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A WORLD CLASS APPROACH TO PROCESS SAFETY MANAGEMENT (PSM) AFTER THE TEXAS CITY DISASTER

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There are many major facilities, such as Texas City which are aging with many legacy issues (e.g. atmospheric venting blowdown drums). These were built to conform to the industry practices of their day. Such facilities can be run safely provided more attention is focused on process safety than would be necessary in more modern facilities. Such sites need some guidance as to what operational safety programs they need to implement and monitor through life for their specific designs and safety challenges. Operational excellence benchmarking can be dangerous if this leads to under management of safety issues because peers operate safely with less.

The Baker and the Chemical Safety Board Reports following the Texas City Disaster have already had ramifications across the world. The major oil companies have each taken the report seriously and in their several ways are taking appropriate action. Many operators are creating a large program around Control of Operations and why many are so keen on the barrier approach.

DNV have compared the different industry approaches to Process Safety Management and have drawn some key lessons on the vital components to an effective system. These form a balance between the management of risk and the maintenance of effective barriers with the optimisation of performance. All robust systems have a component of measured improvement and DNV is providing just such a service to main players across the world with its isrs7 – PSM assessments.

This paper will conclude with some trends that are starting to emerge in the area of PSM which will dictate the Operators' activities over the next decade.

CONTENT

- The three areas of focus, investment, process optimisation and process safety management
  - Refining Investment pattern-growth
  - Optimising Performance
- The dilemma between declining frequency of occupational health events and regular losses through process events
- The Baker and CSB reports
- Trends from the main operators – comparing the approach between refining and offshore approaches
- What can we do to create a robust Process Safety Management approach
- Measured Improvement – one approach by DNV

1. INTRODUCTION

The refinery industry is making good margins today and we are seeing performance enhancement projects, expansion of existing refineries and new builds across the world. Loss statistics show an expensive dilemma over the last decade for the industry. While the frequency of occupational injuries and ill health have declined from around 2.5 to 1 per 200000 hours per year the trend of incident costs have risen from $200 to $300 million over the same period. Such events often mean a financial disaster as well as a physical event, that significantly affect the Profit & Loss Account and in extreme cases they can herald ruin.

The industry is feeling significant influences, the high oil prices, perceived shortage of capacity, increased demand for low sulphur fuels and the events at Texas City all of which have coincided to produce a decade of change. The continuing high oil price, currently $76 per barrel for Light Sweet Crude, combined with an increasing demand for environmentally friendly fuels has created some new refining trends. Three areas emerge

1. Investments, new builds and mergers
2. Production Optimisation – getting more from what you have
3. Minimising losses – by preventing major accidents, currently drawing on the learning's from Texas City and others

2. CURRENT INVESTMENT DEVELOPMENTS

For the last ten years we have seen mergers of the majors with the assets of Aramco, Elf, Fina, Mobil and others all being integrated into larger owners. This trend has continued and three typical developments illustrate the investment levels that are in play in the last few years:

– OMV's purchase of the Romania's oil industry Petrom (some 40,000 employees) to create the largest central European refining group
– Kuwait National Petroleum Company's planned construction of a 615k bpd refinery at Al Zour and consequent realignment of their existing 3 refineries
– Saudi Aramco's plans for several world scale refining and petrochemicals facilities

DNV believes that similar patterns of investment will continue for the next decade. This will accommodate the changing demand pattern for fossil fuels to optimise our carbon footprint.

However this is the subject for a different paper.

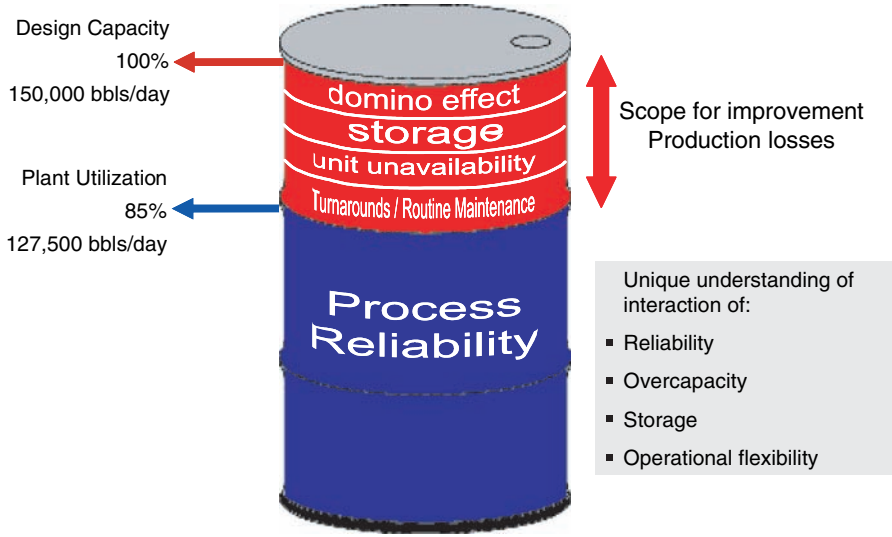
3. OPTIMISING PERFORMANCE – SOME DIFFICULT QUESTIONS

In parallel with investment pattern, asset owners want more margin from their current facilities. In times of high refining margins, maximising throughput and minimising downtime is critical. They are doing this by attempting to optimising performance. The operators are however faced with some difficult questions:

– Will we achieve target performance of 96% on-stream factor/availability?
– What is the optimum intermediate storage to protect against feed unit unavailability? Do we have too much?

– Do I have enough sulphur recovery capacity and redundancy?
– Do I have a reliable hydrogen supply?
– What is the impact of 1% increase in hydrotreater unit availability?
– What is the impact from crude import logistics issues (berthing, demurrage, storage)?; will there be feed shortfalls?

The challenge is how to reduce the production losses:

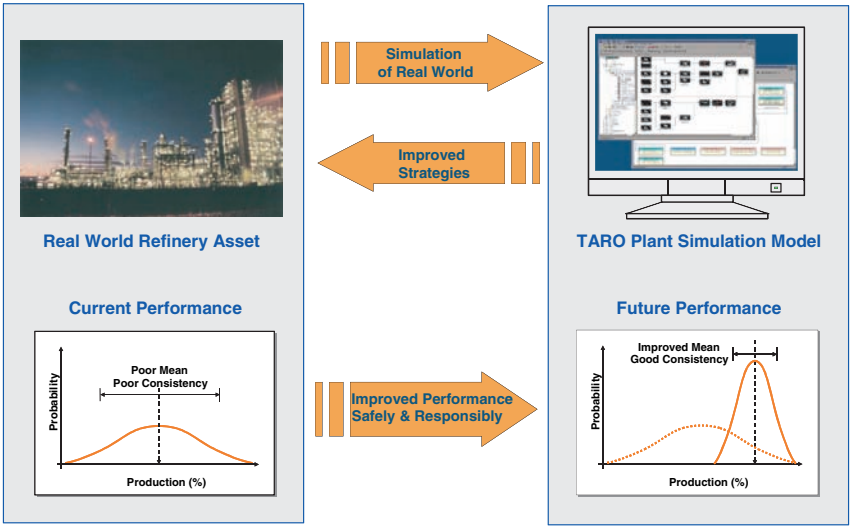


We at DNV are helping a range of Refineries address these issues through the active use of our TARO Plant Simulation models. TARO models such areas as process flows, current design envelopes, the equipment, units and their inter dependability, the storage volumes (for Feed, intermediate and product storage), the operations, maintenance and storage history, the refinery slate and material balance, the market forecast and demand profile.

TARO runs a series of simulations to establish the sensitivity of plant utilisation to a range of operational changes or investment strategies. The TARO model then provides

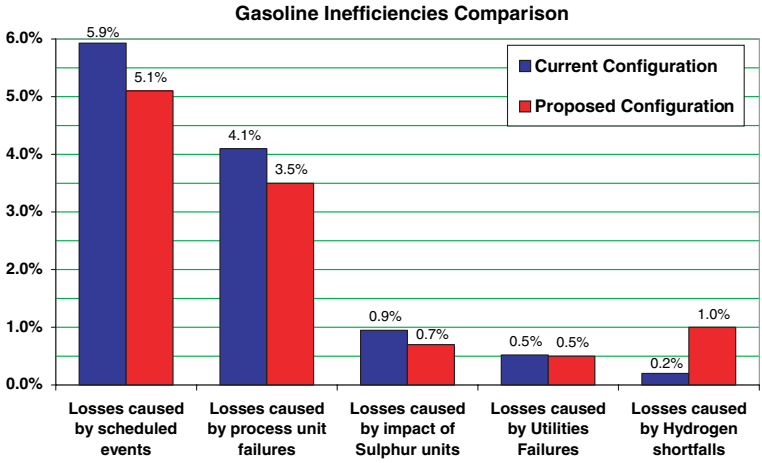
– Production Efficiency for the planned product streams
– Unit Criticality analysis and Unit Utilisation
– Storage Utilisation
– Production Improvement Opportunities
– Detailed forecasts for project and plant economics

In summary where to focus to achieve the clients' objectives



Refineries across the world are addressing these issues and benefiting accordingly. Here is a typical result:

Scenario	Proposed Design	Optimised Design
Gasoline Production Efficiency	88.30%	89.20%



This is how Shell Canada described the benefits realized from the refinery performance analysis:

- Having the ability to analyze and study the affect that plant capacity, reliability, and refinery tankage have on overall refinery production. We are able to analyze the trade-offs between intermediate tankage and plant reliability for example.
- Helping us to quantify, validate, and rank and/or add to the initial focus areas. Up to now, the focus areas were identified and prioritized based on our collective knowledge and intuition, but we have no ability to analytically rank them other than by intuition and knowledge of historic gaps.
- Having the ability to distinguish critical equipment "Worst Actors" by unit, system, or asset type versus their contribution towards gap closure as worst actors are corrected.
- Having insight into the relationship between production and Solomon Utilization, what features contribute significantly to both and through what mechanism."

This subject deserves a more thorough coverage than can be achieved here and I refer interested readers to the referenced papers.

4. IMPROVING PROCESS SAFETY PERFORMANCE

The third area that refiners are focussing on is to minimise the unplanned events. These range from production upsets, through minor losses of containment to the significant event that can destroy the annual finances and damage your corporate reputation.

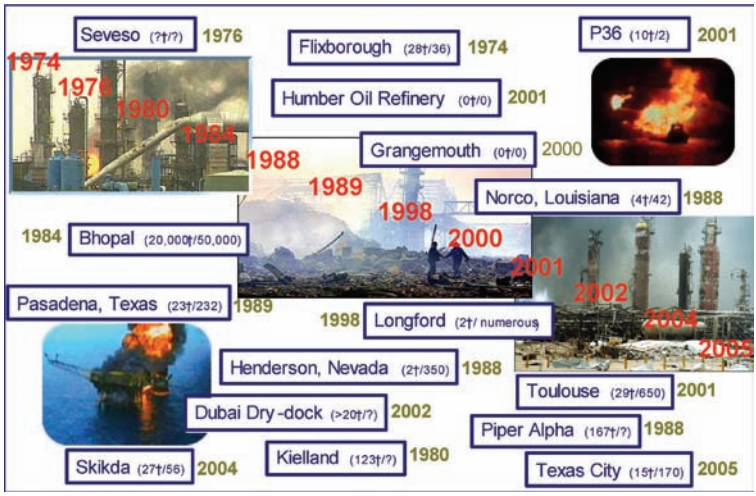
Plants built in the 1970's or earlier will be faced with aging aspects and legacy hardware no longer used in the industry – especially items which are prone to loss of containment – such as any system that vents to the atmosphere in a process area. Aging assets require more Process Safety care than current designs to provide a comparable safety performance.

Although the media focuses on the major events, the financial damage of a series of minor events should not be ignored these have been known to mount up to economic significance, several hundred million Euros over a three year period was compiled by one major refiner.

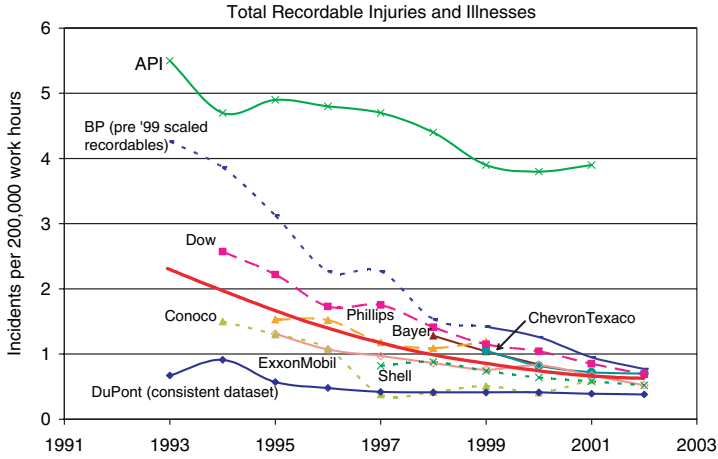
Headline grabbing events occur with depressing regularity indicating that a least some of the lessons from previous events have been ignored.

There are four reasons why the industry should suffer such repeated events:

- The recommendations from a previous event has not addressed the fundamental issue
- The recommendation has not been transposed into engineering barriers, rules or sound operating procedures by the operating company concerned
- The rules have been ignored, the procedures have been set aside or the physical barriers have been allowed to decay by the site. This may have been precipitated by restriction on investment or inappropriate financial allocation controlled from above.
- Leadership attention to process safety is lacking



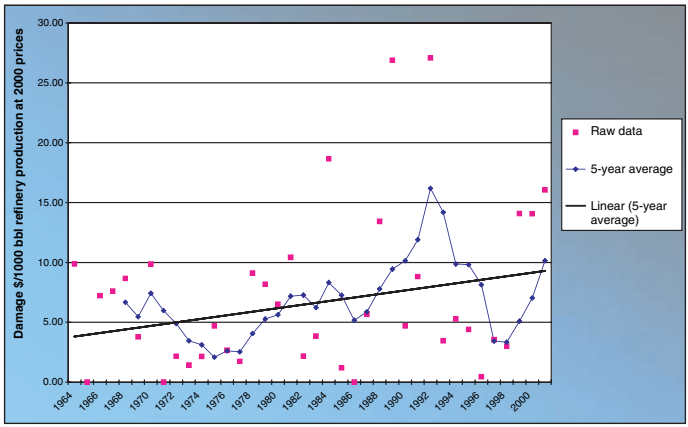
This brings us to the current dilemma in the process industry. Since the late 1980's the industry has focussed on HSE Management Systems and major advances have been made. Many companies have achieved a three times improvement, over 10 years even starting from a good initial performance, e.g. Conoco:



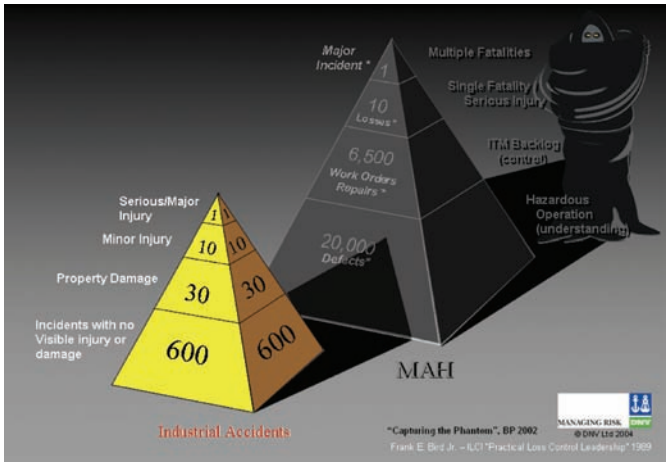
Most majors have deployed three approaches to achieve this result:

- Improving formal safety management systems
- Deploying risk assessment programs
- Most recently deploying safe behaviour programs

However, by contrast the trends in refinery material damage costs have not shown a decline curve, they have actually grown during this period. Considering the incident costs – $ per 1000 bbls refinery capacity corrected to 2000 prices we see a progressive increase:



Most companies recognise the Bird triangle of losses and have been working on the HSE areas to reduce losses. However there is a parallel triangle related to outstanding work orders reflecting the PSM issues and always in the background stands the spectre of a major event.

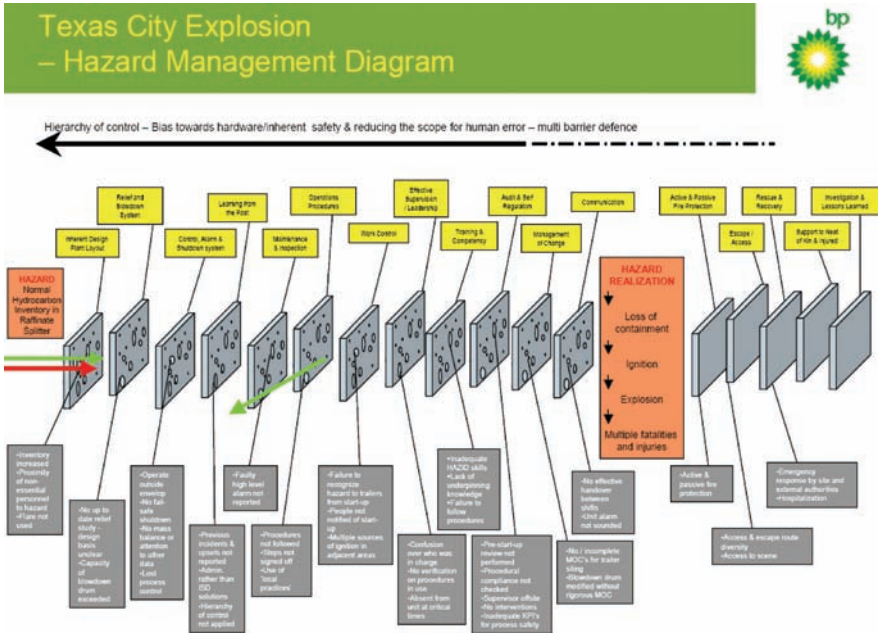


5. TEXAS CITY 2005

This was the largest accident to have occurred in the US in 20 years. It represented a wake-up call to the refining industry, suggesting that major assets are not completely protected by current safety methods and investment strategies.

The Baker Panel has done an excellent job assessing safety management system and culture issues in BP's US refining operations. The CSB investigation has also now been released. So what can the industry learn?

Michael Broadribb, BP's Lead Investigator, pointed out that at Texas City there were twelve layers of protection that could have prevented the event, each one failed.



The pre-event failed controls included:

Management Control Related	Asset Integrity
Effective Supervision and Leadership	Inherent layout/design of the flare system
Work Control	Relief and Blow down System
Learning from Previous Events	Process Control, alarms and Shutdown System
Communications	Maintenance and Inspection
Training and Competence	Management of Engineering Change
Adherence to approved operational procedures	
Audits and Self Regulation	

However there were post event failures too. These included the Fire Protection Systems (Passive and Active), Escape and Access Routes and the Rescue and Recovery Arrangements.

These facts were also reflected by Baker who can be summarised as having concerns about:

Corporate Safety Culture
- Process safety leadership and management decisions for process safety
- Resources and positioning of process safety capabilities
- Employee empowerment and process safety cultures at BP's U.S. refineries

Process Safety Management Systems
- Process risk assessment and analysis
- Compliance with internal process safety standards and external good engineering practices
- Process safety knowledge and competence
- Effectiveness of BP's corporate process safety management system

Performance Evaluation, Corrective Action, and Corporate Oversight
- Measuring process safety performance
- Process incident and near miss investigation
- Process safety audits
- Timely correction of identified process safety deficiencies
- Corporate oversight

6. THE PROCESS INDUSTRY FOLLOWING TEXAS CITY

Many companies are reflecting on the Texas City event and considering whether these failures could equally describe some of their own operations:

- DNV are seeing the Majors reinforcing the deployment of sizeable asset review teams to each of their downstream operations in turn. In a number of cases, we are supporting these review activities. These teams test the robustness of their PSM philosophy, provide a structured verification of barriers and actions and develop suitable improvement programmes. These teams are spending between 12 and 45 man weeks on each site and so represent a significant investment in situation analysis. Most are using a Maturity Model Approach. Shell, BG, BP, C-P and parts of Total all undertake formal bi annual Asset Integrity reviews, reporting corporately.

This focus on analysis is likely to uncover significant requirements for additional investment.

- Several Majors are investing in enhancing PSM knowledge. They are running a series of Process Safety Management Workshops to ensure that the fundamentals of PSM are understood by sufficient of the operational staff to effectively lead their peers.
- Some companies are now forming/reinforcing PSM knowledge circles/experience exchange clinics to ensure best practise is shared across their group.
- DNV knows of two majors who are re-examining their performance metrics to create a better reflection of inherent risk, overall plant condition (through a collection of lagging PSM indicators) and the status of critical controls (through a selective collection of leading PSM indicators).

7. WHAT HAS WORKED FOR MAJOR ACCIDENTS

DNV believe that major hazards are as amenable to reduction as occupational health – provided companies do the necessary work. As described above occupational health has had a major improvement in the past 20 years (see Dow Chemical statistics showing a factor of 10 improvement). We know in the North Sea that HSE leak statistics show a 4 fold reduction since 1995 – and major accidents almost always start with a loss of containment.

Perhaps this is why many major upstream operators have exported the North Sea solutions across the world with good reason. The North Sea approach has been dramatically effective with the last headline grabbing event in the North Sea being Piper Alpha in 1988.

In UK – the safety case approach establishes performance standards for safety critical elements which are supported by an independent verification regime. In Norway there is a risk based process to demonstrate integrity. For Upstream assets there is more emphasis on Major Accident Control. They deploy:

- full safety management and mechanical integrity system driven by best practice risk assessment
- detailed holistic risk assessment, with a consolidated Hazard and Risk Register
- identification of the most important safety barriers/controls – hardware and systems (safety critical elements) and establishing performance standards for these controls
- valuing of every control, and independently verifying sufficient controls are in place for the level of risk and performance standards are achieved
- development of tracking metrics using recent data and real-time tools
- linking incident investigations back to the Hazard and Risk Register and the identified controls that failed

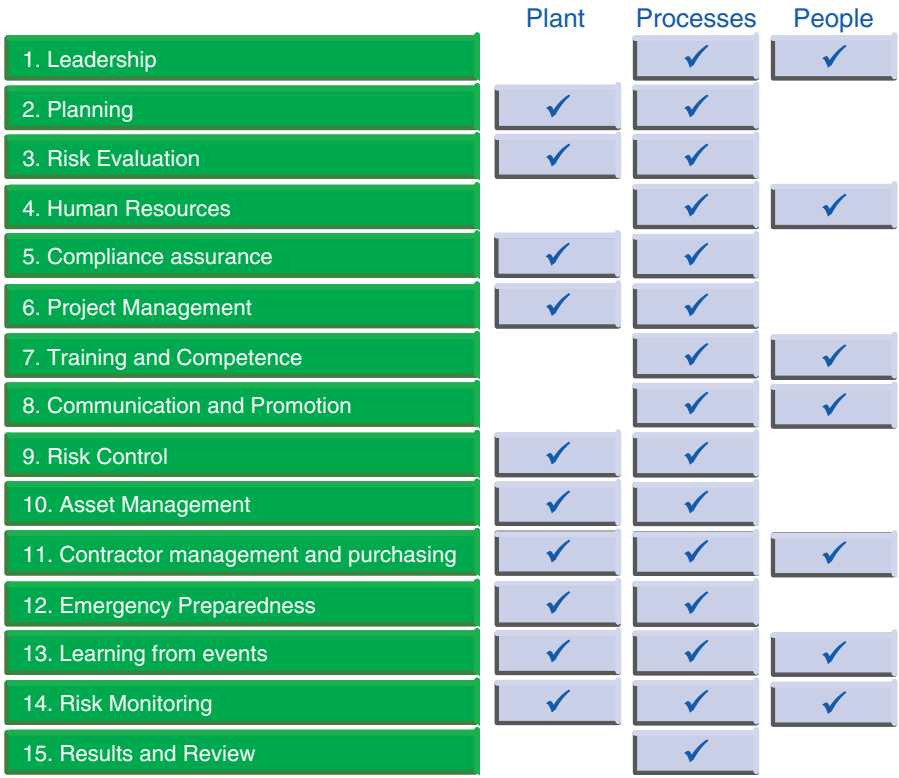
We are seeing that Numerical Techniques (QRA) being only selectively deployed with simpler Bowtie approaches growing in use and the demand for effective HAZOP/HAZID growing.

8. WHAT CAN BE DONE FOR REFINING PSM?

DNV is in the centre of much of this activity; we have drawn some fundamentals from our work and produced tools to assist companies evolve and demonstrate robust PSM.

We believe that an integrated approach to risk management is essential to ensure a robust system. The Refinery should:

- Design a sound layout and establish a robust operating envelope
- Understand the hazards at enterprise, site and unit level
- Work within the operating envelope and maintain its integrity
- Understand their critical controls
- State what they expect them to do
- Make sure they do it through effective inspection and maintenance
- Provide effective leadership in PSM, similar to the successful focus already applied to occupational safety issues
- Adequately resource the key functions
- Measure performance year on year ask and how they can make the situation better

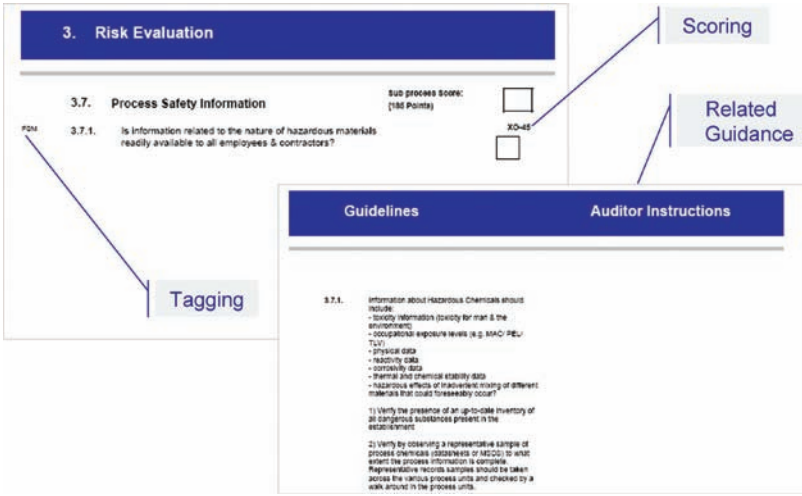


We believe that a structured approach to managing the various layers of protection is essential:

DNV have incorporated world best PSM practise into a reference, measurement and development tool called isrs[7] PSM. This has emphasis on:

- Design Integrity
- Process Safety Information
- Management of Change
- Asset Management
- Process Hazard Analysis
- Operating Procedures
- Pre-start-up Safety Reviews
- Managing Proprietary Knowledge
- Technology Development

This PSM tool has incorporated OSHA 1910, MES, SEVESO, Baker Report and CSB Report from Texas City into the existing **isrs**[7] Omega tool. It uses the same quality control criteria, reviews the systems in place and the results they produce. It is supported by assessment guidance to ensure consistency in application. It can be used in a flexible way by supporting an integrated business management approach, by developing the PSM System or to develop the HS, E, or Q systems as required. It can focus on one specific area of PSM, Asset Integrity for instance or can delve into particular issues and develop the approach.



World majors are already using **isrs**[7] in a range of ways. Three are using it as a reference tool to develop their corporate PSM system. Two are using it as a Selective Improvement Tool. Three are using it as an Assurance Protocol mapped against the company's MS and two are using it as a full System Improvement Tool and Assurance Protocol.

However the PSM performance cannot be assured or evolved through good PSM systems alone. This must be balanced by focussed assessment of the Physical Conditions or barriers. DNV has developed a complimentary Physical Conditions Assessment (plant walkdown) that ensures that PSM systems are implemented through actual good management of physical assets. The PCA looks at typical areas of weakness known to DNV through its work with the industry. Many majors are using the barrier approach to PSM and isrs7 will link to this – through the field inspections. Isrs7's PCA will be looking at the status of critical safety barriers, safety defeat logs, etc and is integrated into scoring of overall assessment specifically focusing on:

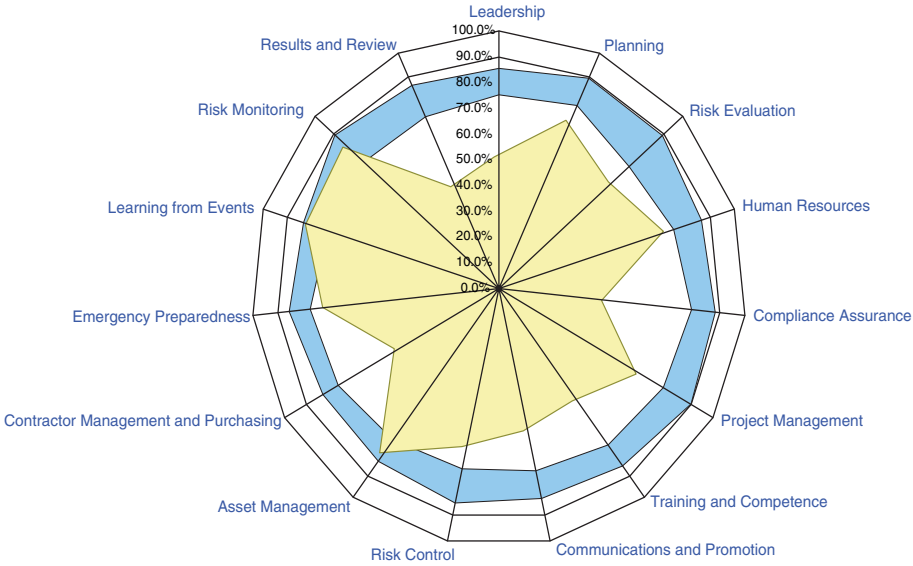
- Bypasses and isolations
- Control system overrides
- Locked Close/Locked Open/Normally Close/Normally Open Valves
- Pipe, Flanges and Blinds
- MOV/ROV/Excess Flow (Depressurizing) Valve
- Small Bore Fittings (<2″) & Conduit
- Control Valves & Check Valves
- Relief Valves and Rupture Discs
- Culverts & Drainage
- Field Instrumentation
- Tankage and Bunds
- Fired Vessel (Furnace, Incinerator, Main Combustion Chamber, Package Boiler, Gas Turbines, etc.)
- Unfired Pressure Vessel (Column, Vessel, Reactor, Heat Exchangers, etc)
- Rotary Equipment
- Chemical Storage & Usage
- Emergency Equipment
- Electrical controls

DNV believes in Measured Improvement, and this structured tool will allow clear comparison of the health of the PSM system through benchmarking. Here is an example of a site being compared with a group of peers. The system will allow comparison with:

- Past performance
- Sister companies
- Market competitors
- World class performers

Companies who use the classic isrs find that it provides a basis for setting short and medium term objectives, calibrates internal measurement activities and sets a clear standard set so performance levels can be easily recognised and next steps understood.

It can be seen from the previous illustration that the approach makes the problem identification activity much clearer. Across a group the variations in performance indicate robustness of PSM implementation which will allow deployment of resources and avoid PSM events.



Nuclear Power stations are considered by many to have a high societal and installation risk profile, the consequence of a loss of containment are higher than a refinery. Many UK installations have used ISRS for the last decade to identify and manage their risk profile. This is what the Operations Director responsible for 14 UK stations said about the value of this approach:

> *"ISRS has given us the challenge and the recognition to continually and consistently improve in all aspects of efficient, safe and environmentally responsible operation of our sites.*
>
> *It has achieved strong staff participation and enthusiasm by measurable goals to drive overall site improvement plans."*
>
> Magnox Electric – Chris Marchese Chief Operations Officer 2006

9. CONCLUSION

The industry is going through a period of significant change with tremendous opportunities for performance improvement. High oil prices and a shift in demand pattern are all

driving investment while the spectre of a "Texas City in my company" is ensuring that companies take their PSM responsibilities seriously. DNV is working with many major players to assist in the optimisation of performance in the refinery through its TARO tools. However the work DNV is doing with isrs7 PSM is assisting companies to:

- Set standards, both corporate and on a site
- Implement change
- Assess performance
- Develop improvement plans in a transparent way.

This will assist the industry meet the increasing expectations of multiple stakeholders. Stakeholders will need Refiners to continually measure, improve and most of all demonstrate the PSM health of their business. In short, to ensure that companies maximise the performance of their assets in a safe and sustainable manner.