barrier envelope.

Example 1

An influx was taken during drilling and the well was shut-in using the BOP. Surface pressure increased and a leak developed at the connection between the BOP and the wellhead. Initially, the leak was drilling mud, but after some time this transitioned to hydrocarbons and the crew were forced to evacuate.

- With no remaining well barriers, this flow is uncontrolled and is a Level 1 WCI.

Example 2

During survey work on a live well, a wireline tool string became stuck across the Christmas tree valves and the wireline BOP. During attempts to free the tool string, gas started leaking from the wireline grease injection head. Increasing grease injection pressure failed to stem the leak. The Christmas tree valves and BOP could not seal around the wireline tools and shearing capability was compromised.

- With no remaining well barriers this flow is uncontrolled and is a Level 1 WCI.

Example 3

On a snubbing operation, prior to entering the well, the pressure gauge connected to the wellhead side outlet was to be changed. When the old gauge was removed, the well started flowing through the side outlet at a rate that prevented it installing the new gauge. Working the side outlet valves upstream of the gauge failed to stop the flow.

- With no remaining well barriers this flow is uncontrolled and is a Level 1 WCI.

Example 4

During tripping out of hole, the well began to flow. The annular BOP was closed prior to installing the full opening safety valve and subsequent flow from the drill pipe prevented the crew from installing the valve. The blind shear rams were activated shearing the pipe and successfully closing in the well.

- The hydrostatic barrier failed. The subsequent well shut-in did not go as expected and the sheared drill pipe has complicated remedial activities including the well kill; the well flowed only while well control procedures were implemented. This is a Level 2 WCI.

Example 5

An influx was taken during drilling and the well was shut-in using the Subsea BOP. A small volume of influx had migrated above the BOP and was in the marine riser before the well was shut-in. The influx above the BOP was safely circulated out without actuating the diverter and the well was conventionally killed.

- The influx occurred as a result of the hydrostatic barrier failing. Remedial activities to remove the influx from, and restore overbalance to, the well were complicated by the requirement to first safely remove the influx volume from the riser. This is a Level 2 WCI.

Example 6

An influx was taken during drilling and the well was shut-in using the annular BOP. During circulating out the influx losses were experienced. The well was eventually controlled using a revised response plan which involved placing a floating mud cap in the hole which allowed casing to be run to isolate the loss zone.

- The hydrostatic barrier failed, allowing an influx into the well. The onset of losses complicated the well control response. This is a Level 2 WCI. If, following the influx, the well had been killed using planned, conventional techniques such as the Driller's method or losses were sufficiently low that conventional techniques could still be successfully implemented this would have been a Level 3 WCI.

Example 7

During drilling increased flow was observed from the well. The driller followed the hard shut-in procedure, securing the well. The well was subsequently killed using the driller's method before drilling operations resumed with a slightly higher mud weight.

- The response and subsequent recovery actions were exactly as per plan; however, the hydrostatic barrier failed. This is a Level 3 WCI.

Example 8

During slickline operations on a live well, the pack-off seals began to leak. The job was stopped, and the slickline BOPs were activated, successfully shutting in the well. The pack-off seals were replaced without incident. The job was completed, and slickline pulled out of the hole without further complication.

- One barrier envelope failed when the pack-off seals leaked; however, the slickline BOPs functioned successfully and the well was closed in. This is a Level 3 WCI.

Example 9

Workover of a pumping well was planned assuming the reservoir had no potential to flow. During pulling of the pump, string flow from the well was observed, and upon closing the annular BOP a small shut-in pressure was measured. The well was killed by bullheading with a slightly weighted brine. Reservoir recharge is assumed to have occurred from the time the workover was planned up to the time the operation commenced.

- The assumed hydrostatic barrier was not present. This is a Level 3 WCI as one barrier remains

Example 10

During well test operations, there was a failure of the low-pressure gas outlet line on the separator and there was a gas release to atmosphere. The emergency shutdown system works as planned, the surface and subsurface safety valves are automatically actuated and the X-tree valves are closed remotely.

- This is not a well control incident.
  Whilst this example describes a serious incident with process safety potential, the line failure occurred downstream of the well barrier envelopes. The well barrier elements functioned as designed and well control was not lost.
  This is a Loss of Primary Containment (LOPC) and is reported as a Process Safety Event (PSE).

Example 11

Surface seepage and gas bubbles were observed during the location clean-up of an old plugged and abandoned well.

- Whilst this is a potentially serious event requiring further investigation, it is not a WCI as well operations were not being conducted.

Example 12

A production operator identified a leak on a producing well at the production wing valve. The well was secured by closing all X-Tree valves and depressurizing the flowline. Subsequent investigation identified that the gasket material in use was not compatible with the highly corrosive well fluids.

- This event occurred on a producing well, not during well operations, and is therefore not a WCI. Due to the LOPC, it should be assessed for its potential PSE Tier classification.

For further examples see Part F.

References

[1] IOGP Report 660 - *Well Control Incident Definitions*

Glossary

Scope

The industry glossary for Process Safety.

It contains some terms from API RP 754. These terms are integral to classifying Tier 1 and Tier 2 PSE.

Acids/bases, weak [From API RP 754]

Substances with GHS Skin Corrosion Category 1C [7] or substances with a pH ⩾ 2 or pH ⩽ 11.5. Either definition may be used for classification. The GHS definition is considered more precise for skin corrosion classification; however, availability of this measurement may preclude its use.

Note GHS Skin Corrosion Category 1C [7] is defined as substances that cause destruction of skin tissue, namely, visible necrosis through the epidermis and into the dermis in at least one animal after exposures > 1 hour and ⩽ 4 hours and observations ⩽ 14 days.

Acids/bases, moderate [From API RP 754]

Substances with Globally Harmonized System of Classification and Labelling of Chemicals (GHS) Skin Corrosion Category 1B [7] or substances with pH ⩾ 1 and < 2, or pH > 11.5 and ⩽ 12.5. Either definition may be used for classification. The GHS definition is considered more precise for skin corrosion classification; however, the availability of this measurement may preclude its use.

Note: GHS Skin Corrosion Category 1B [7] is defined as substances that cause destruction of skin tissue, namely visible necrosis through the epidermis and into the dermis in at least one animal following exposure > 3 minutes and ⩽ 1 hour and observations ⩽ 14 days.

Acids/bases, strong [From API RP 754]

Substances with GHS Skin Corrosion Category 1A [7] or substances with pH < 1 or pH > 12.5. Either definition may be used for classification. The GHS definition is considered more precise for skin corrosion classification; however, availability of this measurement may preclude its use.

Note GHS Skin Corrosion Category 1A [7] is defined as substances that cause destruction of skin tissue, namely visible necrosis through the epidermis and into the dermis in at least one animal after exposure ⩽ 3 minutes during an observation period ⩽ 1 hour.

Active staging [From API RP 754]

Truck or rail cars waiting to be unloaded where the only delay to unloading is associated with physical limitations with the unloading process (e.g., number of unloading stations) or the reasonable availability of manpower (e.g., unloading on daylight hours only, unloading Monday through Friday only), and not with any limitations in available volume within the process. Active staging is part of transportation.

Any truck or rail cars waiting to be unloaded due to limitations in available volume within the process are considered on-site storage.

Asset

Facilities and associated infrastructure, e.g. structures, wells, pipelines, reservoirs, accommodation and support services.

Asset integrity

Asset integrity is related to the prevention of major incidents. It is an outcome of good design, construction and operating practice. It is achieved when facilities are structurally and mechanically sound and perform the processes and produce the products for which they were designed.

Availability

The ability, measured in terms of uptime percentage, of a system to perform its required function.

Barrier

A risk control that seeks to prevent unintended events from occurring, or prevent escalation of events into incidents with harmful consequences.

Competence

A person's ability to meet – accurately and reliably – the performance requirements for a defined role.

Construction

Major construction, fabrication activities and also disassembly, removal and disposal (decommissioning) at the end of the facility life. Includes construction of process plant, yard construction of structures, offshore installation, hook-up and commissioning, and removal of redundant process facilities.

Contractor and subcontractor

Any individual not on the Company payroll, whose exposure hours, injuries, and illnesses occur on site.

Destructive device [From API RP 754]

A flare, scrubber, incinerator, quench drum, or other similar device used to mitigate the potential consequences of an engineered pressure relief (e.g. pressure relief device (PRD), safety instrumented system (SIS) or manually initiated emergency depressurisation) device release.

Direct cost [From API RP 754]

Fire or explosion direct cost includes the material and labor cost of (1) in-kind repairs, replacement, or restoration of process and non-process equipment and tangible public or private property to pre-event condition whether completed or not, (2) aftermath cleanup, (3) material disposal, and (4) short-term cleanup and material disposal associated with fire/explosion emergency response efforts that result in off-site environmental impact (e.g. fire-fighting foam/water runoff).

Direct cost does not include the cost of (1) emergency response personnel, equipment, materials, and supplies utilized to manage the event or incidental damage caused by the emergency response, (2) engineering or inspection assessments to determine the extent of damage or necessary repairs, (3) opportunity upgrades to materials or technology, (4) superficial or cosmetic only damage that

does not affect function or performance to company-owned process and non-process equipment, (5) indirect costs, such as business opportunity, business interruption, fines, and feedstock/product losses, (6) loss of profits due to equipment outages, costs of obtaining or operating temporary facilities, or (7) costs of obtaining replacement products to meet customer demand.

Direct cost does not include the cost of repairing or replacing the failed component leading to LOPC if the component is not further damaged by the fire or explosion. Direct cost does include the cost of repairing or replacing the failed component leading to LOPC if the component failed due to internal or external fire or explosion.

Employee

Any individual on the Company payroll whose exposure hours, injuries, and illnesses are routinely tracked by the Company. Individuals not on the Company payroll, but providing services under direct Company supervision are also included (e.g. government sponsored interns, secondees).

Escalation

The process by which initial and sometimes small events trigger further – sometimes larger – events.

Event

An unplanned or uncontrolled outcome of a business operation or activity that has or could have contributed to an injury, illness or physical damage or environmental damage.

Exploration

Geophysical, seismographic and geological operations, including their administrative and engineering aspects, construction, maintenance, materials supply, and transportation of personnel and equipment; excludes drilling.

Explosion [From API RP 754]

A release of energy that causes a pressure discontinuity or blast wave (e.g., detonations, deflagrations, and rapid releases of high pressure, e.g., a sudden phase change of material).

Fire [From API RP 754]

Any combustion resulting from an LOPC, regardless of the presence of flame. This includes smouldering, charring, smoking, singeing, scorching, carbonizing, or the evidence that any of these have occurred.

First aid

A consequence of an event that required medical attention, often consisting of one-time, short-term treatment and requiring little technology or training to administer. First aid can include cleaning minor cuts, scrapes, or scratches; treating a minor burn; applying bandages and dressings; the use of non-prescription medicine; draining blisters; removing debris from the eyes; massage; and drinking fluids to relieve heat stress. A full list of 14 first aid treatments is provided by IOGP [3]. First aid cases are not classified as recordable incidents for the purpose of reporting to IOGP but may be used by companies as a criterion for reporting of events as Tier 3 KPIs.

Functionality

What a device or system is designed to do.

High potential event

Any event that had the potential to result in one or more fatalities under slightly different circumstances.

Hospital admission [From API RP 754]

Formal acceptance by a hospital or other inpatient health care facility of a patient who is to be provided with room, board, and medical service in an area of the hospital or facility where patients generally reside at least overnight.

Treatment in the hospital emergency room or an overnight stay in the emergency room would not by itself qualify as a 'hospital admission'.

Human factors

All the interactions of individuals with each other, with facilities and equipment, and with the management systems used in their working environment.

Incident

An event or chain of events that has resulted in recordable injury, illness or physical damage or environmental damage.

Indoor release [From API RP 754]

A release within a structure composed of four walls, floor, and roof.

Note: The potential consequences of indoor releases are magnified due to hazards associated with congestion, confinement, personnel proximity, and limitations on egress. Open doors or windows and powered or natural ventilation systems do not change the definition of indoor.

Key Performance Indicator (KPI)

Information or data that provides evidence of a Company's performance in managing its key risks.

KPIs may also be referred to as performance metrics.

Lost Time Injury (LTI)

A fatality or lost work day case. The number of LTIs is the sum of fatalities and lost work day cases.

Lost Time Injury Frequency (LTIF)

The number of lost time injuries (fatalities + lost work day cases) per 1,000,000 work hours.

Lost Work Day Case (LWDC)

Any occupational injury or illness, other than a fatal injury, which results in a person being unfit for work on any day after the day of occurrence of the occupational injury. 'Any day' includes rest days, weekend days, leave days, public holidays or days after ceasing employment. A LWDC is a recordable incident.

Loss of Primary Containment (LOPC)

An unplanned or uncontrolled release of any material from primary containment, including non-toxic and non-flammable materials (e.g. steam, hot water, nitrogen, compressed CO_2 or compressed air). Note: The duration of the material release is assessed from the beginning of the release to the end of the release, not from the beginning of the release to the containment or mitigation of the release. [From API RP 754]

For well operations, any unplanned or uncontrolled release to the surface (seabed or ground level) should be included. LOPC is a type of event. An unplanned or uncontrolled release is an LOPC irrespective of whether the material is released into the environment, or into secondary containment, or into other primary containment not intended to contain the material released under normal operating conditions.

Major incident

Hazardous event that results in:

- multiple fatalities or severe injuries, or
- extensive damage to structure, installation or plant, or
- large-scale impact on the environment (e.g. persistent and severe environmental damage that can lead to loss of commercial or recreational use, loss of natural resources over a wide area or severe environmental damage that will require extensive measures to restore beneficial uses of the environment).

Note 1: This definition is adapted from ISO 17776 [4].

Note 2: This definition is intended to incorporate terms such as 'major accident'.

Management system elements

Management System Elements that group processes and practices designed to prevent LOPC and other types of asset integrity or process safety events and mitigate any potential consequences of such events. Management System Elements support hardware and human barriers.

Material release threshold quantity

The weight of gas, liquid, or solid material released from an LOPC which, if exceeded, results in the event being recordable as either a Tier 1 or 2 PSE. The threshold quantities are described more fully in API RP 754 and follow the UNDG classification system.

Medical Treatment Case (MTC)

A recordable incident involving injury or illness that has required management and care of the patient above and beyond first aid, but not severe enough to be a reportable fatality or lost work day case or restricted work day case.

Mitigation barrier

A barrier which reduces or limits the consequences of an LOPC.

Near miss

An event or chain of events that has not resulted in recordable injury, illness or physical damage or environmental damage but had the potential to do so in other circumstances.

Number of employees

Average number of full-time and part-time employees involved in exploration and production, calculated on a full-time basis, during the reporting year.

Number of fatalities

The total number of Company's employees and/or Contractor's employees who died as a result of an incident. 'Delayed' deaths that occur after the incident are to be included if the deaths were a direct result of the incident. For example, if a fire killed one person outright, and a second died three weeks later from lung damage caused by the fire, both are reported.

Occupational illness

Any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. Occupational illness may be caused by inhalation, absorption, ingestion of, or direct contact with the hazard, as well as exposure to physical and psychological hazards. It will generally result from prolonged or repeated exposure.

Refer to the latest IOGP/Ipieca *Health leading performance indicators report* [3].

Occupational injury

Any injury such as a cut, fracture, sprain, amputation, etc. which results from a work-related activity or from an exposure involving a single incident in the work environment, such as deafness from explosion, one-time chemical exposure, back disorder from a slip/trip, insect or snake bite.

Officially declared [From API RP 754]

A declaration by a recognized community official (e.g. fire, police, civil defence, emergency management) or delegate (e.g. Company official) authorized to order the community action (e.g. shelter-in-place, evacuation).

Offshore work

All activities and operations that take place at sea, including activities in bays, in major inland seas, such as the Caspian Sea, or in other inland seas directly connected to oceans. Events involving transportation of people and equipment from shore to the offshore location, either by vessel or helicopter, should be recorded as 'offshore'.

Onshore work

All activities and operations that take place within a landmass, including those on swamps, rivers and lakes. Land-to-land aircraft operations are counted as onshore, even though flights may be over water.

Operating (or operational) discipline

Colloquially defined as "doing the right thing, the right way, every time", operating discipline is created though the commitment by every member of an organization to carry out each task the right way every time and the assurance that the specific activities necessary for the successful daily operation of a company's operations are running as they should be. This can include specific goals, missions, and guidelines [4].

In the context of Tier 4 KPIs, operating discipline relates to the accuracy and timeliness of the implementation of a Company's requirements, within its Management System (including subordinate processes, procedures and work instructions), that support hardware and human barriers.

Performance standard

A measurable statement, expressed in qualitative or quantitative terms, of the performance required of a system, item of equipment, person or procedure, and that is relied upon as the basis for managing a hazard.

Precautionary (evacuation, public protective measure, shelter-in-place) [From API RP 754]

A measure taken from an abundance of caution.

For example, a Company may require all workers to shelter-in-place in response to an LOPC independent of or prior to any assessment (e.g., wind direction, distance from the LOPC, etc.) of the potential hazard to the workers.

For example, a recognized community official (e.g. fire, police, civil defence, emergency management) may order a community shelter-in-place, evacuation, or public protective measure (e.g. road closure) in the absence of information from a Company experiencing a process safety event, or 'just in case' the wind direction changes, or due to the sensitive nature of the potentially affected population (e.g. school children, the elderly).

Pressure Relief Device (PRD) [From API RP 754]

A device designed to open and relieve excess pressure (e.g. safety valve, thermal relief, rupture disk, rupture pin, deflagration vent, pressure/vacuum vents).

Note: A PRD discharge is a LOPC due to the nature of the unplanned release. The PRD discharge is evaluated against the consequence criteria to determine if it is a Tier 1 or 2 PSE.

Prevention barrier

A barrier which prevents an LOPC.

Primary containment

A tank, vessel, pipe, truck, rail car, or other equipment designed to keep a material within it, typically for purposes of storage, separation, processing or transfer of gases or liquids.

The terms vessel and pipe are taken to include containment of reservoir fluids within the casing and wellhead valving to the surface.

Primary containment also includes closed systems that have a pressure boundary such that there is no exposure of process material to the atmosphere. Where there is a pressure boundary, liquids

and vapors are recovered or controlled, and at no time is material directly in contact with the atmosphere. Examples include closed drainage or collection systems, rapid de-inventory systems, double-walled tanks, etc.

Process

Facilities used in well and production operations in the oil and gas industry. This includes rigs and process equipment (e.g. vessels, piping, valves, boilers, generators, pumps, compressors, exchangers, refrigeration systems) and includes storage tanks, ancillary support areas (e.g., boiler houses and waste water treatment plants), on-site remediation facilities, and distribution piping, wells and other well operations equipment – see note below - (e.g., rig equipment, well control equipment, fluid storage pits/tanks, degassers, temporary pipework, frac pumps, flow-back & well test equipment, coil tubing, etc.) under control of the company.

Note: well operations equipment is only considered part of the process while connected to the well.

Process safety [From API RP 754]

A disciplined framework for managing the integrity of hazardous operating systems and processes by applying good design principles, engineering, and operating and maintenance practices. It deals with the prevention and control of events with the potential to release hazardous materials or energy. Such releases can result in toxic effects, fire or explosion, and could ultimately result in serious injuries, property damage, lost production and environmental impact.

Process Safety Event (PSE) [From API RP 754]

An unplanned or uncontrolled release of any material including non-toxic and non-flammable materials (e.g. steam, hot water, nitrogen, compressed CO2 or compressed air) from a process, or an undesired event or condition, that under slightly different circumstances, could have resulted in a release of material.

Process Safety Event Rate (PSER)

The number of process safety events per 1,000,000 (1 million) applicable work hours (applicable total hours worked includes employees and contractors for applicable company functions within the scope of reporting and refers to IOGP Safety Data Reporting User Guide for further details on scope and definitions)

Production

Petroleum and natural gas producing operations, including their administrative and engineering aspects, minor construction, repairs, maintenance and servicing, materials supply, and transportation of personnel and equipment. It covers all mainstream production operations. Gas processing activities with the primary intent of producing gas liquids for sale including:

- Secondary liquid separation (e.g., Natural Gas Liquids [NGL] extraction using refrigeration processing)
- Liquefied Natural Gas (LNG) and Gas to Liquids (GTL) operations.

Production operations

Activities related to the extraction of hydrocarbons from source such as an oil or gas well or hydrocarbon bearing geological structure, including primary processing, storage and transport operations. Includes normal, start-up or shut-down operations

Rainout [From API RP 754]

Two-phase relief (vapour and entrained liquid) from a vent or relief device with the vapor phase dispersing to the atmosphere and the remaining liquid falling to grade or ground or the evidence that the remaining liquid has fallen to grade or ground.

Recordable

A type of event or incident, including an LOPC or an occupational injury or illness, or other outcome which has been determined to meet or exceed definitions, criteria or thresholds for inclusion and classification in data provided to IOGP (or other agencies or stakeholders). The broader term 'reportable' is often used to indicate the wider range of KPI data collected within the Company for local or corporate use, of which only part will also be recordable.

Recovery

Safe and timely resumption of normal operations after an incident.

Reliability

Proportion of occasions a barrier or equipment item will function as designed (%).

Residual risk

Risk that remains when a barrier, or combination of barriers, operates as intended.

Restricted Work Day Case (RWDC)

Any work-related injury other than a fatality or lost work day case which results in a person being unfit for full performance of the regular job on any day after the occupational injury. Work performed might be:

- an assignment to a temporary job
- part-time work at the regular job
- working full-time in the regular job but not performing all the usual duties of the job

Where no meaningful restricted work is being performed, the incident should be recorded as a lost work day case (LWDC). This is a recordable incident.

Secondary containment [From API RP 754]

An impermeable physical barrier specifically designed to mitigate the impact of materials that have breached primary containment (i.e., an LOPC). Secondary containment systems include, but are not limited to tank dikes, curbing around process equipment, open drainage collection systems, trenches, pits, open sumps, the outer wall of open top double-walled tanks, etc.

Shelter-in-place [From API RP 754]

The use of a structure or portion of a structure and its indoor atmosphere to temporarily separate individuals from a potentially hazardous outdoor atmosphere.

Survivability

Protection required by a barrier or equipment item to ensure continued operation during a major incident.

Tier

One of the four levels of the IOGP framework for process safety KPIs as described in this report, which is in turn based on the API RP 754.

Third party [From API RP 754]

Any individual other than an employee, contractor or subcontractor of the Company, e.g. visitors, non-contracted delivery drivers, residents.

Material release threshold quantity

The weight of gas, liquid, or solid material released from an LOPC which, if exceeded, results in the event being recordable as either a Tier 1 or 2 PSE. The threshold quantities are described more fully in API RP 754 and follow the UNDG classification system.

Total Recordable Incidents (TRI)

The sum of fatalities, lost work day cases, restricted work day cases and medical treatment cases.

United Nations Dangerous Goods (UNDG) [From API RP 754]

A classification system used to evaluate the potential hazards of various materials when released, which is used by most international countries as part of the product labelling or shipping information [5].

UNDG Class 2, Division 2.2 (non-flammable, non-toxic gases)

Non-flammable, non-toxic gases (corresponding to the groups designated asphyxiant or oxidizing) excluding air.

- Asphyxiant
  - Gases which are non-oxidizing, non-flammable, and non-toxic which dilute or replace oxygen normally in the atmosphere.
- Oxidizing
  - Gases, which may, generally by providing oxygen, cause or contribute to the combustion of other material more than air does. These gases are pure gases or gas mixtures with an oxidizing power greater than 23.5% as determined by a method specified in ISO 10156 [6].

Unsafe location [From API RP 754]

An atmospheric PRD or upset emission discharge or a downstream destructive device (e.g. flare, scrubber) discharge that results in a potential hazard to personnel, whether present or not, due to the formation of flammable mixtures at ground level or on elevated work structures, presence of toxic or corrosive materials at ground level or on elevated work structures, or thermal radiation effects at ground level or on elevated work structures from ignition of relief streams at the point of emission as specified in API 521, Section 5.8.4.4.

Excluded from the definition of an unsafe location are those ground level and elevated work structure locations that have a known potential for exposure of personnel to flammable mixtures, toxic substances, corrosive materials, or thermal radiation effects if access to those locations is controlled by virtue of authorized access or hard barriers with appropriate warning signs.

Note: The term "unsafe location" is used in the description of one of the four potential Tier 1 or Tier 2 consequences associated with an engineered pressure relief or an upset emission from a permitted or regulated source. The assumption is the discharge from the engineered pressure relief whether directly to atmosphere or via a downstream destructive device or the emission from a permitted or regulated source are engineered for safe dispersion of the release.

Upset emission [From API RP 754]

Any condition that exceeds the documented permit parameters or conditions associated with routine emission from a permitted or regulated source. This could include process parameters such as temperature, pressure, volume, rate, concentration, and duration or release conditions such as timing, location, day/night, wind speed/direction, and simultaneous operations.

Note: Upset emission applies to specific identified assets (e.g. furnace stacks) and not general or fugitive emission sources (e.g. seals, packing) that are covered under blanket or site-wide permitting.

Well barrier element

A physical element (including a fluid column) in combination with other well barrier elements forms a well barrier envelope to prevent flow.

Well barrier envelope

One or several verified well barrier elements that collectively prevents unintentional flow from a source. Often abbreviated to well barrier, e.g., primary or secondary well barrier.

Well operations

All well activities related to well construction (e.g. exploration, appraisal, injection, production drilling and completions), well testing, surveillance, interventions and workovers (e.g. wireline, stimulation, coiled tubing), and abandonment (including downhole plugging and temporary abandonment).

References

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[2] IOGP 544 - Standardization of barrier definitions

[3] IOGP/Ipieca *Data series. Health leading performance indicators*. Published annually.

[4] ISO 17776:2016, *Petroleum and natural gas industries – Offshore production installations – Major accident hazard management during the design of new installations*, ISO - ISO 17776:2016 - Petroleum and natural gas industries — Offshore production installations — Major accident hazard management during the design of new installations (Accessed 15 May 2023)

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[7] United Nation's Globally Harmonized System of Classification and Labelling of Chemicals (GHS), 9th editon, New York and Geneva, 2021. https://unece.org/transport/standards/transport/dangerous-goods/ghs-rev9-2021 (Accessed 15 May 2023)

International Association of Oil & Gas Producers

The global oil and gas industry has expended considerable effort developing process safety procedures aimed at preventing major incidents. The upstream oil and gas industry, in response to major incidents, has developed improved process safety key performance indicators (KPIs) to learn from events with less serious outcomes and to manage system performance. Report 456 enables companies to establish effective leading and lagging indicators that assess the health of barriers that manage the risk of process safety events (PSEs), particularly those that could result in a major incident.

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