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RISKworld

The Newsletter of Risktec Solutions

In this issue

Welcome to Issue 35 of RISKworld. Feel free to pass it on to other people in your organisation. We would also be pleased to hear any feedback you may have on this issue or suggestions for future editions.

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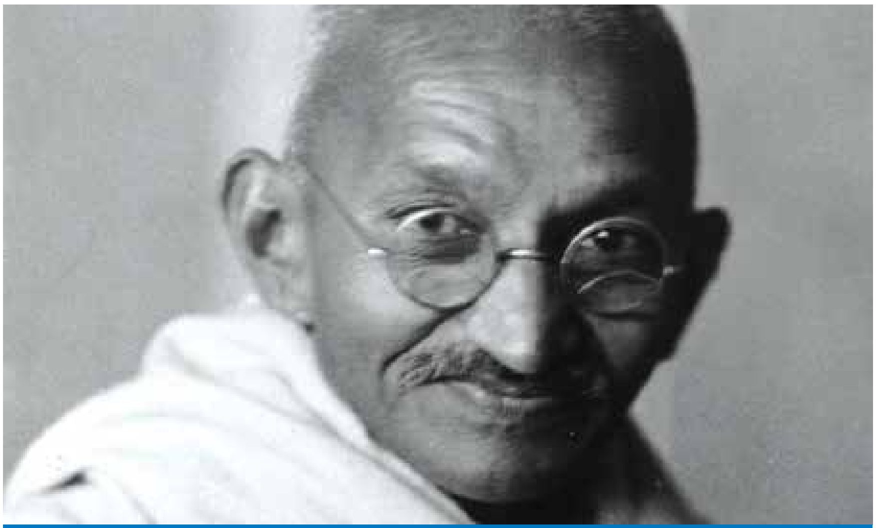
Coming Soon – The Future!



"The future depends on what you do today." – Mahatma Gandhi

Like everyone, we have been closely following the Brexit negotiations and, whilst at the time of writing there is still significant uncertainty over the UK's exit from the EU, we are confident that there will be limited direct impact on our business. Risktec and our parent company TÜV Rheinland is present in most of the 27 EU countries, which enables us to be very flexible in servicing our clients in the region.

This ability to be flexible and responsive to changing requirements is an important part of our solutions ethos and is a strong message from our latest client satisfaction survey. The results from the survey, which covers the second half of 2018, show that we continue to achieve very high levels of client satisfaction: 98% of clients are satisfied with our service, 100% rated our flexibility as very good or good and 100% would recommend us.

It is now over five years since Risktec became part of TÜV Rheinland. During this time we have successfully expanded our service portfolio and increased our international presence. Today we provide a comprehensive range of consulting, learning, resourcing and inspection services from 16 offices in 8 countries, motivated by our goal of helping clients to make their operations safer and more reliable.

For those of you viewing this issue of RISKworld online you will have noticed a major facelift to our website. The new website represents a step change in our online presence, and includes an enhanced version of our 'Knowledge Bank' of technical articles, papers and presentations, and our Risktec Essential series, as well as a new 'social hub' where you can find all of our social media posts in one place.

We hope you enjoy the articles in this edition of RISKworld, which has one eye firmly on the future. As always, we welcome your feedback and look forward to your continued support.

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Pressure system integrity management in the conventional power sector

Failures from high energy steam and hot water pressure parts can result in significant process safety risks and are often associated with costly damage to other assets in the vicinity, loss of plant availability and negative publicity. Serious incidents may also result in prosecution. With numerous factors to consider, such as plant age, history of defects, operating regime, system design, materials of construction, build quality and experience from the wider industry, the development of robust condition monitoring strategies to manage plant integrity and to ensure regulatory compliance is suited to a risk-based approach.

REGULATORY COMPLIANCE AND RISK

Taking the UK as an example, steam and hot water pressure parts on power plants are covered by the Pressure Systems Safety Regulations 2000 (PSSR). To help interpret the requirements of the PSSR and understand the various defined roles and responsibilities, there is an associated Approved Code of Practice and guidance document (Ref. 1).

The objective of the PSSR is *"to prevent serious injury from the hazard of stored energy, as a result of the failure of a pressure system or one of its component parts."* However, the guidance provided for achieving compliance is deliberately very general and non-specific, for example: *"When deciding on the periodicity between examinations, the aim should be to ensure that sufficient examinations are carried out to identify at an early stage any deterioration or malfunction which is likely to affect the safe operation of the system. Different parts of the system may be examined at different intervals, depending on the risk associated with each part."*

This non-prescriptive, 'goal-setting' approach places the onus on the operator to do the right thing. In essence, to be compliant with the PSSR, due consideration should be given to all potential degradation mechanisms that could lead to component failure (and result in serious injury), ensuring that sufficient and proportionate inspections are completed to understand and mitigate the risks. Across steam and hot water pressure systems on a power plant, the range of active degradation mechanisms can be wide. For example, in a heat recovery steam generator that is used intensively, you might expect to encounter issues such as creep, thermal fatigue, creep fatigue, mechanical fatigue, Flow Accelerated Corrosion (FAC), corrosion and corrosion fatigue, amongst others.

Looking further afield, legislation can vary significantly from one country to the next. Unlike the PSSR, there are cases where the nature and frequency of examinations is very prescriptive. Whilst prescriptive legislation may appear to be a safe, conservative approach on the face of it, there is the danger that not all potential threats, especially emergent issues, are addressed as part of the inspection plan.

For this reason, many operators outside the UK have chosen to adopt the general thrust of the PSSR, or parts of it, where this provides for a more robust and risk-based approach to pressure parts integrity management. Of course, by achieving compliance with the PSSR, not only is the primary issue of process safety being addressed - it also naturally follows that the owner can expect to see benefits in terms of improved plant reliability and availability.

IDENTIFYING THE RISKS

All relevant risks relating to pressure parts operation should be identified and an appropriate action plan put in place for maintenance and condition monitoring, e.g. visual inspection, non-destructive testing and analysis of plant data. Situations should be avoided where condition monitoring strategies only evolve in a reactive way, in response to failures and leaks, and where only the higher energy systems are addressed, i.e. creating 'Cinderella' systems that are overlooked, even though their failure could still represent a significant process safety risk and statutory non-compliance.

A landmark example of this in the power industry is the terrible incident at the Mihama 3 nuclear plant in Japan in 2004, where the catastrophic rupture of a feed water pipe resulted in five fatalities. The degradation mechanism was FAC, which had caused in-service thinning of the pipe and, although the operating pressure of the pipe was relatively low (only 9 bar compared to 200 bar for some high pressure feed water lines), the large pipe diameter meant that the amount of stored energy was significant. As well as acting as a sobering reminder of the specific threat posed by FAC, this incident highlights the need to adopt a risk-based approach to the management of steam and hot water pressure systems, so that condition monitoring strategies encompass the risks from the whole plant.

CONCLUSION

Robust condition monitoring strategies that are risk-based provide the vehicle for achieving cost-effective regulatory compliance, managing process safety risk and increasing plant reliability and availability.

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References: 1. Safety of pressure systems, Pressure Systems Safety Regulations 2000, Approved Code of Practice and Guidance on Regulations, UK HSE, L122, 2nd Edition, 2014.

A modern introduction to Reliability-Centred Maintenance (RCM)

When Stan Nowlan and Howard Heap of United Airlines introduced Reliability-Centred Maintenance (RCM) in 1976, it is reasonable to assume they could not have envisaged that RCM would become the cornerstone of preventive maintenance regimes across multiple industries. They may not have imagined either the advances in condition monitoring technologies and data analytics that have enabled huge strides in determining the optimal point when maintenance is required.

WHAT IS RCM?

RCM is the process of determining the most effective maintenance approach, such that the function of the equipment is preserved, with the required reliability and availability at the lowest cost.

In their seminal work (Ref. 1), Nowlan and Heap stated RCM's objectives:

1. To ensure realisation of the inherent safety and reliability levels of the equipment.
2. To restore the equipment to these inherent levels when deterioration occurs.
3. To obtain the information necessary for design improvement of those items whose inherent reliability proves to be inadequate.
4. To accomplish these goals at a minimum total cost, including maintenance costs, support costs and economic consequences of operational failures.

The current established international standards for RCM are captured in SAE JA 1101 and 1102 (Refs. 2, 3).

HOW HAS RCM EVOLVED?

The objectives and processes of RCM have not changed fundamentally since its introduction – RCM-derived Preventive Maintenance (PM) tasks continue to preserve functionality. Neither has the basic nature of PM interventions - a pump overhaul remains a pump overhaul, for example. RCM simply helps determine if the overhaul is applicable and effective.

Traditionally, interventions were scheduled according to a conservative, and often notional prediction of 'wear-out'. Today, modern maintenance management draws heavily upon Condition-based Maintenance (CbM) to determine when maintenance is required. CbM techniques for performance monitoring of plant operating parameters, such as temperatures, pressures and mass flows that are recorded during operator rounds, combined with more sophisticated condition monitoring, e.g. vibration, thermography and oils analysis, has helped to reduce scheduled interventions. That is to say, intervention only takes place when early signs of incipient failure flags up a need to do so.

What has changed and continues to develop are the technologies available for condition monitoring. Performance monitoring of industrial plants using new sensor technologies can help reduce unplanned losses and provide an accurate indicator of impending faults when combined with traditional condition monitoring methods. This can help optimise planned maintenance shutdowns, avoid unplanned losses and reduce cost.

MODERN TECHNOLOGIES AND DATA ANALYTICS

Within the UK nuclear industry, for instance, performance monitoring of plant operating parameters via ultrasonic technology is a contemporary approach which is currently being piloted. Ultrasonic sensor technology offers clear benefits, including:

- Reduced installation costs due to a minimal requirement for cabling.
- Easy to deploy over long distances (maximum range 80m).
- Fast set up time.
- Poses no Radio Frequency Interference (RFI) hazard to plant and can thus be used in all areas.

As such, there is an appetite within the industry to define an accepted wireless sensor solution rather than utilising traditional connection methods (such as ethernet cabling) to increase the availability of plant data.

Making plant data available on a central database platform allows data to be easily accessible on a single screen that can then be remotely

viewed by system engineers and operators. Having a centralised data platform creates a 'one stop shop', providing the capability to interface between many different monitoring systems, and store and analyse data in one place.

Integrating performance monitoring data with traditional condition monitoring data provides an overall context of system health. The methods for displaying data have also evolved in recent years so that data is more readily interpreted, e.g. the use of wireless tablets to support operational plant walk downs and remote thermal imaging technologies to highlight abnormal component temperatures.

Trending data on a continuous basis over extended periods is key as it can be used to assess the condition of plant in service, historically and currently, while predicting defects in critical components using rate of change analytics. Other analytical methods such as early anomaly detection offer real-time warnings; and setting up notifications to warn engineers of 'exceptions' in system health prior to unacceptable degradation enables early intervention.

SO IS MODERN TECHNOLOGY THE SOLUTION?

Clearly, monitoring technologies and data analytical methods are now becoming sufficiently mature to achieve the objectives of RCM in innovative ways. Yet even with these improvements, an unwillingness to trust this information remains a barrier to its use as the basis for intervention. In the most conservative of industries – the civil nuclear sector – the International Atomic Energy Agency (IAEA) has long advocated the adoption of CbM but highlights the challenges that must be overcome:

"Do you listen when your equipment speaks to you, or do you wait and see what will happen?

Today's problem does not lie in the knowledge that there is new technology or whether to use it in daily maintenance. Instead the difficulty often lies in letting go of the 'old' methods (tried and tested), being able to change to a new culture and breaking the traditional barriers.

For the nuclear industry to achieve the results from CbM we must be willing to dare to change the organisation, responsibilities, established routines, and trust the surveillance-control, the newly adopted knowledge, and the newly developed competence for steering daily maintenance. Additionally, we must move resources from the traditional maintenance role and focus them on developing the new surveillance-control, follow-up, and analysis processes." (Ref. 4).

CONCLUSION

Fundamentally the objectives and processes of RCM have not changed since it was introduced to industry from the aviation sector in the late 1970s. What has changed are new monitoring technologies and data analysis methods that enable more accurate timing of maintenance interventions. However, unless an organisation tackles the cultural and resource challenges inherent in letting go of the old to embrace the new, the benefits will stay tantalisingly beyond reach.

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References:
1. Reliability-Centered Maintenance, F.S. Nowlan and H.F. Heap, United Airlines, for Office of Assistant Secretary of Defense, 1978.
2. Evaluation Criteria for RCM Processes, SAE JA 1101, 1999.
3. A Guide to the RCM Standard, SAE JA 1102, 2002.
4. IAEA TECDOC 1551, 2007.

Virtual Reality – Can a digital twin help reduce risk within high hazard sectors?

Despite being around for some time, Virtual Reality (VR) has never really gained traction within the high hazard sectors as a tool to help reduce risk. Perhaps this is because it's seen as a gimmick – a solution without a problem? So what is VR and can it indeed be used to reduce risk?

WHAT IS VR?

VR is the use of computer technology to create a simulated environment. Its most immediately recognisable component is the Head-Mounted Display (HMD) which brings a 3D computer model of an asset to life and immerses the user directly inside this experience. By stimulating as many senses as possible, such as vision, hearing, touch and even smell, the HMD acts as a portal into the artificial world depicted by the computer model. The only limits to near-real VR experiences are the availability of content and computing power.

VR IN HIGH HAZARD SECTORS

Perhaps the main reason that VR has not so far found favour is that industry remains understandably focused on hardware and operations. It is interesting, however, to step back and consider what wider benefits this technology offers across the business.

VR is one of a range of ways of presenting what is known as a "digital twin" – a digital carbon copy of a real asset whether that be an offshore oil and gas platform, a passenger train, wind turbine, etc. When you view VR as a means of bringing this digital twin to life, rather than merely a technology that needs an application, that's when the benefits really start to become apparent, as illustrated in Figure 1. For instance, imagine if you could not only walk through a developing design, but could also in real time visualise hazards, such as fire or explosion, to shape improvements and help plan the best route for escape.

Another potential barrier to the adoption of VR within high hazard industries is the perception that it is very expensive. There have been instances of isolated pockets within large corporations unknowingly developing duplicate 3D models to achieve different goals. This duplication clearly drives up cost, but is perhaps understandable given that the benefits are spread across very diverse facets of the organisation, whether department, function or lifecycle stage. By developing a single digital twin for the complete asset, and actively communicating and sharing this across the business, significant economies of scale can be realised, presenting a very cost-effective way of proactively reducing risk.

Furthermore, it is highly likely that a 3D model of the asset will already exist somewhere within the business, perhaps known only to someone who is unaware of the wider opportunities it presents. For example, the designers of the facility may have built a 3D computer model to aid structural analysis or layout design.

The UK's Construction Design and Management (CDM) Regulations 2015 require designers to maintain and collate detailed documentation to fully and accurately represent the as-built status of the facility to be handed over to the owner/operator. This is commonly achieved via Building Information Modeling (BIM) data. This is a hugely powerful but grossly underused resource. It can

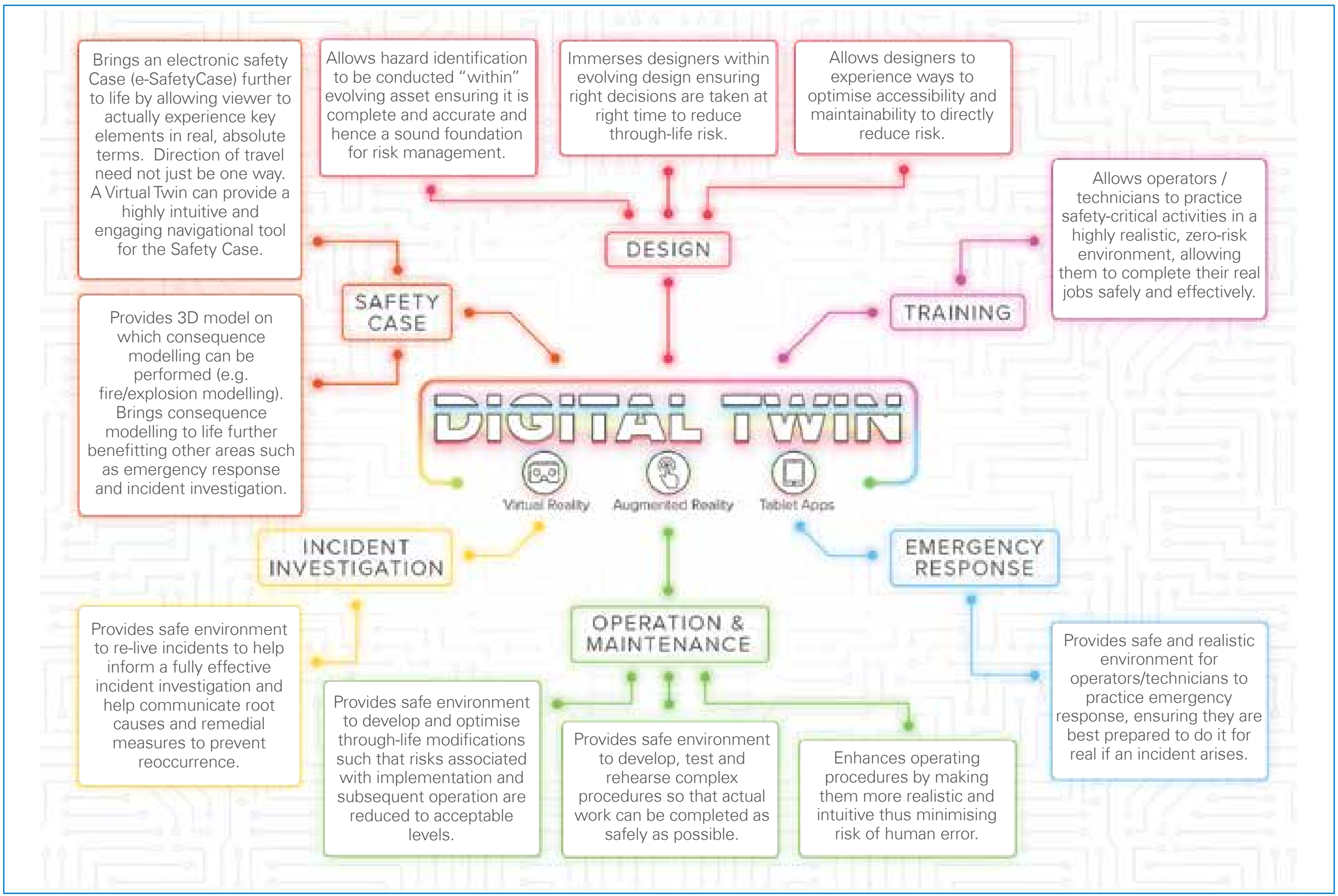

Figure 1 - How Virtual Reality can reduce risk within high hazard facilities

be easily converted into a digital twin allowing the business to realise all the benefits illustrated in Figure 1 throughout the life of the asset. It is also crucial to remember that we are only talking here about risk reduction benefits. Creating a digital twin of any asset delivers a multitude of wider cost and efficiency savings and programme and quality benefits, further spreading the associated costs and making the application of VR even more attractive.

Finally, you don't need an expensive, high-spec VR simulator housed within a dedicated facility to achieve these benefits. Very simple low-cost hardware like Google's VRcardboard goggles (see Figure 2), which cost just a few dollars, convert a standard smart phone into an HMD that delivers a sufficiently immersive experience to achieve these benefits. Perhaps even more importantly,

Figure 2 - Google's "VRcardboard" Virtual Reality goggles

such simple hardware is highly portable and, when blended with the ubiquitous smart phone, makes this VR tool readily accessible to everyone across the business. It can be used anytime, anywhere, by anyone, maximising its use and impact.

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CONCLUSION

Do you have a digital twin of your asset? If so, is it being shared across the business to help reduce risk? If not, what's stopping you? *"Virtual reality is like dreaming with your eyes open."* (Ref. 1). As risk management professionals, we dream of ways to reduce risk. Harnessing a digital twin through VR can help make these dreams a reality.

References: 1. Brennan Spiegel - Director of health research at Cedars-Sinai, California (via Twitter).

The Human Factor – Cost-effective safety critical task analysis

Human failures have contributed to many major accidents in high hazard sectors, such as Chernobyl, Ladbroke Grove and Deepwater Horizon. However, the analysis of safety critical tasks has lagged behind efforts to analyse hardware failures, mainly driven by the perception that assessing the enormous number of tasks at an industrial facility would be too time consuming. Today, practical methods have been developed to help the cost-effective analysis of safety critical tasks.

WHAT IS SAFETY CRITICAL TASK ANALYSIS?

Task analysis is the process of breaking down a task into its component subtasks and determining a plan for how the subtasks should be carried out.

Safety Critical Task Analysis (SCTA) focuses on those tasks which are safety critical, to make sure that they are undertaken correctly, when required. SCTA determines the potential for human failures when conducting critical tasks and identifies the current and potentially additional controls required to prevent or mitigate such failures.

WHAT ARE THE DIFFICULTIES AND CHALLENGES WHEN CONDUCTING SCTA?

Accurate and effective SCTA requires key information about how the tasks are carried out in reality. One way to collect information for SCTA is to run workshops with the teams who perform the actual tasks. However, experience has shown that this approach can be very resource intensive, time consuming and inefficient. Further, and particularly for smaller and leaner organisations, the experienced workers who possess the required knowledge may not be available to participate in lengthy workshops. Therefore, a compromise must be reached between collecting sufficient, accurate information for SCTA and minimising cost, time and resources.

A PRACTICAL APPROACH TO SCTA

A practical four-step approach to SCTA is outlined below. This complies with guidance from the Energy Institute (Ref. 1), but adopts time- and cost-saving strategies such as constraining scope, applying checklists, making full use of existing written material and interviewing or observing appropriate personnel.

Step 1 – Identify safety critical activities

Safety critical activities are those activities which have a causal relationship with major accidents. The first step establishes what major accidents may occur at the facility, as described in the safety case or hazard assessment.

For a facility of a specific type (e.g. drilling rig, onshore refinery), a list of typical operating and maintenance activities can be cross-checked against the major accidents to determine which activities are safety critical. Where a facility has a good set of written procedures, these provide a completeness review, but application of a standard activity list saves time and ensures the analysis is pitched at the right level from the start.

Step 2 – Prioritise safety critical activities

Inevitably, a facility will have many safety critical activities and detailed analysis of them all would take considerable time and effort. Initially therefore, the analysis should focus on the most safety critical of activities, which can be prioritised according to their significance for major accidents. For example, activities which directly cause a major accident may be deemed more critical than activities that mitigate the consequences of a major accident. Additionally, if there is a clear link between the activity and previous incidents or near misses then the activity may also be prioritised.

Traditionally, Steps 1 and 2 of the process are undertaken in a multidisciplinary workshop but a relatively accurate first pass can be achieved by review of the safety case, incident records, etc. Workforce involvement is crucial, however, and the prioritised list of activities must be reviewed and agreed with those who are familiar with operations before proceeding to Step 3.

Step 3 – Represent safety critical subtasks

Starting with the most critical activities, the aim of this step is to establish a step-by-step description of the subtasks involved, ready for further analysis.

This may be achieved by reviewing written procedures or task instructions, interviewing workers, or by observing the activity directly or via ‘walk-through’. A combination of all three is recommended, but the most effective approach depends, for example, on the quality of the procedures, availability of personnel for interview, etc.

Step 4 – Safety critical task analysis

Again, it is important to focus effort on the task steps which are most critical. The potential consequences of a human failure in carrying out the task step determine the criticality, as does the level of human involvement. Further analysis is then only carried out for those subtasks which fall into the high priority zone of a pre-defined task criticality matrix.

For each of the subtasks identified as high priority, potential human failures are identified by applying a standard checklist. Then the possible consequences of the failure are described – if major accident level consequences are not possible, further analysis of the subtask is not required.

Person-, job- and environment-specific Performance Influencing Factors (PIFs) which may encourage human failure are recorded using a standard checklist of factors to ensure efficiency and completeness. Experience shows that PIFs are best gathered through interviews and observations to explore any genuine human factor-related concerns.

There may already be control measures in place to prevent failure of a subtask, or to mitigate the consequences if a failure occurs. Suggested additional controls should also be sought and may include improvements in procedures, engineering modifications, improved access to equipment and provision of training or additional checks.

Where additional controls are suggested, above and beyond mandatory controls required by law and established good practice, their benefit, in terms of risk reduction, and the effort involved in implementing them, need to be considered in order to decide if implementation is warranted on the grounds of reasonable practicability.

Where there are limits on workshop time and resources, Steps 3 and 4 are essentially completed through a combination of documentation review, interview and task observation. However, a concluding workshop to review findings and endorse actions is an essential final part of the SCTA process.

CONCLUSION

SCTA determines the potential for human failures when conducting critical tasks and identifies current and additional controls required to prevent or mitigate such failures and reduce human error-related risks to as low as reasonably practicable levels.

Traditionally, SCTA is carried out in large workshops, which are resource intensive and can be impractical. However, a proven, pragmatic approach is available that complies with recognised SCTA guidance and results in realistic, meaningful risk reduction improvements.

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References: 1. Guidance on human factors safety critical task analysis, Energy Institute, March 2011 (update due in 2019)

CASE STUDY

For a modestly sized offshore platform (10 producing wells, single processing train), about 40 Safety Critical Tasks (SCTs) were identified, for example:

- Control room operations.
- Process train pressurisation.
- Sphering (pigging).
- Well start-up.

The initial screening to identify the SCTs took 4 days plus a 1 day workshop and a further day post-workshop analysis.

Three high priority SCTs were analysed in detail, each taking about 4 days onshore and 1 day offshore.

Several risk reduction measures were recommended, for example:

- Introduce additional check step into procedure.
- Include equipment items as a specific job plan in maintenance management system.
- Install ‘hop-up’ or similar to allow access without standing on pipework.
- Improve valve labelling.
- Install interlock to prevent task from proceeding if safety system is not engaged.
- Relocate gauge to allow easier reading.

Proportionality – The role of safety management in climate action

The recently popularised term "Anthropocene" alludes to the impact of human life and endeavour upon the geology and ecosystems of our planet. As the dawn of this new geological epoch breaks upon the Earth, worldwide awareness is steadily rising of the harsh realities of climate change. Encouragingly, viable technologies are now emerging with the potential to reduce emissions and sequestrate atmospheric carbon dioxide.

NEW TECHNOLOGIES, NEW HAZARDS

Effective climate action will require an ambitious expansion of new and existing technologies, including (for example) renewable energy generation, electric vehicles, smart energy management, carbon capture and storage, and a hydrogen economy as a substitute for natural gas. These bring hazards such as:

- Impacts from wind turbine blade failures.
- High energy battery fires and explosions.
- Asphyxiation from gross releases of carbon dioxide.
- Hydrogen fires and explosions.

Emerging technologies have suffered disastrous setbacks in the past, where a rush to market resulted in loss of life. In the post-war race to commercialise jet airliners, for instance, the de Havilland Comet captured the public's imagination and looked set to corner the airline market. However, within two years of entering service, five aircraft suffered highly publicised accidents. Two were caused by unexpected stall characteristics during take-off, and three involved catastrophic in-flight break-ups. The catastrophic failures were later attributed to metal fatigue from cyclic loading, which was not fully understood at the time, aggravated by stress concentrations and the riveting method. Sales never recovered and within ten years Boeing emerged as the leading supplier of commercial aircraft by an overwhelming margin.

EXCESSIVE SAFETY?

We live in different times now; times in which we are more cautious and more aware of the importance of safety, both of itself and of its impact on reputation. Our safety assessment processes and tools are manifold and tried and tested.

Inevitably, there is a temptation to impose higher standards of safety and regulation on new technologies, compared to those that they replace. Raising the bar in this way risks stalling the introduction and proliferation of solutions that could quite literally save the planet. With new technology, there is the opportunity to get the balance right from the start, without setting a precedent that could be difficult to overturn.

There is an interesting parallel here with the UK nuclear industry ten years ago. More and more it was becoming clear that the exacting nuclear safety case regime (and its regulation) was delaying or even preventing the decommissioning of nuclear facilities, not least because of the cost and effort required. In other words, the same standards and expectations were being applied to decommissioning hazards as were originally intended to prevent a catastrophic reactor core meltdown. As a result, the industry has re-invented itself to arrive at decommissioning safety cases that are proportionate to the risk and recognise the safety benefit of getting the job done.

ACHIEVING BALANCE

For safety professionals, the desire to achieve continuous improvement must go hand in hand with an awareness and determination to avoid excessive intervention. Key to this will always be a disciplined application of risk acceptance criteria – including the requirement to reduce risks As Low As Reasonably Practicable (ALARP) – with a holistic consideration of the broader context in which our new technologies for climate change must function.

A good example is the developing UK wind power industry. Consider for a few moments the prospect of building and operating a wind turbine adjacent to a school, or a gas storage depot, or a nuclear power plant. To assess and manage these and other hazards many of the leading operators in the wind industry apply a cost-effective safety case style framework, which expends effort according to risk.

Get this approach wrong, of course, and a single accident can change the regulatory landscape – for example, the Piper Alpha disaster in 1988 completely transformed the safety requirements for the UK offshore industry.

There is clearly a balance to strike between what might be entirely proportionate and reasonable measures to bring to bear upon an emerging high-technology industry, and the otherwise over-bearing and costly burden of excessive 'paper safety' that could ultimately risk the success and very survival of a new technology before it can secure its place in history.

CONCLUSION

By playing our part in assuring the safety of new technologies for climate action, we also have a duty to take a proportionate approach that weighs novelty against both risk and the long-term goal of saving the world.

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