Overview of leading indicators for occupational health and safety in mining

Health and Safety
November 2012
HOW TO USE THIS INTERACTIVE PDF

This overview has been colour coded to ease navigation through the pdf. Each of the eight sections is numbered and colour coded – **click on the section you want to go to** and the pdf will take you forward or back to the start of that section of this overview.

On each page you can **scroll over and click** the coloured boxes at the top to return to:

- the beginning of the report
- the start of the section you are in
- the start of any other section.
Too often we look back after mistakes are made, draw lessons and try to correct the results. With fatalities and accidents doing so is too late. So we need to look forward, anticipate and prevent the incidents before they occur.

Given the importance of this issue, ICMM members have collaborated in the development of a common framework and understanding of what leading indicators are and how they can be applied to occupational health, occupational hygiene and safety (OHS) in the mining industry. Although found in other high-risk, high-reliability industries, this guidance is a first for the mining industry.

This approach reflects part of what is needed to prevent undesired outcomes, such as loss and harm to people, the environment and/or equipment. It is also an invitation to those who are responsible for the health and safety of their people to enhance the value from existing work and data.

It does so by offering a perspective change that illuminates root causes of unwanted events and outcomes, in order to implement effective and proactive control measures BEFORE an incident occurs. Applying this approach will help each company identify a set of leading indicators. It does not offer a pre-determined list of indicators or a prescription of the steps that must be followed in each case. These must be carefully tailored to the needs and conditions faced by each company.

The full journey of establishing an effective anticipatory corporate culture is much more than is summarized here. It encompasses leadership and human behaviour that together establish a deep, values-based corporate culture that champions respect for human health and safety above all else. On this journey we have some way to go.

My thanks to the member companies who contributed to this document. I encourage readers to use and share this collective learning with your colleagues both within and outside of the mining and metals industry.

Dr. R. Anthony Hodge
President, ICMM
ICMM has prepared an overview of the purpose, identification, use, measurement and application of leading indicators for occupational health (including hygiene) and safety (OHS) in the mining industry.

**LEADING AND LAGGING INDICATORS**

Lagging or outcomes indicators have been used for some time in the mining industry to track when damage, injury or harm has occurred, in an attempt to introduce measures that will prevent future harm. Leading or activities indicators measure the direct and indirect precursors to harm, and give advance warning before an event occurs that might lead to an undesired outcome, providing an opportunity for preventative action to be taken. The value proposition for the use of leading indicators is that of prevention of loss or damage, whether to people, the environment or property. To be effective, leading indicators must be integrated with the overall business objectives, strategy and decision-making processes to deliver on desired performance.

The closer an organization gets to “zero harm”, as measured using lagging indicators, the more difficult it is to ensure safety through tracking lagging performance, and to determine the factors that contribute to improved performance. It is also unreliable to make any generalized causal inferences based on these rare events. Management efforts should therefore be focused on more frequently measurable leading indicators of precursor circumstances. It is reported that lagging indicators have also lost their ability to motivate or influence measurable safety performance improvement.

**COMPLEX CAUSAL PATHWAYS**

OHS outcomes can result from an accumulation of multiple causes; for a leading indicator to contribute to improved OHS performance there must be a demonstrable cause and effect relationship established between the leading indicator and OHS performance. Leading indicators can point to root causes of OHS outcomes.

Precursors of undesired OHS outcomes lie in areas relating to:
- people (including leadership, behaviour and degree of ownership)
- organizations (including culture)
- systems (across all business areas)
- processes (especially technical, but also administrative)
- physical plant and processing (technical and technological).

**LEADING INDICATORS AND MANAGEMENT SYSTEMS**

If leading indicators are used, they must be placed within the context of a formal management system; a robust OHS management system makes use of both lagging and leading indicators, and ideally frames them within an index to demonstrate overall performance with other indicators of business success. No organization within or external to the mining sector should interpret the content of the overview as prescriptive.
EXECUTIVE SUMMARY

EVOLVING LEADING INDICATORS, RISK AND MATURITY

Unlike lagging indicators, leading indicators evolve throughout the life of an organization, depending on a number of factors, not least of which is the organization’s level of maturity. Three levels of leading indicators – compliance, improvement and learning – have been linked to five levels of organizational maturity. The intention in so doing is not to create expectations of “advancing upwards” towards higher maturity levels. Rather, it has been shown that if an organization attempts to implement a higher-level leading indicator and is not at the appropriate level of maturity, these measures can be unsuccessful. For the purposes of this overview, an organization that has a mature OHS culture is one in which leadership is demonstrated at all levels of the organization, through a caring culture that is explicit in all activities, communication, interactions, tasks and measures of OHS success.

This on-going evolution therefore means there is no single set of leading indicators that can be used in perpetuity within an organization. Similarly, leading indicators appropriate for use in one organization may not be transferable to or comparable with other organizations. As the maturity of the organization evolves, the intention is not that the “lower level” maturity leading indicators are discarded. Appropriate compliance and improvement leading indicators must be kept to ensure that basic preventative management measures are delivering expected outcomes.

Leading indicators should be linked to the highest-priority OHS risks affecting an organization. As per the traditional risk-control hierarchy, leading indicators that can identify measures relating to the elimination or avoidance of risk have the greatest opportunity to deliver desired OHS outcomes.

LEADERSHIP

Some organizations believe that leadership, culture and beliefs about safety may be the most important factors in determining organizational safety performance. Other organizations believe that it is more valuable to focus on failures closer to the incident, by monitoring the implementation of critical control integrity linked to material risks. Irrespective,

it is widely recognized that in the absence of sound leadership, other measures to manage OHS often fail. The use of leading indicators relating to appropriate measures of leadership (as opposed to the more commonly recognized “behaviour-based safety” measures) is an area of increasing research and focus.

THE IMPLEMENTATION PROCESS

A 15-step iterative process has been identified to assist organizations in implementing leading indicators. Leading indicators are most effective when they are identified and used across all levels and functional areas of the organization. This provides multiple partial views of the organization that together give a more complete picture of management efforts than any single measure might. Leading indicators are of most use when they are developed, applied and used by the people responsible for implementing the appropriate preventative action. The process of developing leading indicators should, nonetheless, be informed by multidisciplinary viewpoints and by representatives from all levels of the organization, because of the complexity of causal pathways.

DATA AND REPORTING

Leading indicators can be presented as qualitative and quantitative data, and should ideally demonstrate trends, rather than instantaneous measures of performance. This approach does not correlate well with current OHS reporting practices, which may need to evolve to accommodate leading indicator reporting.

CONCLUSION

Leading indicators thus contribute to an organization’s ability to develop appropriate proactive action strategies to prevent harm, through recognizing early signals, with allied safety, health, financial and other business benefits.
INTRODUCTION

1.1 Purpose of this overview
1.2 Methodology
1.3 OHS indicators
1.4 Terminology
Indicators have been used for many years in mining and other high-reliability and high-risk industries (Grabowski 2006). Indicators are used to track performance in occupational health and safety (OHS) in order to prevent damage, injury, illness or death through the identification of hazards. In the context of this overview, occupational health includes the discipline of occupational hygiene. Wherever used, the acronym OHS and the term “health” therefore by implication include occupational hygiene, unless otherwise specified.

Indicators are also useful in determining progress in the implementation of management systems, and whether business objectives and targets have been met. Appropriate OHS indicators should serve to drive change within organizations and lead to improvements in performance (Janicak 2003). Indicators are, nonetheless, merely one set of inputs within the larger business decision-making process.

The target audience for this overview is management and technical experts within the mining industry; it may, nonetheless, be of use to other stakeholders as a starting point on which to engage about issues of OHS and leading indicators. The information in this document can be used to inform strategic interventions, as well as to provide practical “on the ground” material for the use of leading indicators.

This overview is neither prescriptive nor all-encompassing; approaches should be tailored to suit the circumstances and culture of each unique company, country, site or department.
1.2 METHODOLOGY

A review of existing literature (see references) was undertaken and was further informed by the outcomes of various ICMM workshops held between 2011 and 2012. Guided by a semi-structured interview protocol, additional discussions were held with mining company representatives involved in OHS management to inform the overview.

1.3 OHS INDICATORS

Historically, there has been a tendency within the mining industry to focus more attention on the development, use and reporting of safety indicators than on occupational health. This arose not least from the immediacy of the consequences associated with safety and the associated regulatory focus, as well as the longer time lag between cause and effect in health-related issues.

Safety and health, while treated as separate disciplines, are nonetheless significantly interdependent. The use of the term “health and safety” is neither merely a linguistic convenience nor industry tradition; it is influenced by this interdependent relationship.

Not every safety issue correlates with every health issue, but there are distinct areas of overlap. For example, certain medication may lead to drowsiness, which could increase the risk of a safety incident. A recent study demonstrated that “by focusing on activities that are designed to improve health, organizations can reap benefits in a distinct but related area of functioning, namely safety performance” (Mearns and Reader 2008: 394).

Both health and safety leading indicators are therefore equally necessary to ensure the total well-being of people working in the mining industry.

1.4 TERMINOLOGY

Terminology relating to OHS leading indicators is not consistent, which compounds problems in sharing successful approaches and problem areas. The following are proposed as standard terms for the purposes of this overview. Each term is followed by an explanation and/or characteristics.

’Safety and health, while treated as separate disciplines, are nonetheless significantly interdependent.’
## INTRODUCTION

### The Need for OHS Leading Indicators

#### What Are OHS Leading Indicators?

OHS leading indicators are measures that provide insights into concepts that are difficult to measure directly (OECD 2003). They describe what is being measured (OECD 2008). Leading indicators do not reach the threshold of causality to create an incident (CCPS 2008). They measure safety-relevant activity, not safety per se (Hopkins 2007). They measure inputs (Hopkins 2007). They measure precursors to harm. Leading indicators can be used as predictors of future performance and changes can be made to improve the probability of good performance (CCPS 2008).

"Leading indicators ... are conditions, events or measures that precede an undesirable event and that have some value in predicting the arrival of the event, whether it is an accident, incident, near miss or undesirable safety state. Leading indicators are associated with proactive activities that identify hazards and assess, eliminate, minimize and control risk" (Grabowski 2006:8).

"Something that provides information that helps the user respond to changing circumstances and take actions to achieve desired outcomes or avoid unwanted outcomes" (Mearns 2009: 491).

Signal that a condition has been met that may directly, and/or in the presence or absence of other conditions, result in an undesired outcome, with or without a degree of time delay (Grabowski 2006).

#### OHS Leading Indicators and Management Systems

An approach to implementing OHS leading indicators involves the use of information management for leading indicators. This approach is essential for ensuring the effective implementation and monitoring of leading indicators in an organization (OECD 2008).

### Conclusion

The overview of leading indicators for occupational health and safety in mining highlights the importance of adopting a proactive approach to health and safety management. By focusing on leading indicators, organizations can identify risks early and implement preventive measures to minimize the occurrence of accidents and incidents. This strategy not only enhances safety outcomes but also contributes to a culture of continuous improvement and innovation in workplace safety.
<table>
<thead>
<tr>
<th>TERM</th>
<th>EXPLANATION</th>
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<tbody>
<tr>
<td>Maturity</td>
<td>An evolving process whereby an organization (or subset of, such as a system) becomes fully fit for purpose through an internal unfolding of approaches, rather than through externally imposed approaches.</td>
</tr>
<tr>
<td>Metric</td>
<td>A system of measurement used to quantify performance. Metrics are the standards of measurement ([Janicak 2003) – such as injury rates. Describes how the indicator is measured ([OECD 2008).</td>
</tr>
<tr>
<td>Objective</td>
<td>The level of achievement expected from the implementation of the goals. Generally, objectives should be expressed in terms that are measurable ([OECD 2003).</td>
</tr>
<tr>
<td>Performance measures</td>
<td>Performance measures evaluate the safety process ([Janicak 2003). Safety performance measures are indicators that focus on the differences between actual safety performance and what has been defined as acceptable, i.e. measuring the gap ([Janicak 2003).</td>
</tr>
<tr>
<td>Precursors</td>
<td>Events, conditions, circumstances or factors that precede a desired or undesired outcome, and to which it is linked through a causal chain. Also known as antecedents.</td>
</tr>
<tr>
<td>Proxy/surrogate indicator</td>
<td>Substitutes or approximations for leading indicators; they are more easily measured, captured or analysed than are the true leading indicators, and they have predictive associations with adverse events ([Grabowski 2006).</td>
</tr>
<tr>
<td>OHS climate</td>
<td>“can be regarded as the surface features of the (OHS) culture discerned from the workforce’s attitudes and perceptions at a given point in time” ([Flin et al. 2000: 178).</td>
</tr>
<tr>
<td>OHS culture</td>
<td>“The product of the individual and group values, attitudes, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization’s health and safety programs” ([HSE 2002). Key indicators include management style, management visibility, communication, pressure for production, training, housekeeping, job satisfaction and workforce composition ([Flin et al. 2000).</td>
</tr>
</tbody>
</table>
THE NEED FOR OHS LEADING INDICATORS

2.1 Achieving zero harm
2.2 The business value case
2.3 The evolving complexity of business
THE NEED FOR OHS LEADING INDICATORS

2.1 ACHIEVING ZERO HARM

With the well-being of people in the mining industry an overriding priority, prevention of harm is a core driver of management approaches to OHS.

The closer an organization gets to “zero harm”, as measured using lagging indicators, the more difficult it is to ensure safety through tracking lagging performance, and to determine whether it is luck or design that is keeping numbers low (Step Change in Safety Undated); confidence intervals are infinitely wide for rare events, including catastrophic accidents (i.e. low-probability, high-consequence events) (Grabowski 2006). It is therefore unreliable to make any generalized causal inference from too few data points (Hopkins 2007). Management efforts preferably should be focused on more frequently measurable leading indicators of precursor circumstances. Moreover, lagging indicators have lost their ability to motivate or influence measurable safety performance improvement (Broadbent and Arnold 2011c).

For a leading indicator to contribute to achieving zero harm there needs to be a reliable and valid cause and effect relationship established between the leading indicator and OHS performance (Janicak 2003). The further away from the undesired outcome (such as a safety incident) a leading indicator is identified up the causal pathway, the better the chance of addressing the shortcomings that might result in the incident, but the more difficult it is to identify causality (CCPS 2008). This is because OHS outcomes can result from an accumulation of multiple causes (see Section 2.3).

2.2 THE BUSINESS VALUE CASE

The use of leading indicators contributes directly and indirectly to the mining value case. The precursors of undesired OHS outcomes lie in areas relating to people (including behaviour and degree of ownership), organizations (including culture), systems (across all business areas), processes (especially technical, but also administrative), physical plant and processing (technical and technological).

The business case for the use of leading indicators is loss prevention across all of these areas. Lagging indicators can only measure performance after the potential for harm, loss or damage has manifest. Leading indicators can assist in anticipating outcomes in which damage or harm may be a consequence by identifying weaknesses in OHS management, thus creating the opportunity to implement proactive measures to reduce the risk of the harm occurring.

Leading indicators require an organization to change its mindset (Broadbent and Arnold 2011), from one of exclusively event tracking and external benchmarking, to one of value preservation, risk avoidance and sharing of measures shown to improve performance (Goldcorp 2011). Leading indicators are an important tool for risk avoidance.

‘Leading indicators require an organization to change its mindset from one of exclusively event tracking and external benchmarking, to one of value preservation...’
THE NEED FOR OHS LEADING INDICATORS

2.3 THE EVOLVING COMPLEXITY OF BUSINESS

OHS performance is a complex phenomenon operating at many different levels – individual, group, organizational – and therefore cause and effect relationships are very difficult to establish and verify (Mearns 2009). Indicators may also be individually or broadly focused within the same “domain”, although there is evidence that process-type incidents are “predicted” by a different set of leading indicators than personal injuries (Mearns 2009).

The shift towards leading indicators has been driven in part by the increased awareness that organizational and human factors rather than purely physical or technical failures are prime causes of OHS incidents (Flin et al. 2000). Many workplace incidents can be traced to unsafe behaviours or acts (Janicak 2003). By identifying precursor factors, events and activators, behaviour-based leading indicators can provide advance warning of potential hazards and resultant outcomes. Behaviour-based programs are therefore part of the leading indicator “arsenal”; they have been almost exclusively focused on safety, and their applicability to occupational health management needs to be verified.

Because of the complex relationships in OHS causality pathways, it is important to identify priority areas for action when choosing a manageable set of leading indicators. This means identifying those aspects of the organization that pose the highest risk to desired OHS outcomes (OECD 2008). Depending where along the causal pathway the leading indicators are chosen, they can identify the initiating event(s) (root causes) and/or the contributory task, process, person, site or organizational elements or factors. In so doing, they can inform and direct appropriate preventative actions.

Using leading indicators should improve or maintain the well-being of people through tracking internal performance (OECD 2003). To be effective, leading indicators should be part of the overall business philosophy, strategy and OHS management process (Step Change in Safety Undated). Leading indicators allow organizations to measure the relative importance (weighting), effectiveness, applicability and relevance of policies, procedures, practices and activities in achieving desired OHS outcomes (OECD 2008).

Identification of a leading indicator that has moved outside of its acceptable parameters has to prompt appropriate actions as part of the process of monitoring, feedback and control. In other words, organizations should implement preventative actions related to leading indicators (OECD 2003). Leading indicators thus contribute to an organization’s ability to develop appropriate proactive action strategies to prevent harm, through recognizing early signals, with allied safety, health, financial and other business benefits.

‘The shift towards leading indicators has been driven in part by the increased awareness that organizational and human factors rather than purely physical or technical failures are prime causes of OHS incidents.’
WHAT ARE OHS LEADING INDICATORS?

3.1 Introduction to OHS leading and lagging indicators 16
3.2 The relationship between leading and lagging indicators 18
WHAT ARE OHS LEADING INDICATORS?

3.1 INTRODUCTION TO OHS LEADING AND LAGGING INDICATORS

Good OHS indicators (leading and lagging) should be reliable, repeatable, consistent and independent. Linearity and ease of use are beneficial but not necessary characteristics (Broadbent and Arnold 2011e). To be of use in improving safety and health, leading and lagging indicators should:

- allow accurate and detailed comparisons
- lead to correct or help avoid erroneous conclusions
- be well understood by everyone, especially those responsible for implementing change
- have a quantitative basis (even when measuring a qualitative dimension)
- measure what they are supposed to, consistently, accurately and reliably
- collect information that is relevant to the required management decisions and actions
- adequately map and identify causal linkages (root causes, precursors, events and outcomes)
- prompt an appropriate response (Hopkins 2007), leading to consistent focus on implementing change (Goldcorp 2011).

All OHS indicators measure performance (Janicak 2003) in order to identify problem areas, stimulate actions, document management efforts and reinforce improvements in behaviour. The distinguishing feature between leading and lagging indicators is that these objectives are achieved before the potential harm (leading) or after the potential harm (lagging).

3.1.1 Lagging indicators

Historically, the most commonly used indicators are those that measure “after the fact” information. Following an incident, injury statistics are recorded to identify the level of harm or potential for harm (including fatalities), and the immediate cause of the incident and the injury. These indicators are referred to as lagging (or outcomes) indicators. Lagging indicators measure final outcomes – they are tools that identify the hazard once it has manifest (Janicak 2003). Thus, the cause of the incident and its effects can be identified, but only after the incident and (potential) injury has occurred. Lagging indicators have been the focus of attention not least due to the ease of data collection and measurement, as well as having been driven by regulatory reporting requirements.

3.1.2 Leading indicators

Prevention of negative OHS outcomes is a key moral imperative and business value driver. Avoiding immediate and longer-term damage to people, the environment and property is sound financial business practice that also reduces business interruptions. Ideally, a hazard should be prevented from manifesting by understanding and managing the circumstances preceding it. Indicators that can measure these circumstances – that can give “advance warning” about what might be going wrong (Step Change in Safety Undated) – are called leading indicators. Using leading indicators, mining companies can identify whether proactive risk-lowering decisions and actions are being effective, and why a desired result has or has not been achieved (as measured by a lagging indicator) (OECD 2008). In this way, leading and lagging indicators together trace cause and effect pathways.

3.1.3 Comparative characteristics

Leading and lagging indicators coexist within an organization, but are of different relative usefulness, depending on the unit of analysis – from individual, through department, to site and whole company level (Grabowski 2006). Table 1 reflects some key differences between the characteristics of leading and lagging indicators.
### Table 1: Key differences between the characteristics of leading and lagging indicators

<table>
<thead>
<tr>
<th>LEADING INDICATORS</th>
<th>LAGGING INDICATORS</th>
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<tbody>
<tr>
<td>are actionable, predictive and relevant to objectives</td>
<td>are retrospective</td>
</tr>
<tr>
<td>identify hazards before the fact</td>
<td>identify hazards after the fact</td>
</tr>
<tr>
<td>allow preventative actions before the hazard manifests as an incident</td>
<td>require corrective actions to prevent another similar incident</td>
</tr>
<tr>
<td>allow response to changing circumstances through implementing control measures before the incident</td>
<td>indicate that circumstances have changed; control measures can be implemented after the incident</td>
</tr>
<tr>
<td>measure effectiveness of control systems</td>
<td>measure failures of control systems</td>
</tr>
<tr>
<td>measure inputs and conditions</td>
<td>measure outcomes</td>
</tr>
<tr>
<td>direct towards an outcome that we want or away from an outcome that we don’t want</td>
<td>measure the current outcome without influencing it</td>
</tr>
<tr>
<td>give indications of systems conditions</td>
<td>measure system failures</td>
</tr>
<tr>
<td>measure what might go wrong and why</td>
<td>measure what has gone wrong</td>
</tr>
<tr>
<td>provide proactive monitoring of desired state</td>
<td>provide reactive monitoring of undesired effects</td>
</tr>
<tr>
<td>are useful for internal tracking of performance</td>
<td>are useful for external benchmarking</td>
</tr>
<tr>
<td>identify weaknesses through risk control system</td>
<td>identify weaknesses through incidents</td>
</tr>
<tr>
<td>are challenging to identify and measure</td>
<td>are easy to identify and measure</td>
</tr>
<tr>
<td>evolve as organizational needs change</td>
<td>are static</td>
</tr>
</tbody>
</table>
Effective leading indicators also need to be:

- simple to understand and demonstrate objectively how they are making a difference (Gordon 2011)
- cost efficient in terms of the equipment, personnel and additional technology required to gather the information
- educational, create positive energy, drive continual improvement and sustainability and cost reduction (Broadbent and Arnold 2011)
- able to fit in with other strategic measures of the organization (Goldcorp 2011).

A simple example of a generic health leading indicator would be obesity. Being obese (a root cause) can lead to potential problems such as heart failure, the development of diabetes, vascular problems and joint degeneration (undesired outcomes). Knowing that obesity can have these consequences allows early action. In identifying the appropriate action, it is important to trace back the causal pathway of obesity (also in itself an undesired outcome). Therefore, measuring a more specific leading indicator, such as calorific intake or levels of exercise, can help reduce the risk of obesity. If obesity is already a factor, implementing a weight loss program through improved diet and increased exercise (the action strategy) would reduce the risk that any of these longer-term problems might occur.

As one example in the safety field, there has been a growing trend in the measurement and elimination of the leading indicators of unsafe acts and behaviours (Janicak 2003).

The shift in attention and associated benefits from lagging to leading indicators can also be conceptualized as a switch from “feedback” to “feed-forward” control (Flin et al. 2000). Both can, however, help move a company towards improving future performance, and a balance between both is required in the successful management of OHS (Goldcorp 2011). Used in conjunction with each other, leading and lagging indicators give a more complete picture of all the factors affecting desired performance levels than they do in isolation. Indicators are only useful in as far as they form part of a broader OHS metrics program, which in itself is part of a total OHS management system.

Leading and lagging indicators should both have:

- a definition: states what is being measured in terms that are meaningful to the intended audience (OECD 2008) and
- a metric: define the unit of measurement or how the indicator is being measured. This should be precise enough to highlight trends over time and/or highlight deviations from expectations that require a response (OECD 2008).

Leading indicators for OHS will only improve performance if they are directly related to the organization’s overall goals and objectives (Janicak 2003; OECD 2003). The more specific the objectives and related indicators, the more likely it is that the specific decision, activities, related outcomes and appropriate precursor actions will be identified. Adopting an appropriate mix of leading and lagging indicators is of most benefit (Hopkins 2007). The relationship between leading and lagging indicators, and OHS performance is depicted in Figure 1 (adapted from Step Change in Safety Undated).
A marked difference between leading and lagging indicators is that leading indicators are not static to the extent that lagging indicators are. As an organization matures, leading indicators will be refined to give increasingly advance warning of hazards and their potential outcomes. Thus, leading indicators are internally specific to a company, compared to lagging indicators that can be used for external benchmarking. Leading indicators are typically not suitable for external benchmarking at a large scale [Step Change in Safety Undated]. The probability of being able to create a universal and stable set of OHS leading indicators in the near future is therefore low [Flin et al. 2000]. The development of leading indicators is also an iterative process, setting in motion a continuous improvement cycle.
OHS LEADING INDICATORS AND MANAGEMENT SYSTEMS

4.1 Introduction 21
4.2 OHS leading indicators and risk management 22
4.3 OHS leading indicators and maturity 22
4.4 The role of leadership, culture and beliefs in OHS leading indicators 25
4.5 Causality and OHS leading indicators 26
4.1 INTRODUCTION

Leading indicators should not be adopted in isolation, but be developed and used within an overarching framework of OHS management. They should be evaluated according to pre-determined triggers (such as regular scheduling or particular circumstances) and refined or changed to meet the needs of the evolving organization. If chosen correctly, leading indicators can drive an organization towards increasing maturity; the leading indicators will have to evolve with changing maturity levels. This iterative process of developing leading indicators thus sets in motion a continuous improvement cycle.

4.1.1 Criteria

Criteria for selecting the most appropriate leading indicators (adapted from Step Change in Safety Undated) include that:

- the most significant threats to achieving organizational objectives (including OHS) are addressed
- focus is on areas with the greatest opportunity for improvement; these are often gaps in existing management systems or processes
- quantitative and qualitative information is covered and measurable, i.e. quantifiable, even if the indicator is qualitative
- information is provided on which interventions can be based to create improved performance
- the level of control is the same as that at which leading indicators are implemented, with appropriate cross-, up- and downward feedback on effectiveness.

Leading indicators should always be used within the context of a formal management system; a robust OHS management system makes use of both lagging and leading indicators. They can be used collectively to create an index of performance, not only in safety and health, but across all aspects of business performance and organizational well-being. Leading indicators should be used for both safety and occupational health. The longer lag times between cause and effect, and the more complex causal pathway of occupational health outcomes makes the identification and use of occupational health leading indicators more challenging.

As with any business process, the implementation of leading indicators requires a structured systematic approach to encourage success. The use of leading indicators to achieve first-class OHS performance should be aligned with the typical systems approach of “plan, do, check, and act”, as applied to OHS (CCPS 2008; OECD 2003).

4.1.2 Integration

With respect to the use of leading indicators, the management of OHS should be:

- integrated with all other management systems, because the root cause of an OHS outcome may lie within another system within the organization, for example finance, human resources, procurement or engineering (Janicak 2003)
- implemented within the risk management system of the organization (see Section 4.2)
- fully integrated with an understanding of the culture and maturity of the company (see Section 4.3).

As with all other management programs, when introducing and using leading indicators for OHS, critical success factors are leadership, accountability, collaboration and co-ordination, resourcing and an understanding of all business processes (Janicak 2003; OECD 2003). Finally, leading indicators should be implemented as business-critical tools, fully integrated with relevant management systems and not as “yet another health and safety initiative”, the effectiveness of which has been shown to be decreasing through initiative weariness or overload (Mearns and Reader 2008).
4.2 OHS LEADING INDICATORS AND RISK MANAGEMENT

To be effective, leading indicators should be appropriately integrated with the risk management processes of the organization. Proactive risk management helps to avoid system failures, reduces the potential for incidents that cause loss or harm and improves efficiency (OECD 2008). A number of factors affect risk, including the nature of the activity (such as inherently risky processes involved in mining), the use of technology that is either inherently risky or that exacerbates the risk, human factors and organizational culture that may encourage risk taking or risk aversion (Grabowski 2006).

Risk is typically controlled using a five- or six-level hierarchy of approaches, in order of priority:

1. eliminate or avoid the hazard
2. substitution
3. engineering controls/reduction at source/isolate hazard
4. administrative controls/behavioural controls/reduce exposure
5. personal protective equipment (PPE).

The further up the hierarchy the risk control is implemented, the longer term and the greater the value delivered by the control measure. The level of risk control used should be commensurate with the level of risk identified, and the risk appetite of the organization. In the case of OHS, risk appetite should be linked to the aspiration of zero harm, and risk tolerance levels should by definition be very low. Leading indicators that can identify hazards that can be avoided or eliminated are therefore valuable in the management of OHS performance. Similarly, leading indicators that identify root cause(s) (whether close to or distant from the undesired outcome) are useful in mitigating against risk. In certain organizations, the level of authentic leadership displayed at all levels is potentially the most effective risk avoidance leading indicator (Eid et al. 2012). In other organizations, material risk controls proximate to the incident are highlighted as being more valuable.

There is a wide range of leading indicators that can be used; to be manageable, the set of leading indicators chosen should be prioritized through linking them to the critical aspects of the enterprise that create the highest risk (OECD 2008; Step Change in Safety Undated). This prioritization of leading indicators can be done in a stepwise way, starting with only a few that address the highest risks, and expanding the set as the organization gains experience (OECD 2008). The appropriate use of a mix of leading and lagging indicators should deliver progressively on achieving risk avoidance or elimination.

In closing, it has been found that the stronger the focus of and involvement in OHS by leaders, the more effective the change process in eliminating the risk identified through leading indicators (Goldcorp 2011). The identification of uncertainty related to risk “requires ... a supportive risk-aware culture and staff at all levels who are committed, competent and professional in their approach to risk management. These are the characteristics of a ‘risk-mature’ organisation, able to handle risk effectively at all levels” (Hillson 2006: 3, 4).

4.3 OHS LEADING INDICATORS AND MATURITY

The ability of an organization to adopt leading indicators successfully is dependent on the level of maturity of the organization and of its management systems. The types of leading indicators used are similarly dependent on organizational maturity. Typically, there are three levels of leading indicators linked to various levels of maturity: a level 1 indicator is used where maturity is low, and a level 3 indicator is appropriate in a mature organization (see Figure 2).
The aim is not to move through “stages” of maturity from levels 1 to 3, but rather to identify the appropriate level of maturity of the various parts of the organization, and to apply the appropriate leading indicators. Trying to apply level 3 indicators where a business unit has low maturity, for example, will likely fail. The linking of maturity and leading indicators is therefore useful in effective OHS management, rather than being an aspirational goal.

There is no single definition of a “mature” organization. For the purposes of this overview, an organization that has a mature OHS culture is one in which leadership is demonstrated at all levels of the organization through a caring culture that is explicit in all activities, communication, interactions, tasks and measures of OHS success.

Maturity depends on complex interactions and relationships between various factors. The following 10 elements interact in an OHS culture maturity model, and therefore provide opportunities to identify leading indicators (adapted from Fleming 2001):

- management commitment and visibility
- communication
- productivity versus OHS performance
- learning organization
- OHS resources
- participation
- shared perceptions about OHS
- trust
- industrial relations and job satisfaction
- training.

4.3.1 Maturity models

“Different maturity models embody both different concepts and different suggestions as to the route to maturity” (Cooke-Davies 2004). There are similarly various safety maturity models: for the purposes of this guideline, these have been extrapolated to include occupational health and hygiene. It is, however, critical to note that there are unique issues relating to occupational health that should be taken into consideration when implementing leading indicators. It is not always adequate to simply expand current safety leading indicators to incorporate occupational health issues – this is addressed further in Section 6. It is nonetheless anticipated that, as the approach to maturity models provides a sound basis for achieving step changes in safety culture, it offers the same opportunity for occupational health.

The available maturity models have a significant degree of overlap and commonality, including that maturity is delineated into five or six distinguishable levels. Therefore, the 10 elements identified by Fleming (2001) interact in different ways to produce these five levels of maturity. Maturity can vary within an organization, between departments, sites and, indeed, individuals.

Leading indicators are specific to the various levels of maturity, and are typically divided into three levels. It is important when choosing appropriate leading indicators that organizations determine the level of maturity for the unit to which the leading indicators will be applied, before making the choice of leading indicators (Janicak 2003; Broadbent and Arnold 2011c).

‘...there are unique issues relating to occupational health that should be taken into consideration when implementing leading indicators...’
Figure 2: Models of OHS culture, maturity and leading indicators

<table>
<thead>
<tr>
<th>Models of OHS culture maturity levels</th>
<th>Typical characteristics of maturity level</th>
<th>Levels of leading indicators</th>
<th>Typical characteristics of leading indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1*</td>
<td>Continually improving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2*</td>
<td>Generative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 3*</td>
<td>Global leader</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 4*</td>
<td>Resilient</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: Learning</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: Improvement</td>
<td></td>
</tr>
<tr>
<td>Cooperating</td>
<td>Systematic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Involving</td>
<td>Proactive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managing</td>
<td>Calculative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emerging</td>
<td>Reactive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pathological</td>
<td>Not aware</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Continually improving**
  - OHS driven by the desire to prevent harm
  - Management systems fully integrated, complementary, and are "the way of doing business"
  - Caring leadership demonstrable, tangible and felt by all
  - Expectations, pride, responsible and fully committed

- **Generative**
  - Routine measurement of metrics that positively drive OHS performance
  - Learning loops closed and drive positive change
  - Better awareness of the dynamics of the OHS and interrelated systems

- **Global leader**
  - Identify areas of greatest weakness, with greatest opportunities for improvement
  - Engagement, integration, accountability and ownership
  - Risk treatments have "the right" elements, with little focus on quality, context or dynamics
  - Cautious two-way flow of information
  - No/limited closing of learning loops

- **Resilient**
  - Routine measurement of metrics that positively drive OHS performance
  - Learning loops closed and drive positive change
  - Better awareness of the dynamics of the OHS and interrelated systems

- **Localised specificity and greater divergence of indicators**
  - Demonstrate business value case: improved OHS and morale, decreased costs and risks
  - Proactive (leading) and reactive (lagging) elements in place

- **Mature OHS culture**
  - Continually improving
  - Generative
  - Global leader
  - Resilient

1. Fleming (2001) and Step Change in Safety (undated)
3. Fletcher (2011)
4. Badenhorst and Fox (2011)

At each level of maturity, the issues, tools and improvement techniques needed to evolve to higher maturity levels differ. The more mature the organizational culture, the more closely linked the development of leading indicators is to the unit of business at which they will be used. Possible sources of leading indicators are also linked to the level of maturity:

Figure 2 is based on existing safety maturity models; the synthesis presented includes occupational health issues. It is important to note that in this representation, the stages of maturity and leading indicators are not as distinct as might be implied by the linearity of the tabulation; their thresholds are not exact. The intention is not to imply a one-to-one relationship, but rather to reflect similarities in the characteristics of the stages of each model.
4.4 THE ROLE OF LEADERSHIP, CULTURE AND BELIEFS IN OHS LEADING INDICATORS

Although anecdotal perspectives differ, recent formal safety research has found that leadership, culture and beliefs about safety are important factors in determining organizational safety performance (Eid et al. 2012), and thus represent potential sources of leading indicators. Employees pay close attention to the attitudes and beliefs of supervisors and managers apropos safety, as evidenced through their expectations and actions (Mearns and Reader 2008). Leadership behaviour – specifically, the quality of leaders’ relationships with others, the perceptions of leadership commitment to safety and the leaders’ extent of self-awareness – is positively correlated with the degree of commitment to safety at all levels, and is predictive of safety outcomes (Eid et al. 2012). High-quality relationships, demonstrably high commitment to safety and a high degree of self-awareness in leaders provides positive (OHS) modelling through which levels of mutual trust are heightened via honest non-threatening engagement. Safety performance is highly dependent on levels of trust (Grabowski 2006) and high levels of demonstrated support, which is interpreted as care (Mearns and Reader 2008). Supervisory leadership (Flin et al. 2000) is as important as senior leadership in this regard (Hopkins 2007) and builds a positive culture of “safety citizenship behaviour”. At the same time, research found that supervisor support for health is a stronger predictor of safety behaviours than workmate support for health (Mearns and Reader 2008).

Leaders are the primary determinants of organizational culture and related beliefs. A positive safety climate is distinct and measurable, providing motivational precursors for key dimensions of safe behaviour: this provides for the application of leading indicators in this area.
“Authentic” leaders demonstrate congruency between words and actions. In safety terms, it has been shown that performance is traceable to workers’ beliefs about whether or not management truly care about their well-being. These beliefs are correlated with employees’ perceptions of leaders’ safety priorities versus other competing priorities. “The most important factor for achieving a safe workplace is the belief by all personnel and others involved in the operation that safety is critical” (OECD 2003: 29).

It is possible to infer from these observations, therefore, that factors related to leadership provide important opportunities for leading indicators of safety and health performance. The precursors of perceived organizational support for OHS – and therefore of possible use as leading indicators for leadership issues, are:

- fairness in the way resources are distributed among employees and the quality of interpersonal treatment in resource allocation;
- the degree to which supervisors value employee contributions and care about employee well-being; and
- the organizational reward and recognition of employee efforts alongside general work conditions provided by the organization (Mearns and Reader: 390).

This is supported by the observation that the standards that are adopted by a company are a leading indicator of company values (Step Change in Safety Undated). Given that other axes of organizational performance are also linked to leadership behaviour, that health has implicit links to safety and, based on empirical research (Mearns and Reader 2008), it can be inferred that leadership behaviour is equally positively correlated with occupational health outcomes.

The development of leading indicators should therefore take into account that there is “increasing emphasis on competence in non-technical skills [e.g. leadership and decision making] which are regarded as contributing factors to safe operations” (Flin et al. 2000). It may be that addressing leadership will overcome the residual OHS risks (and related undesirable performance) not addressed by engineering solutions and traditional OHS management (Mearns and Reader 2008).

4.5 CAUSALITY AND OHS LEADING INDICATORS

In setting leading indicators, there should be identifiable causal or correlational links with the desired performance outcome, as measured by lagging indicators. This pathway may be direct or indirect, and appropriate leading indicators should be chosen to account for both. Statistical analysis and expert group knowledge are useful in identifying these causal or correlational linkages.

The causes of safety incidents and occupational health outcomes are complex and interrelated. Root causes of undesired OHS outcomes may be found in any combination of human, technological, activity-based, process, systems and administrative factors, close to the incident (proximate) or distant from it. Proximate and more distant root cause leading indicators should be used for all factors that significantly affect performance outcomes, on a risk-prioritized basis. In some organizations, leadership indicators (distant) are perceived to add most value, while in others, the focus is on monitoring of material risks and critical controls more proximate to the hazard.

Due to the complexity of the causal pathway of OHS outcomes, leading indicators may not be measuring what they are intended to (Janicak 2003). It may in fact be that a cause and effect relationship between the measurement and the activity does not exist. This is compounded by the small leading indicator data set currently available (Grabowski 2006).

This relational complexity means that it is beneficial to take “multiple partial views” through the organization. In practice, this means addressing causal factors (with associated leading indicators) distant from and close to the OHS outcome. Distant leading indicators could address, for example, issues of culture, leadership, systems, strategy and policies. Moving further down the causal pathway towards the outcome, leading indicators may address OHS specific procedures, site staffing and resourcing, and auditing performance. The most proximate leading indicators could relate to specific activities or tasks, be behaviour based, relate to human factors such as fatigue or relate to the fulfillment of planned maintenance schedules (technical factors).
It is assumed that distant factors provide the framework within which the more proximate factors evolve, and therefore influence these factors. For example, an organization with a poor safety culture (distant) may not have good management training in OHS issues (closer), which in turn might lead to workers habitually taking short cuts (immediately proximate) to meet production pressures without corrective interventions. Proximate and distant factors can be in play at any scale of operation, from department, to site, to the entire company: assessing all of these units of scale provides another type of multiple partial view through the organization. Each level lends itself to the application of leading indicators; see figure 3 (adapted from Grabowski 2006).

The importance of the precursor factors in the causal chain should be weighted in terms of how much they contribute to the undesired outcome. Leading indicators should ideally focus on high-weighted factors.

A note of caution is necessary: the predictive validity of leading indicators may be difficult to establish due to the lack of simple one-to-one relationships between leading and lagging indicators (Mearns 2009), or due to lack of actual causality (Step Change in Safety Undated).

This can result in erroneous conclusions being drawn, and the implementation of well-meaning but ineffective (and even potentially harmful) corrective actions.
5.1 Explanation of implementation steps
5.2 Key findings from ICMM members
The overall process by which to develop, choose, implement, measure, respond to and report on leading indicators aligns with that of any typical management process – plan, do, check, act.

Leading indicators cannot be prescribed, and every organization should adapt them to their specific conditions.

Figure 4 indicates specific steps to create and use leading indicators within an overall OHS management system, located within an overall business strategy process. The section following briefly describes each step.

**Figure 4: The development and implementation of OHS leading indicators**
5.1 EXPLANATION OF IMPLEMENTATION STEPS

The following steps apply irrespective of the level of the organization at which leading indicators are being developed. In other words, the process can be followed for entire organizations, sites, departments and at job-task level. Each step should be undertaken with the target users in mind.

Step 1: Establish multidisciplinary team

A multidisciplinary team comprising all relevant disciplines should be created to identify leading indicator need and use. The inclusion of all disciplines is important because the root cause of incidents can lie in organizational culture, structures and processes (including people, systems, policies or procedures), and in technical issues (including specific high-risk tasks, in equipment or resources). People who will be affected by the leading indicator results should be included so that immediate preventative or improvement action can be taken where necessary. A sign of a mature organization is when leading indicators are set at the lowest possible level of management and operation by the people who will be involved in the activities for which the leading indicators are chosen. Ideally, staff from a cross-section of seniority should be part of the team to contribute to the multiple partial views of the organization (OECD 2008: Step 1).

Step 2: Set goals and objectives, including OHS

The value proposition of a business is articulated through its goals, objectives and performance targets at all levels. OHS goals and objectives should always be aligned with those of the organization as a whole, and contribute to the ultimate direction of the company. Similarly, the higher-level organizational goals should create the framework for the more specific goals and objectives, including issue-based such as OHS, or scope-based such as departmental or site level.

Step 3: Determine the characteristics of the relevant business unit

The successful adoption of leading indicators is dependent on a number of characteristics, the state of each of which should be assessed prior to the choice and adoption of leading indicators. At a minimum, the following characteristics should be established in relation to each other:

- **Maturity**: of the relevant business unit, of the people involved and of the existing OHS systems. The level of maturity will dictate the mix of leading indicators most appropriate for the business unit. As organizations mature, new leading indicators will emerge that are appropriate. This does not, however, imply that existing leading indicators should be dropped from use. Certain compliance and improvement leading indicators should remain in place to ensure that root causes across all aspects of the organization are monitored.

- **Culture**: of the relevant business unit and pertaining to OHS. All levels of seniority should be assessed as perceptions of culture differ significantly across the hierarchy. If possible, individuals’ and applicable group (such as team, department and site) cultures should be assessed relative to the critical issue. Culture can be determined through perception surveys, voluntary feedback and performance observations.

- **Risk appetite**: the risk appetite of the business unit delineates the relative weighting of each precursor in terms of its capacity to hinder the achievement of objectives. If there is a low appetite for risk, there may be a tendency to try and identify more leading indicators relevant to the desired outcomes, and vice versa. Action responses for low-risk appetite issues will also be triggered earlier than in high-risk appetite situations.

- **OHS climate**: competency and capacity: the OHS climate includes issues such as the physical environment, the equipment and the interfaces between the workers and the work environment. The competency of people involved with OHS is a limiting factor for improving maturity and OHS performance. Similarly, capacity issues such as human, financial and technical resources, as well as infrastructure, should be understood.
Step 4: Identify all areas of OHS performance

Organizations at all levels make use of strategies, policies, processes and systems, and carry out operational activities. Across all of these aspects, failure or vulnerability to deterioration that may affect OHS outcomes should be identified (various areas for consideration are provided in OECD 2003: 30ff.). This should include consideration of emergency and other special conditions (such as planned shutdowns, temporary mothballing), as well as assessment of policies, strategies and procedures.

Step 5: Identify and prioritize critical OHS decisions and issues

When identifying and prioritizing critical OHS decisions and issues, attention should be paid to the results of risk assessments (Joy 2000), the history of OHS incidents and the experiences of similar organizations. All issues of OHS concern should be identified across all aspects of the business – the multiple partial views of the organization. In so doing, it is important to recognize that the well-being of people within the organization is affected by, for example, human behaviour and decision-making processes, technical issues and technological, systems, administrative, engineering, cultural and production factors (OECD 2008: Step 2).

Step 6: Identify current indicator use

A mature organization makes use of an appropriate mix of lagging and leading indicators at all levels of the organization, across all aspects of the business, using quantitative and qualitative measures. Many indicators already in use can be adapted for use as leading indicators. Organizations should build on the existing OHS and other management systems in use, identify what leading and lagging indicators are already in use, and establish their effectiveness in meeting the predetermined goals and objectives.

Step 7: Precursor analysis

There are multiplicities of complexly interrelated precursors that ultimately affect OHS outcomes. While typically applied at “event” level, precursor analysis (or causal route decomposition) should be used to determine what factors undermine the total value proposition of the business, specifically related to OHS in this case, irrespective of the scale or focus of assessment. For example, if a high-risk issue identified in Step 5 by a business unit is that people do not take occupational health seriously, the precursor analysis might focus on issues of leadership, culture, communication, performance incentives and perceived production pressures. At a different scale, if a business unit identifies fatalities from falls of ground as a critical risk issue, more “traditional” precursor analysis techniques such as fault tree analysis might be applied, which could also include issues of culture, equipment failure, capacity and the like.

The assessment of the precursor factors that undermine organizational value in the areas of OHS aims to identify and manage the root causes of this reduced value, whether they lie in “intangible” characteristics such as culture, in systems or in technical aspects such as engineering, design or technology (OECD 2003).

To close out this step, in combination with Step 6, gaps, vulnerabilities and weaknesses in the current OHS system should be identified, relative to delivery against the highest-risk issues.
Step 8: Identify leading indicators

Identify leading indicators that are aligned with the appropriate level of maturity of the organization and/or OHS system, as noted in Step 3. These leading indicators ideally should be traceable to lagging indicators associated with the issues of highest risk, and the identified gaps, vulnerabilities and weaknesses. The leading indicators chosen should demonstrate strengths and weaknesses in the organization, and should be adapted to suit local circumstances, including strategies, vocabulary, standards and procedures.

As leading indicators are tailored to maturity levels, to key risk areas and to changes in priorities, it is likely that only a limited number will be useful at any particular stage of an organization’s development. Also consider who will use the results of the leading indicators, at what level of the organization they will be used and how the results will be used.

Identification and measurement of leading indicators can be difficult. Organizations should take care to measure what should be measured to deliver improved performance, rather than what can easily be measured (OECD 2008).

‘Some leading indicators are easy to determine and quantify, whereas others are more complex and subjective...’

Step 9: Define the leading indicators

Each leading indicator should be clearly defined according to the desired performance outcomes and maturity level. Appropriate metrics should be chosen for each leading indicator. Some leading indicators are easy to determine and quantify, whereas others are more complex and subjective (OECD 2003); this will be evident in the metrics that will have to be used (OECD 2008: Step 4). Metrics can be of three types:

- **descriptive** – a condition measured at a certain point in time
- **threshold** – compares data from descriptive metric to tolerance levels
- **trended** – change in descriptive metric over time (see OECD 2008: 25 for further detail).

It is recommended that leading indicator choice focus on trend identification and analysis. It should be noted that difficulties can arise in the definition of leading indicators. For example, “leading indicators” of more serious incidents may be lagging indicators of less serious circumstances. For example, the number of complaints about unsafe working conditions may be a leading indicator for an injury, but is still a lagging indicator for safe conditions (OECD 2003). Another example is that certain authors cite “near misses” as leading indicators, while others cite these as lagging indicators, because no harm occurred. Definitions should be carefully considered and uniformly implemented.

Step 10: Set target performance levels

The desired targets for the leading and related lagging indicator should be set in order to be able to track progress towards improved OHS and increasing maturity. The use of leading indicators should lead directly to actionable change in factors affecting the outcomes through suitable decision-making processes. If trending is being used, limits should be set, as opposed to targets, beyond which an appropriate management response is prompted.
Step 11: Collect data

Data should be collected according to a predetermined protocol. It can be collected directly (through measurement) or indirectly (through, for example, observation), and it can be qualitative or quantitative. An appropriate data management system should be in place for reporting and analysis of data (OECD 2008: Step 5).

Step 12: Analyse data

Data can be analyzed using quantitative and/or qualitative methods. Quantitative statistical analysis is preferred as it allows for more defensible determination of causal relationships. However, qualitative techniques such as brainstorming are equally valid where quantitative techniques are inappropriate (i.e. where factors are not measurable). “Consideration might also be given to applying a ‘weighting scale’ to the measuring system so that certain indicators (e.g., those that have a greater impact on the levels of safety) might be given a greater emphasis in the overall analysis of trends” (OECD 2003).

Caution should be employed when aggregating leading indicators: if this is to be done, the weighting of the indicator measurement should be applied before aggregation. Aggregation of leading indicators is not recommended as it is likely to obscure the causal relationships that the leading indicators are chosen to represent (Broadbent and Arnold 2011b).

Step 13: Compare actual results with desired outcomes

Tracing the causal pathway, the results of leading indicator information should be assessed against the targeted OHS outcomes (desired or undesired) as measured by lagging indicators, the desired leading indicator trend and/or the results of risk assessments.

Step 14: Act on the findings

The results of leading indicator analysis should lead to actions on the highest weighted causal precursor. To be most effective, decisions and actions will be carried out by the responsible people at the level of the business unit at which the leading indicator is being applied (OECD 2008: Step 6).

Step 15: Reporting and feedback

Leading indicator findings should form part of routine business reporting processes at all relevant levels of the organization. Cross-hierarchical feedback on leading indicator results should also be provided, especially to those responsible for implementing decisions and changes in activities. Leading indicators should be refined if performance does not meet targets (OECD 2008: Step 7), and as appropriate to the evolving circumstances (including maturity) of the organization.

5.2 KEY FINDINGS FROM ICMM MEMBERS

The following observations regarding the implementation process are taken from the experience of some ICMM member companies that are already using leading indicators for OHS.

5.2.1 A mix of indicators

Leading and lagging indicators should be used in an appropriate mix. Companies should address risks at source level but they also need to measure the system failures and impacts of risk exposures. The risks (leading indicators) are different within and across companies, even though the results (lagging indicators) might be the same (injury, illness and/or fatalities). This is the very reason why tracking only lagging indicators has not led to achieving zero harm.

5.2.2 Leading indicators should evolve

Leading indicators should evolve as the organization changes and/or as circumstances change. Variability in leading indicators across groups, divisions and/or sites should be allowed, at least in the early stages of developing the use of leading indicators. One or two will probably emerge that can be applied across the entire group.

The implementation of the use of leading indicators has no “end date” as they are constantly evolving. The introduction of the systems on which the effective use of leading indicators is built can take up to five years.
5.2.3 A “bottom-up” approach

The use of leading indicators needs the support of the organization’s top leadership. Companies can also consider that business units should be consulted when leading indicators are being developed, to ensure that those chosen are relevant and useful at site level – this is what is meant by a “bottom-up” approach. In the absence of this, the application of leading indicators may be unsuccessful, if they cannot demonstrate value at business unit level, and if there is no ownership of the leading indicators at all levels of the organization. This is particularly relevant when targets are being set for leading indicators.

5.2.4 Education and awareness

Extensive education and awareness building is required about the use and context of leading indicators. They are not simply lagging indicators projected “forwards” in the causality chain. Leading indicators are different and unless everyone, especially senior people who receive reports on performance, understands this, mismatched expectations will undermine the successful implementation of leading indicators.

‘People in the mining industry are largely uncomfortable with, and therefore can be resistant to, the qualitative data that can emerge using leading indicators.’

5.2.5 Data and reporting

The consistency and quality of data is probably the most important limiting factor in tracking the usefulness of leading indicators.

Where possible, use should be made of existing data. Appropriate mathematical manipulation of the available data can allow for its application to leading indicators.

Reporting levels and frequencies should be linked to who is responsible for the required response and to the associated risk. The tracking of leading indicators can increase the reporting burden, a factor that can affect the desire to implement them (Cole et al. 2005).

The factors that prevent employees from reporting lagging indicators may still affect the reporting of leading indicators (Azaroff et al. 2004). People in the mining industry are largely uncomfortable with, and therefore can be resistant to, the qualitative data that can emerge using leading indicators.

For reporting brevity and to provide higher-level overviews, there is a tendency within the industry to aggregate indicators. This should not be done to leading indicators (Step Change in Safety Undated).

5.2.6 Indicators, indices and fit with the organization

Focus should be on a few, highly weighted leading indicators, especially at the start of the implementation process.

It may be more appropriate to consider moving away from the term “indicator” when used in the leading sense, to “leading indices”. Indices highlight trends, which is more appropriate than an exclusive focus on quantitative data in the traditional sense of safety indicator reporting.

Each organization should ensure that the leading indicators chosen suit their unique circumstances and requirements. OHS leading indicators should be linked to the broad business-related strategic requirements of the organization.
5.2.7 Health and safety

The time differences regarding exposure to risk and emergence of occupational effect related to health – the long latency periods – are neither well understood nor accepted in the industry. The justifiable focus on safety means that the “worldview” is short term and immediate; it is proving difficult for people to shift from this perspective to manage occupational health appropriately.

In summary, some of the findings from the ICMM members confirm the following barriers to implementing leading indicators (Broadbent and Arnold 2011):

- **at company level**
  - management understanding
  - acceptance of risk
  - data management issues
- **at industry level**
  - lack of shareholder drivers
  - acceptance of risk
  - data management issues
  - changing personnel.

ICMM member case studies regarding leading indicator experiences are provided in the appendix, section 8.1.

A synopsis of the responses to the survey conducted with ICMM members is provided in the appendix, section 8.2.

‘The justifiable focus on safety means that the “worldview” is short term and immediate...’
6 INFORMATION MANAGEMENT FOR OHS LEADING INDICATORS

6.1 Introduction  
6.2 Collection, management and analysis of data  
6.3 Examples of leading indicators
6.1 INTRODUCTION

Although there are significant areas of overlap, and they may be managed via an integrated OHS system, leading indicators for both occupational health and safety should be treated separately at times, with equal attention and importance.

It is not always appropriate to simply expand safety indicators (which have a longer historical use in the industry) to include health matters. The causal pathway of occupational illness and outcomes is often more complex than that of safety, and has far longer lag times between cause and effect. Leading indicators are useful for monitoring of “quality of work-life” (QWL), which impacts on various dimensions of employee health, including well-being (Cole et al. 2005). This aspect is of particular relevance when considering leading indicators related to maturity levels; in other words, it may be that the more intangible life-quality issues are important leading indicators of health outcomes for high-maturity organizations.

Leading indicators can be used for safety and health at process and personal level. Process issues (in their broadest sense) include organizational structure and design, communication interfaces, formal learning systems, safety prioritization processes and problem identification procedures. Personal issues include empowerment, ability to report, feedback processes and responsibility (Grabowski 2006). Leading indicators can measure management activities themselves, or the outcomes of management activities (Hopkins 2007).

6.2 COLLECTION, MANAGEMENT AND ANALYSIS OF DATA

Data collection, analysis and management are inextricably linked to the metrics chosen for leading indicators. While performance rates are very popular ways of representing indicators, their use can be misleading for both lagging and leading indicators. Rates can hide reality; actual OHS performance may not be improving if the denominator increases, rather than the numerator decreasing. Rates should be used with caution, especially as they can obscure causal linkages.
6.2.1 Quantitative Analysis

Leading indicators are measured at input stage, whereby several inputs or lack thereof can contribute to the final outcome. This makes the causes of final OHS outcomes complex to analyse and monitor. Analyses that identify degrees of correlation are useful in that they involve a measure of the association or relationship between inputs (leading indicators) and outcomes (lagging indicators).

Quantitative statistical analysis is useful to verify linkages between leading and lagging indicators (Step Change in Safety Undated), and to identify the extent of causality or correlation on OHS matters (Broadbent and Arnold 2011d). At a task level, tools that can be used to trace root causes of incident and link lagging and leading indicators include logic model frameworks and systems safety techniques (including fault tree analysis, procedure analysis, failure modes and effects analysis, and root cause analysis) (Janicak 2003). Cause and effect analysis, including joint event analysis and compound or conditional probability analysis, identify the various factors that may contribute to the outcome.

Techniques such as Pareto analysis help to weight the factors in terms of their contributory role to the outcome. Control charts and run charts are useful in clarifying chance variability in relationships, thereby validating causal analysis. This makes them particularly useful when measuring leading indicators. Finally, trending and forecasting techniques are critical for leading indicator analysis.

A cautionary note: statistical methodologies can be useful in tracking precursors of undesired circumstances, but their use can be complicated. Statistics can create a false sense of confidence about safety if they are not measuring the appropriate things (refer to Janicak 2003 for extensive guidance on the use of statistical methodologies of data analysis).

6.2.2 Qualitative Analysis

Qualitative data gathering and analysis techniques differ from quantitative, and are useful in determining the more intangible aspects of OHS leading indicators such as behaviour, attitudes, culture and beliefs. Where quantitative methods often test specific hypotheses, qualitative inquiry (Janicak 2003):

- is conducted in natural settings
- utilizes the researcher as the chief “instrument” in both data gathering and analysis
- emphasizes “thick description”, that is obtaining “real”, “rich”, “deep” data that illuminate everyday patterns of action and meaning from the perspective of those being studied
- tends to focus on social processes rather than primarily or exclusively on outcomes
- employs multiple data-gathering methods, especially participant observation and interviews
- uses an inductive approach to data analysis, extracting its concepts from the mass of particular detail that constitutes the database.

There are many assessment instruments designed to determine safety culture/climate, typically self-report questionnaires administered as large-scale surveys (Flin et al. 2000). It is also impossible to measure all factors at all times: sampling is therefore required. Random sampling allows assumptions about the overall status of the safety program to be inferred (Janicak 2003).

Finally, it is worth noting that the mere presence of an accurately measured and appropriately reported leading indicator, with strong causal validity, will not change the outcome – i.e. the OHS performance – unless appropriate decisions and actions are taken (Mearns 2009).

‘Statistics can create a false sense of confidence about safety if they are not measuring the appropriate things...’
6.3 EXAMPLES OF LEADING INDICATORS

Some specific examples of occupational health and safety leading indicators (Tables 2 and 3) and related metrics (Tables 4 and 5) are provided below. Every organization needs to have an array of these indicators: even mature organizations need compliance and improvement indicators.

Table 2

<table>
<thead>
<tr>
<th>EXAMPLES OF OCCUPATIONAL HEALTH LEADING INDICATORS NOT LINKED TO MATURITY LEVELS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational health risk assessment</td>
</tr>
<tr>
<td>Occupational health risk register [linked to critical controls]</td>
</tr>
<tr>
<td>Occupational health improvement plan [based on risk register]</td>
</tr>
<tr>
<td>Change in exposure risk categories, e.g. decrease of number of employees in A of B exposure categories</td>
</tr>
<tr>
<td>Number of at-risk employees that have undergone medical surveillance according to the hazard exposure</td>
</tr>
<tr>
<td>Number of employees at risk that have undergone appropriate job-related health-risk training</td>
</tr>
<tr>
<td>Health concerns of employees are formally represented at an appropriate group, e.g. Health and Safety Committee</td>
</tr>
<tr>
<td>Spend (US$) on new control measures and maintenance of current controls</td>
</tr>
<tr>
<td>Occupational health budget as a % of total operational budget</td>
</tr>
<tr>
<td>Grievances and overtime [Cole et al. 2005]</td>
</tr>
<tr>
<td>Preventative activities such as training and immunization [Cole et al. 2005]</td>
</tr>
</tbody>
</table>

*see also Micromex Research 2011; Badenhorst and Fox 2011

Table 3

<table>
<thead>
<tr>
<th>EXAMPLES OF SAFETY LEADING INDICATORS NOT LINKED TO MATURITY LEVELS (OECD 2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence and effectiveness of critical controls for material risks [see BHP Billiton case study, Section 8.1.3]</td>
</tr>
<tr>
<td>Procedures in place to address safety-critical incident investigations</td>
</tr>
<tr>
<td>Degree of openness and transparency in reporting all safety incidents</td>
</tr>
<tr>
<td>Adequacy of on-site emergency preparedness plan</td>
</tr>
<tr>
<td>Degree of co-operation with other safety-critical enterprises</td>
</tr>
<tr>
<td>Relevant information for all hazardous substances is readily available</td>
</tr>
</tbody>
</table>
INFORMATION MANAGEMENT FOR OHS LEADING INDICATORS

Table 4

EXAMPLES OF OHS LEADING INDICATORS LINKED TO MATURITY LEVELS

<table>
<thead>
<tr>
<th>LEADING INDICATOR LEVEL</th>
<th>OHS LEADING INDICATOR</th>
<th>METRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3: Learning*</td>
<td>Agreed responsibilities and accountabilities</td>
<td>% staff</td>
</tr>
<tr>
<td></td>
<td>Jobs/tasks for which risk assessments are performed</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>OHS elements in toolbox talks</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>Perception of a caring organization</td>
<td>Consistency across levels</td>
</tr>
<tr>
<td></td>
<td>Effectiveness of OHS briefings/training</td>
<td>Observation/questionnaire</td>
</tr>
<tr>
<td></td>
<td>Improvements shared between sites</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>Effectiveness of visible felt leadership</td>
<td>Various</td>
</tr>
<tr>
<td></td>
<td>Feedback on positive and negative issues</td>
<td>Reported at and by all levels</td>
</tr>
<tr>
<td>2: Improvement</td>
<td>Health and safety policy</td>
<td>Adequately communicated</td>
</tr>
<tr>
<td></td>
<td>Management commitment to OHS</td>
<td>Staff perception</td>
</tr>
<tr>
<td></td>
<td>OHS plans and objectives set and achieved</td>
<td>Extent</td>
</tr>
<tr>
<td></td>
<td>Planned risk assessments vs completed</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>OHS briefings</td>
<td>Frequency</td>
</tr>
<tr>
<td></td>
<td>Close-out of audit recommendations</td>
<td>% on time</td>
</tr>
<tr>
<td></td>
<td>Behaviour-based task observations</td>
<td>% against planned</td>
</tr>
<tr>
<td>1: Compliance</td>
<td>Health and safety policy</td>
<td>Published</td>
</tr>
<tr>
<td></td>
<td>OHS legislation addressed by procedures</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>Management system compliant with recognized system</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>Statutory training requirements</td>
<td>% complete</td>
</tr>
<tr>
<td></td>
<td>Behaviour-based task observations</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>OHS included in communication</td>
<td>Frequency</td>
</tr>
</tbody>
</table>

* There is a view that learning indicators should be more about the effectiveness of control strategies of material risks.

Table 5

EXAMPLES OF OCCUPATIONAL HEALTH LEADING INDICATORS LINKED TO MATURITY LEVELS

<table>
<thead>
<tr>
<th>LEADING INDICATOR LEVEL</th>
<th>OCCUPATIONAL HEALTH LEADING INDICATOR</th>
<th>METRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3: Learning</td>
<td>Periodic water analysis</td>
<td>Changes in</td>
</tr>
<tr>
<td></td>
<td>Exposure hours for hazardous activities</td>
<td>% reduction</td>
</tr>
<tr>
<td></td>
<td>Reduction in the use of PPE as control at source improves</td>
<td>%</td>
</tr>
<tr>
<td>2: Improvement</td>
<td>Reduction in health risks at design stage by including standards/expectations in purchasing policy</td>
<td>Number or % of total</td>
</tr>
<tr>
<td></td>
<td>Medic consultations for health surveillance issues</td>
<td>Number or % of total</td>
</tr>
<tr>
<td>1: Compliance</td>
<td>Personnel assessed for fitness for work</td>
<td>% of total</td>
</tr>
<tr>
<td></td>
<td>Legislated controls for special health hazards in place</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>Medics and first-aid refreshers completed in time</td>
<td>%</td>
</tr>
</tbody>
</table>
CONCLUSION

7.1 Summary
7.2 Limitations of leading indicators
7.3 Opportunities for further work

42
43
43
7.1 SUMMARY

Leading and lagging indicators should be used to provide as much information about the status of OHS management and outcomes in the mining industry as possible.

The identification and use of leading indicators is an emerging field and this overview is the first consolidated sharing of learning and experience regarding their implementation in the mining industry.

Key considerations regarding leading indicators are:

- As business becomes more complex, the use of OHS leading indicators can drive business value through loss prevention towards the achievement of zero harm to property, people and the environment.

- Leading indicators are intended to reduce the risk of harm or damage through risk identification and actions to control precursors.

- Unlike lagging indicators, leading indicators must evolve as circumstances change, and with changes in maturity: they are thus best suited to internal performance tracking.

- Leading indicators should be integrated within all business systems to be an effective part of OHS management.

- Leading indicator measurement can produce qualitative data, as well as quantitative. The mining industry is largely uncomfortable with, or not geared towards, interpretation of qualitative data.

- Leading indicators can contribute to achieving risk elimination or avoidance through early identification of conditions that precede the manifestation of hazards.

- Leading indicators can be used to create multiple partial views through the organization, at different scales, and at different stages along the causal pathway of incidents. For example, leading indicators of leadership can be used, as well as leading indicators more proximate to a potential incident, such as the monitoring of critical controls of material risks. In this way, a more complete interpretation of the multiple complex linkages in the causal pathway of OHS outcomes can be created.

- Different leading indicators are appropriate for different levels of maturity of an organization and of their management systems, although the former is more important in achieving desired OHS performance. Even mature organizations need a suite of leading indicators, including the most “basic”, such as those that track compliance.

- The process of implementing leading indicators must be systematic. A 15-step process has been derived from available literature and the interviews to guide the mining industry.

- The collection of consistent and relevant data is one of the biggest hurdles to the implementation and use of leading indicators.

- The use of leading indicators for occupational health management is even more complex than for safety, due not least to the time delay between the causal factor and the eventual outcome as ill health. This is compounded by the time lag between implementation of actions for leading indicators and the manifestation as improved outcomes.
7.2 LIMITATIONS OF LEADING INDICATORS

Throughout the sections of this overview, some cautionary notes have been highlighted where relevant. In addition, the following should be noted when considering the use and interpretation of leading indicators:

- The predictive ability of leading indicators is highly variable. The time delay between the activity and the measurement, a possible lack of reliability in the measurement process, and outside factors may influence results.

- The sensitivity of the outcomes (as measured through lagging indicators) to the various leading indicators can be difficult to determine.

- Although audits can reveal leading indicators, they are not necessarily useful in that they often focus on compliance rather than ensuring that systems deliver the desired outcomes (OECD 2008).

- Given the intention of leading indicator use, it is doubtful whether linking incentive schemes to leading indicators is advisable and may even result in perverse outcomes. “The moment there are financial consequences attached to performance with respect to an indicator there is an incentive to manage the indicator itself rather than the phenomenon of which it is supposed to provide an indication” (Hopkins 2007: 13). Counter to this, Step Change in Safety (Undated) states that leading indicators lend themselves very well to incentive schemes.

- Limited organizational resources may mean that the necessary attention and appropriate responses to indicators are lacking (Mearns 2009).

- New concepts that will add value to leading indicator use are evolving, such as resilience (Mearns 2009). It is unclear if the industry has the ability to collectively shift an entrenched mindset of reactive responses to safety failings to address these ideas and recruit a different skills set to the industry.

7.3 OPPORTUNITIES FOR FURTHER WORK

The use of leading indicators for OHS is relatively new and growing rapidly. A significant amount of work is needed involving industry, academia, labour, regulators and civil society to gain maximum benefit from their use, and to achieve the industry’s ultimate goal of zero harm. Such work will take time, and the issues below should be seen as aspirational.

There are three primary areas of further work that could contribute to improved use of leading indicator, namely:

- Co-operation: regular and frequent sharing between mining companies, and at an industry level of what has worked, and perhaps more importantly, what has failed to achieve intended outcomes when implementing leading indicators.

- Improving understanding of safety climate/safety culture: safety climate has been identified as a leading indicator of safety performance (Flin et al. 2000). More work is, however, needed in this area, including on understanding the precursors of positive safety climates and on leading indicators for process events (Mearns 2009). The emerging concepts relating to culture hold much promise for moving even further down the causal chain relating to OHS outcomes and improving effective risk management. Identifying the relevant key leading indicators will require high-quality, systematic research (Mearns 2009).

- Elevating the prominence of health issues: safety has been justifiably a strong focus in the mining industry (Mearns and Reader 2008). Occupational health leading indicators warrant focused attention, separate from safety considerations where necessary and integrated where appropriate.
Overview of leading indicators for occupational health and safety in mining

8.1 Case studies
8.2 What our members think
8.1 CASE STUDIES

The following case studies are not intended to provide exhaustive direction on the development and use of leading indicators. They reflect the key facts of the approaches adopted by some ICMM members.

8.1.1 Anglo American: leading safety indicators (Gordon 2011)

The seven leading safety indicators used by Anglo American are directly linked to the existing safety management strategy, known as the Anglo Safety Way. This strategy effects continual improvement through the standard management system elements of policy, planning, implementation and operation, checking and corrective action and management review.

In developing the leading indicators, various options were evaluated, along with their possible unintended consequences, as per table 7.

These leading indicators are used to prompt positive actions, and are able to evolve as the organizational needs change. They are applicable to all sites, and at all levels of the organization, and make maximum use of existing data so as to not overload the sites. Each measure is designed to promote behaviours and actions that will lead to zero harm. By measuring the same indicators across the entire Anglo American group, good practice and areas for improvement can be shared and focused on.

<table>
<thead>
<tr>
<th>LEADING INDICATOR</th>
<th>METRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety leadership acts</td>
<td>% of safety leadership acts carried out against target</td>
</tr>
<tr>
<td>Delivery of risk management training</td>
<td>% individuals who completed training, against targets</td>
</tr>
<tr>
<td>Ensuring safety competence</td>
<td>% training sessions completed against target</td>
</tr>
<tr>
<td>Maintenance delivered to program</td>
<td>% safety and production critical maintenance completed to plan</td>
</tr>
<tr>
<td>Quality of risk management improvement</td>
<td>% of engineering controls or better</td>
</tr>
<tr>
<td>HPI reporting</td>
<td>% of HPIs reported to centre</td>
</tr>
<tr>
<td>Close-out of safety actions to program</td>
<td>% of actions closed out in reporting period</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPTIONS</th>
<th>POSSIBLE UNINTENDED CONSEQUENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use data from across the functions and external sources (financial, HR, etc.)</td>
<td>Poor quality of systems and understanding results in a non-starter/over-complex method does not produce accurate predictions = measures devalued</td>
</tr>
<tr>
<td>Use overlapping, internally supporting metrics</td>
<td>Perception could be that the onus is on the central systems rather than the factors within the site’s control</td>
</tr>
<tr>
<td>Measure number of reports/training sessions</td>
<td>Poor quality of reports/under-reporting/low integrity of data = measure devalued</td>
</tr>
</tbody>
</table>
8.1.2  Anglo American: occupational health leading indicators (Badenhorst and Fox 2011)

Prior to the implementation of health leading indicators, the following business considerations, inputs and needs were evaluated:

- **business considerations**
  - indicators for occupational hygiene and occupational medicine are both required
  - the maturity of the current occupational health management system
  - have a combination of management system indicators, lagging indicators and leading indicators
  - reporting requirements: for systems indicators, quarterly or biannually; for lagging, monthly; and for leading, quarterly, at operational, business unit and group level

- **inputs and needs included**
  - management awareness and commitment
  - health policy, standards, management systems, etc.
  - occupational hygiene program and exposure results
  - occupational medical surveillance program
  - resources – skills people and equipment.

This demonstrates that there are a number of considerations that should be in place before organizations should contemplate the use of leading indicators.

In terms of maturity, it is anticipated that indicator use, from least mature to most mature, progresses from system indicators, through lagging indicators, to leading indicators. Focusing on leading indicators, consideration was given to reasons for reporting, timing and recipients to characterize reporting needs. Considerations included the simplicity of report, using dashboards, trends and the required level of detail. Anglo American has a five-level categorization of incidents (1–5 being least to most harmful), and uses levels 1 and 2 as leading indicators, and levels 3 through 5 as lagging indicators. They relate incidents to failures of control measures. They also use planned maintenance of these control measures as indicators for health.

8.1.3  BHP Billiton (McDonald and Jenkins 2012)

The approach adopted by BHP Billiton is to:

- identify all material risks
- identify critical controls for each material risk
- establish a performance standard for each critical control
- implement verification processes for critical control performance standards
- regularly assess effectiveness
- deliver this approach within an organizational structure, supported by the right systems and processes, that enables each business to adequately plan work and work the plan, improving stability, predictability, safety and productivity.

This approach recognizes that lagging safety indicators and the traditional methodologies based around the safety pyramid did not reflect the true business risk profile nor was it effective in consistently delivering a working environment free of serious injury or fatality.

BHP Billiton is driving simplification of the way it manages safety and improving the focus on the identification and management of risk. The simpler its requirements the more transparent they are and with this comes greater likelihood it will achieve consistent compliance.

The future is a place where BHP Billiton will have simple, effective safety systems logically matched to its risks, with systems in place that track compliance with critical control performance standards. Leading performance metrics will give early indication of breakdown in critical controls and provide an opportunity to remedy them before incidents result.

The main focus is on doing the critical few – flawlessly and consistently.

One of the key messages from the BHP Billiton experience is that the successful implementation of leading indicators takes time and engagement of leadership at all levels. The company also understands there may be tension between lagging and leading indicators and this should be accepted and worked with, not avoided. Finally, BHP Billiton’s focus on verification of the critical controls for material risks, and their effectiveness, is an important governance process.
Goldcorp recognizes that the goal of measuring organizational factors is to lead to top-tier performance and drive safety performance. In preparing to implement leading indicators, Goldcorp:

- chose the term key performance indicators (KPIs) instead of leading indicators, to ensure consistency
- recognized that KPIs vary up and down the business, they change with time and it is too early at this stage for external comparisons using KPIs
- fit the KPIs in with other performance measures across six strategic pillars
- noted that data were already available, and that it is the mathematical manipulation that needed to change.

The six strategic pillars are split into two categories of “what matters”: people and results. Within the “people” category, the three strategic pillars are:

- partnerships
- people
- safety.

Within the “results” category, the three strategic pillars are:

- production
- reserves
- margins.

When formulating the KPIs, Goldcorp considered four separate streams: benefits and boundary conditions, processes, performance systems and implementation issues.

The Mining Safety Roundtable members (including Goldcorp, Barrick, Newmont, Teck, DeBeers Canada and IAMGOLD) have noted that top-performing energy companies have:

- responsive, disciplined leadership involvement
- high rates of action with timely execution
- a strong culture of reporting and fixing.

Leading indicators should encourage the development of these characteristics. Some examples of certain leading indicators discussed are included in table 8.

### Table 8

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LEADING INDICATOR</th>
<th>METRIC(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>Leadership engagement</td>
<td>% of investigated potential fatal occurrences/extreme health risks and exposures investigated (all called PFOs) by executive management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% of investigated lost time injuries (LTIs) investigated by vice-president (VP) level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% of investigated total recordable injuries (TRIs) investigated by management level</td>
</tr>
<tr>
<td>Risk management</td>
<td>Action execution</td>
<td>% of potential fatal occurrences (PFOs) or high/extreme health risks that establish controls in hierarchy of control greater than or equal to level 3 (incl. elimination, substitution and engineering controls)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% of actions completed by risk level and due date/time (risk level L-M-H) or mean time to close corrective/preventative actions for potential and actual level 4 and 5 events</td>
</tr>
<tr>
<td></td>
<td>Action execution and leadership engagement</td>
<td>Rate of job safety analysis (JSA) reviewed per supervisor per month</td>
</tr>
<tr>
<td></td>
<td>Reporting culture</td>
<td>Ratio of high-level incidents (PFOs) vs high-level incidents (potential or actual)</td>
</tr>
</tbody>
</table>
Newmont’s leading indicators are linked to their five-year Health and Safety Strategic Plan through critical success factors as recorded on a customized performance tracker. The percentage conformance with the health, safety and loss prevention (HSLP) five-year plan is measured, as is HSLP education and HSLP performance. Lag indicators of injury performance are also measured and recorded.

Newmont uses the term “lead activity” for measurement and reports reporting of % key activities performance within “Our Safety Journey”, HSLP business plans, significant risks and corrective actions, on a monthly/quarterly/annual basis.

According to Newmont, the Mining Safety Roundtable has agreed to use the following:

- % of PFOs investigated by executive management
- % of LTIs investigated by VP-level management
- % of PFOs or high potentials that establish controls level 3 or higher in hierarchy of control
- % of PFO corrective actions completed on time
- PFO frequency rate.

**WHAT OUR MEMBERS THINK**

This section presents a summary of the members’ responses to the semi-structured survey questions, which guided the interviews. The summary is presented for each question.

1. **What prompted your company to look at using leading indicators?**

   - The prevention of injury, incidents and illness.
   - Lagging indicators don’t give a full enough picture of what’s going on in the business, and don’t allow proactive risk management and actions.
   - Recognize that the traditional "safety pyramid" does not reflect reality.
   - Want meaningful control over our destiny at all levels of the organization, with the confidence that reporting will be understood at all levels of the organization.
   - The maturity of the organization reached the right level to allow the move into leading indicators.

2. **What was your biggest hurdle in developing/using leading indicators?**

   - Data quality and the information management system to deal with the data.
   - Going through the change management process: establishing a reliable baseline, quality of data, entering data timely and accuracy of data – that management process will take three to five years.
   - High administrative burden, not least due to difficulty in aggregating the leading indicators.
   - Understanding of people at senior level who are used to getting “typical” quantitative safety reports at high frequency, to which leading indicators are not suited.
   - How to make indicators useful and meaningful at the levels where they are needed, but also understandable and useful at reporting levels.

3. **What leading indicators do you use for safety and what for health?**

   - We believe the most important leading indicator across all levels of maturity of the organization to be (i) the identification of critical controls for material risks, (ii) the development of performance standards for those critical controls and (iii) the implementation of a verification process that assesses those controls to be effective and in place.
   - Many leading indicators are still qualitative: this leaves some people uncomfortable. It depends on the level of maturity and how far along the leading indicator process the company is.
   - Leading indicators should be designed to evolve, and become more proactive with improved levels of maturity. We are using ones at different levels of maturity across the organization. If the process is new, we are using extremely basic ones like developing a robust exposure baseline, and % planned vs unplanned work.

4. **How did you choose them (safety and health)? Did you create new ones, adopt or adapt? Describe the process briefly.**

   - Bottom up! Lots of internal consultation and workshops. We asked people to set their own, based on what they thought, test them and revise them if needed.
   - Need to get a balance of desirability and achievability. Use only a few – max. 10. Base them on the risk profile. The higher up the control hierarchy the control occurs, the more confidence that the potential is removed from the workplace.
8. On what part(s) of the organization do(es) your leading indicator(s) focus? Human factors, technology, organizational structure, other?

- Across all aspects. Leading indicators work best when integrated with all other aspects of the organization. As the organization matures, the ability to integrate improves. One company is progressing well along the maturity path, starting to link leading indicators in other areas, such as finance and HR, with safety outcomes.

9. What has worked in your process, and what has not worked?

- Getting people involved in the process makes it work. Leadership commitment works.
- Data quality is a limiting factor. The time it takes to get the processes implemented, let alone get results, is very long. Some information is better than no information and lack of perfection should not lead to paralysis. Do what you can with what you have, knowing its limitations.
- Aggregation very difficult if you want to present concise overview at senior levels.
- Difficult to achieve a stable baseline from which to measure progress.
- Not enough education or executive engagement and awareness on the importance of leading indicators and the leadership’s part in playing a role on it. Organizations also do not understand their risk tolerance levels properly and the implications this has for leading indicator use and application.
- It is difficult but necessary to link the change (to leading indicators) to performance indicators for the entire organization through aligning the leading indicators with how people are measured in terms of performance. This requires strong leadership.
- Health is not just another type of safety indicator: it is completely different and cannot have the same expectations.
- Using incentives such as the bonus schemes do not work for us.
- There is difficulty in the definitions of leading indicators: they should be broad enough to accommodate the wide spread of business unit types and cultures, but specifically defined enough to make sure that the same things are being measured. One example is “leadership actions” (from Anglo American).
- Some organizations are at the point of examining very progressive risk-control linkages, for example trying to link safety outcomes to budget processes, overtime processes and the like through a centralized data warehouse.
10. What still needs to be done to make the implementation and use of leading indicators fully successful (within the organization and at an industry level)?

- Make them more quantitative and find a few that can be used to benchmark.
- Detailed quantitative research is needed into actual causal pathways.
- The desire to benchmark is holding up progress in sharing: rather track internally because we’re trying to prevent our people getting injured. Eventually, two or three may emerge that can be shared meaningfully.
- Give it time – there will always be tension between leading and lagging indicators and we have to learn to work with this rather than work to remove it.
- Learn to deal with continual change: leading indicators will evolve just as we think we’ve got them “right”. Still need to clearly understand this concept of maturity and how it affects all business performance areas.
- Need to reposition leading indicators as a tool to help manage risk.
This overview was prepared based on a review of the documentation detailed in the references. The additional input from the following people and companies during the compilation of this overview is gratefully acknowledged.

ICMM MEMBERS

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ICMM TEAM

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