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A New Policy Direction in Offshore Safety Regulation

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Abstract

A series of disasters in the offshore oil and gas industry in the 1980s led to a major change in regulatory policy regarding offshore safety. Prior to that time, regulations detailing prescriptive requirements focussed on control of activities in the field. These were replaced by a risk-based form of self-regulation in which operating companies are required to make a case for safety that demonstrates risk to workers is as low as reasonably practicable – the 'safety case' approach.

Despite the widespread adoption of this regulatory approach in Europe and Australia (and in other industries in these and other countries), firm evidence of its effectiveness has proven to be elusive. Social science analysis of serious accidents continues to show that issues such as leadership, organisational structures, separation of functions, judgement, experience and professionalism of personnel play a major role in accident causation and yet these issues are ignored in safety regulation that focuses on the use of technical risk management techniques.

Using the Montara blowout as a case study, this paper makes the case for inclusion of social science aspects into regulation of safety in the offshore oil and gas industry, showing that this change is likely to improve safety and is also not inconsistent with the safety case concept. There is a developing consensus that safety culture should be included in offshore safety regulation but this is yet to extend to a framework as to how culture might be addressed or even a common definition of the meaning of the term safety culture. This paper proposes a different approach where issues related to people and organisations can be incrementally included in safety regulation based on factors known to impact upon safety performance.

1. Introduction

In 2011, three of the five largest companies in the world (based on revenue) were publicly owned oil companies – Royal Dutch Shell, ExxonMobil and BP (Fortune, (n.d.)). Chevron, Total and ConocoPhillips are also included in the top twenty. The oil industry's safety record on average is consistent with broad industrial sector experience but the environmental and social impacts of accidents, when they do occur, are sometimes substantial. The history of the offshore oil and gas sector has been punctuated by a series of major disasters. In 1980, the *Alexander Kielland* drilling rig capsized off the coast of Norway, causing 123 fatalities. The *Ocean Ranger* drilling rig sank off the Canadian coast in 1982 with eighty four fatalities, and when the *Piper Alpha* production platform off the UK coast was destroyed by fire in 1987, 167 lives were lost. More recently, the blowout from the Deepwater Horizon drilling rig, working under contract to BP in the Gulf of Mexico, has demonstrated yet again the hazards of offshore oil. In this case, the cloud of hydrocarbons flowing from the uncontrolled well ignited immediately, causing the deaths of eleven crew members. The subsequent oil spill caused major environmental damage in areas of intense human activity. The financial cost to BP and its shareholders has also been significant and is ongoing. The rig itself, destroyed in the disaster, cost $350 million to build in 2002 (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011b, 2). Following the accident, BP established a $20 billion compensation fund and, as of August 2011, had paid out over $7 billion to individuals, businesses and government impacted by the oil spill (BP, (n.d.)). Litigation is expected to continue for decades.

Given the potential for disaster, the offshore oil industry is heavily regulated. Further, regulatory policy regarding safety on offshore facilities has gone through a series of major reforms in recent decades, driven largely by accidents such as those mentioned above. In this paper, it will be argued that regulation continues, however, to ignore important lessons about accident causation derived from the expanding body of social science research into industrial disasters. The paper will begin by outlining what has been learnt about accident causation from a specific case, a blowout during development drilling at the Montara oilfield off the north west coast of Australia in 2009, and the regulatory failures that allowed this accident to occur. The paper will go on to summarise offshore safety regulatory policy development that has led to the widespread adoption of the safety case concept and efforts to demonstrate the effectiveness of this form of safety regulation. Sociological explanations for industrial accidents and the contrast between these theories and the approaches to risk assessment and safety built into regulatory frameworks are then explored.

It is one thing, of course, to note the disjuncture between sociological research and regulatory policy. It is quite another to draw the two together. The paper will also, therefore, attempt to offer practical suggestions as to how social and techno-scientific perspectives on risk can be brought together in regulation to reduce accidents and their associated social and environmental consequences.

2. The Montara Blowout

2.1 The incident

The continental shelf off the north-west coast of Australia holds rich reserves of oil and gas with hydrocarbon exploration and production activities in the area stretching back over decades. On 21st August 2009, those in charge of drilling the Montara H1 oil and gas well in this area lost control of the well, resulting in uncontrolled flow of hydrocarbons to the environment. This type of event is known in the oil industry as a blowout. The incident has been the subject of a statutory inquiry (Borthwick, 2010).

The Montara field is located 250km off the coast. At the time of the blowout, the facilities in the area were the *West Atlas* drilling rig with a crew of sixty nine people operating over the small unmanned *Montara Wellhead Platform* and *Java Constructor*, a construction barge with 174 people on board. As a hydrocarbon cloud engulfed the facilities, the vessel rapidly moved away from the drilling rig and the drilling rig personnel evacuated. Initially, the leaking fluids did not ignite. Oil and gas flowed for more than ten weeks before a relief well was successfully put in place. The drilling of the relief well coincided with the ignition of the release. The resulting fire continued for a further two days before the flowing fluids were brought under control on 3 November 2009 and the fire extinguished due to lack of fuel. A month later, the well was finally declared safe.

No-one was injured or killed as a result of this incident. It has to be said that this is more good luck than good management and, if the blowout had ignited immediately, the result could have been similar to the Deepwater Horizon incident which resulted in eleven fatalities and many injuries. At the time of the blowout, the construction vessel *Java Constructor* was located close to the facility. As photographs taken at the time show vividly, if the gas cloud had ignited immediately, it is possible that the crew of the vessel (as well as those on the drilling rig itself) could have been adversely impacted. Apart from the loss of the drilling rig and the platform due to the fire, the physical consequences of the Montara event include environmental pollution and, even in this area, luck has played a part. Given the light nature of the escaping fluids and the remote location of the well, by far the majority of the hydrocarbon has simply weathered away and relatively little has impacted the Australian coast or marine life (Borthwick, 2010, 26).[i]

Blowouts are a well-known hazard in the offshore oil and gas industry. There were thirty nine such incidents on the US Outer Continental Shelf in the period 1992 to 2006 (Izon, Danenberger and Mayes, 2007). The Australian offshore industry had also experienced six blowouts prior to Montara (with the immediately previous one being in 1984) (Borthwick, 2010). Given the potential for disaster, and because of the large sums of money involved, drilling and well construction activities in this global industry are tightly controlled, both within operating companies and by regulation. Despite this, all well control systems failed at Montara.

2.2 Barriers to prevent flow from the well

At the time of the incident, the H1 well was in the development drilling phase. The well had been drilled and two sections of concentric pipe known as *casing strings* had been put into place in the well. The outer 13 3/8" casing ran from the surface to a depth of 1640m and the inner 9 5/8" casing ran inside that to a depth of approximately 3800m. This is the depth at which hydrocarbons were expected to be present. The detailed sequence of events that led to the blowout starts with the cementing of what is known as a casing shoe at the bottom of the 9 5/8" casing. This device is simply a one way valve designed to prevent flow from the hydrocarbon zone or reservoir up the casing and to the surface.

The operating company's Well Construction Standards required two proven barriers to uncontrolled flow from the reservoir to the surface to be in place when the well was suspended. The primary pressure-containing barrier should have been the cemented casing shoe at the end of the 9 5/8" casing. Based on the pressure and flow profiles seen during the cementing operation, it is apparent that the integrity of the cement was never proven and that the outcome was what is known as a *wet shoe* with the cement contaminated by drilling and/or reservoir fluids. Such contamination meant that the device could not be relied upon to prevent flow from the reservoir to the surface. Various organisational arrangements made this situation possible, if not likely. Company management failed to adequately supervise field personnel to ensure that work was carried out in accordance with documented requirements. Also, the organisational structure in place at the time of the incident did not include separate management and technical integrity functions which meant ultimately that various key technical decisions made offshore received no technical input or review.

Secondary barriers that should have been in place (according to the final well design) were two pressure containing corrosion caps (PCCCs). The well design called for these to be installed on the top of both the 9 5/8'' string and the outer 13 3/8" string. Information from the manufacturer of the caps indicates that these are not designed as well control barriers and yet the operating company chose to use them for this purpose, again illustrating the weak technical function within the drilling department. In fact, despite the fact that it was reported from offshore that both caps were installed, only one of the caps was put in place (on the 9 5/8'' string). The 9 5/8" PCCC was later removed for operational reasons and then not re-installed. The blowout occurred approximately fifteen hours later.

Table 1: Summary of Well Control Barriers

Barrier	Status
Cement Shoe	Errors during installation resulted in a "wet shoe" with impaired functionality. Test results that demonstrated this were ignored.
9 5/8" Pressure Containing Corrosion Cap (PCCC)	Not designed for blowout prevention but included in well design partly for that purpose. Removed for operational reasons just before the blowout.
13 3/8" Pressure Containing Corrosion Cap (PCCC)	Not designed for blowout prevention but included in well design partly for that purpose. Never installed.
Fluids in the well bore	Could have provided a barrier, but weight not sufficient for that purpose and level not monitored.

The well control barriers that were included in the well design and their status at the time of the blowout are shown in Table 1 above. Ultimately, when the reservoir pressure was sufficient to overcome the weight of the column of fluids in the well bore, hydrocarbons were able to flow to the surface due to failure of the 9 5/8" cemented casing shoe. This was the only physical barrier to flow that was present on the well at the time the blowout occurred. The choices made in the months leading up to the blowout introduced a series of latent failures into the system of multiple barriers, hence negating the entire design philosophy and leaving the system in a very vulnerable state. Under these circumstances, uncontrolled flow of hydrocarbons to the surface was inevitable. It is tempting to put responsibility for these events at the feet of the individuals on the facility at the time and to see these events as issues of the technical competence of those people. This explanation is ultimately unsatisfactory. These individuals worked in an organisational context and many others within the organisation knew (or should have known) what was occurring offshore. The next section explores a broader organisational explanation for the failures that led to the blowout.

2.3 Organisational factors

Complex systems require multiple barriers in place to ensure operations remain safe. The ongoing effectiveness of such systems depends on those with responsibility for decision making to maintain their collective ability to recognise developing problems before they become critical. This section proposes three ways in which company management could have provided more effective leadership on these issues and thus have made an accident such as the blowout of the H1 well a much more remote possibility.

2.3.1 Providing active supervision

One of the most startling failures in the events leading up to the blowout is the failure to install the 13 3/8" PCCC followed by the reporting to onshore management that such a cap had indeed been installed. It is difficult to escape the conclusion that someone (indeed probably several people) knew that the cap had not been installed, and yet reported to onshore management that it was in place.

This event can perhaps best be considered as an indication of the relationship between offshore and onshore personnel within the organisation. The onshore management team appear to have taken a very 'hands off' approach regarding work done offshore. In his statement to the Commission of Inquiry (CoI) the Drilling Superintendent stated that "…if there was an issue with a forward plan that could not be resolved offshore [the Senior Drilling Supervisor] would call me to discuss the issue …The plans were not normally sent to the [onshore] office for review unless there was an issue that could not be resolved offshore…if the Senior Drilling Supervisor…needed additional expertise from onshore staff, he would telephone me…" (Wilson, 2009, 33). To emphasise this point, the attitude of onshore management is to assume that offshore personnel were competent and operating in accordance with approved standards without ever conducting any checks as to whether this was actually the case.

The Drilling Superintendent also states that, with regard to checking the reports on cementing operations, he had no reason to check the reports in detail and he "reviewed the [daily drilling report] to see if there was any obvious errors or issues. There were none" (Wilson, 2009, 185). As the CoI report points out (Borthwick, 2010, 3.123), the role of the Drilling Superintendent was the day-to-day supervision of activities offshore, and this involves much more than simply looking for obvious errors in written summaries of work done, especially work involving a critical safety function such as the cementing of the casing shoe. The Drilling Superintendent indicates again his overall attitude to supervision when he says "…as there were no indications or reasons after 21 April 2009 to think that the wells were not suspended per the [drilling plan] and subsequent change control, there was no reason to conduct any form of audit to check that all work that was thought to be performed had in fact been completed…" (Wilson, 2009, 266(c)). In fact, there was evidence available, particularly in relation to the state of the cemented casing shoe, if only he had looked.

The fact that critical activities were apparently conducted with no supervision is a key failing on the part of the organisation as a whole. It should be emphasised that this is not a matter of considering that employees may be dishonest. The principle of active supervision is that employees take their cue as to what is important from what their superiors pay attention to, and further that people respond to positive reinforcement of appropriate behaviours. If no-one ever asks about well control barriers being in place or checks that integrity tests have been done in accordance with written requirements, then the message given is that these issues are not cues that need to be considered in deciding how work should proceed.

The statements provided by management of what was regarded as important reveal the following communication. Five days before the blowout, the Drilling Superintendent sent an email to a wide range of people (including on rig personnel, the overseas parent company managers and government representatives) which states: "Whilst we have been busy drilling some our guys have been working offline to suspend Montara H3ST-1 and Montara H1. Both wells will be fully suspended by the end of the day. This has saved us about 12-18hrs of rig time by being able to do this activity offline – a job well done" (PTT, 2009). In these circumstances, it is not difficult to imagine a scenario in which the 13 3/8" cap was found at the last minute to be unserviceable (as the organisation initially reported to the CoI) and offshore personnel decided to proceed and suspend the well without the additional barrier. It is perhaps significant that it is the Daily Drilling Report dated 17 April (the day after the above general note) from the offshore team to onshore management that first reports the fictional installation of the 13 3/8" PCCC. By sending such a report, the offshore personnel were simply confirming what onshore management wanted to hear.

2.3.2 Separation of engineering integrity and operations functions

Another unsatisfactory organisational feature revealed by the quotes from the Drilling Superintendent in the previous section is the level of technical discretion given to offshore personnel, in particular the lack of any engineering integrity function within the organisation that was independent of line operations activity. To emphasise this point, this means that operational personnel were in control of whether or not engineering input was required, meaning that there was no separation between engineering integrity and operations functions. As is clear from the details of the cementing activity (Hayes, 2011), the personnel responsible for conducting these activities offshore apparently had serious gaps in their technical ability to understand what was happening and to know at what point they needed to seek specialist advice.

This situation appears to have its roots in the roles previously held by the various individuals involved. The Drilling Superintendent had previously (prior to the operational drilling phase) held the role of Senior Drilling Engineer (Wilson, 2009, 12) In that role, he had been responsible for (amongst other things) the design of the wells. Once the drilling program moved into the operational phase, he took on the role of Drilling Superintendent with all the offshore drilling crew reporting to him, including both Senior Drilling Supervisors and all the Drilling Supervisors (Wilson, 2009, 16).

Importantly, this is a significant change in role from technical expert in well design to manager. Sensemaking theory (Weick, 2001; Weick, Sutcliffe and Obstfeld, 2005) reminds us that the cues we see depend critically on our perception of our role (or organisational identity). In this case, there was perhaps an intention on the part of the organisation that the Drilling Superintendent maintain some technical oversight, but he seems to have a different understanding of the new role. He seems to have adopted an attitude to supervising the personnel that was based on providing advice when asked, rather than proactively providing input to the work that was being done. He goes on to say, "Although there was appropriate communication between [the Senior Drilling Supervisor] and me on 7 March 2009 there was information that I consider, with the benefit of hindsight, could have been given to me so that I would be better able to make decisions about what needed to be done in the face of the apparent failure of the float valve". Further, "...my post incident analysis indicates that the 9 5/8" casing shoe most probably did not form an adequate primary tested barrier however on the day with the information supplied to me, I had no reason to suspect that it was not an adequate barrier" (Wilson, 2009, 259). He seems to have conceptualised his role as one of giving advice when asked, rather than actively supervising or providing a level of specialist technical oversight of well integrity issues.

This significant confusion over the role of senior management personnel with an apparently high level of technical knowledge was also seen in the decision not to reinstall the 9 5/8" PCCC after the cleaning of the threads on the 13 3/8" casing. In his statement, the Well Construction Manager (who was on the facility at the time) says that, based on the other barriers in place, "...there was no compelling reason to re-install the 9 5/8" corrosion cap" (Duncan, 2009, 251). Contrary to this, he told the Inquiry during the hearing that he had expected that the cap would be reinstalled once the cleaning work was complete and that when he discovered that it had not been installed he did not insist on the basis that "he did not want to give the impression to personnel on the rig that he was trying to teach them how to do their jobs" (Borthwick, 2010, 3.187). In fact it was the Well Construction Manager's role both to ensure that work was done in accordance with plans (and he apparently planned that the cap would be reinstated) and also to ensure the technical robustness of activities undertaken. To leave a well barrier uninstalled for such a reason is clearly an abrogation of both the managerial and technical responsibilities of this role. The blowout occurred approximately fifteen hours later.

Another independent check on activities might have been the corporate Health, Safety and Environment (HSE) specialists. The Well Construction Manager had overall responsibility for the development drilling activity. He reported to the Montara Project Manager, who reported to the Chief Executive Officer (CEO) (Jacobs, 2009, 4, 17-23). Corporate HSE functions report via a separate line to the CEO and appear to have played no role in integrity assurance in drilling activity, despite the statement from the Chief Operating Officer (COO) that the Well Construction Department works under the Corporate Safety Management System (Jacobs, 2009, 4, 26).

Similar issues related to organisational design (that is, structure, roles, reporting lines related to technical specialists) have been highlighted in analyses of other accidents. Analysis of the circumstances surrounding the Texas City refinery accident (Hopkins,

2008) showed that those with technical responsibility for process safety issues were marginalized by the organisational structure. This left them unable to raise their concerns with senior management in any way that was effective in initiating action. Similarly, the report into the *Columbia* space shuttle disaster discussed attributes of organisational design related to the power and authority of technical specialists that could be expected to prevent such incidents from occurring again. In particular, the report called for (amongst other things) “a robust and independent program technical authority that has complete control over specifications and requirements, and waivers to them” (CAIB, 2003).

The situation here seems to have been even more unsatisfactory as there was no effective engineering input into well operations and no integrity assurance function operating in the organisation with regard to well activities at the time of the blowout.

2.3.3 Effective change management - rule compliance versus risk assessment

The lack of specific direction from onshore management apparently left work on the rig being done in accordance with company written standards and other documentation. As the COO says “...the [company] system relied upon the personnel involved in well construction following the requirements of the Well Construction Management System...it also relied on the expertise of the [rig] operator’s supervisory personnel and the [company] drilling supervisors to monitor and check that the [rig] personnel complied with the drilling programs...” (Jacobs, 2009, 77). This seems to indicate that what senior company management expect from offshore personnel is compliance with written rules and standards.

In his statement, the Well Construction Manager explains the role of one of the key documents, the Well Construction Standard (WCS), as follows: “The purpose of the WCS is to provide standards for all aspects of well design, construction, testing, abandonment and intervention that involve a risk to safety, quality or integrity. The WCS are applicable to all aspects of well design, well construction, well servicing and well abandonment. We generated and prepared the WCS through a series of reviews and workshops with the well construction team. However, the WCS was not a prescriptive set of rules to cover every possible scenario but includes processes to risk assess and manage scenarios not considered between document revisions” (Duncan, 2009, 43).

He is taking a rather different view of the role of the technical requirements (on such critical safety issues as well control barriers) contained in the WCS. This material has effectively been downgraded from something that requires mandatory compliance to playing the role of a guideline that can be varied based on a risk assessment. One example of how this was working in practice is the documentation regarding the change to the well design from cement plug to PCCCs. Part way through the drilling of the H1 well, the written drilling plan was changed to include PCCCs, despite the fact that this device is not listed as a well control barrier in the WCS. Arguments used by various company personnel in favour of the change include:

- PCCCs are better than cement plugs;
- PCCCs have the same functionality as other devices that are listed in the WCS so they are, in effect, approved;
- The WCS allows for two suspension options:
    - Temporary suspension “where the [rig] remains on location”; and

- Long term suspension "when the [rig] leaves the site. Wells must be suspended so that they can be abandoned with rig-less intervention to meet the standards below."

In the case of Montara, the drilling rig was leaving the site, but there was no plan to abandon the wells, so the company argued that it was reasonable to use the standards applicable to temporary suspension, even for the period when the drilling rig was elsewhere (Wilson, 2009, 152; Duncan, 2009, 159). Their point seems to be that the WCS does not allow for batch drilling. That is the case where wells are suspended and the rig departs, knowing that it will return for more planned work. This is indeed a situation where the rules may not be applicable and a risk assessment of the batch drilling case could have been used to develop a new range of acceptable well control barriers based on the risks involved.

Putting that aside, other claims about the functionality and effectiveness of the PCCCs are not supported by the information supplied from the manufacturer. The Drilling Superintendent says he sent the manufacturer's instructions offshore so that "…the caps could be installed as per the manufacturer's instructions. I assumed that those instructions would call for an in situ pressure test after installation and I did not note prior to sending out the manufacturer's instructions that they themselves did not call for the PCCCs to be pressure tested once installed" (Wilson, 2009, 198). In fact, the Operating and Service Manual for the PCCCs explicitly states that they are not designed to operate as barriers against blowout and are only meant to be used on a well that has been plugged and secured. It seems likely that, in preparing the risk assessment on the proposed change, the Drilling Superintendent did not read any of the material provided by the manufacturer for this critical safety device (Borthwick, 2010, 3.215).

Hopkins (2010) has highlighted the interrelationship between risk assessment and rule compliance. He points out that rules are often based on risk assessments and that, as far as possible, risk assessments should be formulated into rules to assist end point decision makers such as those involved in operational drilling activities. He highlights other accidents where the temptation to risk assess one's way out of specific safety requirements has contributed to accidents, as appears to have been the case with Montara.

This section has proposed three ways in which organisational systems could have been improved to the point that the blowout may have been avoided. The common factor is maintaining an organisation-wide focus on well integrity issues driven by management constantly paying attention to them. Decision making research in high hazard organisations (Hayes, 2009b) has highlighted the value of shared stories about past failures as a way of keeping alive the level of respect that is necessary in order to make effective decisions in these circumstances. In complex systems, management decision making is not only about finding the right answer. It is also critically about asking the right question. This is a key function of managers in their role as *sense givers* for the organisation (Weick, 1995, 10). It seems likely that a fly on the wall offshore or in the office would not have heard stories about past failures and the need for integrity assurance, but rather talk of operational priorities and cost savings.

Technical decisions were left to those offshore who adopted an attitude of trial and error learning. This is highly problematic and such attitudes can be contrasted with those that HRO researchers tell us are necessary to avoid accidents in the long term, such as preoccupation with failure (Weick and Sutcliffe, 2001). Instead, these people as a group seem to have moved to an attitude that assumes everything is fine until proven otherwise. Use of trial and error learning in a high hazard environment such as offshore drilling makes the occurrence of a serious incident only a matter of time.

2.4 Regulatory failure

For historical reasons that are not directly relevant here, well integrity is regulated outside the main Australian offshore safety case regime. Despite this, the two sets of regulations have a common approach to safety assurance. The fundamental requirement of the type of goal setting regulation used throughout the offshore oil and gas industry in Australia is that operating companies must set their own standards based on the hazards and risks posed by their activities, and then do what they say they will do (Ayres and Braithwaite, 1992; Hood, Rothstein and Baldwin, 2004). In the case of Montara, this system failed. PTT failed to comply with its Well Construction Standards (WCS) in numerous ways including:

- failure to test the cemented casing shoe and subsequent reliance on this untested barrier;
- reliance on pressure containing corrosion caps (PCCCs) as a well barrier when these are not approved in the WCS;
- failure to install sufficient barriers to meet the requirements for long term suspension of the well when the *West Atlas* left the field; and
- failure to monitor completion fluid parameters to ensure overbalance and subsequent reliance on this unmonitored barrier during temporary suspension (when the *West Atlas* returned to the field).

The Montara Commission of Inquiry reported that “the regulatory regime was too trusting and that trust was not deserved” (Borthwick, 2010, 18). This refers to the lack of enforcement activity to ensure that the operating company complied with their own procedures and standards. It is true that stronger enforcement may have made a difference to the outcome, but to limit the regulatory response to issues of ensuring more active enforcement fails to address the fundamental issue which is that the current regulatory regime does not address the types of issues raised. In fact, the fundamental management problems described above require a different regulatory response – one that addresses directly the need for organisational competence and capacity in recognising and learning from problems.

The following section moves from the Montara case study to consider how the goal setting approach to safety came about.

3. Background to Current Regulatory Policy

The Australian regulatory regime for offshore safety is based on the same theoretical frameworks as the equivalent regimes in Europe. This section describes the background to this method of societal control of the offshore oil and gas industry in an effort to ensure safety of workers and the public.

3.1 Regulation of offshore safety

In most jurisdictions, prior to the mid 1980s, the safety of workers in the offshore oil and gas industry was regulated through a set of prescriptive rules with which companies were required to comply. In some cases, the rules were contained in the regulations themselves and in other cases the regulations referred to established industry-based standards. The primary safety focus was on physical dangers associated directly with the work undertaken in the offshore environment – issues such as exposure to toxic chemicals or asbestos, electrocution and work at height or in a confined space.

A series of major disasters in the offshore industry in the 1970s and 1980s highlighted the limitations of this approach and provided a driver for major regulatory change in Europe and Australia (but not the US). In 1980, the *Alexander Kielland,* a drilling rig that had been converted to a *flotel* to provide offshore accommodation for almost 400 workers, was operating in the Norwegian sector of the North Sea and 123 people died when the facility sank in heavy weather as a result of a structural failure. This incident graphically highlighted the limitations of a regulatory approach that at that time largely ignored low frequency but potentially high consequence events (Haukelid, 2008).

Several years later, in 1987, the *Piper Alpha* platform in the UK sector of the North Sea was destroyed by a series of fires and explosions and 167 people died as a result. The public inquiry that followed (Cullen, 1990) recommended major changes to various aspects of the offshore industry, including the philosophy underlying the extant regulatory regime. Operating companies were thus required to prepare and submit a safety case that would be accepted (or not) by the regulatory authorities. This case literally requires companies to demonstrate that their facility is sufficiently safe by describing the processes by which hazards are identified, risks are assessed and, most importantly, that they are appropriately and sufficiently controlled in an ongoing manner. The overall requirement is the demonstration that risk has been reduced to a level that is as low as reasonably practicable (or ALARP).

This proposal for regulatory change was adopted in the UK (Paterson, 2000) and, with only minor amendments, this regulatory regime remains in place today. The Cullen Report was also very influential in policymaking outside the UK. Holland made similar changes to both offshore and onshore petroleum regulation (Hale, Goossens and van de Poel, 2002) and Australian regulation of the offshore oil and gas industry also moved to a safety case regime, firstly for new developments and then for all existing facilities. This type of regulation is often called *goal-setting* as opposed to the previous *prescriptive* approach because the regulations describe processes that must be put in place, rather than specific measures that must be taken, to ensure safe operations (Kirwan, Hale and Hopkins, 2002).

Risk-based regulation of this kind (with or without using the term *safety case*) is now widespread in complex socio-technical systems – both in the industrial sector and related to public infrastructure. Demonstration of adequate risk management practices is now commonly used in Europe and Australia as the basis for regulation of worker and public safety in aviation (Maurino et al., 1995; McIntyre, 2000), nuclear power (Schobel, 2005; Williams, 2002), chemicals (Hopkins, 2002; Oh, 2002) and railways (Hale, Heijer and Koornneef, 2003) amongst others. The perceived benefits of this approach include placing the responsibility for safety clearly with the operator, rather than the regulatory body, allowing innovative solutions and use of innovative technology and focussing enforcement efforts onto risk controls that are specific to the hazards and risks on each facility.

3.2 The effectiveness of the safety case

Since this approach to ensuring worker (and public) safety has been so widely adopted, it might be expected that it has been shown to be effective in reducing injuries or fatalities. To date, it has been very difficult to make an objective determination regarding the effectiveness of safety case style regulation. If this approach is successful, then the ultimate benefit should be shown in improved safety performance but since serious incidents are relatively rare, statistical conclusions are difficult to draw in an industry where other environmental factors are constantly changing. Several studies have attempted this exercise and all have tentatively reported positive results based primarily on qualitative, rather than quantitative, arguments (HSE, 1995; HSE, 2003; Rose and Crescent, 2000; Vectra, 2003; Vinnem, 2010). Further, a risk-based safety regime does not eliminate the need for a competent and well-resourced regulatory agency. In fact, reviews of the effectiveness of safety case regulations typically become reviews of the effectiveness of the regulator in enforcing the regulations, rather than a critique of this approach per se.[ii]

This issue has come under particularly close scrutiny following the Deepwater Horizon incident in the Gulf of Mexico. At the time of the incident, the safety regulation in place for the offshore oil and gas industry in the US took the form of a prescriptive, standards-based regime. The report of the National Commission on the Deepwater Horizon Blowout includes a summary of the development of the safety case approach in the nuclear, chemicals, aviation and offshore oil and gas industry (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011b, 69). The report points out that the fatality rate in the offshore oil and gas industry in the US is at least four times the fatality rate in European jurisdictions that have operated for several decades under safety case legislation.[iii] The Commission had no hesitation in recommending that the US move to "… a proactive, risk-based performance approach specific to individual facilities, operations and environments, similar to the 'safety case' approach in the North Sea" (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011b, Recommendation A2 page 252). It must be noted that, continuing the strong resistance to this approach that has been historically a feature of the US offshore oil and gas industry, it appears likely that this recommendation will not be adopted.

Whilst objective evidence is somewhat ambiguous, there is no doubt that operating under a safety case regime has increased the attention paid to safety within the industry. Hale, Goossens and van de Poel (2002, 104) describe the benefit of ten years of risk-based regulation for the petroleum industry in Holland as "companies have become more risk aware, safety cases and safety management systems are positive developments and there is more understanding of how and why risk control and management measures work". A major benefit of the safety case regime comes from the ongoing conversation about safety and engagement with safety-related issues within industry, especially related to relatively rare events that would otherwise generate little discussion.[iv]

4. Continuing Disasters – the Social Science View

The links between the events surrounding the Montara blowout and the actions of those in the operating company described in section 2 are not unique. In parallel with the regulatory developments described in section 3, social scientists from various fields (sociology, management, organisational psychology) have taken an increasing interest in industrial safety. The work is generally of two kinds – accident analysis and normal operations studies.

A significant body of analysis has grown up based on the work of social scientists regarding the causes of specific disasters in complex socio-technical systems - for example, the loss of the space shuttle *Challenger* (Vaughan, 1996), the loss of US Black Hawk helicopters (Snook, 2000), the loss of the space shuttle *Columbia* (Starbuck and Farjoun, 2005), the explosion and fire at Exxon's Longford gas plant (Hopkins, 2000), the BP Texas City Refinery fire (Hopkins, 2008) and the Montara blowout (Hayes, 2011). This has led to generalised models regarding the organisational causes of accidents, the most well known of which is James Reason's Swiss cheese model (Reason, 1997). In this way of thinking about accidents, there is a range of defences in place that are functionally designed to prevent any given hazard from leading to a loss of some kind (such as an accident). In practice, these defences are imperfect (like holes in Swiss cheese). The various hardware and procedural measures in place ensure that failure of any individual measure is not catastrophic. An accident occurs when the holes in the cheese line up and provide an accident trajectory through all the defences.

In this model, the holes in the cheese have two interesting features. Firstly, they may be due to active failures – errors made by field personnel - or they may be latent failures. Latent failures are weaknesses in the system that do not, of themselves, initiate an accident, but they fail to prevent an accident when an active failure calls them into play on a given day. Problems arise when latent failures in the system accumulate – maintenance is not done, records are not kept, audits are not done. The consequence of a small active failure can then be catastrophic as the protective systems fail to function as expected. The second quality of the holes in the Swiss cheese is that they are a function of the organisation itself. In this model of accident causation, operator actions in the field are linked to workplace factors such as competency, rostering, control room design, task design etc and these issues are linked to organisational factors such as budgets, safety priorities, leadership etc. In this way of thinking about safety defences, the performance of all components in the system is interlinked.

In parallel with this work, there has been another complementary strand of social science research looking at successful organisations and how they achieve high levels of safety performance. Researchers who favour this *high reliability* view favour an ethnographic or sociological approach to what are known as *normal operations studies* (Allard-Poesi, 2005; Bourrier, 1998; Bourrier, 2011; Hopkins, 2009; La Porte and Consolini, 1991; La Porte, 1996; Roberts, 1994; Rochlin, 1999; Schulman, 1996; Weick, 1987; Weick, 1993; Weick and Sutcliffe, 2001; Hayes, 2009b). Researchers in this field have published many organisational studies of the qualities of high performing organisations, but the only integrated theory which draws all these strands together is Weick and Sutcliffe's High Reliability Organisations (HRO) theory (2001). These researchers claim that high functioning, or high reliability, organisations have the ability to detect and respond to system variations due to their state of mindfulness about their operations. In turn, mindfulness is fostered by five qualities, which are:

- preoccupation with failure – seeking out small faults in the system and using those to improve performance;
- reluctance to simplify – valuing diversity of views and resisting the temptation to jump to quick conclusions;
- sensitivity to operations – valuing experienced operating people who have a nuanced system understanding'
- commitment to resilience – using layers of protection, valuing redundancy in equipment and people;
- deference to expertise – placing appropriate value on the advice of technical experts in decision-making.

There has been significant practical uptake of these research results primarily in the field of incident investigation. It is now common for formal investigations to include a social science perspective in addition to a review of more proximate technical issues - for example, the investigation into the storage tank fire at Buncefield (HSE Major Incident Investigation Board, 2008), the Baker Panel review of BP's US Refining Operations after the Texas City refinery fire (Baker, 2007), the review of the Columbia Investigation Board (CAIB, 2003) and the report of the National Commission following the Deepwater Horizon blowout (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011b). These analyses rarely reveal new technical information regarding the causes of accidents but, rather, show that existing technical information has not been applied, usually for social, rather than technical, reasons. Despite this practical use of the large body of theoretical work, these issues have largely been ignored by oil and gas safety regulators. The exception is Norway, where regulations requiring an operating company to promote a sound safety culture have been in place since 2002 (Høivik et al., 2009; Hopkins, 2007).

In summary, a series of serious accidents in the 1980s provided the impetus for some major changes in safety regulatory policy to address high consequence accidents. Despite the fact that several serious accidents had occurred, they were still relatively rare events and a new regulatory approach based on an assessment of facility specific hazards, risks and controls was developed. This safety case style of regulation has been in place in many high hazard industries and many (non-US) jurisdictions for more than two decades. Despite the popularity of this approach, compelling evidence that such regulation is effective has proved to be elusive. In fact, major disasters have continued to occur and analysis of the causes of these incidents by social scientists has shown that a range of organisational factors are common causes. These factors are excluded from consideration in safety cases. The next part of this paper discusses some of the reasons why this is the case.

5. Incorporating Organisational Issues into Offshore Safety Legislation

The previous section has described how research into organisational causes of accidents has been largely ignored by regulatory policy makers (with the exception of policy makers in Norway). This section focuses on three key issues that impact the integration of an organisational view of safety into the current risk-based regulatory policy.

As Power says:

> [D]espite the motivational power of the many insights derived from post-disaster analysis, and their roots in soft organizational psychology, the managerial institutionalisation of these insights has been problematic. It is not that practitioners of risk management are resistant to these ideas - quite the opposite is true; they are completely persuaded of the importance of 'risk culture' and constantly make judgements about it. But these judgements are difficult to represent within rationalized designs for risk governance and the climates of auditability within which they operate. Risk insights can only acquire formal managerial significance within the conceptual and operational space of auditing and internal control systems (Power, 2007, 178).

The first problem is that organisational issues apparently do not fit into the risk-based model of safety cases. In fact, the narrow way in which concepts of risk are used to address offshore safety effectively hides organisational causes. Since these causes are real, risk-based thinking needs to be broadened to allow such concepts to be taken into account.

The second difficulty in incorporating organisational issues into regulation is that there is no widely accepted unified framework for organisational safety on which to base regulatory requirements. This is not a reason to ignore the current substantial body of academic knowledge in this area, and some factors on which there is broad agreement are proposed as a starting point.

The third issue, addressed below, is the view that using anything other than a risk-based frame of analysis is inconsistent with goal-based regulations such as safety cases. This is true only in the narrowest of views of this self-regulatory approach and, again, the approach should be broadened to allow organisational issues to be considered if safety performance is to be effectively regulated.

5.1 Incorporating organisational issues into consideration of risk

The foundation of the safety case approach is to identify and document the specific hazards, specific risks and the specific engineering, administrative and procedural measures that address them. To meet regulatory requirements, submissions to regulatory agencies must provide concrete details. Ultimately compliance and enforcement activities focus on engineering hardware and activities in the field, prioritised on the basis of risk. In this case, risk is conceptualised by operating companies and regulators as the product of frequency and consequence and is often quantified. This in turn allows the results to be compared with numerical criteria and the justification for physical changes that reduce risk to be assessed on the basis of cost benefit analysis (Paterson, 2000).

In some ways, this narrow conceptualisation of risk has served society well. There is no doubt that safer designs are produced when engineering failures that could occur during operation are explicitly considered as part of the design development process. Modelling techniques for physical effects such as the prediction of explosion overpressure and the impact of fires on structures have improved dramatically in the past two decades. On the other hand, attempts to incorporate human and organisational error into this narrow definition of risk have been largely unsuccessful (Forester et al., 2006). Whilst the power of the safety case approach is in the concrete and the specific (Rasmussen and Svedung, 2000), the nature of the organisational contribution to safety performance is universal and diffuse. This means that, despite the evidence described regarding the organisational contribution to risk, the insistence on measurement and quantification of risk has led to these issues being systematically ignored.

Based on the collective imagination of technical professionals dealing with offshore design decisions in particular, risks are discussed and managed as if they are real phenomena – a physical property of the engineered system that can be measured and manipulated. The role of human judgement and experience is often unacknowledged in technical decision making (Hayes, 2009b; Power, 2007). Regulators and operating companies have lost sight of the view that risk is a mental model of how actual harm can be predicted and controlled (Aven, Renn and Rosa, 2011; Douglas and Wildavsky, 1982; Power, 2004; Power, 2007; Renn, 2008; Wildavsky, 1988). In making sense of the world, technical organisations and regulators have considered technical cues in constructing and enacting their reality because these are the issues that are apparently controllable. According to Scheytt et al (1993), "we call something a risk when we seek to bring the future into the present and act upon it, i.e. make it decidable".

The technical view of risk systematically emphasises those risks that can be calculated and quantified. Whilst this has led to improvements in engineering analysis, it has also resulted in issues such as leadership, professionalism, competence, experience and judgement being ignored despite compelling evidence that the potential for harm from any hazardous activity depends critically on these factors. A broader understanding of the concept of risk is needed to encompass identification and management of relevant organisational factors.

5.2 Organisational issues to regulate

Incorporating requirements in safety legislation about how operating companies should manage organisational issues, implies agreement on an appropriate model which defines what issues impact safety and how they should best be managed. Unfortunately, there is no unifying practical framework that allows organisational issues to be addressed in the same way as technical safety risk although attempts to create such a framework are often drawn together under the general description of safety culture.

Many theorists have noted inconsistencies in the way this term is used and the implications for its utility in improving safety performance (Antonsen, 2009; Haukelid, 2008; Høivik et al., 2009; Hopkins, 2005; Klein, Bigley and Roberts, 1995; Ocasio, 2005; Pidgeon, 2010; Silbey, 2009), for example,

- lack of agreement over whether culture is a fundamental property of an organisation or a process that enacts organisational life (or both);
- linkage (or lack of) between the concept of safety culture and broader organisational culture;
- the extent to which culture is homogeneous across an organisation; and
- how / if safety culture (or safety climate) can be measured.

These issues have a direct impact on the extent to which culture is manipulable by management (and appropriate for regulatory attention) in ways with predictable outcomes for safety performance. This has certainly been the goal of much of the work in this area, but the results have been mixed. Power maintains that efforts to audit organisational culture are "essentially reductive" and that "indicators lose their proxy status and become regarded as the things they stand for". His view is that good risk management is an "organizational conversation" which does not lend itself to standardised routines and auditable processes (2007,177).

Rather than seeking to regulate organisational culture overall, a better approach may be to focus initial policy in this area on some specific factors where there is general theoretical agreement. One issue on which high reliability theorists, resilience engineering practitioners and safety culture academics all agree is the importance of learning from incidents – both small and large. This provides a potential place to start in regulating organisational issues. This is not simply a matter of ensuring that an incident reporting system is in place but rather requires a broader focus on organisational learning (Hayes, 2009a). Various authors (Busby, 2006; Hopkins, 2008; Pidgeon and O'Leary, 2000; Pidgeon, 2010) have noted barriers to learning from accidents and incidents. Pidgeon (2010) describes the main reasons that organisations are blind to latent failures in their systems as lack of "safety imagination" and conflicting interests as a result of organisational power and politics whereas Busby (2006) proposes a range of factors that are either requisite for mobilisation or can undermine change once it is underway. Hopkins' analysis of the BP Texas City refinery incident (2008) identifies a number of organisational factors that prevented BP from acting on evidence of problems, including the sidelining of technical specialists and the lack of senior management performance incentives regarding process safety performance.

There is ample research available that provides indicators of the factors that are important in ensuring that organisations notice small incidents and act on the lessons that can be learned. This would be a useful focus for regulatory attention without requiring an agreed universal framework for systematically addressing all organisational contributors to accident causation. Whilst a broader engagement with organisational issues may ultimately be desirable, it is worth noting the general experience on the utility of the safety case for technical safety issues as described above. The evidence suggests that paying attention to these issues is, in itself, important. Requiring organisations to pay more attention to learning lessons from small incidents is a valid and useful regulatory goal in its own right.

5.3 Safety cases and enforced self-regulation

The safety case concept requires that operators demonstrate that the systems and processes that they have adopted ensure that their facility is sufficiently safe for all those people who are possibly impacted by their activities (workers and contractors at their facility, passengers and customers, people who live and work in surrounding areas). Most safety case regulations require the demonstration to take the general form of showing that risk is as low as reasonably practicable ie ALARP (or that risk has been reduced so far as practicable – SFAP). Clearly, safety cases are an example of the broad trend toward risk-based regulation (Hood, Rothstein and Baldwin, 2004).

Safety case regulations can also be characterised as a type of enforced self-regulation (Ayres and Braithwaite, 1992). This type of arrangement achieves regulatory goals firstly by requiring organisations to produce their own set of standards that they must undertake to meet and secondly by enforcing compliance with those standards. Paterson (2000, 243) describes the safety case approach to regulation as "instead of translating engineering or management norms into generalised legal norms, it allows the production of context-specific social norms and holds the operator to compliance with its own standards and procedures".

Requiring organisations to submit as part of their safety case a company-specific description of how small failures are identified and lessons learned would fit well within this framework. Guidelines that invite companies to address such issues as organisational structures, defined roles and responsibilities, remuneration packages and bonus arrangement, separation of technical and managerial responsibilities and other organisational factors would ensure that consideration was not focussed only on traditional management system items such as databases and forms.

6. Preventing another Montara

If the operating company of the Montara development had been required to make a regulatory submission about relevant failures in industry and in their own operations – how they are identified and what lessons can be learned – would the blowout have been less likely to occur?

The organisational processes described seem to indicate that trial and error offshore was the primary method of organisational learning regarding drilling practices at Montara and that very little heed was taken of past experience. On the other hand, there was plenty of information about past incidents and accidents available to the organisation that was directly relevant to H1 activities if only someone had taken the time to seek it out. This could have impacted on the decisions made if only systems and processes had been in place to ensure that such information was considered in well design and operations.

Firstly, in relation to the installation of the cement shoe, cementing is generally understood to be a safety critical activity in well construction. Cemented shoes, cement plugs and similar devices are used as primary well control barriers and cementing problems contributed to eighteen of thirty nine blowouts on the US Outer Continental Shelf in the period 1992 to 2006 (Izon, Danenberger and Mayes, 2007). If demonstration of learning from accidents is an explicit requirement of the regulations, then it is difficult to see how cementing of the shoe would not be seen as safety critical with the integrity of the final arrangement closely controlled. In that case, the company would have to make better arrangements for technical review of the results of the cementing operations and subsequent testing.

If the justification for use of PCCCs had required a review of where these devices had been used previously for well control, this could have revealed that the devices were not designed for the function that they were proposed to be used for on the H1 well.

In addition to processes to ensure that critical technical activities were identified, social science based guidelines regarding learning from incidents would also address issues such as the location of technical experts within the organisation. This would require organisations to consider this issue explicitly and hence give regulators access to monitoring and enforcement actions linked to these issues.

In common with the other parts of the safety case regulations, the benefit of including social science aspects is that it requires explicit consideration of and commitment regarding safety controls by the operating organisation. If such a requirement had been in place before the Montara incident it is possible that the operating company would have been more aware of its specific vulnerabilities in this area and taken steps to address the large gaps in the way the integrity of well operations was assured.

7. Conclusions

Offshore safety regulation is an example of self-regulation, where internal company governance processes form the basis of public trust. Safety in the offshore oil and gas industry is primarily the responsibility of the duty holder, but accidents are also an indication of the failure of government and regulation. Many researchers have shown that accidents in complex socio-technical systems such as offshore drilling rigs and production facilities are caused by organisational failures and yet the prevention of failures of this type is not commonly addressed by risk-based safety regulation. Processes relating to identification and control of technical risks receive a generally high level of regulatory scrutiny but, with the exception of the Norwegian regulatory arrangements, issues such as leadership, professionalism, competence, experience and judgement remain unexamined despite their criticality in preventing deaths, environmental damage and major financial losses.

Attempts made to date to incorporate these issues into consideration of risk have not been very successful, primarily because of the three issues described above – difficulty in linking organisational factors into the current risk management tools, lack of a universally agreed framework for organisation issues, and a narrow understanding of the concept of risk leading to a misconception about what can and cannot reasonably be addressed in a safety case.

Regulation is as much about behaviour modification as it is about setting of standards (Baldwin and Black, 2008; Hood, Rothstein and Baldwin, 2004). As Ayres and Braithwaite maintain, "[t]he very behaviour of an industry or the firms therein should channel the regulatory strategy to greater or lesser degrees of government intervention" (1992, 4). Evidence from the Montara incident and other disasters illustrates the need for regulatory change in this area. This paper has outlined a proposal to incorporate social science research regarding learning from incidents and small failures into the technical risk management processes that currently dominate consideration of risk within the safety case framework.

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[i] Whilst the environmental impact of the Montara blowout is limited compared to the Deepwater Horizon incident, there have been impacts felt in West Timor and the Commission of Inquiry has highlighted that the lack of baseline data and the slow response in putting a monitoring plan in place mean that the full extent of the impact of the Montara spill will never be known.

[ii] In Australia, there is a specific requirement (see *Offshore Petroleum Greenhouse Gas Storage Act* section 695) for a review of the effectiveness of the National Offshore Petroleum Safety Authority every three years. In practice, this judgment is made subjectively based on a comparison of NOPSA's practices with those of other regulators internationally and the views of key stakeholders, including industry.

[iii] For a detailed analysis of the available fatality and injury data see also National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011a, "A Competent and Nimble Regulator: A New Approach to Risk Assessment and Management", Working paper 21.

[iv] There is a growing unease amongst some members of the offshore industry that the generation now reaching senior management positions which give them significant decision making powers were not working at the time of the Piper Alpha incident in 1987 and hence have no personal experience of the shock such events cause.

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