



Department of **Energy, Mines,
Industry Regulation and Safety**



GUIDE

Health and safety leading and lagging performance indicators

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Foreword

Western Australia's work health and safety (WHS) legislation came into force in March, 2022. This resulted in the amendment of the various petroleum Acts and the repeal of the associated regulations so that all onshore and offshore petroleum, pipeline and geothermal energy operations are now subject to the requirements of the:

- *Work Health and Safety Act 2020* (the WHS Act)
- Work Health and Safety (Petroleum and Geothermal Energy Operations) Regulations 2022 (WHS PAGEO Regulations).

A key responsibility for the WorkSafe Group (WorkSafe) of the Department of Energy, Mines, Industry Regulation and Safety continues to be the ongoing risk management and safety requirements for the onshore and offshore petroleum, pipeline and geothermal energy operations. To support these requirements, the guides previously developed have been updated to provide support and assist operators to meet their commitments under the WHS Act and WHS PAGEO Regulations.

Application

This Guide is a non-statutory document provided by WorkSafe to assist persons subject to duties under the WHS Act and requirements to conduct audits of the safety management system as prescribed by the WHS PAGEO Regulations.

It has been developed to provide advice and guidance to operators to meet the WHS Act and the WHS PAGEO Regulations requirements administered by WorkSafe.

Who should use this Guide?

You should use this Guide if you are:

- the operator of onshore or offshore petroleum, pipeline or geothermal energy operations under the WHS Act
- responsible for the development, monitoring and reporting of health and safety key performance indicators for your organisation.

WHS legislation

Under the WHS Act, the WorkSafe Commissioner is responsible for performing the functions and exercising the powers of the regulator. Each safety document must be submitted for acceptance by the regulator.

WorkSafe assists the regulator in the administration of the WHS Act and the WHS PAGEO Regulations, including the provision of inspectors and other staff to oversee compliance with the legislation.

For facilities outside the Western Australian waters, the WHS Act does not apply and guidance should be sought from National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). If a vessel does not fall under the definition of “facility” in the Act, operators should contact the Australian Maritime Safety Authority and Department of Transport.

No petroleum or geothermal operations can be conducted on any onshore or offshore petroleum, pipeline or geothermal energy operations unless the facility has an operator registered in accordance with the requirements of WHS PAGEO Regulations.

The WHS PAGEO Regulations provided for transitional provisions in relation to facility operators and safety cases in place or submitted before the commencement of the WHS legislation.

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1 Introduction

WHS PAGEO Regulations r. 32(4)(j)

Specify the leading indicators and lagging indicators for health and safety performance

WHS PAGEO Regulations r. 33

Implementation and improvement of safety management system

This Guide provides operators with assistance to meet their obligations when developing leading and lagging indicators for their facilities and operations.

For the purpose of this Guide, the term “safety case” is used to cover all of the safety case documents for onshore and offshore facilities referred to in the WHS PAGEO Regulations.

The objective of the Guide is to provide clarity on areas of the legislation which may be ambiguous or open to interpretation.

2 The need to develop key performance indicators

WHS PAGEO Regulations r. 32(4)(i)

Specify the leading indicators and lagging indicators for health and safety performance

WHS PAGEO Regulations r. 33

Implementation and improvement of safety management system

WHS PAGEO Regulations r.100

Duty to notify of notifiable occurrences

WHS PAGEO Regulations r. 108

Duty to identify hazards

WHS PAGEO Regulations r. 111

Maintenance of control measures

WHS PAGEO Regulations r. 112

Review of control measures

A lagging indicator is an outcome-oriented metric (such as incident rates or other measures of past performance).

A leading indicator is a process-oriented metric (such as rate of implementation of, or conformance with, policies and procedures that support a safety management system).

The safety case for an operation must:

- specify the leading and lagging indicators for health and safety performance and describe how the indicators are selected
- contain evidence showing that there are effective means of ensuring
 - the implementation of the safety management system
 - continual and systematic identification of deficiencies in the safety management system
 - continual and systematic improvement of the safety management system.

These requirements can only be achieved if the operator has a comprehensive system that identifies where targets are being achieved, where deficiencies in the systems occur and how this data is being used to correct deficiencies and improve the overall system.

To achieve an effective measurement and monitoring system, a program needs to be developed that will effectively measure the performance of the operation and provide the operator, at various levels of management within the operations, with sufficient accurate data to clearly demonstrate compliance or non-compliance with the targets set across the organisation.

The measuring and monitoring system must include leading and lagging health and safety performance indicators that are appropriate for the operation.

3 Establishing a performance monitoring system

Senior management and all relevant stakeholders should be involved in the development of a health and safety performance monitoring system. Depending on the size of the operations, a team of managers and leaders should be established to develop the performance monitoring system and identify the appropriate indicators. This should consider areas of the operation that have specific activities that need to be included in the data collection such as design and engineering, and maintenance of safety critical elements.

The performance monitoring system should aim to identify the areas of the operation that are performing well and meeting set targets, and the areas where deficiencies have been identified. The setting of targets, goals and overall objectives should follow the 'SMART' approach to provide a clear and concise result. The targets and objectives should be:

- Specific – keep the proposed objective as simple as possible. A broad objective will need more complex targets to meet the required goal.
- Measurable – select the right health and safety indicators for the desired outcome, confirm that the outcome is quantifiable, and consider the targets that will confirm the objective has been achieved.
- Achievable – consider setting ambitious goals to encourage higher performance, but ensure the goals are still achievable as unachievable goals may be a disincentive.
- Realistic – once set, closely monitor objectives and targets to assess whether the indicator is a realistic measure of the goal and the expected results are being achieved, and if not they should be adjusted.
- Time related – it is important that objectives and targets have a date by which they will be achieved. These dates should give results in time for regular meetings such as management reviews.

The methodology used to establish the performance monitoring system should be documented in a project plan or procedure with details of how the leading and lagging indicators were identified, the reasoning behind each of the indicators, the results expected to be achieved, how the data will be collected and the type of reporting required.

Because the aim of this monitoring process is to provide early warning of any deficiencies within the operations, it is important that there is an upward flow of reporting to senior management. This should provide a comprehensive understanding of deficiencies and the impact they may have on the operations. Management can also recognise achievements, including ambitious objectives that are reached either on time or earlier than originally forecast.

The management systems and activities of every operation are different and indicators may differ from one operation to another. There is no system to suit every need and many operations will already have key performance indicators covering a number of business activities. It is important that new indicators covering process safety are integrated into, and complement existing arrangements for, business performance monitoring.

It is not necessary to measure every aspect or element of a safety management system. Focussing on a few critical risk control systems will provide a sufficient overview of performance. Problems highlighted in one risk control system should trigger a wider review.

It is important to aim for quantitative measurements rather than qualitative indicators when selecting performance indicators. A quantitative indicator can be counted or measured and is described numerically whereas a qualitative indicator would describe or assess a quality or behaviour. Data collection and analysis is resource intensive so arrangements for monitoring performance should be cost effective. Selection of a few indicators set against the main risks should be sufficient to provide a high degree of assurance across all business areas of an organisation.

The documented procedure should also include details of the managers, leaders or other officers of the organisation who have responsibility for monitoring each of the set indicators so results from collected data can be reviewed regularly and, where necessary, action taken to correct the targets or objectives if the required results are not being achieved. These changes in data collection should then be communicated to workers through prescribed meetings.

3.1 Data collection and reporting

Once the indicators have been selected and the tolerance levels set, it is important to ensure that the relevant information is readily available within the operation. The information and data required to support the suite of performance indicators is usually already available and collected for other purposes, such as quality control or business efficiency. However it is important that the data is collated to form a complete set of information on the work health and safety risks.

The reporting of the performance data should ideally be coordinated through one person who is responsible for collecting all the information, designing and compiling the reports for the management team and flagging the areas with deviations from the set tolerance that need attention.

Keep the presentation of performance data as simple as possible. Senior management usually prefer a single sheet summary that shows deviations from set tolerances or targets and important trends. The use of graphs, charts or dashboards, or a colour coded “traffic light” system that indicates whether the target has:

- been met (green)
- a slight but tolerable deviation (yellow)
- a large or significant deviation requiring immediate attention (red).

Deviation from tolerances must be followed up otherwise there is little point in collecting the information. The main aim of gathering this information is to indicate where controls have deteriorated or are not delivering the intended outcome.

A section should be included in the reporting template where areas of concern can be listed in a one-line explanation for the information of managers. Depending on the area that is not meeting the required tolerances, it may be appropriate to review any relevant performance standards and the safety critical elements (SCEs) identified to verify that the controls are still functioning at the required level to prevent incidents and occurrences. If not then actions should be raised for these performance standards and SCE's to be risk assessed with a view to identifying areas that are non-compliant

As the data collected is also utilised to facilitate and show improvement in the organisation's safety systems and processes, formatting of the data collection should include information for the:

- current period
- previous period
- year to date
- previous year
- score.

This will give senior management a regular visual tool that shows whether:

- the controls for systems and processes are effective
- the safety management system has been implemented effectively
- there is continual improvement from period to period and year to year.

Where an organisation has established a number of regional or workgroup performance measuring requirements, the reporting should include an organisation-wide presentation as well as individual presentations for the regions or workgroups. This type of presentation will enable senior management to assess:

- how the organisation as a whole is performing and meeting its targets and objective
- where there are deviations from the set tolerances, which regions or workgroups are failing to meet the required performance standard.

3.2 Reviewing and adjusting indicators and tolerances

Performance against each risk should be reviewed regularly by senior management to ensure that the whole process safety management system is delivering the intended outcomes and to provide assurance that critical systems continue to operate as intended.

If performance is poor against a group of leading indicators but the associated lagging indicators are satisfactory, it is likely that the leading indicators selected are too far removed from the critical control measure that delivers or maintains the desired outcome. For example, the percentage of induction training may be measured, where more importantly, training and competence in a particular process activity may be more critical to ensuring the safety of that specific activity.

If a group of leading indicators are on target and closely linked to the risk control system but the associated lagging indicator shows poor performance, it is likely that the risk control system is ineffective in delivering the desired outcome.

Indicators should be reviewed every few years, or more frequently if considered necessary, to ensure the scope of the full set of indicators still reflects the main process risks. Indicators may need to be changed because of:

- the introduction of new high-risk processes
- improvement programs
- an alteration in plant design
- a reduction of staff or loss of competence in certain areas.

If reviews are not carried out, process safety indicators may become meaningless and the information collected may not give the necessary assurance to senior managers that the major hazards are under control

Tolerances should also be reviewed as the initial estimation is not always correct. It could be that a tolerance has been set at the wrong point, and is too lenient or stringent, so the information or data does not adequately reflect reality. In such cases the tolerance should be reviewed and reset to an appropriate level.

3.3 Communication and consultation with workers

WHS PAGEO Regulations r. 38
Involvement of workers

It is important that workers are not only involved in the development of the various leading and lagging indicators but also that the periodic reports are made available to them by posting on an internal website that can be accessed by all workers and be reviewed within team or regional meetings.

Involvement of workers enables the human factor element to be taken into account when reviewing the results of the data collection and any proposed remedial actions to be taken. Input from workers provides them with an element of ownership of the process and a better understanding of what the organisation is trying to achieve with the measuring and monitoring program.

This level of ownership can translate to safer working activities and a better awareness of the requirement to adhere to organisational procedures and health and safety processes, resulting in a higher achievement against the indicators and tolerances set.

3.4 Human factors

Human factors are an integral component of safe and efficient operations. Human factors focuses on understanding how human performance is shaped by conditions within the system. Operators can demonstrate the risks associated with major accident events are reduced so far as is reasonably practicable by identifying potential human failures, performance shaping factors, and controls to support the desired human performance.

Just like any other barrier, performance indicators can be developed for human factors barriers and safeguards/degradation controls. Performance indicators for human factors controls allows the Operator and workers to understand and detect when the controls are not performing as intended.

Regular auditing against the performance indicators ensures the barriers and safeguards/degradation controls remain effective. Additionally, performance indicators for controls involving human performance can inform design requirements, organisational arrangements, and training and competence needs of workers.

For further information, refer to the Information Sheet: Human factors: Integrating human factors into bowtie analyses of major accident events, [Human factors briefing note no. 17 – Performance indicators | EI - Publishing \(energyinst.org\)](#) or [Human-factors-performance-indicators-for-the-energy-and-related-process-industries.pdf \(hpog.org\)](#).

3.5 Psychosocial hazards

WHS Act s. 19

Primary duty of care

As the person conducting a business or undertaking (PCBU), the operator has a primary duty of care to ensure, so far as is reasonably practicable, that workers and other persons are not exposed to health and safety risks arising from work carried out as part of the business or undertaking. Health, in the WHS Act, is defined as physical and psychological.

Psychosocial hazards at work are aspects at work and work situations which can harm psychological and physical health. Psychosocial hazards can stem from:

- the way the tasks or jobs are designed, organised, managed and supervised
- tasks or jobs where there are inherent psychosocial hazards and risks
- the equipment, working environment or requirements to undertake duties in physically hazardous environments
- social factors at work, workplace relationships and social interactions.

The operator must have systems in place for preventing and managing psychosocial hazards such as stress, fatigue, burnout, bullying, harassment, violence and aggression, discrimination and misconduct. Performance standards for these types of hazards should be included in the performance data collected and monitored to identify areas that may not be achieving the required targets and put in place action to rectify the issues being reported.

For more information, refer to the *Psychosocial hazards in the workplace*, *Mentally healthy workplaces for fly-in fly-out workers in the resources and construction sectors* and *Workplace behaviour* codes of practice. These three codes of practice detail how to assess and manage psychosocial hazards and risk factors using the risk management approach.

4 Key performance indicators

4.1 Leading and lagging indicators

Performance indicators (or metrics) can be considered to be either leading or lagging indicators. Both types of indicator have a place in an operation's performance measuring system and can often be used in a dual role against a specific performance requirement.

Leading indicators are process-oriented metrics, such as rate of implementation or conformance with policies and procedures that support the safety management system that is capable of predicting performance. They usually relate to the controls on the left-hand side of a bowtie diagram. They often reflect proactive actions taken by the operator, such as proactive auditing or monitoring.

Lagging indicators are outcome-oriented metrics, such as incident rates or other measures of past performance. They usually relate to the mitigating factors on the right-hand side of a bow-tie diagram. A lagging indicator usually relates to outcomes (injuries or near-misses) or reactive actions (emergency response) and often involves incident notification to the regulator or investigation by the operator.

Further, either of these types of performance indicators can be considered to be work health and safety (WHS)-related indicators or process safety-related indicators, although there is some overlap. WHS relates to personal safety, such as slips, trips and falls. Process safety focuses on preventing fires, explosions and incidents or occurrences involving hazardous materials.

Table 1 - Types of leading and lagging indicators

Leading indicators	Lagging indicators
Proactive	Reactive
Predictive	Outcome-based
Left side of bow tie diagram	Right side of bow tie diagram
Auditing and monitoring	Investigating incident

The WHS PAGEO Regulations prescribe that the operator develops the leading and lagging indicators and documents the indicators in the safety case. However, the Regulations do not prescribe the specific leading and lagging indicators. It is up to the operator to develop these indicators to monitor the health and safety performance of their specific operation. It would be impossible to prescribe leading and lagging indicators that would be meaningful for all types of operations that the WHS PAGEO Regulations cover.

Although the WHS PAGEO Regulations require the operator to develop these performance indicators, there is no requirement to report these indicators to the regulator on a regular basis. Instead, it is expected that inspectors will discuss these performance indicators with the operator during inspections, liaison meetings and other interactions.

4.2 Selecting WHS-related leading indicators

A leading indicator or positive performance indicator (PPI) is aimed at evaluating how successfully an operation is performing in its management of health and safety within its workforce by monitoring the processes that provide good health and safety outcomes and highlighting areas where systems and processes or procedures could be improved.

Leading indicators are a form of active monitoring of critical risk control systems to ensure their continued effectiveness. Leading indicators require a routine systematic check that key actions or activities are undertaken as intended. They can be considered as measures of process or inputs essential to deliver the desired safety outcome.

Leading indicators highlight whether the risk control systems in place to deliver the required outcome are operating as designed.

These indicators can be developed either on an organisational basis or a regional or workgroup basis and should involve consultation with workers and other stakeholders to ensure that relevant measures are considered for all areas before setting the objective for each lead indicator.

Once the leading indicators have been decided the development team needs to agree on the targets to be set, the period over which data is gathered and the reporting period when collected information will be reviewed by management and leaders. This is covered in Section 3.3

Examples of leading indicators are shown in Table 2. **Note** – These are examples only, operators must develop their own leading indicators that are applicable to their organisation’s needs and policies.

Table 2 - Examples of WHS leading performance indicators

Leading indicators	Measurement	Validation	Target
Leadership commitment	Health and safety management plan in place	<ul style="list-style-type: none"> Roles and responsibilities in place for managers and leaders 	100%
	Performance and compliance review	<ul style="list-style-type: none"> Weekly and monthly reporting completed within required time frame Audit reports 	100% - senior management to review all performance and compliance requirements
	Management interaction and time spent in field	<ul style="list-style-type: none"> Completed interactions undertaken as scheduled and reports submitted on time 	100%
	Inductions completed within 30 days of starting role	<ul style="list-style-type: none"> Inductions completed and results included in training plans 	Investigating incident
	Worker training plans on schedule	<ul style="list-style-type: none"> All worker training plans up to date and on schedule 	100% target, acceptable 75% completed within 30 days of due date

Leading indicators	Measurement	Validation	Target
Compliance with legislative requirements and company standards and procedures	Legislative requirements – register of legislative obligations in place and up to date	<ul style="list-style-type: none"> Register up to date with evidence of last review against current obligations and inclusion of changed legislation 	100%
	Audits conducted as per schedule (include system and risk based audits)	<ul style="list-style-type: none"> Percentage of audits completed versus schedule Non-conformances identified and actions created 	<ul style="list-style-type: none"> 100% audits completed as per schedule Minimum 85% compliance on any audit 100% close out of non-conformances within 30 days of due date
	Safety case up to date	<ul style="list-style-type: none"> Safety case up to date with internal changes and, where significant change has occurred, updated and submitted to regulator for acceptance 	100%
	Document control – company procedures up to date and reviewed as required	<ul style="list-style-type: none"> All procedures and other relevant documents reviewed and updated as per required periodic review 	100% target – acceptable 85% completed within 30 days of due date for review
Communication and consultation	Daily pre-start meetings held Toolbox meetings WHS committee meetings	<ul style="list-style-type: none"> Attendance register and records Meeting agenda Meeting minutes 	<ul style="list-style-type: none"> Daily – 1 per crew or project Toolbox – minimum 1 per week WHS committee – 1 per quarter
WHS work planning	Permits to work generated and job hazard analysis (JHA) or safe work method statements (SWMS) developed	<ul style="list-style-type: none"> Permits opened and correctly completed and signed on by work crew JHAs or SWMS completed and signed on by work crew 	100% compliance
Maintenance, inspection and testing	Maintenance and inspection of safety critical elements on schedule	<ul style="list-style-type: none"> All identified safety critical elements tested and inspected on time 	100% completed within 15 days of due date
	General planned maintenance on schedule	<ul style="list-style-type: none"> All general work orders completed within 30 days of due date and maintenance system updated accordingly 	100% completed within 30 days of due date

Leading indicators	Measurement	Validation	Target
Design and engineering	Integrity management plans in place	<ul style="list-style-type: none"> Integrity management plans in place for all assets 	100% integrity management plans completed and up to date
	Management of change for SCEs	<ul style="list-style-type: none"> Management of change for SCEs prioritised for timely closure 	100% of management of change for SCEs reviewed and prioritised for action
	Alarm management	<ul style="list-style-type: none"> Effective alarm management in place 	100% of alarms reviewed and cause identified for rectification
	Risk registers reviewed	<ul style="list-style-type: none"> Schedule in place to conduct review of risk registers Schedule of hazard and operability studies (HAZOPs) to be reviewed and updated periodically 	100% of reviews completed within 30 days of scheduled due date
Emergency response	Emergency response plans in place	<ul style="list-style-type: none"> Emergency response plans developed and up to date 	100% complete and available
	Schedule established for emergency response exercises	<ul style="list-style-type: none"> Emergency response exercises scheduled and completed. List of relevant scenarios developed for all sites Reports completed and actions raised following completion of exercises 	<ul style="list-style-type: none"> 100% of scheduled exercises completed or reason for rescheduling noted Scenarios available against which exercises can be conducted All reports completed within 30 days of exercise and corrective actions generated where required
	Inspection and testing of emergency response equipment carried out as scheduled	All emergency response equipment listed in maintenance management system and work orders raised for regular inspection and testing	100% of inspection and testing completed within 30 days of due date of work order completion
Actions generated from investigations, inspections, audits and risk assessments	All actions to be completed and closed out within the allocated time	Review of actions register to cite closed out actions and completion date	100% completed and closed out within 15 days of due date for completion

A tolerance should be set for each leading indicator. This represents the point at which deviation in performance should be flagged for the attention of senior management. For example, for the leading indicator “percentage of overdue safety critical elements maintenance actions”, the tolerance may be set at zero, which means that 100% of actions must be completed on schedule. Alternatively, the organisation may accept a degree of slippage before it is highlighted to the management team, in which case the tolerance should be set below 100%.

The management team should set the tolerance, not the person responsible for the activity. This enables management to decide at what point they wish to intervene because performance has deviated beyond an acceptable level.

4.3 Selecting WHS-related lagging indicators

Lagging indicators are reactive performance measures that identify where a control system has failed, for example the incidents of injury recorded or a loss of containment. Lagging indicators also show whether an outcome has actually been achieved.

Both types of indicator have a place in an organisations performance measuring system and can often be used in a dual role against a specific performance requirement.

Lagging indicators show whether the outcome has actually been achieved. For example, a lagging indicator may be that there will be zero medical treated injuries during a period, but review of reported incidents show that for the period under review there were 2 medically treated injuries. Therefore the outcome of zero medically treated injuries has not been achieved.

For lagging indicators, every time the performance outcome is not achieved there should be an investigation to see why the system failed. This provides an opportunity to consider whether improvements should be made and the lessons learned from these investigations should provide the organisation with an opportunity to consider whether improvements need to be made.

Examples of lagging indicators are shown in Table 3.

Note – These are examples only. Operators must develop their own lagging indicators that are applicable to their organisation’s needs and policies.

Table 3 - Examples of WHS lagging performance indicators

Lagging Indicators	Measurement	Monitoring mechanism	Target
Incidents reported	Fatality	<ul style="list-style-type: none"> Number of fatalities reported during the period 	0
	Lost time injuries	<ul style="list-style-type: none"> Number of lost time injuries reported 	0
	Medically treated injuries	<ul style="list-style-type: none"> Number of medically treated injuries reported 	0
	Number of notifiable incidents reported to regulator	<ul style="list-style-type: none"> Notifiable incidents reported within required period Notifiable incidents reported late 	0 0
Incidents or occurrences reported	Loss of containment	<ul style="list-style-type: none"> Loss of containment 	0
	Damage to pipeline by third party	<ul style="list-style-type: none"> Number of reported strikes to pipeline by third parties 	0
	Failure of safety critical element	<ul style="list-style-type: none"> Number of failures of safety critical elements recorded 	0
Psychosocial incidents reported	No incidents reported relating to harassment, bullying, coercion, violence or aggression	<ul style="list-style-type: none"> Number of incidents reported 	0

4.4 Selecting process safety-related leading and lagging indicators

4.4.1 Process safety-related leading and lagging indicators: the American Petroleum Institute approach

This Guide does not give a detailed procedure or specific examples for developing process safety-related leading and lagging indicators. It refers to three interrelated cross-referenced documents which will assist registered operators to address process safety-related leading and lagging indicators:

- ANSI/API RP 754 *Process safety performance indicators for the refining and petrochemical industries, third edition*. American Petroleum Institute (API), August 2021.
- *Process safety metrics guide for leading and lagging indicators* (Version 4.1). Center for Chemical Process Safety (CCPS), June 2022.
- *Process safety: Recommended practice on key performance indicators – Report 456*. International Association of Oil and Gas Producers (IOGP). Version 2, November 2018.

These documents approach the process safety event as a loss of primary containment (LOPC) event. A loss of containment event could include a slip, trip or fall event if it occurred, for example, in the act of attempting to escape from a loss of primary containment.

The API standard sets the framework for the approach that all three take, and refers to the IOGP guidance for oil and gas applications. The approach is to set out a four-tier framework of process safety key performance indicators (KPIs) which are briefly described below and set out in more detail in the API documentation referenced above.

Tiers 1 and 2 provide lagging indicators of process safety performance. They cover major and less severe incidents. LOPC events are categorised as Tier 1 or 2 depending on the quantity of the loss compared to defined thresholds, and they indicate a failure of multiple barriers. Tier 1 and 2 events are the kinds of incidents or occurrences the operator would normally report to the regulator under s.35 of the WHS Act or r.100 of the WHS PAGEO Regulations. They are so straightforward (e.g. death, serious injury) that there is little need to define the KPIs, but the API does set threshold values for the quantities of LOPC. It is also easy to use the defined events across different operations.

Tier 3 KPIs are a combination of leading and lagging indicators, although there is sometimes an overlap. They are used to monitor the performance of the barriers that prevent Tier 1 and Tier 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 events are the kinds of events that are not normally reported to the regulator. Tier 3 KPIs are intended to be more specific to an operator's own management system. They may be specific to a particular operation. Often if an operator has several operations, the same set of KPIs is used for all of those operations, in which case a comparison can be valid.

Tier 4 KPIs are leading indicators. They 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 events are the kinds of events that are not normally reported to the regulator, the KPIs are intended to be more specific to an operator's own management system and may be specific to a particular operation. Often if an operator has several operations, the same set of KPIs is used for all of those operations, in which case a comparison can be valid.

The above method, and the API's guidance, support the approach taken by the WHS Act and the WHS PAGEO Regulations. Notifiable incidents and occurrences are reported to the regulator under s. 35 of the WHS Act and r.100 of the WHS PAGEO Regulations. Leading and lagging indicators are developed by the operator under r. 32(4)(i) of the WHS PAGEO Regulations. KPIs are not reported to the regulator, but they are used by the operator for continuous improvement.

Tier 3 events can include minor LOPC. It is questionable whether this is a leading indicator or a lagging indicator. In the sense that it is a hazardous event, on a minor scale, it is a lagging indicator. In the sense that it is a warning of a potential failure of a barrier that could lead to a major process safety event, it is a leading indicator. Classifying KPIs as leading or lagging is not important. The important point is to capture information that can be acted upon to identify shortcomings in barriers and correct the situation.

A typical process safety KPI "report card" for a specific time may look something like this:

Table 4 - Process safety KPIs Tier 3 and Tier 4

Process safety Tier 3	June 2022	July 2022	Process safety Tier 4	June 2022	July 2022
Alarm triggered – fire detect event	0	1	Encroachment – level 2	0	2
Alarm triggered – high high (HH) pressure	0	0	Encroachment – level 3	0	0
Alarm triggered – high high (HH) temp	0	1	Excessive vibration of piping or equipment	0	0
Alarm triggered – low temp	0	0	Information technology – unauthorised attempts/access of critical communications, supervisory control and data acquisition (SCADA)	0	0
Corrosion – pipe integrity impact	0	0	Incorrect set points	2	1
Encroachment – level 1	0	0	SCADA tag placed into over-ride	5	4
Erosion/subsidence – level 1 – pipe integrity impact	1	0	SCADA tag inhibited	35	28
Ineffective isolation	0	1	Stress corrosion cracking event	0	0
Odorant release	0	0	Unauthorised design change	0	0
Pressure safety valve (PSV) operates	0	0	Unexpected logic result	0	0
Release of hydrocarbons	0	0	Procedural Issues		
Safety critical elements			Actions created from risk assessments (HAZOP/HAZID) not completed	10	15
SCE device failed or inoperable	3	1	Inadequate procedures identified	1	1
Emergency shutdown system operates	1	0	Changed/updated drawings awaiting completion by drafting	25	39
			Management of change not assessed by engineering	56	72
			Work instructions past review date	26	32

			Safety critical elements		
			Safety critical drawing incorrect	3	2
			PSV maintenance not completed within required timeframe	15	23
			Critical safety device not operating to spec or standard	2	5
			Non-conformances arising from electrical equipment in hazardous areas (EEHA) inspections	56	78
			Pipe not protected by cathodic protection	0	0
			Vessel maintenance not completed within required timeframe	15	23
Total	5	4		251	325

4.4.2 Selecting process safety-related leading and lagging indicators

Monitoring a very large number of different KPIs is not more effective than monitoring a lower number. What is important is to select a few critical indicators that can be used effectively to drive improvement in process safety.

There are a few ways to select these KPIs using the findings from hazard identification and risk assessment studies to identify significant high level events and process safety controls intended to prevent such incidents or occurrences. Hence, the output from the formal safety assessment as part of the safety case process can inform the selection of leading and lagging indicators. WorkSafe Petroleum Safety has seen operators successfully set up a leading and lagging indicator program based on the bowtie diagrams produced as part of the development of the safety case.

It can also be useful to consider previous incident or occurrence investigation and analysis, and shared external learnings such as safety alerts. The API documentation has examples that are more specific.

Appendix 1 Glossary

The following terms are defined for the purposes of this Guide.

Key terms	Meaning
API	American Petroleum Institute
CCPS	Centre for Chemical Process Safety
Competent person	A person who has acquired through training, qualification or experience the knowledge and skills to carry out the task. The definition of 'competent person' in the Work Health and Safety (General) Regulations prescribes specific requirements for some types of work such as diving.
Facility	<p>Geothermal energy facility – a place at which geothermal energy operations are carried out and includes any fixture, fitting, plant or structure at the place</p> <p>Petroleum facility – a place at which petroleum operations are carried out and includes any fixture, fitting, plant or structure at the place</p> <p>Mobile facility – includes an onshore drilling rig</p> <p>The term facility has been adopted throughout this document to cover offshore and onshore facilities and pipelines including aboveground structures associated with onshore pipelines.</p>
Geothermal energy operation	<p>Means an operation to:</p> <ul style="list-style-type: none"> • explore for geothermal energy resources • drill for geothermal energy resources • recover geothermal energy • or is any other kind of operation that is prescribed by the regulations to be a geothermal energy operation for the purpose of this definition <p>and carry on of such operations and the execution of such works as are necessary for that purpose.</p>
IOGP	International Association of Oil and Gas Producers
KPI	Key performance indicators
Lagging indicator	Outcome-oriented metrics, such as incident rates or other measures of past performance
Leading indicator	Process-oriented metrics, such as rate of implementation or conformance with policies and procedures that support the safety management system that is capable of predicting performance
LOPC	Loss of primary containment

Key terms	Meaning
Metrics	Leading and lagging measure of process safety management efficiency or performance. Metrics include predictive indicators, such as the number of improperly performed line breaking activities during the reporting period, and the outcome-oriented indicators, such as the number of incidents during the reporting period (CCPS Bluebook)
Operator	A person who has, or will have, the day-to-day management and control of operations at a facility and is registered as the operator of the facility under r.22(3).
Person conducting a business or undertaking (PCBU)	A PCBU is an umbrella concept capturing all types of working arrangements or relationships. A PCBU includes a company, unincorporated body or association and sole trader or self-employed person. Individuals who are in a partnership that is conducting a business will individually and collectively be a PCBU. A reference to a PCBU includes reference to the operator of a facility.
Petroleum operation	Means an activity that is carried out in an area in respect of which a petroleum title is in force, or that is carried out in an adjacent area, for the purpose of any of the following: <ul style="list-style-type: none"> • exploring for petroleum • drilling or servicing a well for petroleum • extracting or recovering petroleum • injecting petroleum into a natural underground reservoir • processing petroleum • handling or storing petroleum • the piped conveyance or offloading of petroleum.
PPI	Positive performance indicator
Regulator	The WorkSafe Commissioner is the regulator under the <i>Work Health and Safety Act 2020</i> .
Safety case	Documented provisions related to the health and safety of people at or in the vicinity of a facility, including identification of hazards and assessment of risks; control measures to eliminate or manage hazards and risks; monitoring, audit review and continual improvement
Safety critical element (SCE)	Any item of equipment, system, process, procedure or other control measure the failure of which can contribute to an MAE
WHS	Work health and safety – as opposed to process safety
WHS Act	<i>Work Health and Safety Act 2020</i>
WHS PAGEO	Work Health and Safety (Petroleum and Geothermal Energy Operations) Regulations 2022
Worker	Any person who carries out work for a person conducting a business or undertaking, including work as an employee, contractor or subcontractor (or their employee), self-employed person, outworker, apprentice or trainee, work experience student, employee of a labour hire company placed with a ‘host employer’ or a volunteer

Appendix 2 Further information sources

Petroleum safety guidance

Interpretive guidelines

- *Development and submission of a diving safety management system*
- *Development and submission of a safety case*
- *Development and submission of an onshore facility safety case – drilling operations*

Guides

- *Audits, review and continual improvement*
- *Bridging documents and simultaneous operations (SIMOPS)*
- *Dangerous goods and hazardous chemicals in petroleum, pipeline and geothermal energy operations*
- *Decommissioning and management of ageing assets*
- *Demonstration of risk reduction so far as is reasonably practicable (SFAIRP)*
- *Diving start-up notices*
- *Emergency response planning*
- *Facility design case*
- *Hazard identification*
- *Health and safety leading and lagging performance indicators*
- *Human factors fundamentals for petroleum and major hazard facility operators*
- *Human factors self-assessment guide and tool for safety management systems at petroleum and major hazard facility operations*
- *Identification of major accident events, control measures and performance standards*
- *Inspections – Land-based drilling rigs*
- *Involvement of workers*
- *Management of change*
- *Nomination of an operator*
- *Records management including document control*
- *Risk assessment and management including operational risk assessment*
- *Validation requirements*

Petroleum safety guidance can be found at [Petroleum safety publications](#).

Codes of practice

- [*How to manage work health and safety risks*](#)
- [*Mentally healthy workplaces for fly-in fly-out workers in the construction and resources sector*](#)
- [*Psychosocial hazards in the workplace*](#)
- [*Workplace behaviour*](#)

Australian and international standards

- AS 1885.1 *Measurement of occupational health and safety performance, Part 1: Describing and reporting occupational injuries and disease* (known as the Workplace injury and disease recording standard)
- AS 2885.3 *Pipelines – Gas and liquid petroleum, Part 3: Operation and maintenance*
- AS IEC 61511 *Functional safety – Safety instrumented systems for the process industry sector*
- AS ISO 31000 *Risk management – Guidelines*
- AS/NZS 2885.6 *Pipelines – Gas and liquid petroleum, Part 6: Pipeline safety management*
- AS/NZS ISO 9001 *Quality management systems – Requirements*
- AS/NZS ISO 19011 *Guidelines for auditing management systems*
- AS/NZS ISO 45001 *Occupational health and safety management systems – Requirements with guidance for use*
- ISO 17776 *Petroleum and natural gas industries – Offshore production installations – Major accident hazard management during the design of new installations*

Further guidance on leading and lagging indicators

- ANSI/API RP 754 *Process safety performance indicators for the refining and petrochemical industries, third edition*, American Petroleum Institute, 2021.
- *Developing process safety indicators: A step-by-step guide for chemical and major hazard industries*. Health and Safety Executive (HSE), 2006.
- *Lead process safety metrics: Selecting, tracking and learning*. Institution of Chemical Engineers, 2015.
- *Process safety metrics guide for leading and lagging indicators* (Version 4.1). Center for Chemical Process Safety (CCPS), 2022.
- *Process safety: Recommended practice on key performance indicators – Report 456*. International Association of Oil and Gas Producers (IOGP). Version 2, November 2018.



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