MARY KAY O'CONNOR PROCESS SAFETY CENTER
TEXAS A&M ENGINEERING EXPERIMENT STATION

18th Annual International Symposium
October 27-29, 2015 • College Station, Texas

Improving Operational Performance: Connecting the Impact of Process Safety Management to Daily Operations

Mike Neill
President, Petrotechnics North America, LTD.
10497 Town and County Way, Suite 700 | Houston, TX | 77024
Mike.Neill@petrotechnics.com

Abstract

The key to delivering safe, efficient and sustainable long-term, optimized production is effective operational risk management. Many organizations have either implemented or are in the process of implementing operational management or safety management systems based on process safety management principles. Key Performance Indicators (KPIs) are then created to manage performance, but we do not have indicators of real-time risk, since the performance of these systems is not connected to the real cumulative risk impact on daily operations. Daily operations is where operational risks all come together and where decisions are made across the planning to execution process to prioritize, manage, and execute activity that has a direct impact on the risk status of the plant. Often there is no single place where all the risks can be seen as each department (Engineering, Asset Integrity, Maintenance, etc.) manages their risks independently of others and not with the impact on daily operations in mind.

Process Safety Management (PSM) needs to be treated as an operational driver rather than just a compliance obligation. Understanding and managing the specific risk impact and the cumulative risk impact of the deviations or non-conformances with the performance standards of your process safety management system in the context of daily operations is the key. Managing these risks is a powerful driver of operational performance. With increased visibility into operations, having all of the risks in one place, plant operators can improve operational decision-making to get more of the right work done safely, efficiently, and sustainably.

Advances in enterprise software solutions enable organizations to change the perception of PSM by connecting its impact to daily operations. They can help organization systematize a “common currency of risk” that connects PSM performance to daily operations to:

- Better understand and manage the impact of process safety performance on daily operations

- Enable improved coordination and collaboration across functions such as operations, maintenance, planning, engineering, asset integrity, and HSE
- Make better operational decisions regarding the prioritization of activity to be addressed, how best to optimize the activity schedule, and execute frontline activity.
- Organizations can change the dynamic between safety and productivity by reducing risk and improving the productivity of operations

This presentation will demonstrate how to connect PSM performance to daily operations in a practical and tangible way to help treat PSM as an operations requirement and an enabler of optimized business performance.

1. Introduction

Risk-based Process Safety is established as the most common approach to managing major accident risks in the broad Oil and Gas and Chemical industries. Regulation and accepted standards have developed around these approaches, usually in the wake of headline disasters from Flixborough and Seveso in the late 70’s, Bhopal and Piper Alpha in the 80’s, Texas City and Deepwater Horizon in more recent times. Despite this focus on Process Safety, we still experience major events often resulting in fatalities, injuries, and extensive plant outages. If these were happening in obscure plants run by small, inexperienced operators, the outcome might be more explainable. But this is happening with some of the biggest names in our industry, with well-deserved reputations for their comprehensive approaches to plant safety.

The fact that these incidents continue to occur might suggest the Risk-Based Process Safety approach is failing, and we should seek other means of managing our major accident hazard (MAH) risk. Unfortunately it is not that simple since the approach is well founded, seems logical and rational, is based on sound engineering principles, and in truth we would struggle to find a better replacement. Instead, we see many attempts to identify aspects which do not work well and improve upon them. The Industry has made a lot of effort to increase the reliability of barriers throughout their lifecycle. This includes design improvements to prevent or delay equipment failure and improve the predictability of safety critical elements. We also see extensive efforts to improve the adherence to rules and procedures or “Operational Discipline,” since all of these barriers, if not procedural themselves, require human intervention for maintenance and inspection. Performance Indicators are another area where we see efforts to improve early identification of potential barrier failures or weaknesses in the systems responsible for monitoring their health. All of these approaches rely heavily on system audits as the means of identifying non compliances.

Attempts to find ways of improving Process Safety Management (PSM) are typically incremental in their success, and it remains to be seen whether improvements in the reduction of major accidents will result. With their low frequency / high consequence characteristics, such events are difficult to trend against industry initiatives, other than on a long term scale.

Perhaps it is time to approach the problem from a new perspective. One which connects Process Safety with the operational reality of the plant since frontline operations is where everything comes together. Frontline operations is where people intervene in the plant to operate, maintain, and fix equipment. It’s where process systems operate, where people get hurt, equipment is damaged, where the plant ages, where the impact of deferred maintenance is felt, the consequences of aging assets manifest themselves, where operating procedures are used, and importantly where incidents and accidents occur. Plant operations are dynamic and conditions change over time as does the operational risk we carry. As such, we need to find a way of connecting PSM to the day-to-day reality of operations, rather than treating it as a specialized subject which only Process Safety Professionals are qualified to practice.

In this paper, we discuss a new approach which connects the performance of PSM systems with their impact on frontline operations. It addresses some of the complications of company structures which result in critical barrier data being “siloed” within organizational disciplines, rather than being widely shared. It allows all levels in the organization to better understand the level of risk being carried at any given time. The benefits it delivers range from serving as an early warning systems for potential MAH related incidents (allowing organizations to make proactive interventions) and better prioritization of maintenance to more informed decision-making around risk and activity at the daily operations level.

2. Are Our Plants Becoming Any Safer?

The figure below, from the 23rd edition of Marsh & McLennan's publication, "Large Property Damage Losses in the Hydrocarbon Industry," (ref 1) displays the 100 largest loss events since 1974. Each referenced event is based on property damage, debris removal, and clean-up costs, normalized to 2013.

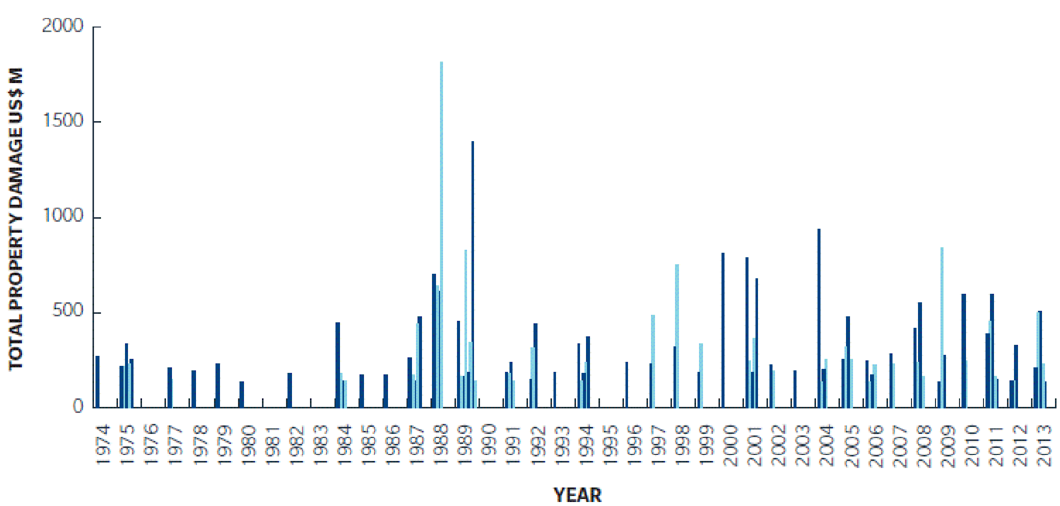

Figure 1: Marsh & McLennan's 100 Largest Hydrocarbon Loss Events Occurring, 1974-2013

Even just a cursory view of this data suggests events are still occurring at a worrying frequency. Since this is the “top 100” normalized for inflation, we would hope to see most of these events in our distant history. Unfortunately, the contrary seems to be happening with the past six or seven years showing an increased frequency.

In a second study by Swiss Re published in 2015 of the common causes of losses in the Oil, Gas, and Petrochemical Industry (ref 2), 45 major loss events over the past 15 years were analyzed. In 52% of the incidents, mechanical integrity failure due to corrosion was cited as the primary cause, and 27% due to failure of operating practices or procedures. Secondary causes were again integrity failure due to corrosion at 42%, and poor design and / or inadequate hazard identification at 33%. While this does not address frequency, it shows evidence of our MAH barriers failing and resulting in significant events.

3. How is Process Safety Implemented in Our Plants?

In most areas, whether by legislation or just good practice, the common approach is to design, build, maintain, and operate hazardous plants with a specific objective of avoiding major accidents. The processing and storage facilities design is typically analyzed for MAH scenarios. Multiple layers of protection (or barriers) are then designed to prevent an event from occurring or to mitigate the consequences if it does occur. The principle being that an unfolding event would need several barriers to fail at the same time for the consequences to manifest. Each country and sometimes even its different regions and sectors, have differing legislative regimes, some prescriptive and some performance based which mandate this type of approach.

Barriers

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.” An example is shown below using James Reason’s Swiss Cheese model (ref 3). In his model the slices of swiss cheese are the multiple layers of protection, and the holes in them represent the imperfection of each slice or “barrier.” In Reasons model, when the holes line up, successive layers of protection fail resulting in an initiating event with the potential to escalate into a major accident.

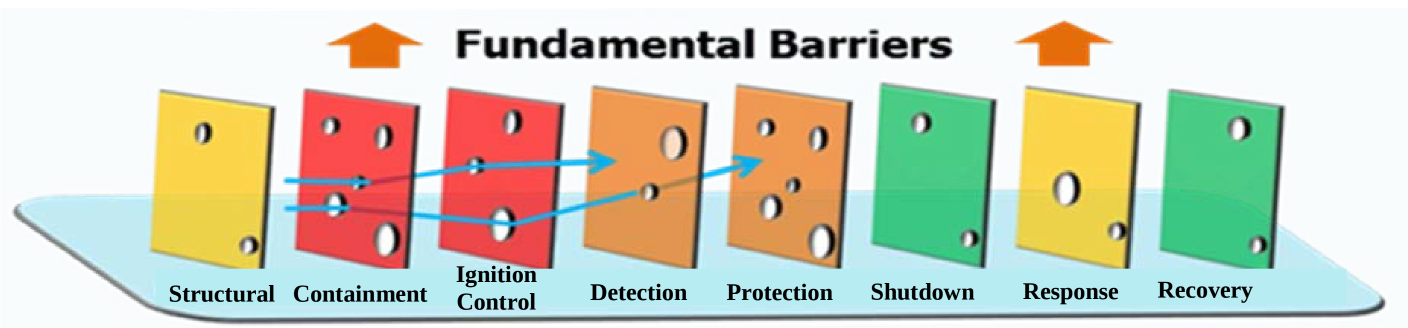

Figure 2. Fundamental Process Safety Barriers

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 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 detectors / 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/or the scale of the consequences will then depend on the mitigation barriers or the ability to respond to the incident.

Examples of barriers which would fit into some of these categories include:

> **Process Containment**: Vessels, Pipelines, Pressure Relief Systems, Pressure Control Systems
> **Ignition Control**: Flare Systems, Positive Pressure Systems, Explosion Proof Equipment, etc.
> **Protection Systems**: Fire Water Systems, Fire Proofing, Blast Walls, Safe Refuge, etc.

It is also important to note not all these barriers will be "hardware" equipment. Some will be software driven, such as plant control and alarm systems, and some will be "administrative" such as startup procedures and check lists, permit to work systems, emergency response plans, etc.

Barrier Element Performance

A barrier is designed to reduce risk, for example, a relief valve is designed to relieve pressure in a vessel before the point where the vessel ruptures. The risk of rupture occurring in the vessel would be eliminated if the relief valve could be guaranteed to operate as designed at all times, in all circumstances. In practice, this standard of reliability is not practically achievable but a minimum level of performance can be assumed with a high level of confidence. As such the risk of vessel rupture is not eliminated but is reduced to a level which is deemed acceptable.

Various quantitative risk assessment approaches are used in the design and calculation of the risk reduction impacts of specific barriers or safety critical elements (SCE). These will use an assumed reliability of the SCE. In the design of a plant, several hundred (or thousands, in the case of a sizeable plant) of such SCE's will be specified with the overall objective being to reduce the overall major accident hazard risk to an acceptable standard.

For hardware barriers, the required level of SCE performance is specified in the design and equipment/materials selection for the role. Confidence of performance can be based on the quality of manufacture or fabrication, the evidence of which is provided in the QA certification. Sometimes we go beyond reliance on certification and test barriers to verify they will perform as expected, such as function checks of pressure switches and control valves, hydrostatic tests of pipe and vessels, and calibration of relief valves, etc. Testing and QA validation is initially carried out during the commission of activities on a new plant before it is introduced to service.

Once into field life, it can be expected that barrier performance, unless properly inspected and maintained, will deteriorate over time. Internal and external corrosion of vessels, pipework, flanges, and structures is frequently the cause of impairments in structural and containment barriers. Corrosion-driven wall thinning or pitting of pipe and vessel walls reduce their ability to withstand internal pressure, increasing the potential for failure and subsequent loss of containment. Other mechanisms such as wear, damage, erosion, over and under pressuring can also compromise the integrity of primary containment barriers.

Continuous inspection, maintenance and testing of SCEs is essential to ensure they perform as expected, when needed. The maintenance regime for these components is usually specified by the equipment manufacturer and the Process Engineer who designed the scheme. Inspection and testing are key components of this regime. However, they can be deferred if not seen as a priority, being neither fix, repair, nor preventative maintenance to ensure performance. Ironically, the frequency of inspection or testing is specified as a means of ensuring a certain level of performance designed to maintain risks at acceptable levels. If inspection or testing is deferred, confidence in the reliability of the equipment is reduced, and overall risk increases since the design performance of the barrier(s) cannot be verified. For example, a high level switch on a vessel may have a performance reliability of 98%, meaning if high levels are experienced 100 times, the switch will not activate on 2 of those occurrences, provided it is inspected and tested every 12 months. If inspection frequency drops to 2 years, the reliability decreases to, say, 95%. As a result, 5 of the 100 high-level events would not then be detected. A simple example shows the result of deferred inspection leads to an increased risk of overpressure or product spillage.

Non-"hardware" barriers similarly need to be maintained and periodically inspected to ensure they are in place and effective. Operating Procedures need to be kept up-to-date with any plant changes. Management processes need to be verified to ensure they are still appropriate and people need to receive appropriate training to ensure competence. Verification that barriers remain in good condition is traditionally achieved through audits of Safety Management Systems, to ensure all elements are in compliance. In the event of non-conformance, this is where one could raise improvement actions.

4. How Do we Currently Monitor the Health of our Barrier Systems?

Our “hardware” barrier systems are composed many hundreds or even thousands of Safety Critical Elements or SCE’s and as we have seen above, each is designed to perform to a specific standard. The Inspection and Maintenance System needs to be set up to ensure these SCE’s are inspected and maintained according to a schedule designed to retain the necessary level of reliability. When equipment is found to be faulty it should be recorded in the system. Assuming it is flagged as an SCE, some priority should be assigned to implementing a repair or replacement. The problem we often face, however, is there are often a number of systems where information on the health of SCE’s is stored. The Maintenance Management System should keep track of whether scheduled maintenance or inspection has been carried out or deferred and it should also track some component failures - but not necessarily all of them. Examples of other systems which keep data on SCE performance include; Digital Control Systems (DCS), data historians, inspection data bases, alarm management systems, third-party inspection systems, incident databases, etc. Non-hardware barrier systems such as procedures and management systems are usually verified by periodic audits. Any non-conformances are identified and remedial actions initiated.

So we will typically have multiple, disparate systems monitoring the health of our barriers. There is often no easy way for Leadership or people at the frontline to see the condition of all their barriers at any one time. To do so would require a deep-dive into a number of internal and external databases, a comprehensive read of several audit reports, and a thorough review of incident / action tracker systems. With data being so dispersed, the industry has relied on Key Performance Indicator (KPI) measures to inform overall process safety performance.

API RP 754 (ref 4) was published in 2010, and recommends Process Safety Management performance indicators. It is based on a 4-tier system/pyramid, with the top two layers based on Loss of Primary Containment events (LOPC); Tier 1 being of greater consequence than Tier 2. Tier 3 represents events involving challenges to safety systems, such as safe operating limit excursions, inspections of primary containment that is outside acceptable limits, etc. Tier 4 categorizes operating discipline and management system performance. The top two layers are based on incident reports and are correctly identified as lagging indicators. Tier 3 is based on part incident, part inspection data. Tier 4 is mostly composed of data from audit-driven reports.

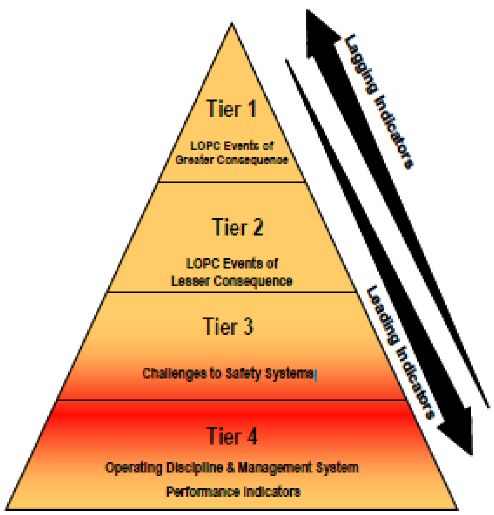

Figure 3. The American Petroleum Institute's Recommended Practice on Process Safety Key Performance Indicators

The positive of a KPI system such as this is tracking actual LOPC events and real impairments that could lead to incidents. Its value to organizations and the industry as a whole is essential to monitor trends and hopefully show quarterly or annual improvements. The negatives of a KPI system such as this is that traditional KPIs are very general, therefore, difficult to apply in specific areas or to specific systems. For example, a KPI which states 94% of safety critical inspections were carried out on schedule in the preceding quarter sounds impressive, particularly if the same quarter last year was only 82%. This metric still begs the question, so what? Can we assume all barrier systems are functioning? No, because we know 6% of inspections were deferred or did not happen. The trouble is we do not know which 6 %, where they are located, and what specific function they fulfil. Furthermore, they cannot be relied on as reflecting current status given the lag time to a lot of the input information. If this information is based on audits, then it can be as much as 1-2 years old!

In the UK, the HSE's guide on developing Process Safety Indicators, HSG 254 (ref 5), recommends focusing on the health of Risk Control Systems (RCS), examples of which include; Inspection and Maintenance, Competence, Operating Procedures, Plant Change, Permit to Work, Plant Design, etc. The UK HSE recommends specifying critical elements of each RCS, then developing leading and lagging indicators to identified impairments. The advantage of this approach places focus on the system that may be the source of highest risk, but it does not provide specific location or equipment references where elevated risk is present, nor does it show how combinations of risk sources act together. Similar to API, the time dimension is also a challenge since much of this information will be dated by the time it is published, and it may not reflect the current status.

While KPI's may work successfully for showing relative improvements over time across a site, they do not help address the more critical questions needed to be answered on a day-to-day basis by Plant Leadership. These include;

1. Is it safe for the plant to operate today?
2. Can I safely execute the program of work scheduled for today?
3. Where should I focus my resources to maintain or improve the level of plant safety in the future?
4. Is my overall risk of MAH increasing or decreasing?

5. The Reality of our Organizations and the Demand of our Daily Operations

We have established that information on the health of our barriers is not easily accessible by everyone, making it difficult to have a common view of MAH risk across the organization. In truth, the information "silos" holding most of this data tend to reflect the organization's shape, with each department holding their piece of the "puzzle." They have a tendency to see things from their perspective alone. This is especially true with an organization managing many disciplines. Take an offshore operation, for example, where the principal discipline groups with impact on daily operations could be: Production Operations, Drilling, Well Services, Maintenance (Inspection & Reliability), Process Safety, Projects, Subsea, Logistics, etc. All of these groups have activities which require the use of common limited resources. This is not just financial resources but more logistical necessities such as bed space for people, lifeboat capacity limiting the numbers of people offshore, and helicopter flights to get them there. Prioritization has to take place, and inevitably, decisions to cancel or defer work have to be made.

How we make these decisions is interesting. Most of our organizations are performance driven with the achievement of annual, quarterly, and monthly targets being important. These targets are typically set at a departmental level and based on measurable criteria. When it comes to prioritizing activities, each department has to argue for which will help progress their own targets. Organizations need a balanced view based on achieving progress, but not to the detriment of overall safety. MAH barriers within their areas of responsibility still have to be maintained, and individual groups, such as Operations, will have production targets but ones which have to be achieved without jeopardizing MAH risk or safety risk in general. This inevitably results in heated debates since we do not have a common way to look at risk, and often decisions are made on the basis of who shouts loudest!

The Need for a "Common Currency of Risk"

Information silos mean all of the data that informs us about risks are stored in different places. Each department or technical authority will risk assesses deviations from performance standards for their areas of PSM responsibility, often against a corporate standard risk assessment (RA) matrix. The challenge with this is they rarely assess in the context of daily operations or in the same way as other departments and technical authorities. With information on deviations and impairments spread far and wide across the business, operators have a difficult time understanding their operational risk; how people, processes, assets, the environment, reputation, health, and major hazard risk come together. This impacts their ability to make daily operational decisions, such that the right work gets done at the right time, in the right way.

Even if we can identify all of the deviations to our risk control systems, we are still faced with the dilemma of how to use the information. How do we assess the impact of multiple system deviations or impairments? How do we understand their combined effect, and when faced with resource choices, how do we decide which has priority? For example, if a Petrochemical plant has to make cuts in their operating budget, how do they decide whether to defer a sizeable activity, for example - bring all piping and instrumentation diagrams (P&IDs) up-to-date, or delay the repair and repainting of deteriorating surface protections on major vessels? For an offshore production platform where bed space has become critical due to ongoing drilling operations, can we prioritize installing a high cost "flotel" to retain maintenance crews who are trying to work down a sizeable backlog of safety-critical maintenance and inspection? To make these decisions, we need to evaluate their impact on MAH risk, or more specifically, their impact on the fundamental process safety barriers protecting against MAH. Where one or more deviations or impairments coincide, there are other risk contribution factors we need to evaluate to effectively understand the combined impact on each process safety barrier system.

Many organizations have built their own barrier management tools to try and see all the risk they are carrying. As mentioned, for most it has been a challenge and typically a very manual process to collect and input data. For some organizations this has meant only being able to provide a snapshot in time (ex. once a month) view of the operational risk they are carrying in terms of the status of the barriers.

In order to fully understand the impact of prioritizing or deferring work or activities, we need to identify which barriers are impacted by our assessed risk, over what period, and how these relate to each other. Finally, we need to have a method for aggregating risk from multiple sources.

From here, we have a "common currency of risk," which is an essential element to improving operational decision-making, with visibility at every stage of the planning-to-execution process: whether prioritizing work, optimizing the schedule, or executing the plan. It allows cross-functional teams across the business to better communicate and collaborate in terms everyone understands - enabling more comprehensive prioritization, optimization, and execution.
In short, a "common currency of risk" helps simplify the complexities of frontline operations.

6. The Reality of Frontline Operations and the Concept of Cumulative Risk

Impairments to Risk Control Systems or more specifically impairments to the specific process safety barriers are a major source of MAH risk - but not the only ones. During daily operations on our plants there are a variety of other activities, situations, or circumstances which can have an impact on MAH risk. Some work activities have the potential to compromise process safety, for example: lifting heavy objects over a live plant (risk of LOPC if dropped); vehicle use (risk of ignition source or collision risk); Hot Work (ignition source); breaking containment (compromising primary containment under lock-out-tag-out conditions); Excavation (risk of breaching buried flow lines); close in Marine Vessel movements (Collision risk with offshore structure). All these activities are usually managed with a permit system and a form of risk assessment where failure scenarios are considered and prevention or mitigation controls put in place. The majority of permitted work lasts just a single shift, but more complex jobs can last a few days. On a typical unit of a Refinery or Chemical Plant, or on a mid-sized offshore platform, 20-30 permits a day would not be unusual. Other than during turnarounds, this work is carried out with the plant live, adding additional hazards with large inventories of volatile, flammable, or toxic fluids being processed.

Other normal operations would include sampling, pig launching and receiving, draining and purging - all which have release potential. There are also situations such as equipment start up and shut down, changes to control settings use of temporary equipment, operation limit exertions, etc. All these situations or activities are time consuming and distracting for the operating crew. All have associated risks and are often accompanied with a higher level of incidents than with normal, steady plant operations.

There are additional contributors to risk such as people and the environment. On the people side this could be attributed to poor competence, lack of experience, low levels of discipline to fatigue, distractions and inadequate staffing levels. On the environmental side it could be temperature extremes, wind, rain, hail, electrical storms, sea state, visibility, etc.

All these factors outlined above in combination with impaired barriers will have an impact on daily MAH risk and will elevate risk in certain areas of the plant, at certain times. Most personnel working on a plant will want a better understanding of risk since they are exposed to it most frequently, over the folks working in the back office. This is certainly true for the Plant Manager, who needs to understand the level of risk exposure for the people and assets on his or her plant, on a daily basis to determine if the level of risk exposure is acceptable. The Plant Manager does not necessarily want to see, on a daily basis, failure risk for all SCE components, but they do want something more dynamic than audit-driven KPI's, which do not change from week-to-week or month-to-month. Plant Managers also want to better understand the impact of multiple sources of risk occurring in the same area, at the same time.

This is referred to as cumulative risk and can incorporate the overall risk of a major accident as a result of multiple contributing factors. The diagram below shows how all these sources contribute to cumulative risk and provide examples of activities.

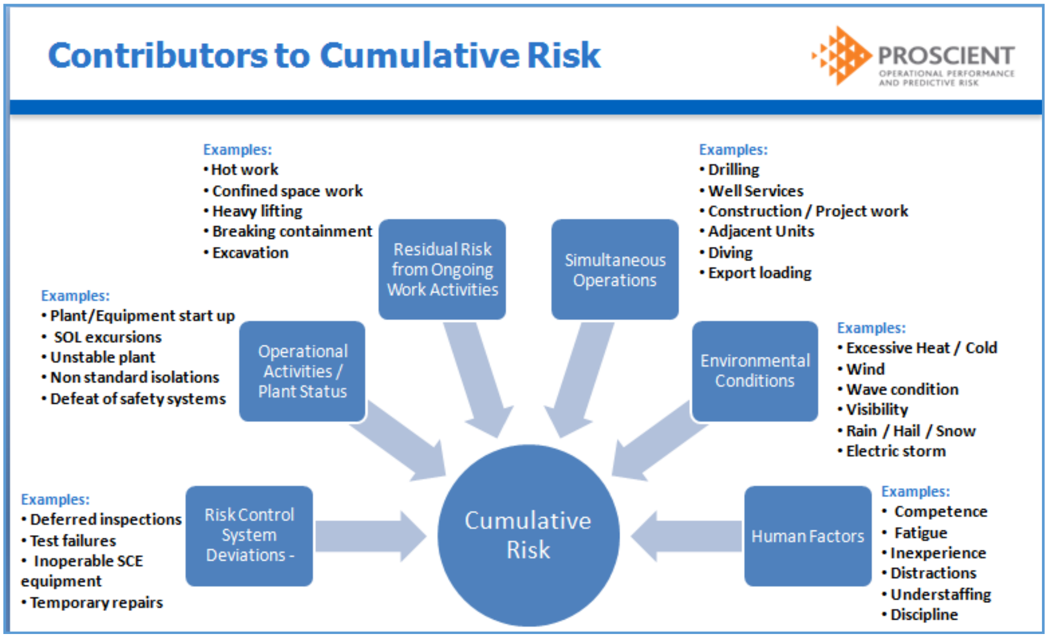

Figure 4. Contributors to Cumulative Risk

The problem with this outline of activities is they are not all managed in a single system or by a single process. These are multiple processes, often disconnected with disparate systems and data silos collecting and storing the relevant information. The other major factor is the situation is dynamic! Operational activities, environmental factors, human factors, and simultaneous operations all change on a daily basis. In fact the frequency is hourly, if not minute-by-minute. The truth is we do not really know or understand how the overall risk changes under such conditions. We do know when we should investigate incidents, and we cannot put a timeline together that shows the multiple causal factors to a moment in time when the final barrier fails and the incident occurs or becomes uncontrollable. Of course by this time it is too late to do something about it.

7. A Better Way of Assessing Real-Time Major Accident Hazard Risk

What we need is the ability to see the impact of multiple activities, situations, and conditions on elevating risk and we need to be able to see this is near real-time. To do this, we can utilize our fundamental barrier model and evaluate any situation or activity against each barrier to understand their impact. The assumption is that risk levels will be determined by the degree of impairment each factor has on each barrier category. The presumption is provided the barrier integrity remains unimpaired, the risk level will be low. The level of risk will also be determined by the number of successive barrier categories which are impaired. We also need to introduce the element of time and space. Time because these impairments need to be coincident to have a cumulative effect and space because they need to be within the same proximity. If containment barrier impairment was to occur in the same area where hot work was ongoing then you have an LOPC and ignition risk in the same area. If the two events are some distance away then it is much less of an immediate concern.

The diagram below shows how this model works.

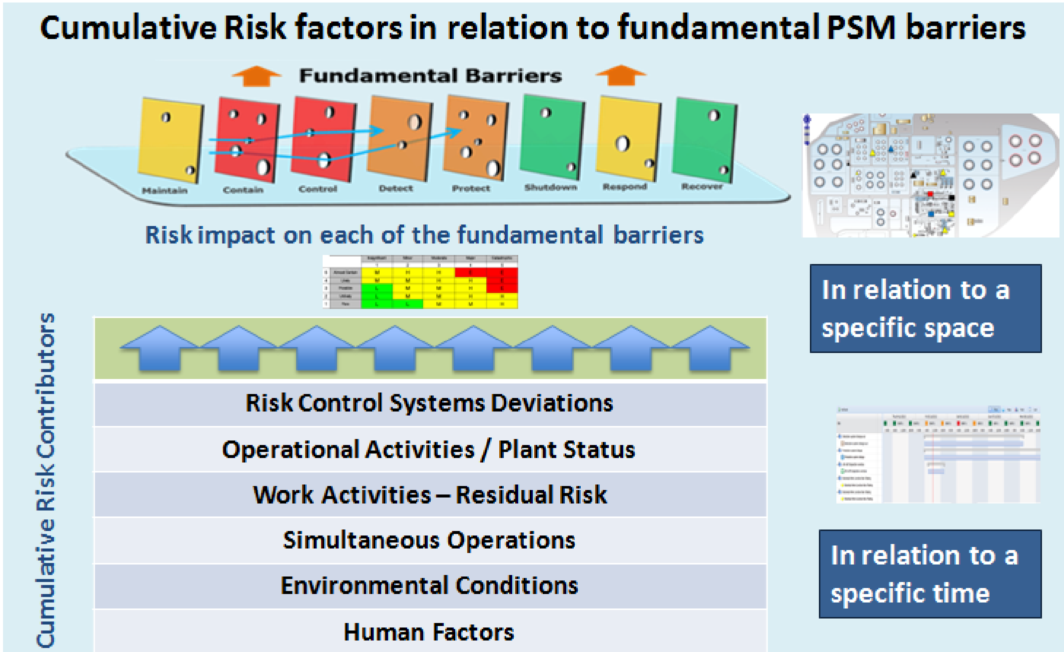

Figure 5. Cumulative Risk Factors in Relation to Fundamental PSM Barriers

The concept of cumulative risk in relation to barriers was written about by Blacklaw, Ward, and Cassidy in 2011 (Ref. 6). They developed a model in response to the regulator of their North Sea offshore operation who was asking how they assessed and demonstrated the cumulative effect of risks on their asset. The model was fed with data from the maintenance management system and their electronic Permit to Work system that captured Operations Risk Assessments and Safety Critical Risk assessments. The barrier statuses were used daily offshore, for operational decisions, as well as monthly for Management review.

New technologies enable us to take a similar approach but to do so on a near real-time basis and integrate barrier impairment management with the other various management systems, enabling a more complete picture to be presented.

8. How Emerging Technology Platforms Can Provide a New View of Operational Risk

The emerging Enterprise Operations Excellence Management software platforms enable companies to understand the uncertainty around all risk to make and execute better decisions around the effectiveness, efficiency, and safety of their operations. They help companies employ a unified approach to assessing operational risk and governing the status of Process Safety barriers. They provide opportunities to produce meaningful real-time and predictive risk indicators, to manage the sequence and execution of activities. They help handle the complexity of cumulative risk modeling, including time and space dimensions. They help companies manage the safe execution of frontline activities according to corporate policies. Operations Excellence Management platforms offer improvements over traditional ways of assessing operational risk and manage the complete planning-to-execution business process. These new platforms are designed to interface with Maintenance Management Systems (CMMS), Inspection databases, Scheduling Systems, etc. A built-in risk assessment engine can assess the impact of deviations to risk control system.

By aggregating this data, operators can identify risk by a specific area of the plant, across a unit and throughout an entire facility, over a specific duration. Dashboards present plant status in terms of risk, trends, peak exposure, and more. When combined with work execution, the elusive measure of productivity versus safety risk exposure can be assessed.

Icons on graphical screens show the area on the plant affected by impairments and deviations, in addition to the cumulative impact on process safety barriers and activities that could contribute to an actual event.

These systems provide a means to manage day-to-day work execution (Operational Risk Assessments, Permit to Work, Lock- Out Tag Out [LOTO], Job Safety Analysis [JSA], temporary defeats), optimize daily work schedules on the basis of safety risk, as well as work efficiency. Operational risk assessments and the performance of all operational activities can be managed, executed, and assessed with the help of enterprise software solutions. Oil, Gas, and Petrochemical operators can see all the contributing factors to safety risk and their impact on safety barriers in one place, in real-time.

The screen capture below shows an example of how using graphical views of the plant indicate where MAH barriers are impaired. Icons show the different categories of impaired barriers. Alongside these, other icons show ongoing or planned activities. The view can be real-time or future-based depending on the shift date selected. The future position is based on planned activities and estimates for the duration of impacted barriers. The system predicts the overall level of risk for that time period and displays with a simple traffic signal red, orange, green pattern to indicate high, medium, or low level risks. It can also highlight the specific area on the plant where the highest risks are predicted.

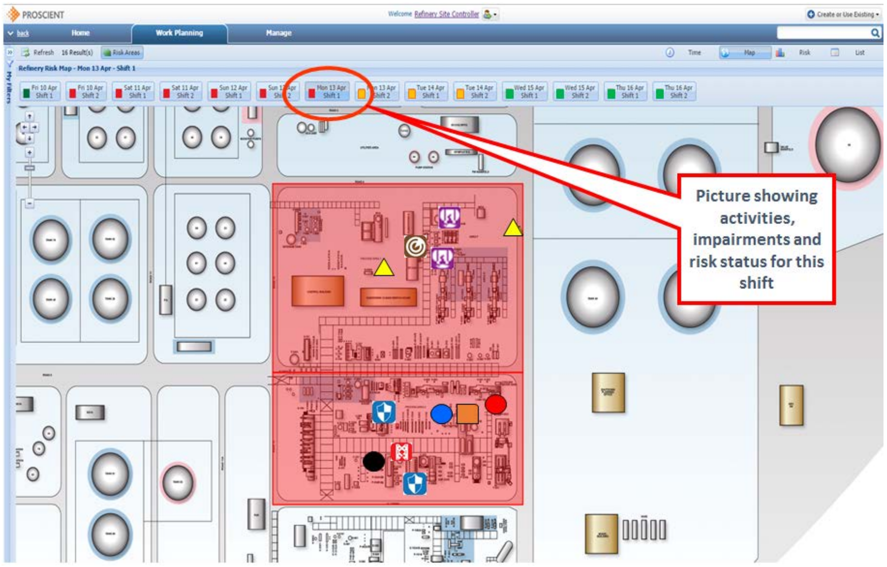

Figure 6. Graphical View of the Plant to Display Operational Risk Impairments and Deviations

Specific risk view screens for each area of the plant allow drill-down into the data to understand which activities or conditions are driving higher risks. This view is also available for current real-time or for future shift periods, with the traffic signals indicating cumulative risk for the facility during that period. This allows an operator to see the current or future state of the fundamental barriers in each area of the plant.

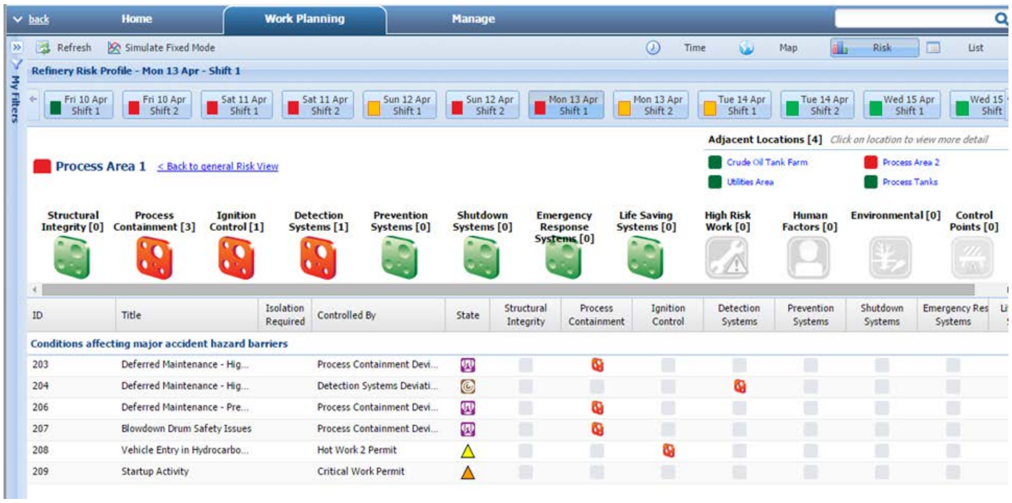

Figure 7. Risk Views Against Specific Plant Areas for Current or Future Shifts

The impact on risk is driven by specific work activities, plant statuses, or barrier conditions. Each of these is captured as a "line item" and displayed in a gantt chart style. Much of this data is "sucked in" from the disparate silo stores and is displayed in a single place showing all future work and conditions. This screen will automatically show conflicts depending on the configuration rules established. For example, if there was a containment issue in an area and an operator was trying to schedule hot work in the same area, the system would prompt a conflict and shows the activities with a red boundary. Even if it was not a conflict rule, the high risk status for the shift would alert the situation. Simple drag and drop features allow Front Line leadership, planning work for the next day or two to simply move conflicts or compounding risk events so that they do not coincide and in doing do, reduce the levels of predicted peak risks.

Using screens like this is easier to identify prolonged barrier impairments which are elevating risk levels in specific areas of the plant to unacceptable levels. Simple simulate/fix functionality empowers operators to see the risk reduction impact of fixing an impaired barrier earlier than scheduled.

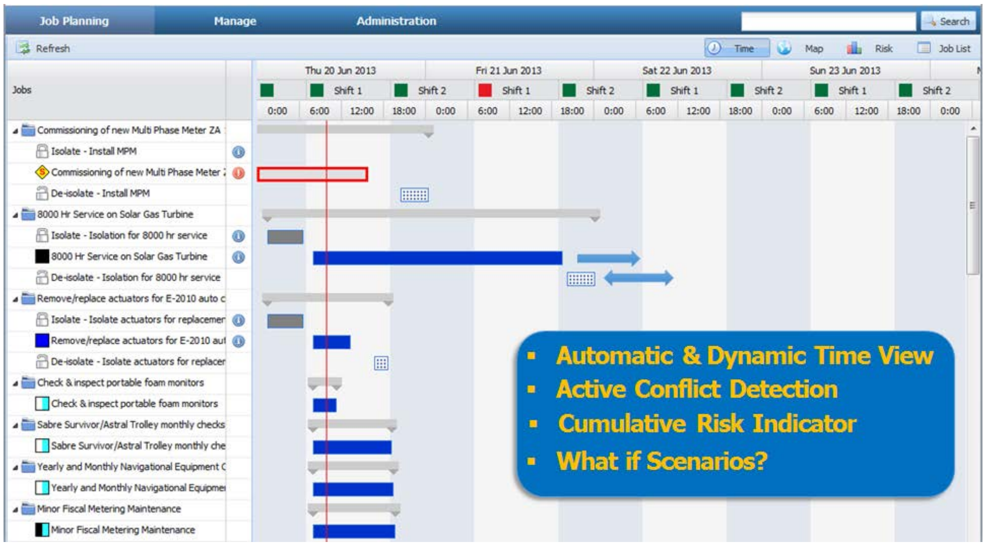

Figure 8. Time View showing Durations of all Planned Activities

Using these systems, the different groups in an organization can utilize a risk assessment engine to evaluate the risk involved in their planned activities. At the same time everyone can see the status of impaired barriers and assess the cumulative risk impact of their activities and those of other departments on all barriers, in all areas, at all times. This means the medium term planning and scheduling (90+ days) can now be prioritized using MAH risk criteria. Rather than just blanket labeling of work priorities with the term “safety critical,” the true impact on MAH risk can be assessed and activities prioritized accordingly.

With this data being collected centrally and used to assess the overall impact on risks, the quality of analysis and reporting surpasses that which has been achievable to date. The screen below show some of the types of reporting possible such as tracking overdue deviations (i.e. deviations or impairments which are not resolved within an expected timeframe), risk control systems impacts and trends and even trending of MAH risks over time.

These systems are designed for enterprise deployment so reporting can cover a whole organization of assets and identify where barrier impairments and resulting MAH risks are highest.

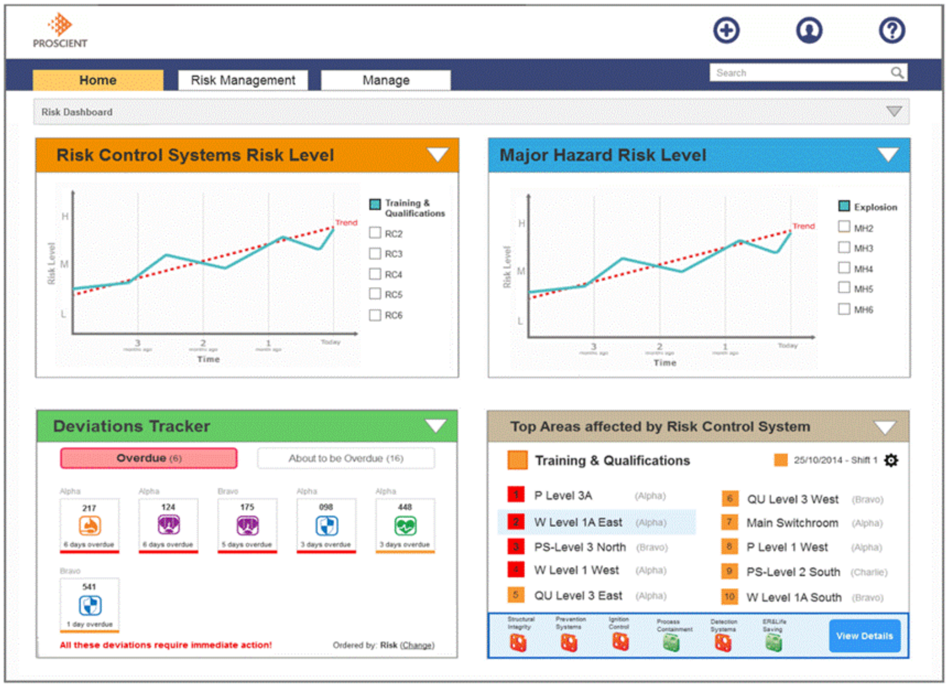

Figure 9. Examples of Dashboard Type Reports

9. Conclusion

This paper has looked at some of the areas where Process Safety practices struggle to integrate with Operational decision-making. This paper has discussed the importance of having up-to-date information on the health of fundamental protective barriers, the main component of PSM. In reality, this is challenging since much of the relevant data is stored in disparate silos, difficult to access and therefore typically absent when daily decision are made. Reliance on current performance indicators is futile since they provide few details to inform decisions. Where we do have access to the data, understanding their impact on specific barriers is problematic without a "common currency" of risk. This is essential if we are to make priority choices when deciding how to prioritize our impaired systems.

Adding to the complexity is the reality of day-to-day operations, where other risk contributors need to be taken into account. Managing this complexity and the dynamic of daily and hourly change is impossible without appropriate tools. Fortunately tools are emerging. Enterprise Operational Excellence platforms can evaluate the impact on barrier systems in specific areas, at concurrent time, based on deviations of risk control systems, operational activities, plant status and other factors which contribute to "cumulative risk." These tools allow Oil, Gas, and Petrochemical operators to see the impact on real-time and predicted risk, based on a defined activity schedule and ongoing impairments, and better prioritize repair and maintenance work based on safety risk reduction and resource efficiency. With this information at hand, frontline leaders can make more informed decisions about their activities. Leadership can also see more comprehensible real-time indicators of risk.

At the beginning, we asked the question whether our plants were becoming safer. The data suggests that despite widespread use of PSM, major accidents still happen. Some of the reasons why have been explored in this paper, and the future is encouraging with a new category of technology enabling Oil, Gas, and Petrochemical operators to better manage the dynamic between safety and productivity.

11. References

[1] The 100 Largest Loss events 1974 - 2013 - Large property damage losses in the Hydrocarbon Industry, 23rd edition, Marsh & McLennan, 2014

[2] An analysis of common causes of losses in the Oil, Gas & Petrochemicals Industries IChemE Safety & Loss Prevention Special Interest Group 7th July 2015 Ron Jarvis. Swiss Re. Risk Engineering Services. London.

[3] Human Error, James Reason, Cambridge University Press, 1990

[4] API Recommended Practice 754 - Process Safety Performance Indicators for the Refining and Petrochemical Industries, API, April 2010

[5] HSG 254: Developing Process Safety Indicators, UK Health & Safety Directorate, 2006

[6] The Cumulative Risk Assessment Barrier Model, Alan Blacklaw, Al Ward, Kevin Cassity, BG Group, SPE, 146255, 2011