Bottom-line Benefits through innovation in Process Safety KPI Management

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With the assistance of the Lockheed Martin, ScottishPower has been able to transform its organisation into a leading global exponent of process safety.

ScottishPower embarked on a project to implement a fully integrated process safety management system based on guidance published by the HSE on developing process safety indicators (HSG 254) and the American Petroleum Institute's Recommended Practice (RP) 754, in addition to drawing on lessons learned from the Texas City refinery and Buncefield oil depot explosions to address process safety at every level in the organisation.

A critical success factor in the project was the implementation of a near real-time Key Performance Indicator (KPI) monitoring system developed by Lockheed Martin, which was introduced to allow staff at all levels to see the current status of the risk control barriers across all sites. This innovative approach to KPI management enables concerns to be addressed well before they become problems and to date has delivered improved safety and reliability as well as tangible bottom-line benefits.

Through this proactive approach to process safety management ScottishPower has realised significant improvements across its business both in terms of asset management, production efficiency and bottom line contribution, including:

A 36% reduction in Operations and Maintenance costs;

A 22% increase in Plant Availability;

A 52% reduction in Equivalent Forced Outage Rates (EFOR);

A reduction in its Annual Insurance Premium.

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; in 2011 it became the subject of one of the first case studies to be published jointly by the UK Health and Safety Executive (HSE, 2011); and in 2013 it won the Institute for Risk Management's award for Global Award for innovation.

Innovation has continued through the partnership. The most recent step in the journey has been the introduction of a live-bowtie view which provide daily visibility of how the barriers are performing around the hazards they are designed to control.

Lockheed Martin and ScottishPower will jointly present a case study on the project highlighting the benefits realised and key learnings.

Introduction

On December 11, 2005, an explosion occurred at the Buncefield oil depot in Hertfordshire, leading to Europe's biggest peacetime fire. In July 2010, following a comprehensive investigation and subsequent prosecution, Gordon MacDonald, a senior member of the UK Health and Safety Executive (HSE) posed three questions:

1. Do we understand what could go wrong?
2. Do we know what our systems are to prevent this happening?
3. Are we getting the right information to assure us that these systems are working effectively?

Answering these three questions has led to the development of a systematic approach to developing Process Safety Indicators (PSPIs) that can be applied to all process industries.

ScottishPower partnered with Lockheed Martin UK as a strategic partner to assist in the development and delivery of the underpinning information technology and information management strategy including the development of a Process Safety KPI Dashboard and associated core IT systems. Central to the program is the development of quantitative leading and lagging Key Performance Indicators from a Bow Tie Hazard identification and analysis process. Of particular importance was the systems integration work delivered in automating the KPI management process, as this automation enables the KPI dashboard to pull data directly from the underlying business system and update the status of the KPI's and "live" Bowties on a daily basis and risk rank them without adding any reporting burden to staff. It has also meant that all staff have a single source of truth in the KPIs that are produced and have the ability to understand current barrier performance in Bowtie format. This innovative approach to KPI development and management enables ScottishPower to be aware of the current, hidden safety, human and asset risk. It enables the organization to make more accurate decisions at shift management to boardroom level before critical barriers fail.

This paper explains how Bowtie theory can be used to develop KPIs covering an entire asset base and the benefits that can be obtained using this methodology.

Description and Application of Equipment and Processes

Establishing the Key Performance Indicators, KPIs

To deliver an integrated process safety and asset integrity management system, and specifically to establish a comprehensive set of leading and lagging process safety performance indicators, ScottishPower followed the UK HSE Guidance on establishing process safety performance indicators (HSG 254)

A multi-functional team from the business (including key contractors where processes were undertaken by external staff) 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 covers a range of power plant technologies it was found the majority of leading indicators could be applied but different targets and tolerances were set according to the power plant type and risk. In total 100+ Leading Indicators were identified across all Risk Control Systems. As below:

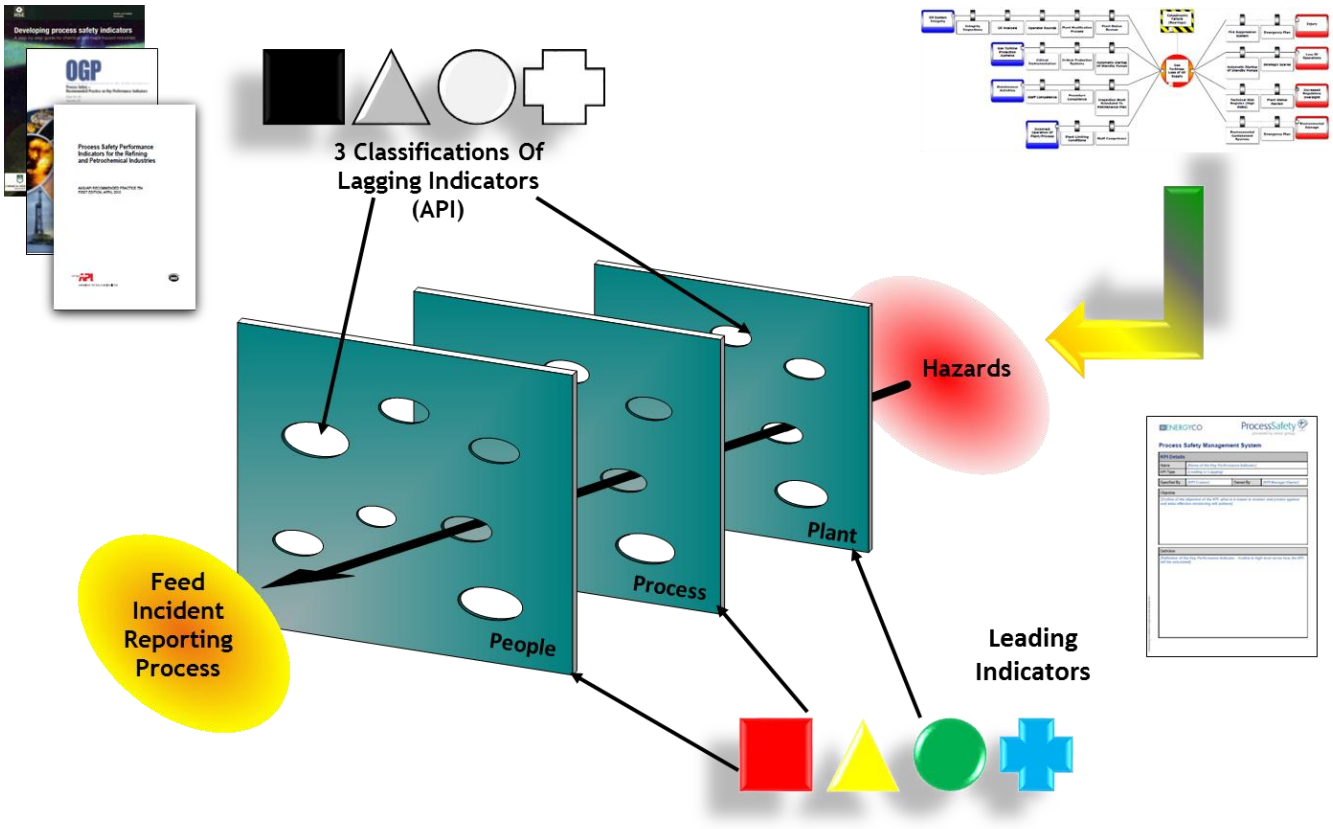


Figure 1 - Risk Control Systems Principles

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 and Asset Integrity Management System (PSAIM system) 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.

Figure 2 shows how this was collated into a formal management system in terms of Risk Control Areas.

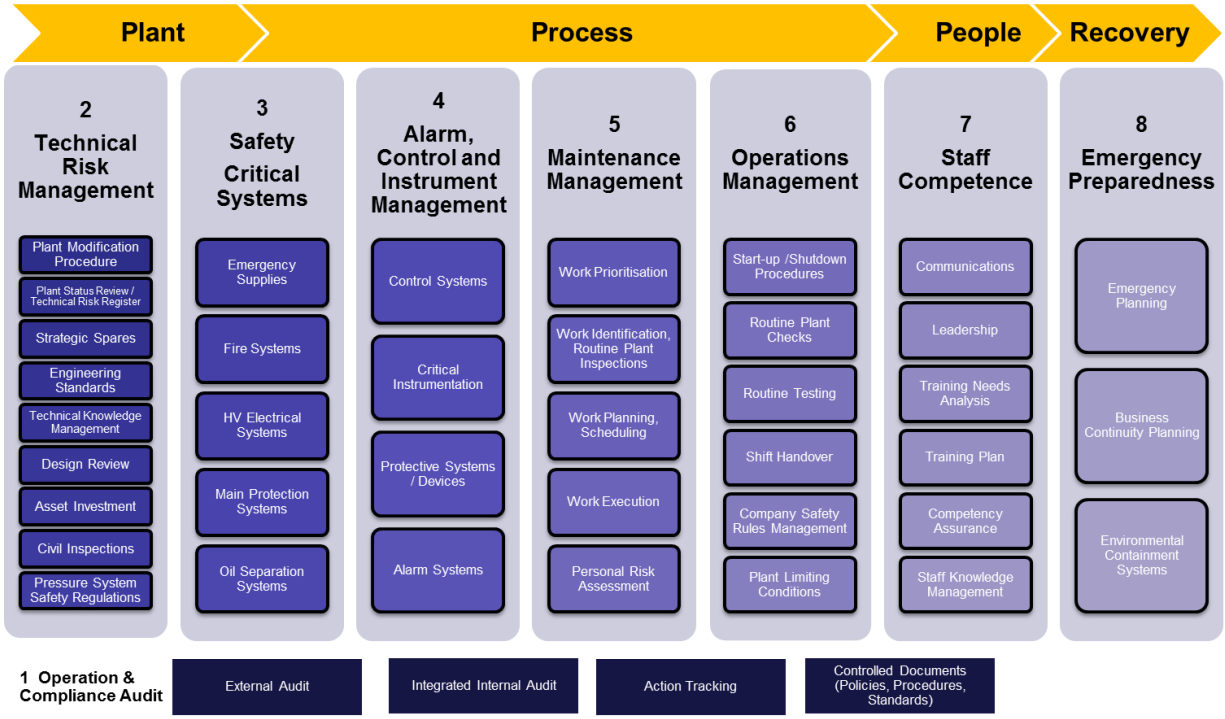
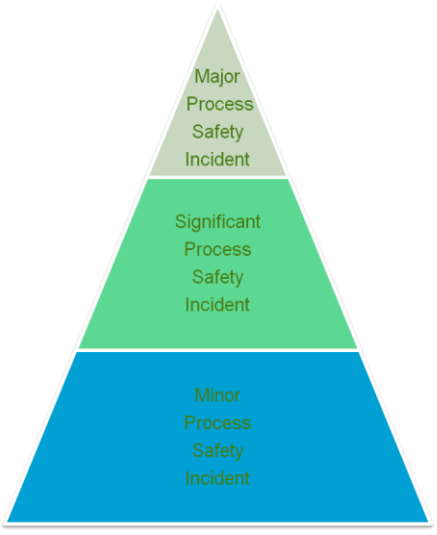


Figure 2 – Risk Control Area Model

In terms of Lagging Indicators, 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 drive out consistent investigation of root causes. To ensure staff report process related incidents and near misses a major cultural awareness program was developed which trained staff on the importance of the role that "lagging" indictors play in learning from events and preventing such incidents occurring again across the power fleet. Further to this a companywide Technical Incident process has been developed.



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

Figure 3 - Process Safety Lagging Indicators

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 shows where it is below acceptable. Both "leading and lagging" indictors are brought together to build a live "Bowtie" model approach. The key focus is always on leading indicators as these are more predictive in terms of preventing a major accident. This was then developed into a visible PSMS to allow the RCS barriers to be measured daily; this is shown in Figures 4 and 5

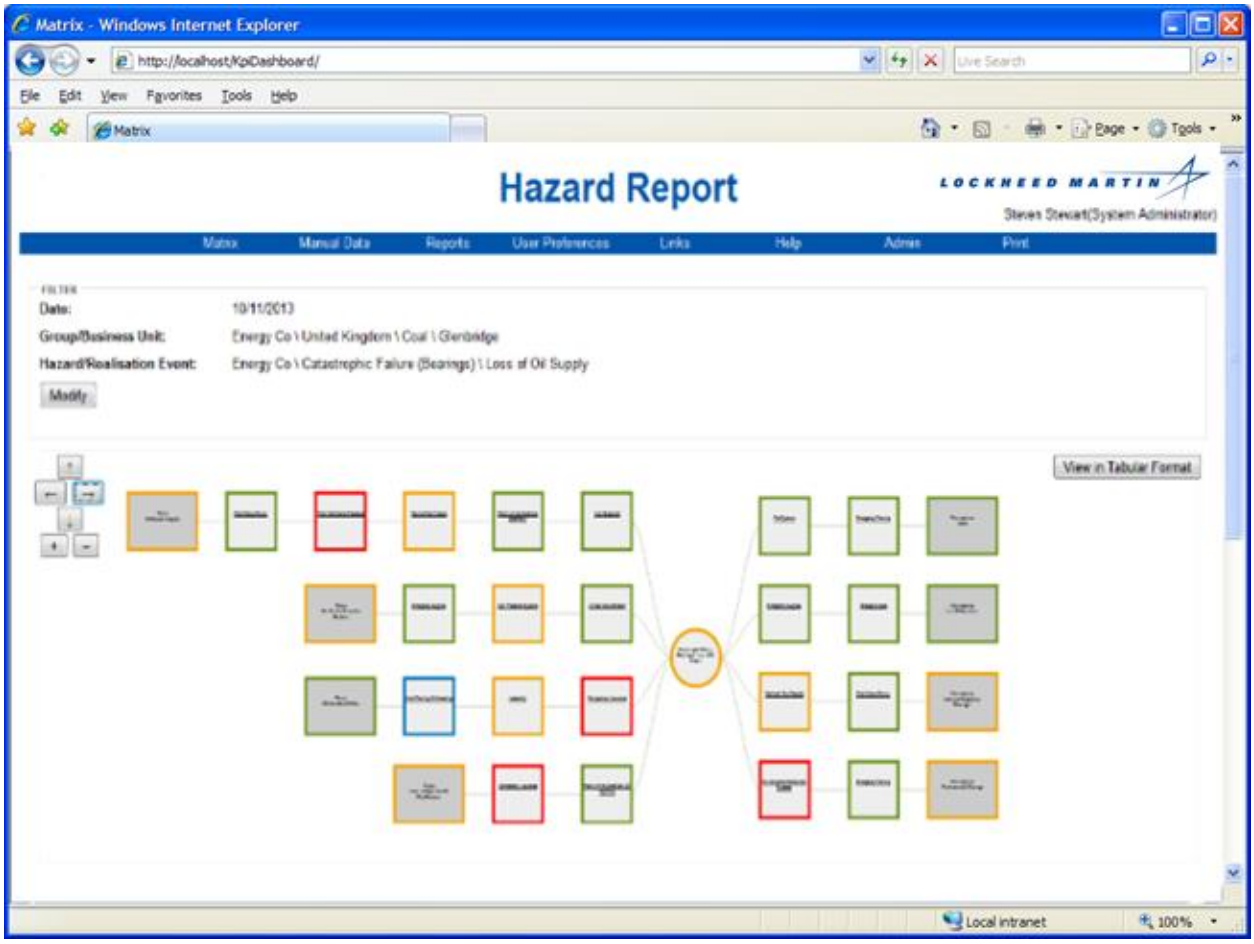


Figure 4 – Live Bowtie

Figure 5 – Management System Live view

A key concept of the approach is that not all indicators are of equal importance when considering predictability in terms of risk. Three types of indicators were identified, Operational Control, Generic and Program Indicators. In terms of preventing a major incident or accident it is the Operational Control Indicators that need to be focused on.

Many organizations have process safety key performance indictors based on program and generic categories as often these are easier to measure. Whilst these indicators are important in terms of setting 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. The types of indictors in each group are summarized below in Figure 6:

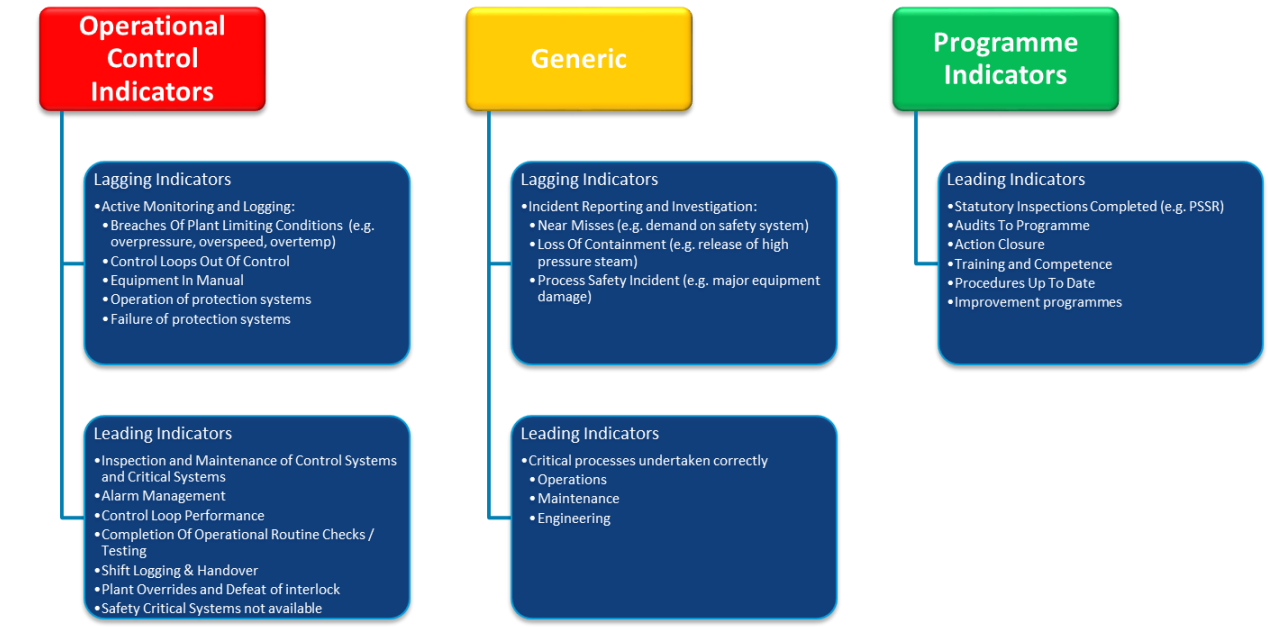


Figure 6: Types of Indicators

Having recognized the categories of KPIs, a risk model and set of mathematical algorithms were developed to allow the important KPIs to be easily visible to the organization. The KPI dashboard was then modified to take these concepts into the governance and management process of the individual indicators and power plants. Figures 7 and 8 shows the concepts:

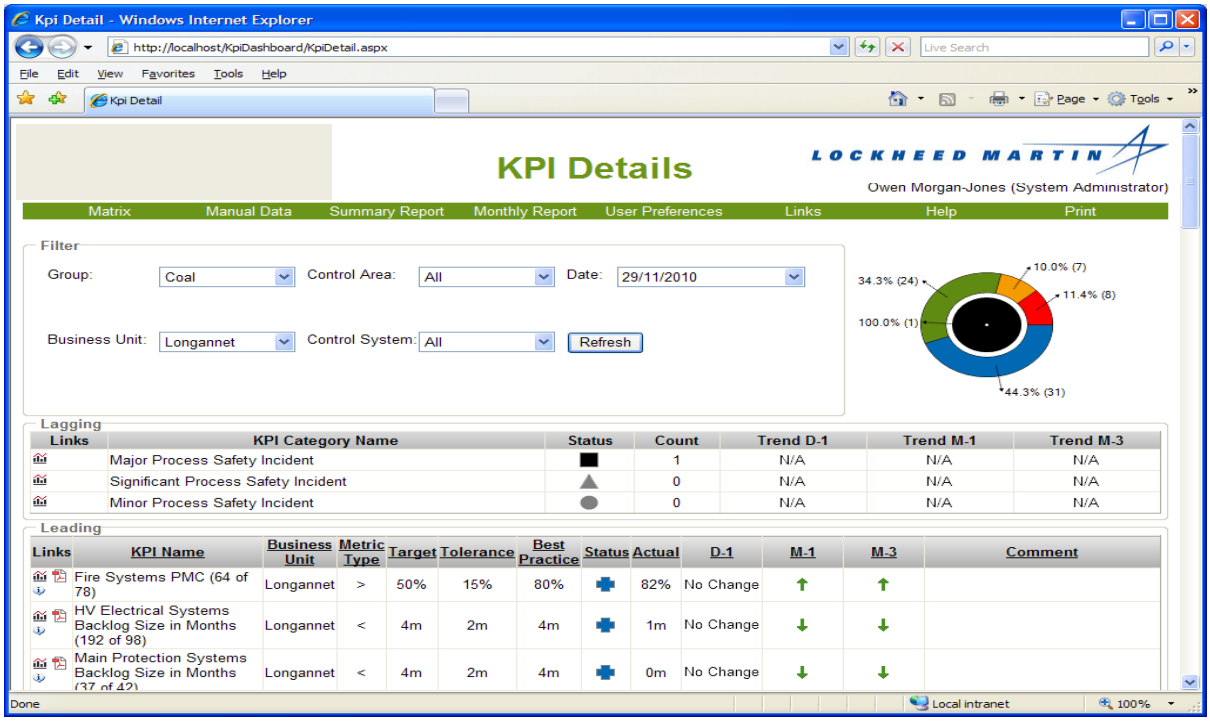


Figure 7 – Risk Ranking of KPIs

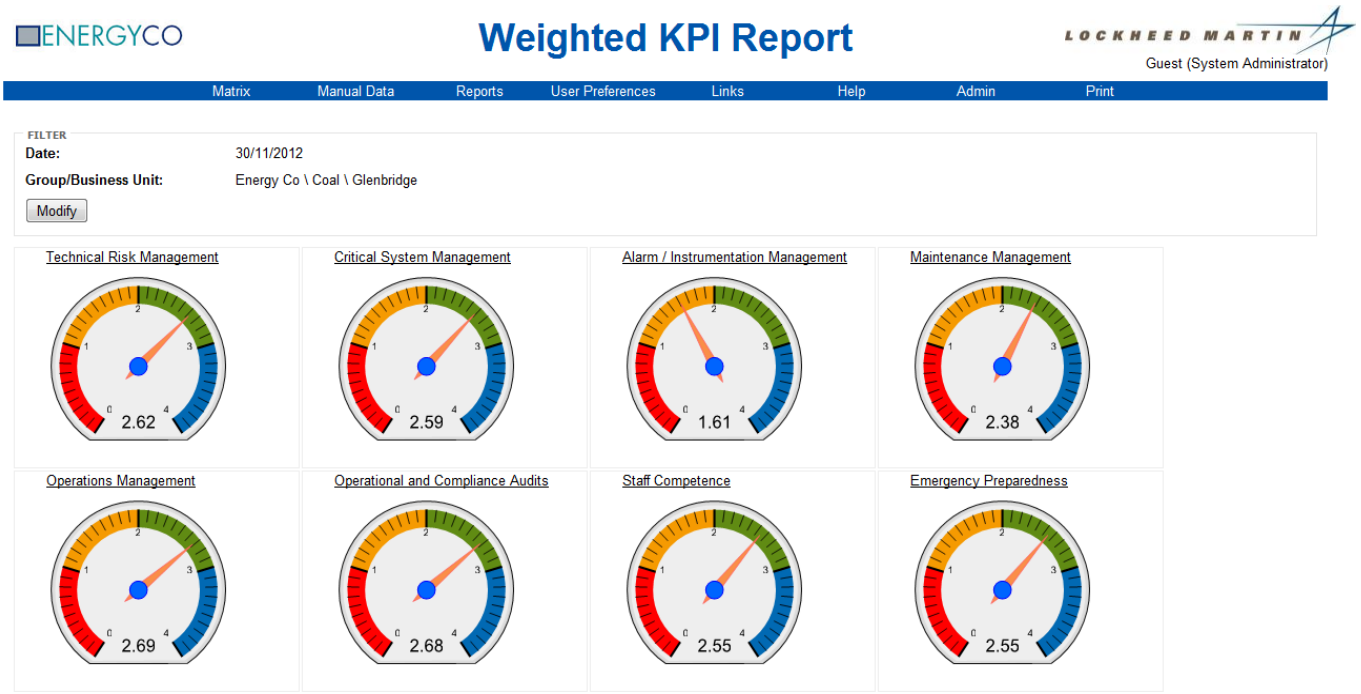


Figure 8 – Portfolio View

Key Hazard Report

Once the KPIs have been developed linking key hazards to risks, 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. This is shown in Figure 9.

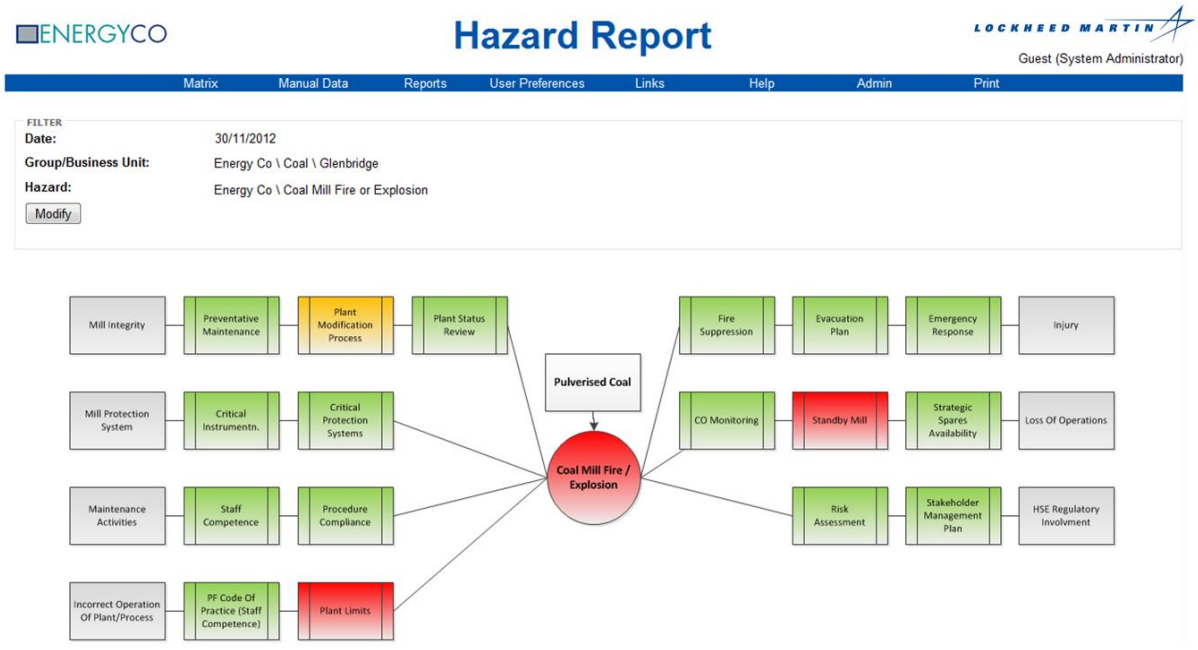
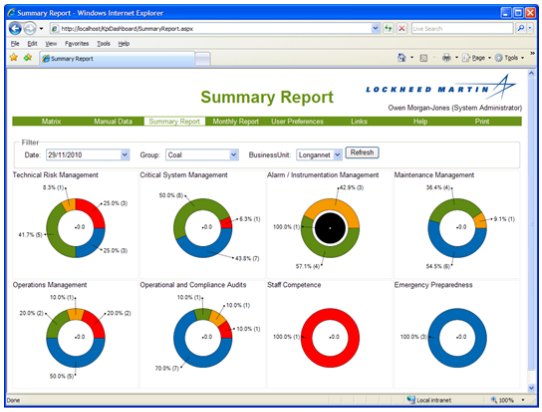


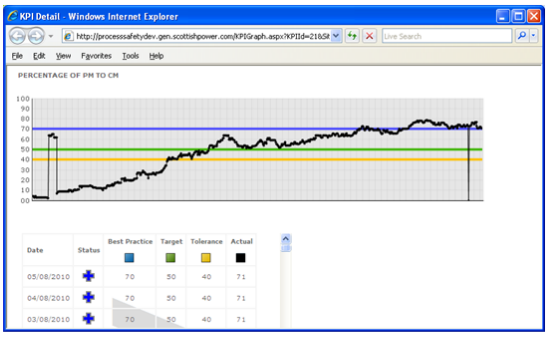
Figure 9 - Hazard Report

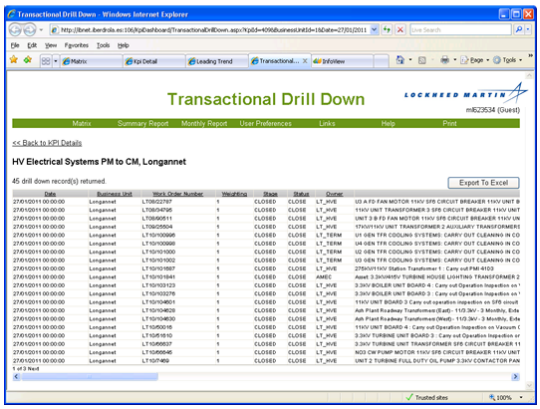
Prevention of a Major Accident Hazards

To prevent a Major Accident Hazard the key performance indicators need to be visible to all in the organization from the operator or maintenance technician up to the CEO level. These indictors then need to be acted upon throughout the organization and seen as the driving force behind the business in terms of reducing safety risk and improving performance and efficiency.

To make this happen the indicators are made visible to all employees of the company, including contractors through the use of the intranet, handheld tablets and daily discussions with staff. This is achieved by proving the dashboard with a number of features such as drill down to individual pieces of work, trending and reporting screens. To ensure no indicators are missed through data aggregation etc. red indictors at a plant level will feed through as red to the top of the organization but the risk ranking process allows the focus to be on those indicators which are of most significance. Figure 10 shows a number of screenshots used by the organization.







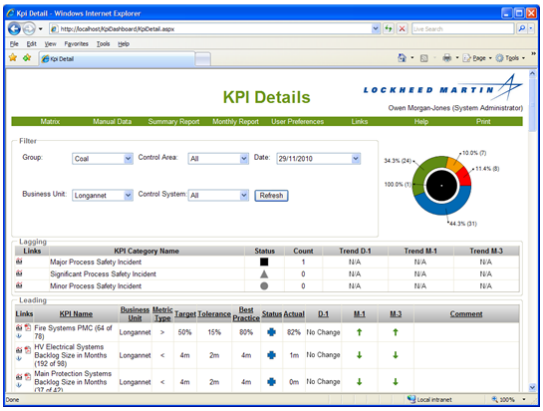


Figure 10 - Dashboard Screenshots

Review and Governance

The Process Safety KPI Dashboard as a monitoring and reporting tool was developed following rigorous, practical application of the HSE's guidance on process safety indicators (HSE, 2006) and delivers the following capabilities:

- Near-time visibility of leading indicators for key risk control systems across all power stations – providing 'at a glance'" assessment of plant condition, the performance of barriers and key processes;
- Improved reporting of incidents and near misses, enabling information to be shared more widely and repeat incidents to be prevented;
- Provision of timely, accurate and comprehensive information to support the governance of process safety through early identification and proactive management of risks;
- A governance framework to ensure that performance and actions are reviewed on a monthly basis.

The dashboard provides directors with information that had not previously been visible. Some staff and contractors felt uncomfortable that detailed information on processes in which they were involved had become so visible. Leading and lagging indicators are a major source of performance information, supplemented by other information such as the Asset Risk Framework, management reviews and audits against business engineering standards, PAS 55, IS0-14001, OHSAS-18001-accident and incident investigations and benchmarking.

The organization had to work hard to respond constructively to some of the information that was being presented. The key outcomes were a better appreciation of the underlying causes of process safety issues and the action plans being put in place to resolve them; and a company-wide focus on tracking actions and seeing the performance improvements coming through onto the dashboard.

It is the visibility and governance framework that has allowed leaders to own and drive the program and to deliver business improvement. ScottishPower set up a Governance schedule that drives regular reviews of process safety performance information at all levels in the business to identify trends and initiate the proactive actions required to prevent plant related incidents. Governance takes two forms:

- Formal Governance – regular review meetings are scheduled at all levels in the organization from facility level up to the ScottishPower Board to establish ownership and accountability for process safety management. The information that drives this process is fully transparent so all staff can play their part in improving performance.
- Culture – alongside the formal governance process, all staff are required to understand the hazards and risks evident in everyday operations and report and challenge any concerns they may have about process safety. This

culture is described as maintaining a ‘chronic sense of unease’; to ensure people are always thinking about what could go wrong and never complacent.

Ongoing Development of Process Safety Indictors

The ongoing development of process safety key performance indictors has been shaped by the review of major process incidents led by regulators in proving a framework. A number of industry bodies have also provided guidance for specific industries to help frame thinking on the subject.

The most difficult part in developing indictors is the actual transformation of a concept on paper to a real and relevant practical, ideally automated approach that reduces the burden of reporting on the organization. To ensure compliance with the requirement to report effective indictors a government oversight or regulatory guidance framework needs to be established.

The development of the identification and definition including the collection and use of indictors to prevent a major accident requires to be driven by Industry and Industry bodies to help define a more detailed approach with a focus on “Operational Control Indictors”. The smart use of IT systems and integration are essential and critical success factors and should not be overlooked in finding an effective, sustainable solution for process safety performance indictors to prevent future major accidents.

Conclusions

Using a systematic and standardized approach, an organization can create a set of Process Safety and Asset Integrity performance indicators that encompass all of the Major Accident Hazards it needs to manage. Undertaking a program to visualize these indicators, an organization can deliver near real-time information on the risk being carried by an asset or business area to staff at all levels, thereby encouraging and supporting a strong safety culture.

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