Why a near-miss is never a leading indicator! (Or why we need to think in system outcomes)

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I have spent over 15 years developing ideas and methodologies on how to identify early warnings of system performance that allows corrective action ahead of catastrophic failure. This should be the ambition and aim of all major hazard businesses and those that aspire to be a 'high reliability' organisation.

Repeatedly, I encounter businesses who struggle with the whole concept of performance measurement and are driven to measuring areas of performance that have little bearing on whether they are operating safely or are running their assets in the most effective manner. Notwithstanding this, comfort is drawn from the act of measurement rather than the utility and benefit gained from the metric.

I have argued strongly against spending much time trying to distinguish between leading and lagging indicators on the basis that the information provided is much more important than the label. Ultimately, it's the action taken to improve the control of risks that counts most. However, an oft repeated position that a near-miss really is a leading indicator as somehow a pre-cursor of a major accident leads to some concern about the most beneficial way to consider and develop key performance indicators. My issue with the concept of a 'near-miss' is that it's a handy category of incident which can so often be dismissed as unimportant or fortunate. Actually, it's an adverse, unwanted outcome of a risk control system or barrier failure that will always provide valuable insights into failure of the process safety management system.

This is now a mature rather than emerging and developing area and KPIs feature in some form or another in most company's monitoring and measurement system. For UK Major hazard facilities covered by the Control of Major Accident Hazard Regulations, COMAH this has partly been driven by a regulatory expectation. Therefore, in this mature environment I'm proposing a re-adjustment to the thinking around this divide between leading and lagging indicators. At the same time, I'm promoting the undervalued benefit of lagging indicators at the expense of more alluring and attractive leading indicators. This may sound like heresy but pursuit of leading indicators can drive companies into measuring obscure and low value metrics which offer little insight into the potential for a major accident. In proposing this shift in thinking I will show how a slight change can actually make 'near misses' feature centrally in smart performance measurement. But before that we need to change into outcome mode, and I have found this is one of the hardest concepts for people to grasp when it comes to process safety management.

Process Safety Outcomes

Every control or mitigation measure, barrier, slice of Swiss cheese, or layer of protection has a safety purpose or successful outcome. I'm often amazed that so few of us consider what these conditions or outcomes are. Instead the tendency is simply to implement the elements of a process safety management systems as per good practice guidance such as the Energy Institute High Level Framework [Ref 1]. Identifying a control measure or system success is central to the HSE Guidelines, HSG 254 [Ref 2]. When writing HSG254 we worked out the critical factor in measuring process safety performance lies in determining whether the system is delivering its intended safety outcome and then seeking information to confirm this or show that something other than the intended outcome was occurring.

This starting point for setting either a leading or lagging indicator seems to have been forgotten.

This difficulty in thinking of system outcomes is illustrated when those involved in critical process safety control systems such as a Permit to Work system have difficulty in completing the sentence or agreeing a common position on 'we have a permit to work system in order to…?' Similar difficulty occurs in determining the outcome of a management of change or even a competence management system. Recently, whilst working with organisations on improving competence management systems I discovered that competence as an outcome rather than a process is a difficult concept to some.

My work on process safety KPIs has resulted in a simple set of questions to help organisations set and implement focussed KPIs. These are:

For lagging indicators:

- What is the intended outcome of the control system under consideration eg what does success in controlling this risk look like?
- Is there common agreement on this outcome and its description?
- Can the intended outcome or the adverse outcome be detected?
- What's the deviation / tolerance form the intended outcome which can be accepted?
- What is the metric to be used to measure outcomes above or below the threshold of tolerance?

For leading indicators:

- What is the most important activity or process required to consistently deliver the intended outcome? This about identifying 'inputs' required to deliver the desired outcome.
- Which of these are dynamic and subject to variation rather than fixed?
- Which of these inputs are undertaken most frequently?
- What's the metric to be used to measure these critical inputs?

To get the greatest benefit from process safety KPIs its essential to set the desired outcomes around the most significant challenges to the integrity of the plant or process that contain hazardous material or stored energy. From research undertaken by HSE / HSL for chemical process plant these are known as:

- Corrosion
- High / low temperature
- High / low pressure
- High / low level
- Mechanical failure – e.g. material, joint or seal failure, wear and erosion
- Impact
- Human error – e.g. opening into containment

Not all KPIs are equal

Measuring performance of process safety systems is important but measuring the right things that give you the best insight into early failures or challenges to the integrity of containment system is vital.

This leads to the conclusion that the most important KPIs are those that provide an insight into whether the systems that protect against the challenges to integrity are degraded. So it's essential to set KPIs around the barriers or risk control systems that guard against these top degradation processes. Moreover, the best benefit comes from continual measurement the outcomes of these control measures and then acting on the first signs of adverse degradation. I've previously described these systems as 'process measures'. The next most important area of performance measurement should be those special controls that manage the interface with the plant containment e.g. high risk maintenance that breaks into the containment e.g. a Permit to work system and controls that manage changes to the process and plant e.g. a management of change system. Measuring other aspects of performance such as outstanding audit actions at the expense of these front line control systems will be much less beneficial.

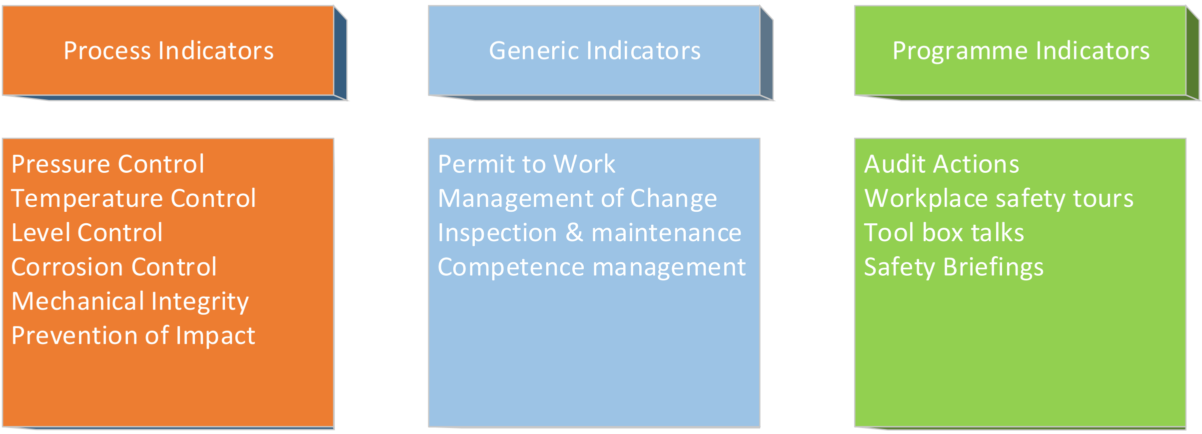


Figure 1: Types of Indicators

This in turn requires a description and agreement of the desired outcomes of all these risk control measures:

- Level control
- Pressure control
- Corrosion management
- Temperature control
- Mechanical integrity
- Human performance - competence

- PTW system
- Management of change

Outcomes

Each of these systems will have a successful outcome in terms of maintaining the integrity of the process but these are often overlooked or forgotten. So the appropriate outcomes for these central control measures are show in Table 1.

Table 1: System Outcomes for Process Control Measure

Control system or barrier	Successful outcome
Level control	Level is maintained with designed normal operational limits – (not to the high level alarm level).
Pressure control	Pressure is maintained within designed normal operational limits– (not to the high level alarm level).
Temperature control	Temperature is maintained within designed normal operational limits– (not to the high level alarm level).
Corrosion management	Sufficient wall thickness remains to contain the maximum pressure in the pipe/ vessel.
Mechanical integrity	The containment degrades at the predicted rate. The equipment continues to operate between inspection / maintenance intervals.
Human performance	Tasks are performed to the required standard.
PTW system	Permission is sought and granted ahead of high risk maintenance activities being started. The safeguards / isolations in the permit are followed in full.
Management of change	Permission is sought and granted ahead of any change to the process / plant or procedure. The outcomes in changed performance / function proposed by the change are achieved in practice.

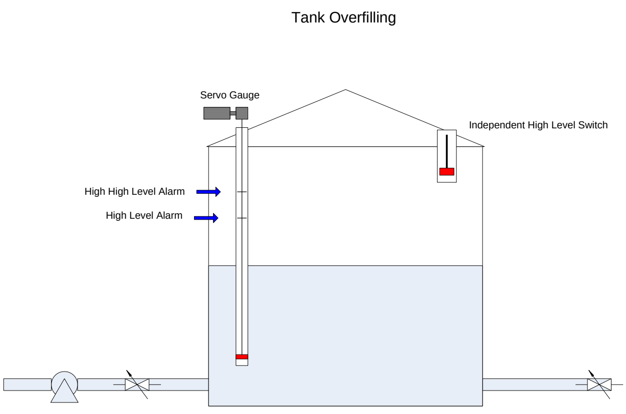


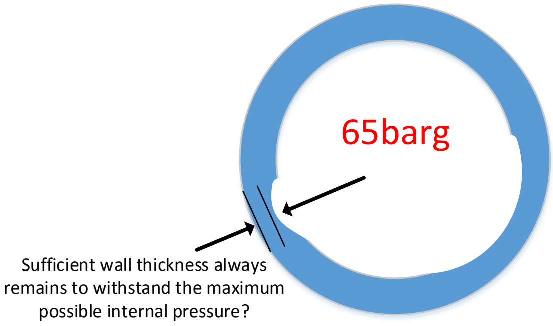
Figure 2: Example of ‘level control’ where the desired outcome is that the liquid level is at the pre-determined level during the course of filling. Note: this is below the high-level alarm.

Diagram 2 illustrates the successful outcome in a control system to prevent overfilling. Success is that the level remains within pre-determined values during the course of filling and once the filling has been completed. An ‘adverse outcome’ would be when the level exceeds the expected level – even by a margin less than that required to trigger an alarm. This is because the system is designed to make no call on the alarms and if this occurs something has gone wrong with the filling system. Identifying this when such an event occurs provides an opportunity to correct this problem ahead of the perhaps the next more serious overfilling where the alarms and the safety cut out may not actually function.

Another confusing issue in the consideration of this point is the term ‘safety critical’ when describing a control measure or barrier. The common perception is that the high – high level alarm and the safety cut out are the safety critical items in this example. However, the front line system of level measurement, the tank level gauge, is actually just as safety critical to preventing an overfill.

Diagram 3 illustrates a similar outcome for corrosion management where regardless of the type or rate of corrosion the desired outcome is always to have sufficient wall thickness left to withstand the maximum expected pressure within the pipe. This should be pre-determined, recorded and feature centrally in the minds of those involved in inspection and maintenance of corrosion vulnerable vessels and pipework.

Figure 3: Successful outcome of management of internal corrosion.



Competence Outcomes

By far the most difficult area to measure is that of human performance or competence. This is because to be effective it requires the person doing the (safety critical) task to be observed in the way the task is performed and then checked that they follow any procedure covering the task. It also involves questioning them on their knowledge of how the hazards and risks associated the activity could give rise to danger or a catastrophic incident. This test of skill, knowledge and procedure is essential in order to evaluate that the expected outcome is achieved in a sustainable way.

The draw back to this form of measurement is that a safe procedure is more likely to be followed when a person is being observed and that it does not mean that the safe system is followed on other occasions. However, it offers the distinct advantage that it is an opportunity for those involved in safety critical tasks to raise concerns about the activity or procedure and to cross-check that the task and the procedure match, picking up on any negative performance influencing factors. It also allows the organisation to reinforce the reason for the control measure and to validate the procedure and the underlying risk assessment against the conditions that exist on site.

Undertaken in a positive and ‘no-blame’ way this is a valuable leading indicator of competence.

Routine ‘task observations’ covering process safety critical tasks form a valuable part of process safety behavioural safety programmes. The best-practice I have seen in this area is when all (process safety) critical tasks have been identified along with all personnel who undertake such tasks. Then a system implemented to check each person against a sample of process safety tasks once a year or more frequently. As such, every person who say issues, or works under a permit to work system should have the way they undertake their tasks checked at least once per year.

There are other less robust, and more frequently employed, ways to measure whether a task is undertaken as required. These usually involve checking logs, registers or work order completions either manually or by extracting data from electronic systems such as Maximo or SAP. The draw back from this form of measurement is that the indicator will only reflect the data entry and not how the task was undertaken in practice. Never the less tracking and measuring that safety critical items of inspection and maintenance have been completed on time is much more valuable than measuring how many people within an organisation have attended a specific training course – the most common form of KPI for competence management I have encountered.

Reporting and investigation of adverse competency outcomes – or process safety near misses, where issues relating to competence are a significant contributing factor is a valuable lagging indicator.

In fact leading and lagging indicators covering competence are probably the most important and valuable KPIs within a process safety management system as human error continues to be the most significant contributing underlying causes of loss of containment event and major accidents. Unfortunately, effective KPIs for competence management rarely feature in most major hazard organisations.

Outcomes and Near Misses

The conclusion of my argument is that as a process safety near-miss represents an unintended or adverse outcome then they are far too important to be dismissed or considered as fortunate outcomes. Instead, near misses that relate to failures of the system designed to maintain the integrity of the plant and process and should be considered as a golden opportunity to detect a deterioration of a barrier or control measure. Identifying, reporting and investigation of process safety near misses is only one side of measuring lagging indicators as the same conditions can be proactively monitored through routine checks on the process conditions such as temperature, pressure, level and most importantly, competence. The sophistication of instrumented systems means that this data logging and analysis can be done automatically and the results displayed in a KPI dashboard in real time.

So let's re-label process safety near misses as 'adverse system outcomes' and treat them as important lagging indicators rather than leading indicators. As such they become central to ensuring the integrity of process plant assets.

I'd like to promote focussed lagging indicators that measure challenges to integrity and human performance as equal to or even more beneficial than some of the less well thought out leading indicators that are common place in major hazard organisations.

References

1. HID Regulatory Model: Safety Management in Major Hazard Industries.

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