MANAGING MAJOR HAZARD INDUSTRY RISK

Best practice for the future of integrated asset management

CONTENTS

INTRODUCTION

There is a rising awareness of the tangible benefits of integrated asset management approaches that transforms the financial, safety and risk performance of energy and high hazard businesses.

In 2011, the UK Health & Safety Executive (HSE) published a case study featuring Scottish Power (now Iberdola) and its work in partnership with us that highlighted the merits of focusing integrating asset management with process safety management within major hazard businesses to ensure success in managing risk whilst delivering significant cost savings. A joint approach has since been implemented within a growing number of major hazard industry operators worldwide.

We have also presented jointly at a multitude of conferences all focused on how to encompass process safety management to address the management of risk, ranging from managing hazards and controls within the current financial environment; implementing process safety management systems to demonstrate compliance; balancing the cost of compliance with operational efficiencies and financial benefits and; managing and mitigating human failures/errors in safety critical activities.

In 2014, the US Chemical Safety Board invited experts to share best practice examples of using leading indicators, rather than just reporting on lagging indicators such as a fire, to manage the potential for catastrophic accidents like the Macondo blowout. While our team's presentation highlighted an example in the power generation industry, similar recommendations were made to the Oil & Gas industry from around the globe about managing key performance indicators (KPIs).

CASE STUDY: MAJOR HAZARD INDUSTRY

Process Safety Approach

A number of high-profile, international incidents have demonstrated that concurrent failures in the areas of people, processes and plant can cause catastrophic plant safety failures. In response, the UK Health and Safety Executive (HSE) developed an approach to process safety management to help organisations operating in hazardous sectors to demonstrate adequate risk control.

ScottishPower embraced this approach and the underlying transformation of automating key performance indicators (KPIs) through its Operational Transformation Programme (OTP). OTP aimed to make ScottishPower an industry leader in process safety and asset management focused through the delivery of a "High Reliability Organisation."

ScottishPower was able to transform its organisation into a leading global exponent of process safety and asset management. In 2009 the company became the first power generator to be certified to BSI PAS 55: 2008 (PAS 55); in 2010 the Institution of Chemical Engineers recognised the company's achievements by awarding it first prize in the IChemE 2010 category of innovation in process safety; and, in 2011 it became the subject of one of the first case studies on this issue to be published by the UK Health and Safety Executive (HSE, 2011).

From the outset ScottishPower determined to deliver full integration of asset management and process safety through the development of new IT systems.

As a strategic partner, Lockheed Martin assisted in the development and delivery of the underpinning IT strategy including the development of the Process Safety KPI Dashboard and associated core IT systems. Of particular importance was automation of the KPI management process, which allowed the dashboard to pull data directly from the underlying business system and update the status of the KPI's on a daily basis. Additionally, KPIs were ranked according to risk to reduce the reporting burden on staff. The dashboard also meant staff have a greater level of trust in the KPIs as they knew the data has not passed through numerous sets of hands before the whole business got to see the results.

Key thinking was developed to answer the following questions:

What if Process Safety risks were as visible as Health and Safety risks?

Which warning signs are most likely to help you avoid an incident?

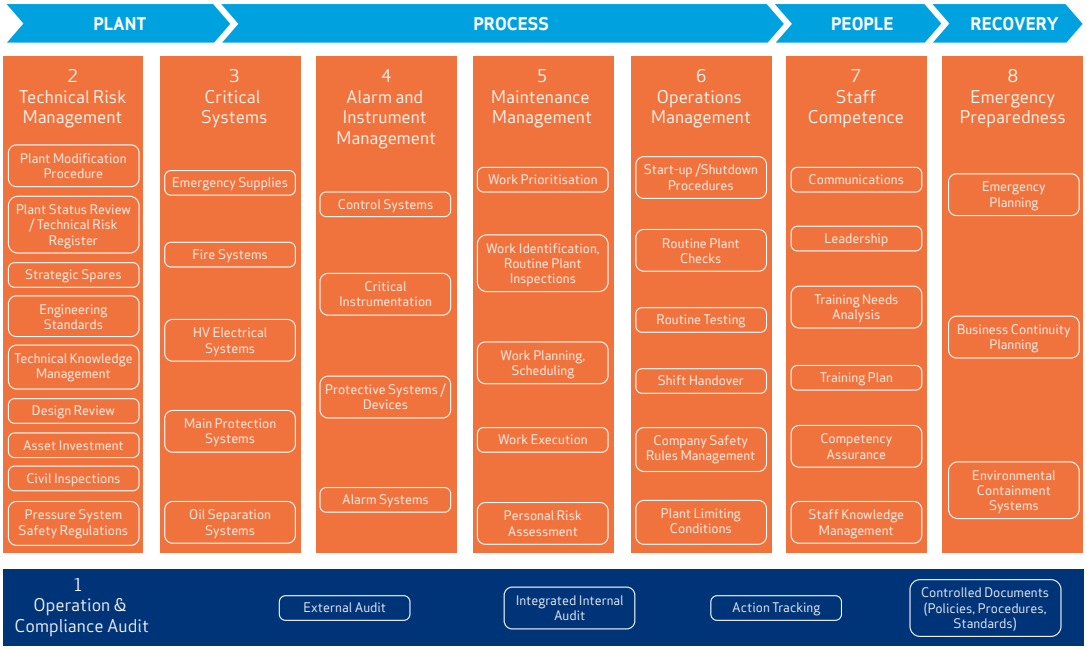
Establishing KPIs at ScottishPower

To deliver the process safety management system, and specifically to establish a comprehensive set of leading and lagging process safety performance indicators, ScottishPower followed the UK Health and Safety Executive's Guidance on establishing process safety performance indicators (HSG 254.)

To establish KPIs a multi-functional team from the business followed the six stage approach in HSG 254 to identify 90 Hazards/Hazardous Events and the 42 Risk Control Systems (or "preventative barriers") that are required to manage these hazards. The team then reviewed each risk control system to identify one or more leading indicators. Crib sheets were used to capture detailed specifications for each KPI. Whilst the process covered a range of power plant technologies it was found the majority of leading indicators could be applied by setting different targets and tolerances according to the power plant type and risk. In total 100+ Leading Indicators were identified across all Risk Control Systems.

Differential rankings of leading and lagging indicators

It was clear that 42 Risk Control Systems and the associated 100+ Leading Indicators was too large a data set to present meaningful information to the management team so the 42 risk control systems were nested into 8 headline Risk Control Areas to form the basis of the Process Safety Management Dashboard that covers Operational and Compliance Audits; Technical Risk Management; Staff Competence; Operational Management; Maintenance Management; Critical Systems Management; Alarm and Instrument Management; and Emergency Preparedness. The following diagram shows how this was collated into a formal management system in terms of Risk Control Areas.



Implementing an Incident Management Process

ScottishPower took a simple view that incidents and near misses were the single source of Lagging Indicators. To capture this lagging data, a new incident management process was implemented to capture and to ensure the consistent investigation of root causes. A major cultural awareness programme was developed to ensure staff report process related incidents and near misses. Staff were trained on the importance of “lagging” indicators in learning from events and preventing such incidents occurring again across the Iberdrola businesses. Further to this a companywide Technical Incident reporting system was developed.

The incident management system was modified to make it very simple for any member of staff or contractor to report an incident on-line. Automated incident reporting of process incidents was included in the development plan for the KPI dashboard. This captured threats such as process excursions or limits being breached (e.g. tank level). A key part of this process was to classify incidents as major, significant or minor (based on API 754 – Process Safety Performance Indicators for the Refining and Petrochemical Industry) and to relate these to one or more of the underlying 42 Risk Control Systems

Classification of Process Safety Incidents based on benchmarking with HSE and API guidance:

Major Process Safety Incident:

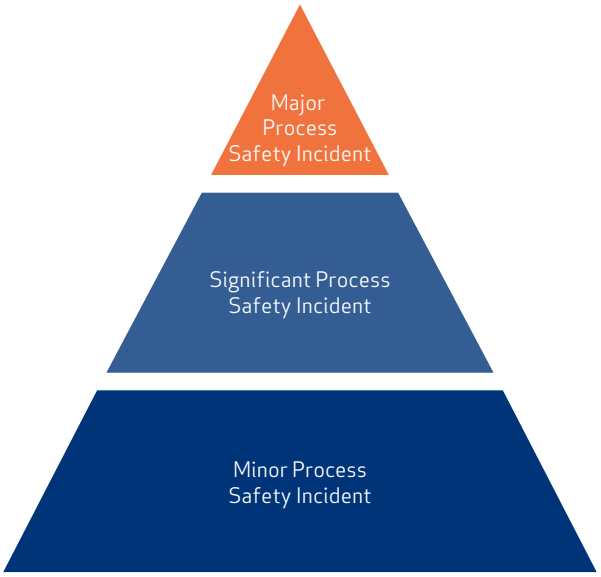
- Equipment damage > £100k
- Loss of production > 24 hours
- Injuries/fatalities (RIDDOR)
- Major environmental impact

Significant Process Safety Incident:

- Equipment damage > £20k but < £100k
- Significant release of energy or hazardous matter
- Fire and explosions

Minor Process Safety Incident:

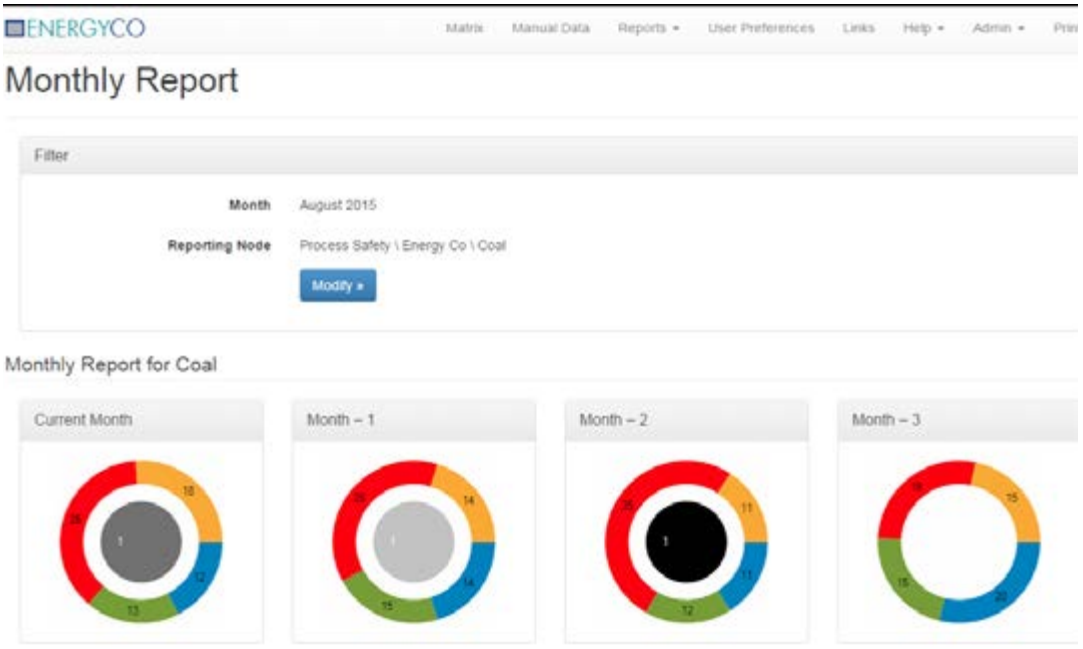
- Demand on safety system
- Process upset – control loops out of control, equipment in manual
- Breaches of plant limiting conditions



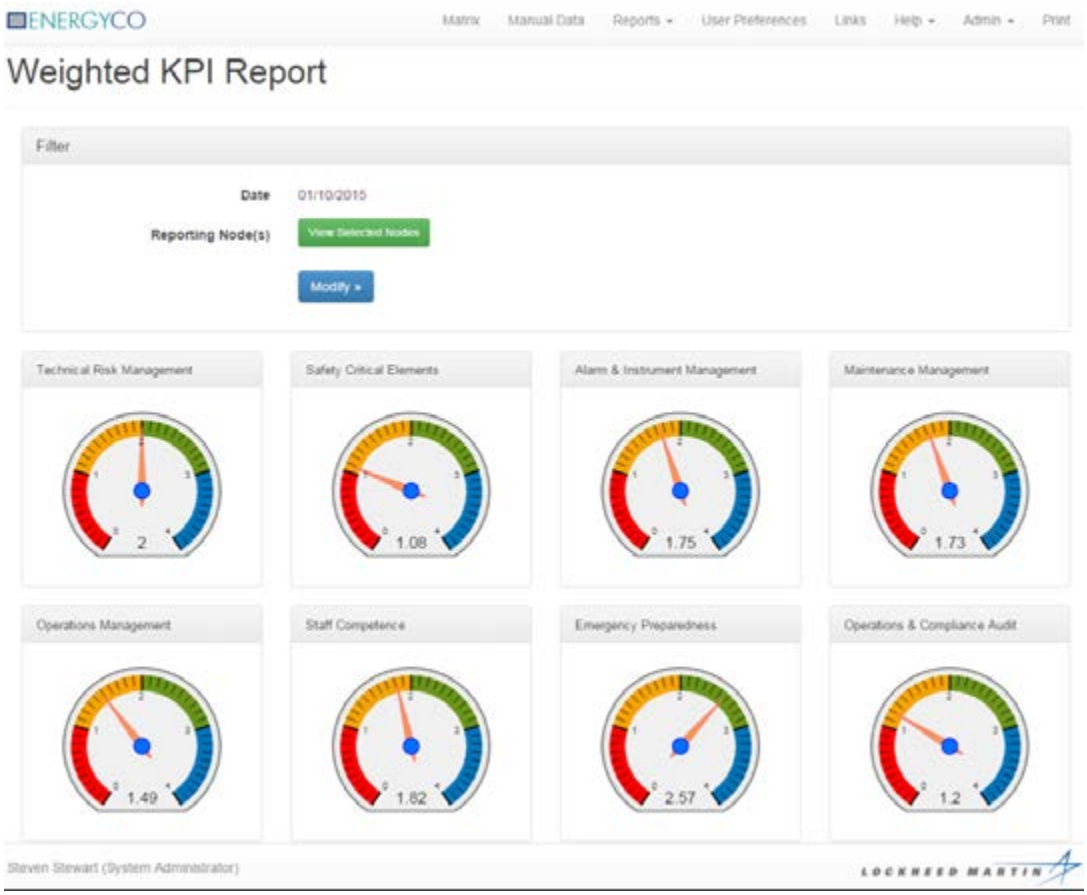
that failed. This is illustrated in the diagram on the following page.

Best Practice to Reporting KPIs

To improve performance and track trends a system of simple colour coded targets were set for each KPI. Blue shows where performance meets a level that is considered industry best practice. Green indicates performance is on target, amber that it is within acceptable tolerance and red to show where it is below acceptable.



Both “leading and lagging” indicators were brought together to build a live picture of performance. The key focus at ScottishPower was always on leading indicators as they are considered more predictive in preventing a major accident. This model was then developed into a visible Process Safety Management System (PSMS) to allow the Risk Control Systems (RCS) barriers to be measured daily.



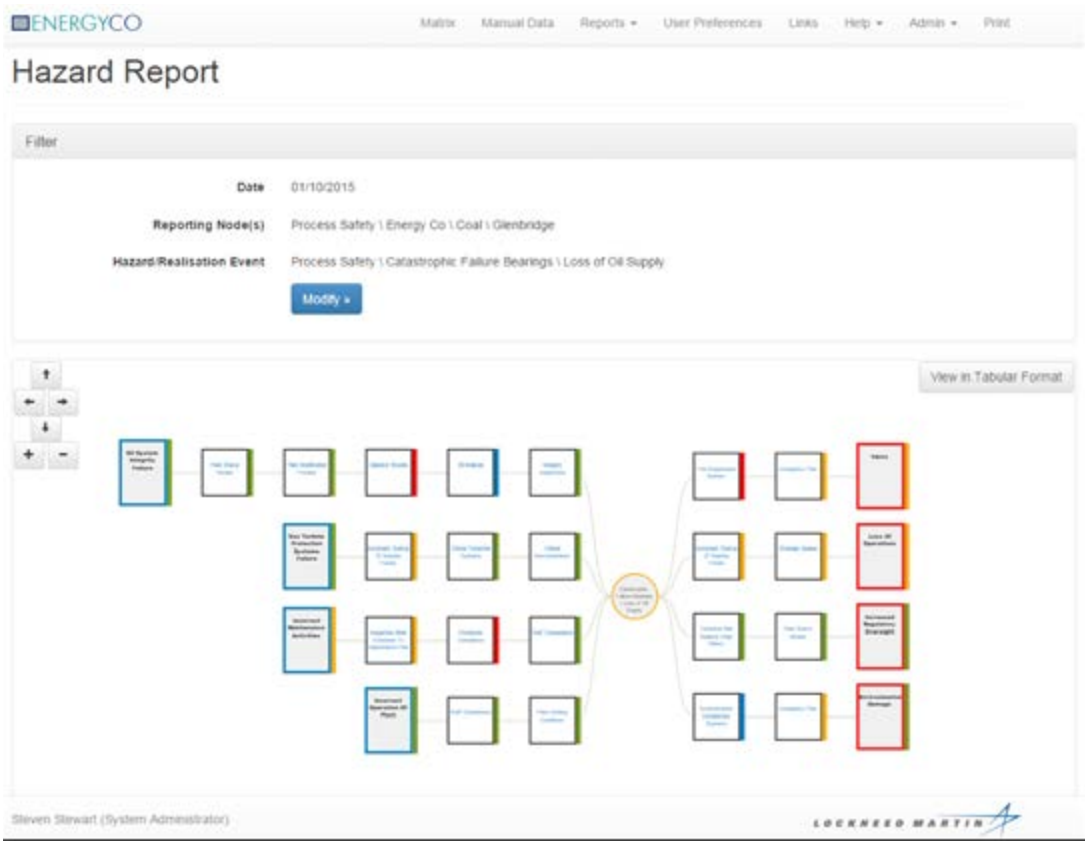
Risk Ranking of KPIs

A key concept is that not all indicators are consider to be of equal importance. Based on HSE's Guidance three categories of indicators were identified, Operational Control, Generic and Programme Indicators. Operational control KPIs measure the direct challenges to the integrity of plant and equipment and the process safe operating envelope, such as temperature, pressure and filling levels. Generic indicators cover the maintenance of key instruments, alarms and ensuring effective control of change, permit to work and other essential risk control measures. Whereas Programme Indicators capture progress with work such as audit programmes and safety tours.

Operational Control Indicators provide the best insight to the risk of a major accident.
Many organisations have process safety key performance indictors based on programme and generic categories as often these are easier to measure. Whilst these indicators are important in terms of leadership and culture they are very rarely involved with the initiation of a process safety incident or event and are often over measured and can give a false sense of security that risks are being managed. Operational Control Indicators are often under collected due to the complexity of requiring some real time data to be transformed into relevant KPIs but are the key to preventing future incidents.
Having recognised the categories of KPIs a risk model was developed which allowed the important KPIs to be easily visible. The KPI dashboard was then developed to take these concepts into the governance and management process of the individual indicators and power plants.

Key Hazard Report

Once the KPIs have been developed linking key hazards to risks then it is a simple task to provide hazard reports and the condition of both preventative and mitigation barriers. Preventive barriers are those leading indicators which prevent and predict an incident such as corrosion inspections and mitigation barriers are those leading indicators which reduce the impact of an incident such as the availability of a main protection or shutdown system.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NEXT STEPS IN THE JOURNEY TO BECOMING A HIGH RELIABLIITY ORGANISATION

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 systems is vital.

Repeatedly 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.

There is a strong argument 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. The 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 (COMAH) [Ref] facilities this has partly been driven by a regulatory expectation. Therefore, in this mature environment a re-adjustment is proposed to the thinking around this divide between leading and lagging indicators. At the same time, the undervalued benefit of lagging indicators is promoted 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 how a slight change can actually make 'near misses' feature centrally in smart performance measurement will be illustrated. But before that we need to change into outcome mode, and 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. 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]. Identifying a control measure or system success is central to the HSE Guidelines, HSG 254 [Ref]. When writing HSG254 HSE 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 it was discovered that competence as an outcome rather than a process is difficult concept to some.

Questions to help organisations set and implement focusses KPIs

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 of the 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 that is 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 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 six 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 describe 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.

Process Indicators	Generic Indicators	Program Indicators
Pressure control	Permit to work	Audit Actions
Temperature control	Management of change	Workplace safety tours
Level control	Inspection and maintenance	Tool box talks
Corrosion control	Competence management	Safety briefings
Mechanical integrity		
Prevention of impact		

Diagram 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
- 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:

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.

Table 1: System Outcomes for Process Control Measure

Tank Overfilling

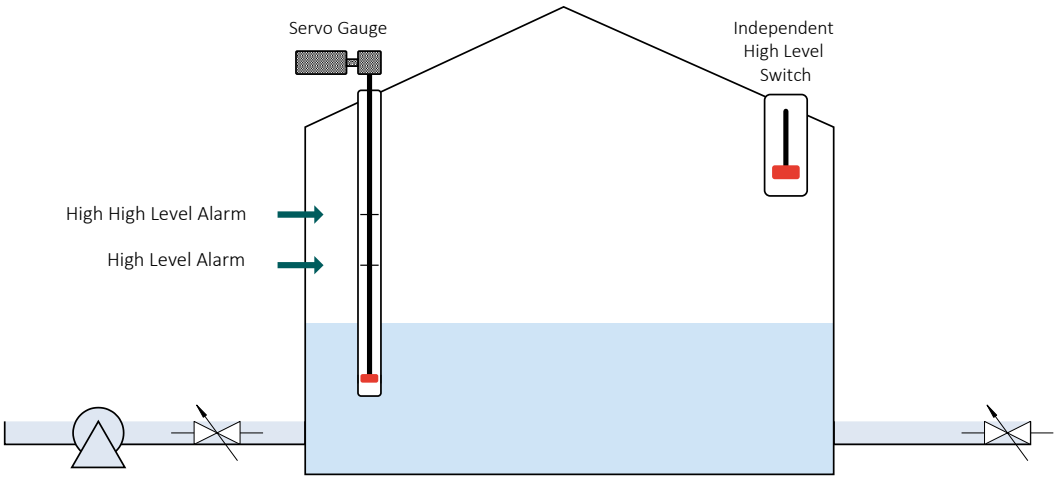

Diagram 2: Example of 'level control' where the desired outcome is that the liquid level is at the pre-determined level during the course of filling. Note: this is below the high-level alarm.

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. 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 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 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.

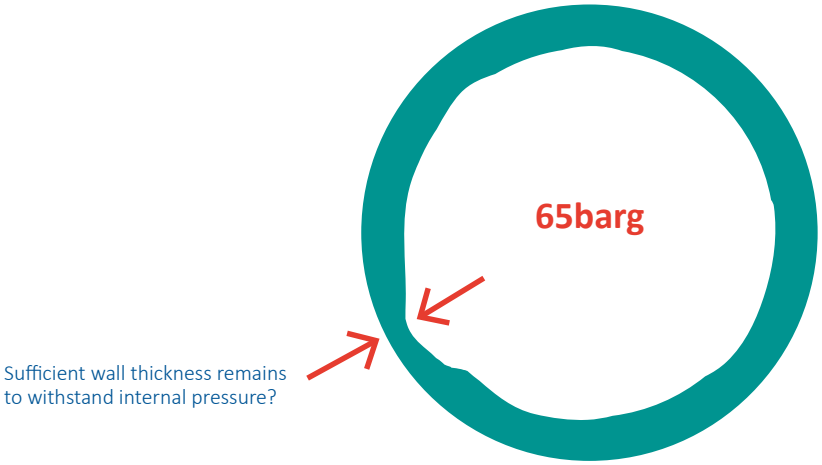

Diagram 3: Successful outcome of corrosion management

CONCLUSIONS

The conclusion 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 are 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 etc. 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 these important lagging indicators as central to ensuring the integrity of process plant assets. This should give such measures priority over less beneficial KPIs such as measuring audit scores, outstanding actions and safety tours.

ABOUT THE AUTHOR

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A world expert on process safety management, leadership and the establishment and implementation of key performance indicators for major hazard industries, Ian holds the Institute of Chemical Engineers' Franklin Medal for his outstanding contribution to Process Safety.

Recently retired from the UK Health and Safety Executive (HSE) as Deputy Director, Chemicals Regulation, Ian is now Principal Process Safety Consultant with Lockheed Martin.

Ian has over twenty five years' experience in the regulation of chemical and major hazard industries and in the investigation of major incidents to discover the underlying causes. He led the joint HSE and industry response to the major fire and explosion at the Buncefield fuel depot in the UK and established the UK Process Safety Leadership Group.

He also chaired the international expert panel to publish the Organisation for Economic Co-operation and Development (OECD) Guidelines on Process Safety Governance which is now the global benchmark on Process Safety Leadership.

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ABOUT LOCKHEED MARTIN

The Energy division of Lockheed Martin has over 20 years' experience providing solutions focused on delivering increased asset performance, safety and security alongside scalable IT managed services in support of our customers' global operations. This track record helps Lockheed Martin provide customers with unique access to advances and best-practice from across the energy industry.

Health and safety warning signs are often visual, and we're all familiar with health and safety procedures that aim to avoid or alert us to triggers before an incident occurs. Process safety alerts may be less visual, but managing risk control barriers with key performance indicators (KPIs) can be just as effective at helping avoid dangerous incidents. Implementing Lockheed Martin's approach to Process Safety is also proven to reduce insurance premiums, extend plant life and help protect staff, contractors and assets.

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