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Do We Really Know How To Manage Risk?

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Abstract

Process Safety approaches developed and implemented over the past 20 – 30 years have, few would argue, enabled us to improve the design basis for our facilities. The use of a risk based approach is commonplace and indeed a requirement of many regulatory bodies around the world. Despite this, our industry continues to experience catastrophic accidents which, when the consequences are dire, receive a lot of media outrage usually followed by multiple investigations and calls for legislative change and / or criminal proceedings. So in most parts of the world where Oil, Gas and Petrochemical operations occur we have a societal intolerance of such events, generally demanding legislation and many would say a strong intent from the industry to operate safely. Yet we still see major incidents occurring at a steady rate each year so the question has to be asked whether we in the industry really understand what it means to manage risk.

This paper will examine traditional approaches to risk management and suggest that while they may be appropriate for design basis they are not so useful to support Operations Management where decisions on risk continuously take place each day and at all levels of the organization. The scenarios used in design are simple and static but the calculating of risk is rigorous and complex generating results which seem credible and complete. The real world of plant operations, however, is neither simple nor static. There are multitudes of potential initiating or escalating events occurring simultaneously, deviations to our risk control systems, changing equipment status, hazards introduced through maintenance and repair work on live plant and human and environmental factors. On top of this we have a wealth of data which could help to manage this seemingly chaotic world but that data is trapped in silos within our organizations making it very difficult to utilize in supporting real time decisions.

What is needed to support Operations is a different approach to risk which is more pragmatic: simple in concept and able to be informed by real time events. The paper will outline an approach which has been used for some years in some parts of the offshore industry where ageing assets and integrity issues compound the risk. What is new is the emergence of Operations Excellence software platforms which can now gather and process data in near real time providing frontline and leadership easier tools to identify, predict and manage risk and activity on a day to day basis.

The promise of big data in process safety could provide an early warning system that looks at potential signals and trends in facility operations data to make major accident hazard risk exposure visible, prominent and available in real-time. With this information, everyone could proactively make better operational decisions to prevent major accidents. Big data promises to help deliver what we all want; an improvement of industrial process safety and the achievement of process safety excellence that keeps people safe and the plant running efficiently.

1. Introduction

Process Safety approaches developed and implemented over the past 20 – 30 years have, few would argue, enabled us to improve the design basis for our facilities. The use of a risk based approach is commonplace and indeed a requirement of many regulatory bodies around the world.

The process safety practices and guidelines for designing, managing and operating the facility are well-known and documented by regulatory and engineering bodies. The rules of how to run facilities, maximize production and manage risks are typically encoded in company's Operational Management systems.

How do we know good practice is being applied? How do we connect this to the frontline? KPIs and audits are our principal tools to try and get this insight.

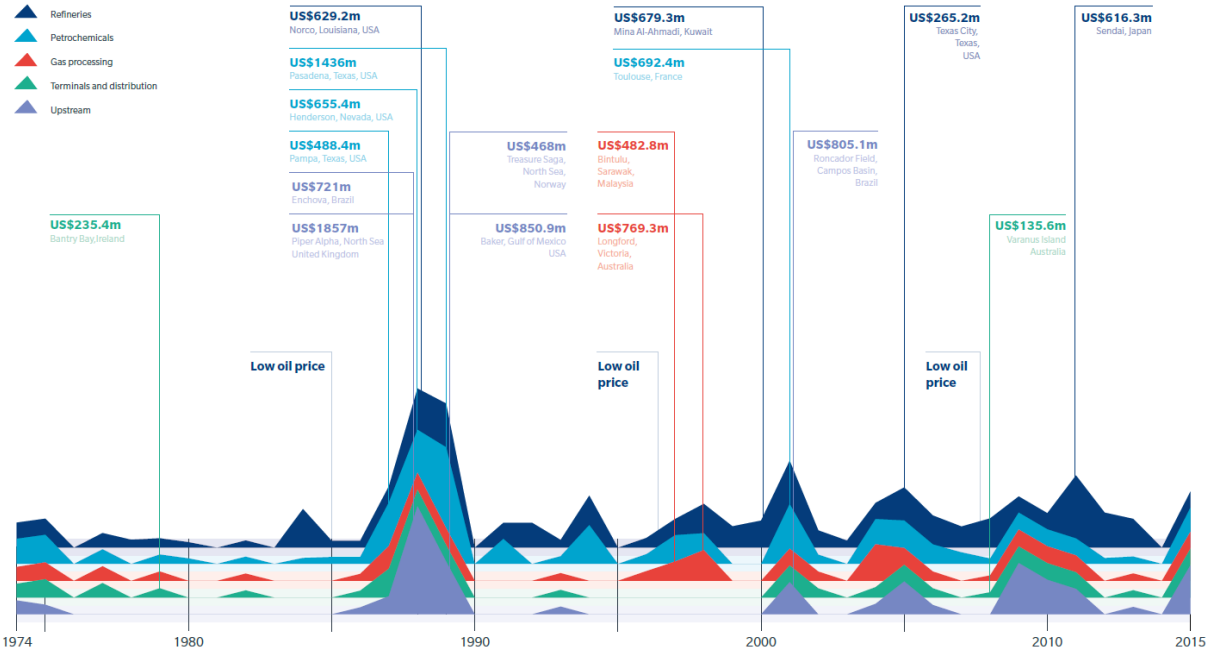
Despite this, our industry continues to experience catastrophic accidents which, when the consequences are dire, receive a lot of media outrage usually followed by multiple investigations and calls for legislative change and criminal proceedings. So in most parts of the world where Oil, Gas and Petrochemical operations occur we have a societal intolerance of such events, generally demanding legislation and many would say a strong intent from the industry to operate safely.

But what are the case studies from major accidents telling us about underlying issues on the plant? And what is the impact of cost structures on safety?

Today's operating environment is under enormous economic pressure resulting from the "lower for longer oil price." Over the past two years, the oil price has fallen about 70%. The fall in price has resulted in a significant impact on the global hydrocarbon industry. Constrained capital and operational funds have meant changes in strategic decision-making.

There is a concern, from the process safety and loss control perspective. Lower revenue from production could potentially result in investment reductions in risk-control measures - which could compromise asset integrity if maintenance and inspection activities are impacted.

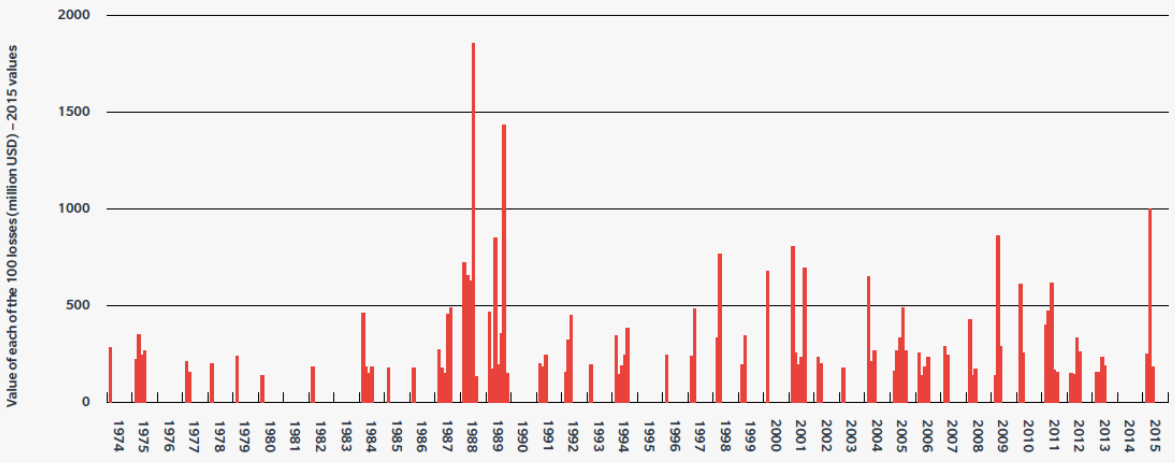
FIGURE 8 PROPERTY DAMAGE VALUE OF 100 LARGEST LOSSES BY SECTOR
Source: Marsh Research



The 2016 Marsh and McLennan report outlines the largest losses in the Hydrocarbon industry between 1974 and 2015. This includes the costs of property damage, debris removal, and clean-up costs- normalized to 2015 costs.

Looking at the distribution of the 100 largest losses in hydrocarbons, there appears to be a significant frequency of loss either during or immediately after significant reductions in the crude oil price.

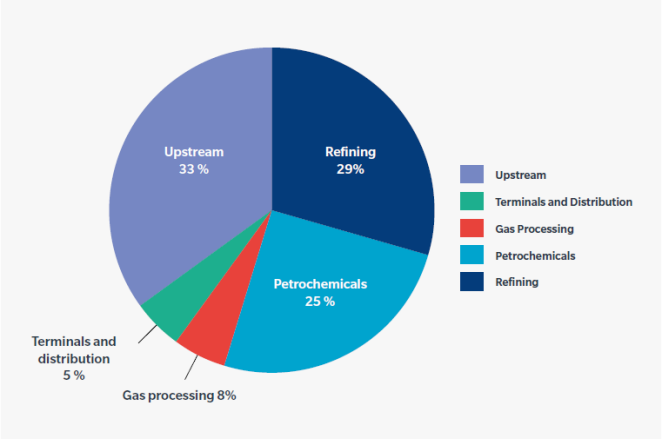
FIGURE 4 DISTRIBUTION OF THE 100 LARGEST LOSSES BY YEAR
Source: Marsh Research



The combined view from all sectors demonstrates no downward trend over time. And furthermore, it seems about 35% of the largest losses occurred within last ten years.

The refining and upstream industries have shown an increased trend in frequency and size of loss over last seven years. And while the Petrochemical industry showed no conclusive trends, and in fact have contributed few events into top 100 in last few years, authors report an average of one significant event per year across the HC sector.

FIGURE 6 PERCENTAGE OF PROPERTY DAMAGE VALUES OF 100 LARGEST LOSSES BY SECTOR
Source: Marsh Research



These three segments account for the largest percentage of property damage, Upstream at 33%, Refining at 29% and Petrochemicals at 25%. Gas processing, terminals, and distribution combined account for 13% of all loss.

According to the authors of the report, the average age refining operating assets are in excess of 35-years, a contributing factor for loss. Additionally, in recent years there have been periods when margins have been significantly reduced, resulting in reduced profits - and some operators pushing production. And finally, Operations in increasingly challenging environments, including upstream operations in deeper waters, present greater exposure in the event of loss.

Process safety barriers are designed to reduce the probability of an event occurring or to mitigate the magnitude of the consequence. The risk reduction they provide is based on the likelihood that the barriers function effectively.

Typically the industry recognizes what can go wrong and can even prescribe correct prevention and mitigation barriers. However, it is the failure of these barriers to perform which seems to be the most common feature of these events.

According to Oliver Wyman,

> *"The proper maintenance of these barriers depends not only on them being routinely inspected and audited but also on senior management's clear support of the safety process and its ability to address any concerns that are brought to light."*

By taking a step back to look at how the complex interactions of frontline operations and process safety are managed, there is an opportunity to drive continuous improvement and Operational Excellence by reducing risk and improving productivity.

McKinsey and Co. reports, profound technological advancements are disrupting old ways of working in oil & gas and are enabling step changes in safety and productivity.

Indeed, the promise of big data in process safety could provide an early warning system that looks at potential signals and trends in facility operations data to make major accident hazard risk exposure visible, prominent and available in real-time. With this information, everyone could proactively make better operational decisions to prevent major accidents.

Big data promises to help deliver what we all want; an improvement of industrial process safety and the achievement of process safety excellence that keeps people safe and the plant running efficiently.

2. Process Safety – establishing what needs to be achieved

Operational risk arises from a complicated set of interrelated parameters and is viewed and managed in differing ways depending on the role and level in the organization. The challenge is to simplify this complexity, enabling all levels of the organization to collectively focus on the major elements of risk that are important.

Process Safety is a mature engineering science – our toolset is strong in defining what needs to be achieved.

Some regulators require companies with hazardous installations to implement process safety management systems. Across the globe, there are a number of differing process safety management models: OHSA, Cal –OHSA, SEMS, HSE, Dupont, etc. And, each company has established risk control or management systems to comply with these models. Common to most system is the concept of barriers or lines of defense, or layers of protection, as a means of understanding the differing ways an operation can be protected against major accident hazards.

Hazard identification and assessment tools identify the risk and magnitude of consequences associated with loss of primary containment events. Our armory of PHA, HAZOP, Bow-tie, LOPA tools, etc. are used to specify the hierarchy of controls and systems needed to deliver the risk reduction required to operate safely.

But all of these systems and tools have led to functionally focused management and risk control systems.

The challenge comes in relating the performance of these systems and tools to the lines of defense in a meaningful way. Management teams on facilities know what could go wrong, what consequences could be, how they should be managed as well as the controls that should be in place to manage the risks. But that knowledge must be translated into every corner of the organization, including the frontline.

Petrotechnics recently conducted its 2017 process safety and operational risk management survey to better understand the "reality of risk" in process industries today. Over 200 process safety, asset integrity and operational risk management senior leaders around the World participated, including representation from the Mary Kay O'Connor Process Safety steering committee, as well as CCPS membership. A few key facts about the contributors to this survey:

- 50% have been in process safety, asset integrity and operational risk for >15 years
- 63% manage at the corporate level (others are single-site, or regionally based)

The contingent revealed interesting perceptions about,

- Safety culture
- Drivers for effective PSM
- The reality of risk and impacts on performance
- Who is responsible for managing risk and their awareness
- The perceived role of regulations
- The availability and effectiveness of systems and tools to support process safety and risk management

Some findings were reassuring, some were surprising, others confirmed what we already understood about the industry and the importance of process safety and operational risk management.

In short, respondents suggested industry must find more effective ways of understanding the balance between safety and productivity – and they need to be more proactive in identifying and managing the associated risks.

- "It's important that we understand hazards on a real-time basis and that the continual state of barriers is maintained as designed to reduce incidents."
- "Everyone would be more thoughtful on ensuring barriers perform to standards if they truly understood what the barrier was trying to prevent."

When asked about their perception of the reality of risk across industries, 70% indicated they believe there are gaps between how process safety is intended and measured and what happens on the plant/asset.

Furthermore, 66% of respondents believe operations do not always understand the aspects of their jobs that are most critical in managing process safety risk.

So, there seems to be a gap when the process safety design "enters the field." And, there seem to be limits on our ability to operate and maintain the plant to ensure the purity and integrity of design intent is met and maintained.

One survey respondent indicated, "Process safety is specialized knowledge, not typically understood by operations and maintenance, leading to implementation gaps."

Operators employ multiple risk control systems to support the frontline and protect organizations from hazards and their consequences.

The real world of plant operations is neither simple nor static. There are multitudes of potential initiating or escalating events occurring simultaneously, deviations to our risk control systems, changing equipment status, hazards introduced through maintenance and repair work on live plant and human and environmental factors.

On top of this, we have a wealth of data which could help to manage this seemingly chaotic world, but that data is trapped in silos within our organizations, making it very difficult to utilize in supporting real-time decisions. The isolated designs of these systems offer only siloed context. Bringing them all together in a joined-up way to see their impact on the operational reality of the asset is challenging enough for Process Safety experts – let alone the rest of the business.

So how might we go about better supporting Operations Management where decisions on risk continuously take place each day and at all levels of the organization?

3. Process Safety and new approaches to operational risk management

What is needed to support Operations is a different approach to risk, which is more pragmatic, simple in concept and able to be informed by real-time events.

Many operators are taking an asset-integrity led approach to identifying process-safety critical systems to drive focus and attention on their maintenance testing and availability.

Process safety tools are typically used to identify and specify critical equipment and systems, and operators are establishing minimum performance expectations for different categories. The model used is one of Safety Critical Elements (SCE) and each category of SCE is comprised of components and equipment. A performance standard is established for each SCE category, and operators assign Engineering Technical Authorities to ensure that the required standards are maintained.

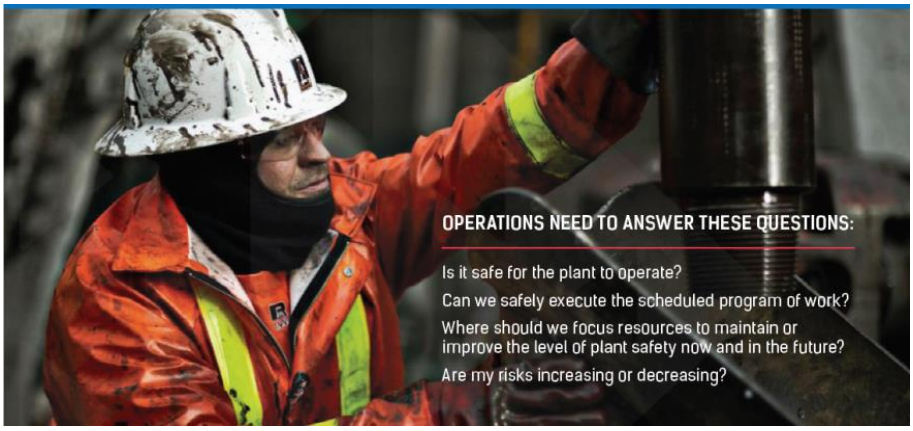
Company processes are aligned to ensure all SCE components and equipment are inspected, maintained and deliver the required performance standard.

This approach has been underway for some time now; however, when asked about how well safety critical maintenance is delivered, the Petrotechnics 2017 Process Safety survey found is a disconnect between the model and how things actually occur in the real world. Only 6% of companies achieve all of their scheduled safety critical maintenance.

Indeed, aging assets were cited as a top challenge for delivering effective process safety management, and maintenance was identified as an area that has one of the greatest impacts on effective process safety management.

When asked “who bears the most responsibility for understanding and managing operational risk”, the majority of respondents, 67%, lean to maintenance for actively managing and mitigating the impact of risk. Certainly, other roles were represented, including operations.

Despite the investment in identifying process-safety critical systems, components, and equipment, there also seems to another disconnect between the model and what actually happens on the ground. The prioritization of the inspection and maintenance of process safety critical equipment isn't always as it should be.



When asked, what critical process safety information is needed by people who make daily decisions about operating and maintaining the plant/asset, 2017 PSM survey respondents indicated a host of information. These included: details about safe operating limits, safety critical equipment, impaired barriers, inspection data, product safety, engineering (P&IDs, MSDS, OEM operating data), management of change, the state of JSAs and risk assessments, knowledge of emergency procedures and management and more.

Looking at this problem from a data perspective, it would appear – at its heart – to be a very simple problem – we need to better tools to understand the process safety impact of,

- any deviations from standard for SCE components and related management systems, and
- any uncertainty associated with the status of those SCE components and related management systems

One challenge associated with this problem is the diverse nature and protective function of the components we are seeking to model. An approach used by several major operators includes defining a common approach to risk assessment and management, associated with these deviations to generate a common currency of risk.

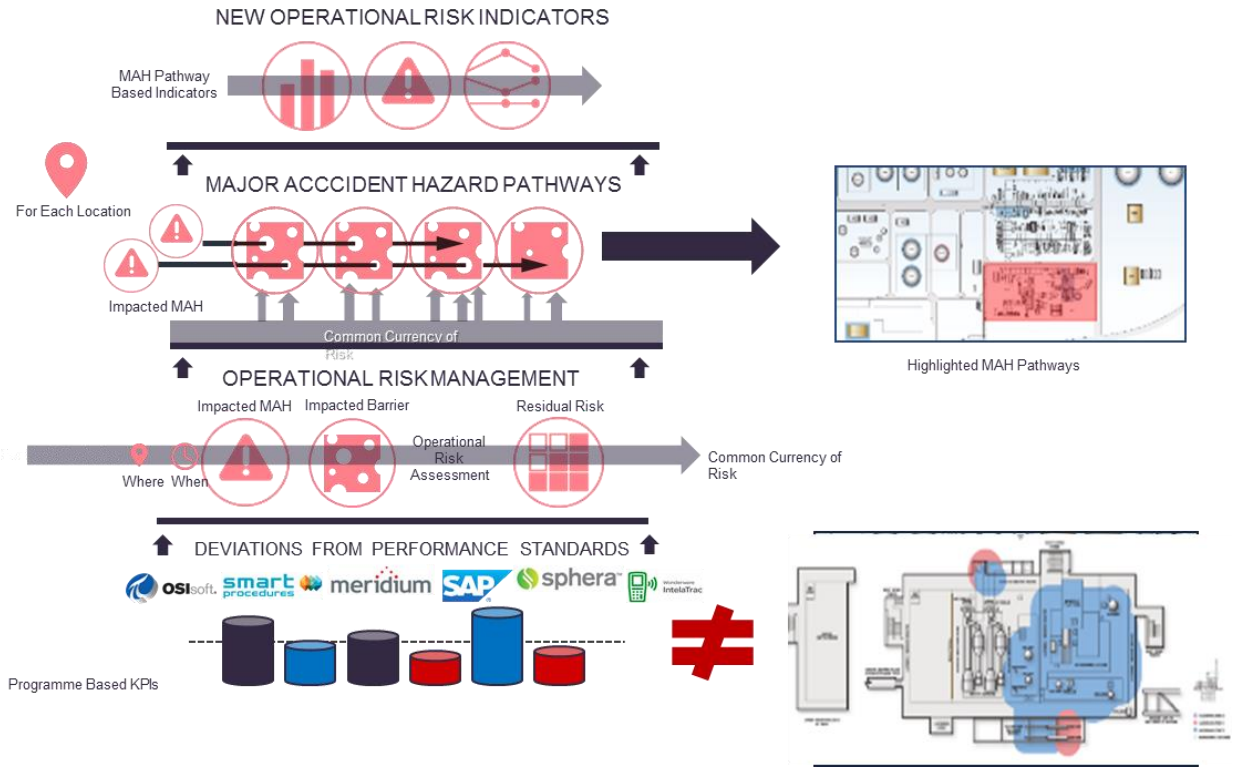
4. Operational risk management and data visualization to better support decision-making

Context is key. Real-time situational awareness is necessary for making sound decisions, especially when executing the organization's strategic goals, including production, safety, and cost management in operating conditions that are constantly changing.

Even a plant with multiple protection layers can experience a major hazard because of an accumulation of relatively harmless decisions. Downstream oil and gas industry expert, Kelly Keim, recently highlighted the CSB report on the explosion at the Torrance refinery. This pointed out that as operations became focused on the tasks required to complete the shutdown, they became unaware of the changing risk profile around them. They didn't know the importance of the key process safety barriers they were altering.

A new approach to managing operational risks and their impacts on process safety barriers is to use major accident hazard (MAH) risk exposure as a key indicator for identifying MAH pathways.

Understanding the role of risk in the context of the activity taking place at the frontline provides insight into the potential outcome. And that enables an operator to predict and manage the outcome – whether that be improved safety performance or productivity gains arising from operational efficiencies.



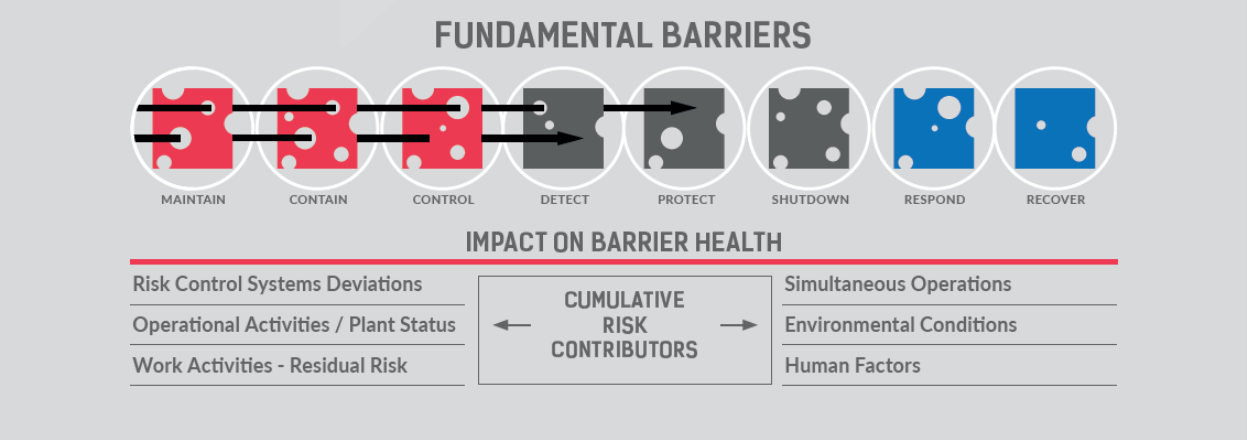
Several major operators are combining the residual risk arising from deviations in any risk control systems. For each risk control system, there will be a technical authority and associated performance standard. Examples of a deviation or a failure include,

- Performance standard failure
- Verification inspection finding
- Safety Critical maintenance overdue
- Override of safety critical system or device
- Management of releases
- Defined life repair
- Temporary equipment
- Absence of or inadequate control system

For each risk control system failure, an operational risk assessment is performed - led by the technical authority. From this, major accident hazards are identified, as well as the fundamental barriers impacted, the interim control measures, authorizations required and the resulting residual risk.

Connecting Operational Risks and Fundamental Barriers

Oil and gas operators are moving towards a fundamental barrier model, based on multiple layers of protection/mitigation. The idea is simple in that if you have impairments in several of the barriers (note these are not individual barriers but a collection of equipment, instrumentation or people driven processes which collectively fulfill the function of the barrier), your risk is increased because you are closer to a major accident occurring.



The diagram above shows this simple model using James Reason's Swiss cheese metaphor. The types of barriers which result from this design approach can be grouped into different categories reflecting the role they play. We call these "fundamental process safety barriers."

The holes in the barriers represent impairments, and when the holes line up, an event can occur and escalate into a major accident. The degree of development of these risk pathways represents the level of risk.

The grouping of the barrier systems is important because it allows us to see how the impairment of barriers can line up sequentially with others, creating a compounding effect on risk. For example, if there is an impairment on the 'containment' barrier at the same time and in the same location as an impairment in the 'ignition control' barrier, the risk of having an uncontrolled release of hydrocarbons to the atmosphere is higher as is the risk of ignition. Combined, they can result in a fire or explosion as the result of sequential failure of more than one barrier system. If the 'detect' barrier (gas and fire detectors) is also compromised, and the ability to protect is compromised (say the water deluge system is inoperable), these are further sequential breaches in multiple layers resulting in the potential occurrence of a major event. The degree of escalation and the scale of the consequences will then depend on the mitigation barriers or the ability to respond to the incident.

By accumulating all the residual risks, operators can display the MAH pathways through the fundamental barriers – including a new KPI based on a common understanding of risk and new, leading MAH risk indicators.

Applying New Leading Indicators of Risk to the Operational Reality

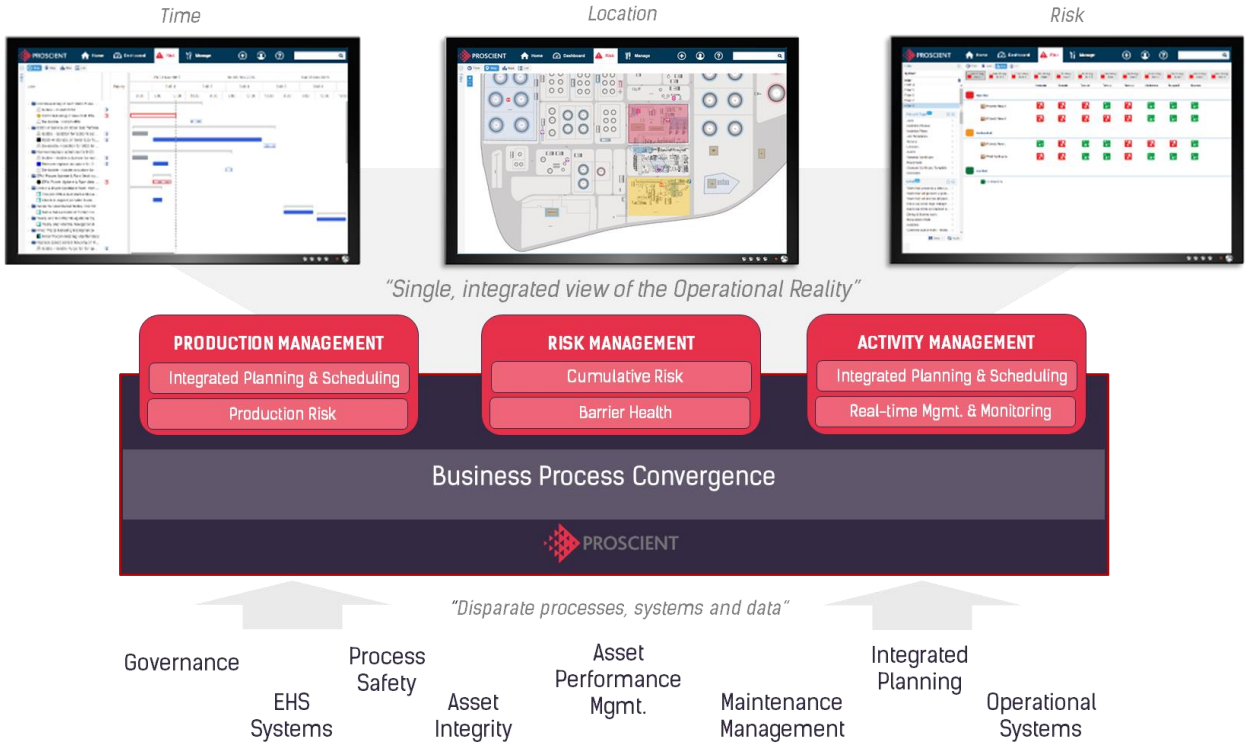
In reality, day-to-day operations are characterized by a changing dynamic where there are multiple sources of potential risk which typically change daily, hourly and sometimes by the second. These multiple sources include,

- Barrier Impairments/risk control systems (RCS) deviations include damage and failure to physical barriers such as corrosion, mechanical failure, temporary repairs, procedure deviations and deferred inspections, testing or preventative maintenance.
- Operational activities such as equipment start up or shut down.
- Operator actions such as hydrocarbon sampling, filter change out, pig launching and receiving, etc. Excursions outside safe operating limits for the plant. Temporary defeats to safety systems. Process Isolations which do not meet company standards. Periods of instability on the processing plant.
- Working on the live plant introduces hazards such as ignition sources from hot work, breaking flanges, heavy lifting over live plant, excavation work, etc. These activities are typically risk assessed and controls put in place (such as gas testing while conducting hot work) which mitigates but does not negate the risk.
- Simultaneous operations compound the risk when working in the same or proximal areas. Some of these activities may be managed separately from Plant Operations such as construction, project work, subsea operations, drilling or well service. So it is essential rules are defined for co-ordination, but residual risks will always remain, and more importantly, they introduce work crews, possibly unfamiliar with the plant, into the hazard zone.
- Environmental conditions such as temperature extremes, wind, visibility, precipitation, electric storms all add risk potential and can compromise work programs
- Human factors such as competence, lack of experience, discipline, fatigue, distraction can compromise the quality of decision making at the frontline.

Faced with this array of potential risk sources, decision makers in the organization are faced with many questions, but our information and data systems and our approaches to managing risk are not well set up to support critical operating decisions. But if we have generated a common currency of risk for all these deviations, we then can present the impact against a fundamental barrier model and use it to drive a cumulative risk heat map. That's where technology can help.

5. Technology, the answer to effective process safety and operational risk management?

A new class of software, called Enterprise Operations Excellence systems, present different views of risk in both real-time and predicted on the basis of ongoing impairments and deviations and planned work activities.



In Location: The spatial view shows the plant with icons representing planned or ongoing work such as hot work, breaking containment, heavy lifting, etc. Other icons show impaired fundamental barriers such as containment, ignition control or protection systems. Algorithms assess the cumulative risk levels in specific areas and can shade in those areas of the plant to show medium risk in amber or high risk in red. An overall risk level for the shift is indicated in the top time line for now and for future shifts.

In time: Data from the maintenance management system is imported including the Gantt chart. Simple tools allow Operations people to add on their specific tasks such as energy isolations, draining, purging, as well as ancillary tasks such as scaffolding and isolation removal. Thus, a complete outline of all tasks is shown in the timeline. The system can be configured to show activity clashes such as breaking containment and hot work in the same area.

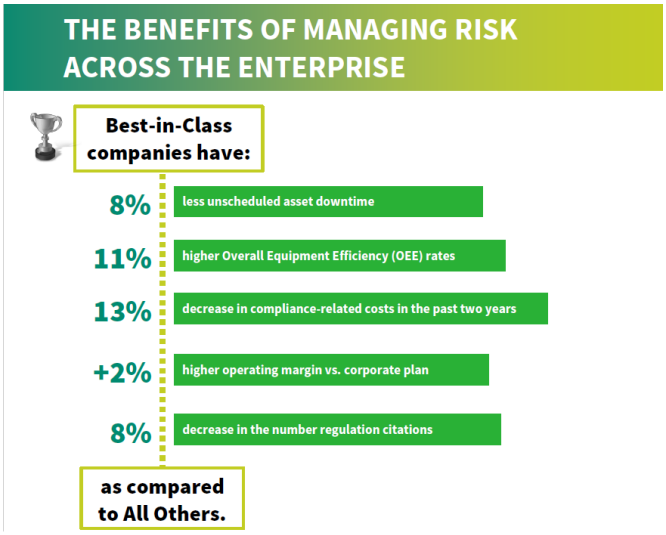
In risk: A summary risk view shows the sub areas where risks are elevated but more specifically it shows the impaired fundamental barriers. Drilling down for each sub area, the specific activities, impairments or deviations can be show and their specific impact on the fundamental barriers.

Other views can map risk to major accident hazard scenarios and also to deviations in risk control systems.

These systems do not just benefit the front line workers. Back office functions, asset leadership, and group leadership can see trending results across an asset with time or across a whole enterprise.

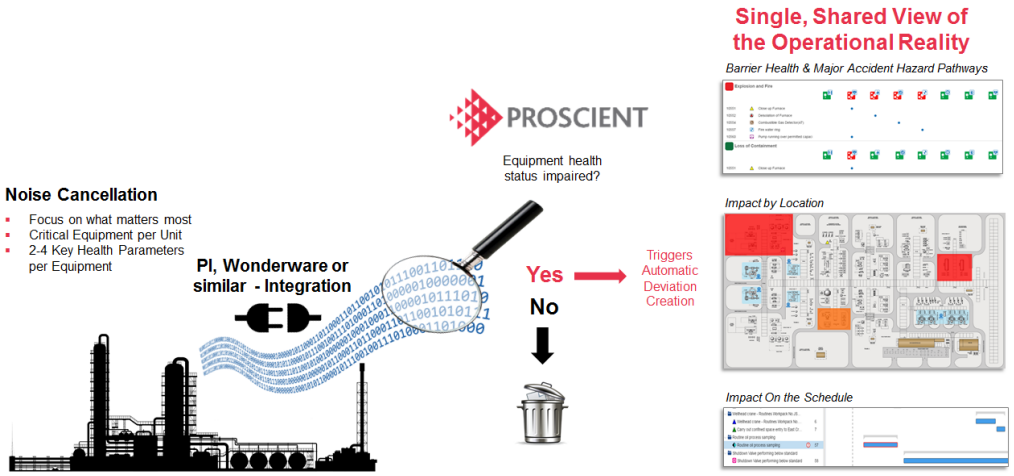
- Real-time indicators of risk are more relatable to what's happening on the plant or across assets
- It is easier to relate risk increases to deviations in risk control systems and the functions responsible for managing them
- Evidence of improved outcomes can be seen, for example, through trending of risk levels versus the efficiency of work execution

These systems are being labelled "Operational Excellence" platforms because they address many of the key areas which Operational Excellence programs address, such as activity and risk management, safety and productivity, harmonization and standardization across an organization.



In short, Operational Excellence systems manage risk, cost, and productivity. They also strongly support a means to connect Process Safety into Operational Excellence initiatives.

Most studies show, companies who adopt an enterprise Operational Excellence approach enjoy fewer outages, increased equipment efficiencies, higher margins, and fewer citations.



The question then becomes, to what extent can I automate this? For certain categories of SCE, there are real-time data sources about the health of the equipment.

One operator recognized a gap between the risk understood on its facility and that shared with senior leadership. The operator has begun to leverage automated systems and solutions to transform its approach to operational risk management by making risk visible, prominent, and available for all, in real-time.

For this operator, once disparate, complex risk data arising from activities, energy isolations, temporary defeats and deviations, such as management of change, is aggregated and displayed in an interactive, dynamic process safety barrier management model.

This simple, elegant approach connects process safety and risk control system performance to frontline operations at any point in time. It's practical, routine and offers context for work plans while taking into account strategic risk management objectives.

The ability to see ongoing and planned activities next to deviations and impairments is something new and of immense value for this operator. Now, they use real-time insights and KPIs to make planning decisions that proactively minimize risk in the forward schedule. This has provided tangible benefits in two areas.

First, the company has elevated its awareness of major accident hazard risk exposure across the organization and has connected risk potential to frontline operations. Now, HSE performance is an integral component of production and sustainability.

Visibility is the second area of benefit. Leveraging Operational Excellence software, the operator was able to see they were using a higher level of control than they needed on work activities. This drove down efficiency unnecessarily. Now new conversations around process safety risk are taking place between senior and plant management.

Enterprise platforms provide anyone in the organization with a sense of where the biggest safety concerns are on the plant. The tool has armed the operator with information and context to have the right conversations about safety and productivity, at the right levels.

Perhaps industry 4.0 technologies could be the way to join up the various silos of our risk management. Connected systems could change how risk and safety are understood, measured and managed. Collaborative tools should enable us to understand the situation and intervene, when necessary, more effectively.

The majority of Petrotechnics 2017 survey respondents believe companies do not have effective systems in place for monitoring and managing impaired process safety barriers or effective systems for managing deviations from management system performance standards. And nearly 75% of companies believe companies do not employ effective, integrated solutions to help monitor and manage the combined risk arising from operational activities, impaired health of process safety barriers and other management system deficiencies. But by using technology correctly, respondents reported that these hurdles could be overcome.

"It's important that we understand hazards on a real-time basis and that the continual state of barriers is maintained as designed to reduce incidents."

In a 2016 Petrotechnics safety survey, 73.5% of survey participants agreed risk awareness and safety would be improved if the workforce and management had access to real-time process safety risk indicators on the plant. This year's industry survey shows 90% of survey participants agreeing to the same - demonstrating a greater reliance on technology to solve safety performance challenges.

Technology can play a key role in delivering operational risk and process safety management. To recognize the benefits of digital transformation, the industry must embrace all that industry 4.0 has to offer. Connected systems and tools, real-time KPIs, and the ability to quickly analyze, summarize and disseminate information when it's needed, where it's needed enables experts to drive effective process safety practices across the organization, in a way that makes sense for everyone.

Technology cannot do the heavy lifting on its own, but it can enable an organization and provide support for a more collaborative culture, in which a disciplined approach to everyday decision-making enables key business objectives.

That's why the fundamental approach to operational risk management is essential. This is what should set the game plan for digital transformation, visualization, and decision-making.

Bringing together once-disparate pieces of information gives an operator a full, three-dimensional view of every asset and facility. When that information is made accessible to the entire organization, in a way that makes sense to everyone, the output will be better decision-making. Everyone can actively participate in driving improvements to the business; reducing operational risk and enabling excellent business practices.

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