Improving the value of Risk Engineering in Onshore Energy Insurance

Nigel Cairns CEng FIChemE, Senior Risk Engineer, Aon Global Risk Consulting, The Aon Centre, The Leadenhall Building, 122 Leadenhall Street, London EC3V 4AN

Energy sites viewed and assessed by insurance risk engineers continue to have losses, seemingly independent of their reported risk quality. Aon proposes a significant change in risk quality assessment using a safety barrier model to highlight strengths, weaknesses and exposures, and give a greater focus to learning from industry losses.

Introduction

Energy insurance risk engineers conduct hundreds of underwriting surveys globally each year, across upstream, midstream and downstream assets. Most of these surveys are conducted by risk engineers working for (or on behalf of) insurance brokers for the benefit of insurers and insureds.

Site operators are extensively audited by stakeholders and regulatory bodies, yet we know anecdotally that insurance underwriting surveys are highly regarded for bringing independent third party and industry good practice advice to sites. However, to some operators the process can often boil down to one question: "What will this mean for my insurance premium?"

The main output from the survey process, the insurance underwriting report, is written to give evidence-based opinion of insurable risk quality to underwriters and insureds. This is, in part, used to help set insurance premiums and policy conditions, and whilst there is insurance-industry guidance on what the content of underwriting reports should be, all insurance surveying organisations have their own method of rating the risk quality of a site, against recognised good engineering and management practices.

However, the fact that the industry as a whole continues to see losses begs the question whether insurance underwriting surveys are sufficiently objective, and suitably structured and executed in order to understand and address the root causes of losses so as to prevent (or reduce) reoccurrence.

The purpose of this paper therefore is to propose a more effective process for assessing insurable risk quality within the confines of an insurance underwriting survey, using a barrier-based methodology, whilst noting that within the framework proposed, the detailed assessment of individual barrier detail is still a work in progress by the author.

The origins of insurance risk engineering

The origins of energy insurance go back to 1972 when the insurance mutual Oil Insurance Limited (OIL) was formed by 16 energy companies in response to two large-scale industry losses in the late 1960s. The combination of an oil spill in Santa Barbara, California and a refinery explosion in Lake Charles, Louisiana highlighted the need for specialist energy insurance, beyond that available at the time from established property insurance markets. But it was the Flixborough disaster of June 1974 which ultimately led to the formation of International Oil Insurers (IOI), and to the recruitment of risk engineers into insurance from industry in an attempt to better differentiate risks. This led directly to the insurance survey process we see today, and the associated methods of risk rating, benchmarking, establishing Estimated Maximum Losses (EMLs), and risk quality improvement through targeted risk improvement recommendations.

Early reports would review site operations, document safety culture, and attempt to give some sort of risk differentiation, but process safety as a concept was in its infancy, and there was more of a focus on developing EMLs so that underwriters and insureds could understand their maximum exposures. However, industry losses continued.

The focus started to shift more towards process safety and away from occupational safety reporting following significant losses at Phillips Pasadena (1989) and particularly after BP Texas City (2005). However, progress has been slow, as insurance has traditionally been a conservative profession, and risk engineering surveys and reports have typically lagged behind the industry-wide push for better process safety management and reporting.

The objectivity of underwriting reports varies when it comes to defining risk quality and differentiating between risks. Anecdotally, there is also a widely-held view that reports generated from some global insurance hubs still over-emphasise the importance of 'after the fact' loss mitigation, rather than scrutinising loss prevention barriers. Overall therefore, the view of much of the insurance underwriting community is that although reports generally give good risk description and information, they do not give underwriters clear guidance on which insured assets are more likely to give them a claim by policy year end.

Asset risk rating

To try and counter this lack of direction, report authors have devised risk rating or risk ranking tools to try to benchmark sites against Recognised And Generally Accepted Good Engineering Practices (RAGAGEP). Sites are typically scored against a number of factors, with a variety of weightings applied to distil a few dozen or few hundred individual scores down to a single indicator, within a range of (for example) '*poor*' to '*excellent*'.

However, this raises a number of questions, such as does the rating process:

- define the health of a site's safety barriers?
- give meaningful guidance to insureds as to where risk reduction improvements could be made?
- give a rating that merely satisfies our appetite for measurable data, regardless of how useful those data actually are?

- differentiate between risks that indicate which are the sites or the insureds most likely to have a loss? This last point is perhaps the most important to underwriters.

The reality is that the industry continues to have a significant number of losses year-on-year, and these losses are happening across all perceived risk qualities. Often the problem is that without sufficient differentiation within the risk rating methodology, ineffective risk-reduction features can get 'normalised' out, masking defective safety barriers. Too many sites which are positively rated by underwriting surveys have property-damage losses, such as fires or vapour cloud explosions (VCEs), and there appears to be no direct correlation between loss-likelihood and risk rating score: in the words of one underwriter "too many good sites are having losses".

Is loss propensity truly independent of risk quality? Or are we using the wrong tools?

Part of the problem is that the risk rating processes in common use by insurance risk engineers are often used as the 'go to' tool for a variety of conflicting purposes, for example, as a benchmarking tool for comparing individual sites or regions, or even as a means for insureds to set Senior Management bonus levels based on performance at the last insurance survey. Consequently, the number of metrics typically measured and scored has gone up rather than down, become less rather than more focused, with the result that rating quality has often been 'averaged out' or normalised into the middle of the bell curve distribution, reducing differentiation. Despite attempts by some organisations to address this by greater weighting of more critical topics, the greater number of topics being scored masks poor barrier performance, and the combining of independent loss control barriers results in them losing their individual identity as performance metrics.

For example, a low score for a poorly-resourced Inspection department could be compensated for by an adequate hazard study process, or low levels of operator competence could be offset by a high level of predictive maintenance. The evidence however is that independent barriers such as asset integrity or operator competence by themselves are key factors when looking at what causes losses and, therefore, must not be 'swapped out' for other barriers or layers of protection.

Therefore, before we can define how we can more effectively measure a site's propensity to have a loss, and thus better define its risk quality from an insurance perspective, we need to understand what actually causes losses.

What causes losses?

Anecdotally, insurers have known for some time what causes losses, but the first formal presentation of data was by Jarvis in September 2016 (Reference 1) on behalf of the Lloyd's Market Association (LMA). This document reviewed 100 major onshore oil, gas and petrochemical property damage losses in terms of monetary value over a 20 year period from 1996 to 2015, excluding natural catastrophe (Nat Cat) events.

Major losses occur because of failures of both loss prevention and mitigation barriers in response to an initiating event. The LMA data highlighted the three main initiating events which led to the majority of the 100 losses considered, as well as those loss prevention barriers which most frequently failed:

- 43% of the 100 losses analysed were caused by mechanical integrity failure; with 70% of these due to internal or external piping corrosion (noting the higher propensity for this in refining over other occupancies such as gas plants or terminal operations).
- Of the 57% of losses not directly caused by mechanical integrity failure, 63% occurred during transient (non-routine, infrequent, abnormal or unplanned) operation.
- Of the 57% of losses not directly caused by mechanical integrity failure, 28% occurred during maintenance activity, typically due to inadequate control of work.

Note that the key messages from the LMA data are supported by evidence from underwriters' own loss data and claims analysis, which typically reference a much larger industry dataset. They suggest that rating asset quality from an insurance perspective would be more effective if focussed on the health of those barriers which line up to prevent or limit losses associated with a range of initiating events.

Of course, this has the potential to significantly change the insurance underwriting survey process as we know it. Insurance surveys are currently organised by discipline; meetings are organised by department, together with a tour of the site being surveyed. Typically, this means spending a couple of hours each with the Engineering, Inspection and Operations teams, among others, with each assessed against recognised good engineering and management practices. But if we are now to focus on the effectiveness of individual barriers in response to defined initiating events, then this is drawing us down a path of site interviews by barrier rather than by discipline – of course the reality is that we'll be talking to the same people, only with greater focus on the specific barriers which stand between a site and a major property damage / business interruption (PD / BI) loss.

And if the survey and rating processes need to change, then so does the reporting process, from discipline to barrier focus.

The insurance underwriting report

Underwriting reports have been based on much the same format for the last 15-20 years. In recent times, some have become shorter, but only because the same information has been presented more efficiently, rather than because of a fundamental shift in what is being reported. Underwriters and their risk engineers rarely have time to read a plethora of 100-page reports, and even if they did, do the reports give a true insight into the health and status of critical safety barriers or the likelihood of a loss? The message from the insurance markets is a resounding 'no'.

Therefore, to better define and report insurable risk quality to markets and insureds, the insurance industry needs to move away from a highly descriptive report style to one which focuses more clearly on the health and quality of defined process safety barriers; one way of doing this is to adopt the look and feel of a "bow tie diagram" (see Figure 1) to give a simple, clear representation of site risk quality to underwriters to help their insurance decision-making processes.

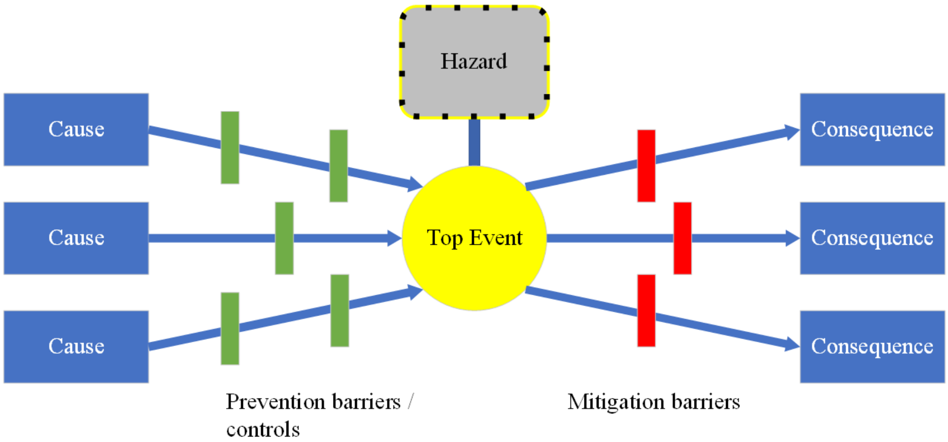

Figure 1, typical "bow tie" diagram used for process safety reporting

The model should be simple and clear enough to effectively report on barrier health for a range of initiating events and causes, yet flexible enough to accommodate a variety of asset types and a range of review frequencies. If the model is too specific, the process becomes restrictive, cumbersome and quickly out-of-date as sites change – this is an important point for sites which will typically be surveyed by insurance risk engineers on a three or four-year cycle.

Adopting a barrier model

Adopting a barrier-based methodology begins with trying to build a process that focuses on the barriers which prevent what have been historically the key initiating events that lead to significant financial loss for insureds. This process can then be updated as loss initiators or barriers themselves change; for example, improved technology giving more inherently safe designs, global economics driving a shift in feedstock slates or changing demographics placing a greater strain on human resources.

Having defined the events or initiating causes which pose the greatest threats, our hazard is invariably hydrocarbons under pressure. Of course, extending the analysis to third party liability effects may require an extension of the methodology to non-hydrocarbons, for example to review the potential effects of the release of a typical refinery toxin such as hydrofluoric acid. For the purpose of the process however, the top event would not be a loss of primary containment (LOPC), but that event with which insurers are directly concerned, namely the fire or explosion which results in property damage. This is an important point, as it clearly defines those barriers which are preventing exposure and those which mitigate; it may also result in some barriers taking on a slightly different position within the model compared to a more traditional model based on an LOPC as the top event. In following this methodology through, no 'preventative' credit is taken for ignition source control on the left hand side (LHS) of our model; this is a deliberate stance from an insurance perspective to assume that a flammable cloud would invariably escalate to a VCE.

Such an analysis includes a range of barrier types and associated degradation controls (NB. passive barriers are typically stronger than active barriers) with barriers relying on human intervention typically among the weakest; refer to Table 1:

Barrier type	Example
Passive hardware	Firewall
Continuous hardware	Active corrosion protection system
Active hardware	Safety Instrumented System (SIS) / automatic emergency shutdown system (ESD)
Active hardware + human	Operator-activated ESD
Active human	Visual fire detection and evacuation

Table 1, example of common barriers used in the process industries

The simplest and most effective way of reporting barrier health and giving a snapshot of performance (covering both the degree to which the barrier is present, and the quality of its implementation / maintenance) would be through the use of 'traffic light' colour coding as demonstrated in Table 2:

Condition	Description
Good	Barrier performing at design / intended effectiveness
Slightly degraded	Barrier performing slightly below design / intended effectiveness
Moderately degraded	Barrier performing below design / intended effectiveness
Out of service	Barrier is not in place, turned-off, deactivated, or fully degraded
Not applicable	Barrier not deemed applicable for that asset (for example, insurers wouldn't typically expect a remote terminal to maintain a full-time professional fire brigade, but might do so for a world-scale refinery)

Table 2, use of colour coding to define barrier status

So, for risk engineering reports, this might be applied to the first significant initiating event as follows.

A fire / VCE from the mechanical integrity failure of piping

For this scenario, Table 3 suggests examples of the key barriers and controls on the LHS of the model for preventing a loss caused by piping corrosion (NB. the constituent component detail of each barrier is pending continuing review by the author):

Barrier / control	Barrier / control type	Comment
Inspection competence	Degradation control	
Inspection programme philosophy	Degradation control / Preventative barrier	Identification and management of corrosion and damage mechanisms, use of appropriate NDT, etc.
Integrity Operating Windows (IOWs)	Degradation control	
Material selection	Preventative barrier	Including QA / QC

Table 3, possible key preventative barriers and controls in a piping corrosion-initiated loss scenario

In terms of the survey process, all of these would currently be discussed with a site's Inspection department, and findings reported in the Inspection section of the underwriting report. In future, the robustness of the site's asset integrity management as a function of its defined barriers and degradation controls would be reported.

Moving from left to right along the model, further barriers and controls then play their part in preventing or mitigating a loss as a result of this threat; a selection is shown in Table 4:

Barrier / control	Barrier / control type	Comment
Engineering standards	Active hardware / preventative barrier	LHS of model
Gas detection	Active hardware / human	LHS – detection prompting action to prevent escalation of an LOPC to a VCE as the top event
ESD	Active hardware	LHS
Unit layout	Passive hardware / mitigating barrier	RHS of model – good layout features will reduce the impact of the top event
Fire detection	Active hardware / human	RHS – detection prompting action to mitigate the effects of the top event
Emergency response	Active human	RHS – typically the 'last line of defence' after the top event to limit escalation

Table 4, possible key preventative and mitigating barriers in a piping corrosion-initiated loss scenario

This starts to build up a picture of how a new risk quality rating process might work, by identifying key barriers and degradation controls that prevent initiating events and threats becoming consequences through the top event.

A fire / VCE as a result of a transient operation

For this second initiating event, Table 5 suggests examples of those barriers and controls specific to the site's Operations team that should be in place to protect against unforeseen or transient events, such as the loss of a plant utility (e.g. power or cooling water). Again, note that the constituent component detail of each barrier is pending continuing review by the author:

Barrier / control	Barrier / control type	Comment
Operator competence assurance	Degradation control / preventative barrier	Includes training and recertification
Shift handover	Degradation control	
Operating procedures	Degradation control / active human	Includes Emergency Operating Procedures (EOPs), and requires action by the operator

Table 5, possible key preventative barriers and controls in a transient operation-initiated loss scenario

There would also be a number of hardware controls upstream of the top event, and beyond this, the mitigation barriers on the RHS would typically be the same as in the earlier piping corrosion case.

A fire / VCE as a result of a maintenance activity

In this example, key barriers and controls on the LHS might include those in Table 6:

Barrier / control	Barrier / control type	Comment
Permit to Work (PTW) management system	Degradation control	
Training and certification of permit authorities	Degradation control	For both issuing and receiving permits
Isolation management procedures and practices	Degradation control	
Shift handover	Degradation control	

Table 6, possible key preventative barriers and controls in a maintenance activity-initiated loss scenario

Again, the mitigation barriers on the RHS would be essentially the same as in the first initiating cause.

Aside from the specific barriers and controls postulated above for the three key loss-initiating events as identified by the LMA, incident investigations carried out by regulatory or industry bodies such as the UK's Health and Safety Executive (HSE), or the US Chemical Safety Board (CSB) have identified other key barriers whose documented absence or degradation has contributed directly to a loss.

There are many published examples of where poor or absent stewardship of key process safety elements has been the direct cause of a significant loss across a variety of initiating events and site operating modes. Examples of such elements include Process Hazard Analysis (PHA), Management of Change (MoC), Process Safety Information (PSI), process safety audits, and incident investigation.

It is worth noting that on an insurance survey, such topics don't always have a natural home for discussion, because from site to site, the processes may be owned by a variety of disciplines or functions. Not all sites have a dedicated Process Safety function managing process safety element responsibilities and ownership, so these topics may lie with any of the Engineering, HSE or even the Operations departments. Hence, they can easily be overlooked if they form part of a 'shopping list' of questions on an agenda for a particular department during a survey; or worse, the person responsible is not on site. Treating each topic as a barrier in its own right, with dedicated discussion time, could provide extra focus during a survey.

Other loss types

Adding the process safety barriers to the event-specific ones discussed earlier adds to the picture of what needs to be investigated and documented in order to determine a site's susceptibility to a large property damage (PD) loss resulting from a fire or VCE.

Of course, there are other types of losses than PD that underwriters pay out for, or that give increased exposure to insureds or clients. These may or may not have the same level of impact financially as a single catastrophic event, but could result in more frequent attritional losses that still significantly affect the bottom line. Then of course there is the Business Interruption (BI) coverage, which is triggered once the initial loss has occurred, to recompense the insured's lost income.

Machinery Breakdown losses

Machinery Breakdown (MB) insurance covers sudden and unforeseen losses to rotating and fixed equipment (i.e. not as a result of inappropriate levels of preventative maintenance, poor operation or corrosion over time), and is typically included on a property damage policy. Therefore, the preventative barriers and degradation controls on the LHS of the model would be similar to those protecting against abnormal or transient plant operating conditions, as they demand a similar decisive response from plant operators. However, a degradation control covering the health of preventative and predictive maintenance schedules should also be included on the LHS to cover specific reference to this type of loss. Mitigation barriers on the RHS of the top event would be similar to those discussed earlier.

Nat Cat losses

Like MB, Nat Cat losses are typically covered by a standard property damage policy, subject to specific limits and exclusions, if the insured is operating in an area of known exposures, such as the Gulf of Mexico (windstorm). It would be unusual for a Nat Cat-related loss to be the defining maximum loss scenario for a single asset, though a Nat Cat event could be an initiator to a greater process safety loss. What tends to impact underwriters however is the aggregation of a number of insured assets in the same area. What stands out is that, aside from a decisive planned response from the site in reacting to the transient condition, the other main barrier that can be assessed is the suitability of the design and engineering codes employed during the site's construction, and the quality of the build.

Cyber event

This is only briefly mentioned here to acknowledge its existence as a threat that can lead to a fire / VCE top event, and that there are barriers that can be put in place and assessed. However, this is currently typically outwith the scope of a typical risk engineering survey and covered as part of a separate insurance programme. This could change in the future.

A note on Business Interruption

Business Interruption coverage is typically triggered by any of the above loss types. As a rule of thumb, across the Energy sector, for every £1 paid out by underwriters for a PD loss, a further £2 is paid out for lost revenues, so underwriters will look for evidence of any mitigating barriers that help keep this figure down (i.e. they will look at preventative barriers and controls to stop the loss happening in the first place). The mitigating barriers will typically be a well understood and rehearsed Business Continuity Plan (BCP), and redundancy in plant, site, or international operations. However, individual sites may not be aware of wider corporate BCPs, which suggests that a fundamental review is needed of how the insurance industry assesses those barriers that are most effective in mitigating BI exposures.

Bringing the barriers together

So far, this paper has identified the critical barriers and controls in this model that need to be examined during insurance surveys in order to try and redefine 'insurable risk quality', in response to the most common threats faced by operating sites.

For the survey process to be effective, the barriers should be grouped together to facilitate effective discussions at site level. This can then define the survey agenda based on the barriers to be assessed.

However, to define the health of each barrier, each one has to be broken down into measurable components or elements for use in site discussions.

For each element, there are aspects of recognised, good engineering practice that must be present before that element can be said to have been achieved at its designed and intended level. If it is not at the required level, then a means for scoring how near it is to the required level must be in place, not just in terms of how site procedures state it should work, but how effective its implementation has been, and what the evidence of its effectiveness is on site. As an example, in order to assess the health of the site's PHA barrier, we would need to consider at least the following elements:

- Site PHA policy and schedule
- The suitability of techniques used
- The provision for the review of process safety incidents as part of the study
- Quality of reference information such as P&IDs
- Quality of the review of abnormal operating modes
- Quality of actions generated and effectiveness of follow-up / implementation

Some barriers and controls will have fewer elements than others, but the overall health of the barrier must be no greater than its weakest element – this is a noticeable change in philosophy from current 'risk rating' systems which aggregate element or component scores, thus diluting the presence of poor performers. Scoring of each individual barrier's health would be done using the colour coding system defined earlier in this paper.

A key feature therefore of this process would be to demonstrate individual barrier health and effectiveness by a clear, colour coded status report, to define where the asset's strengths and weaknesses lie, and how likely they are to have a robust response to the main threats that cause losses.

What will the model look like?

An example of what such a model would look like can be given using the first threat mentioned earlier, that of pipe failure due to corrosion. Figure 2 shows a number of directly applicable preventative and mitigating barriers, with those additional barriers relating to process safety shown in Figure 3, and for emergency response in Figure 4 (NB. the condition of each barrier has been randomly assigned merely to highlight the 'traffic light' nature of effectiveness reporting).

Table 7 gives the barriers under current consideration by the author relating to Figure 2:

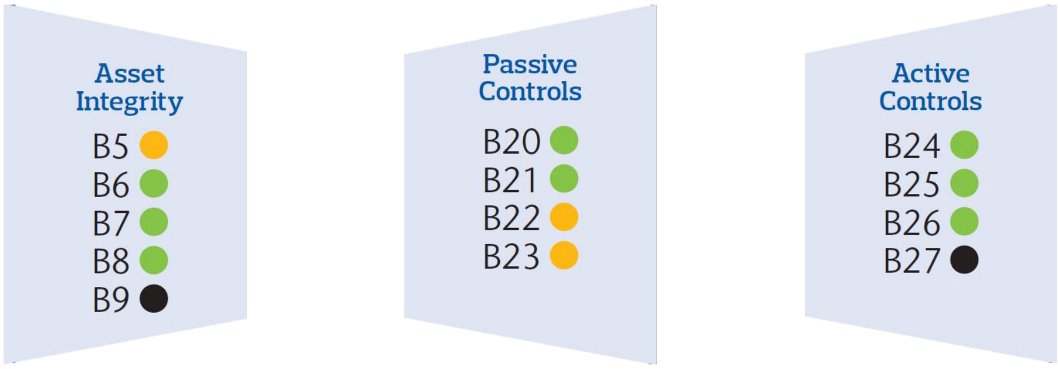

Figure 2, Asset Integrity (LHS) and loss mitigation (RHS) barriers for Passive Controls and Active Controls

Barrier / control	Barrier / control	Barrier / control
B5 – Inspection competence	B20 – Layout	B24 – Emergency isolation
B6 – Inspection philosophy	B21 – Construction	B25 – Fire detection
B7 – IOWs	B22 – Passive protection	B26 – Emergency planning
B8 – Material selection	B23 – Inherent redundancy	B27 – Business continuity planning
B9 – Preventative maintenance		

Table 7, relevant barriers under current consideration for the first threat

In considering the second and third threats, the model then incorporates barriers specific to the site's Operations team; Figure 3 and Table 8 also include additional barriers from the review of learning from global process safety incidents and losses:

Figure 3, representation of Operations and Process Safety barriers (LHS)

Barrier / control	Barrier / control
B1 – Operator competence assurance	B10 – Process Safety Management (PSM)
B2 – Shift handover	B11 – Process Hazard Analysis (PHA)
B3 – Operating documentation	B12 – Management of Change (MoC)
B4 – Control of Work	B13 – Process safety auditing
	B14 – Incident investigation

Table 8, operational and process safety barriers for the second and third threats

Finally, Figure 4 and Table 9 demonstrate additional preventative controls and emergency response barriers which might be common across a range of initiating causes:

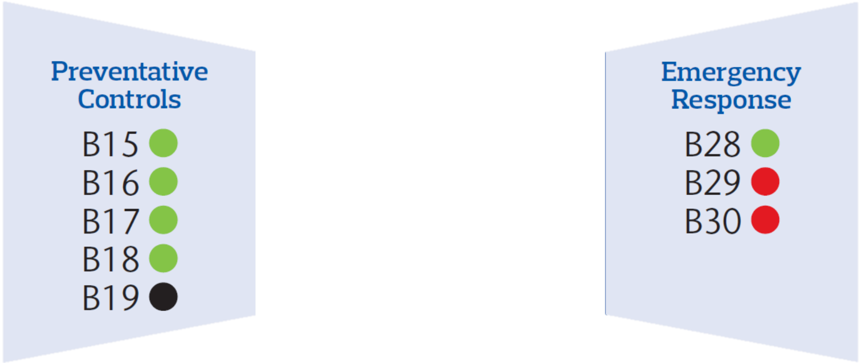

Figure 4, representation of preventative (active and passive) controls (LHS) and mitigating (RHS) barriers

Barrier / control	Barrier / control
B15 – Engineering standards	B28 – Firewater system
B16 – Controls and safeguards	B29 – Active protection
B17 – Gas detection	B30 – Fire brigades and mutual aid
B18 – ESD	
B19 – Relief systems	

Table 9, suggested further preventative and mitigating barriers across all threats

The ratings for the barriers above can be combined to give a summary representation of overall site risk quality, when measured against those threats known to cause energy losses (Figure 5).

Figure 5, how a combined 'barrier diagram' might look in an Insurance Underwriting Report

Were this for an operating asset, a summary similar to Figure 5 at the front of an insurance underwriting report would quickly flag up concerns about the site's approach to process safety. Those reading the summary would be alerted immediately that the site's preventative maintenance programmes needed improvement (which would be a particular concern for underwriters were the insured purchasing Machinery Breakdown coverage). Based on the above summary, markets and the insured's senior management might also be concerned about the site's ability to respond to an abnormal or transient operation (such as loss of a utility), and depending on certain specific findings, would expect to see a number of recommendations from the survey team to address these concerns. The lack of business continuity planning (B27) might be a concern to insurance markets depending on the level of Business Interruption cover purchased by the insured.

Figure 6 shows another potential summary of findings for a site:

Figure 6, additional example of a possible combined 'barrier diagram' in an Insurance Underwriting Report

In this example, both the underwriter and insured could take comfort from the site's positive approach to installing and maintaining preventative safety barriers; if BI coverage had not been purchased in this case (note B27 is 'not applicable'), this would likely make this risk more attractive to insurance markets than that represented in Figure 5. Given the strong 'preventative' LHS of the diagram, the underwriter might not be concerned about the failings of the emergency response systems; this would depend however on underwriter 'loss appetite' and on recent loss history.

Conclusion

Aon Global Risk Consulting is proposing a significant change in the way that the energy insurance industry measures and reports risk quality in its insurance underwriting reports, giving a clear summary of the strengths, weaknesses and risks associated with each site, a greater focus on learning the lessons from industry losses, and a clear indicator of the strength of critical safety barriers at sites visited during insurance underwriting surveys for site operators, insureds and underwriters alike.

We believe that this methodology will give a more effective process to give better differentiation of risk quality across those energy assets surveyed.

References

1. Jarvis, R and Goddard, A, September 2016, An analysis of common causes of major losses in the onshore oil, gas & petrochemical industries, Implications for insurance risk engineering surveys, Lloyd's Market Association (LMA).