Drilling Process Safety 101

Drilling Process Safety is above and beyond the mandate of 30 C.F.R. § 250.401, which requires any operator undertaking to drill and complete a well, to take all "necessary precautions to keep the well under control at all times.", and yet also includes monitoring, accounting, and communicating the combination of factors which together indicate probable consequences and thus able to assess the current dynamic status of risk to make prudent decisions as to operations and also to decide the minimum qualifications of personnel required to make such operational decisions. In essence Drilling Process Safety is assessment of dynamic risk so as to affect conduct in a process that has its first priority as keeping a well under control and subordinates even the priority of personal safety in extreme circumstances and balances focus appropriately with operational and personal safety objectives.

In the past Drilling Process Safety has been widely ignored in deference to sole focuses on commercial risk registers and the reasons are numerous and company specific and yet one reason is worth noting. Drilling experts tend to be overconfident in their predictions only in "low validity" environments (Kahneman & Twersky 2011). "Low Validity" is when feedback on the consequences of their performance is either absent or scarce. There is no better example of a "low validity" environment than drilling process safety. Since the frequency of incidents is tiny many in the industry have deemed the risk inconsequential (in the past and still to this day) and ignored it (and many still do), in terms of commercial risk. As pointed out by scientists in cognitive psychology the judgment of experts in these situations is no where near as good as the performance of formulas (Kahneman & Twersky 2011). Experts can protect themselves from their own error in judgment in "low validity" environments by using a simple formula. There is a formula for assessing the risk in regards to ignoring Drilling Process Safety.

The formula to use is: (Probability of Occurrence) X (Consequential Cost) = Risk.

Using this simple formula it is clear that while the probability of a drilling process safety incident is very low the risk of it is high to moderate and should be on all deepwater risk registers and many onshore. The reason for the lack of attention to drilling process safety that has led to Montaro and Macondo, is that while Probability of Occurrence is low, the Consequential Cost is in the $Billions, and yet people that, for whatever myriad of misguided reasons, want to ignore the drilling process safety risk simply substitute Probability for Risk in their thoughts and arguments. This risk still substituted with probability and ignored in this way in therefore solely commercial risk registers today and in many companies. An argument in the Macondo trial that Drilling Process Safety is inherent in the engineering onshore and on the rig is not true and the proof can be seen in the lack of heightened situational awareness prevalent in the disaster itself. Read the reason why Stop Work programs do not work in regards to Drilling Process Safety and why a dynamic risk assessment is needed and simply while personal safety works on an individual basis, process safety requires a groups assessment of risk, dynamically, and requires this to be constantly conveyed to a team so they can plan their situational awareness levels in terms of competency, redundancy, and heightened awareness in general.


Categorically the Macondo blowout was not from a kick yet from the removal of a barrier (decreased hydrostatic column) yet if the emphasis is on the last barrier never being removed and not on the BOPE as being the last barrier and yet as being the “fail-safe” the psychology of subtly tolerating more risk is mitigated. A kick is more of a failure to predict pressure before
drilling through a sand or perhaps the sand coming in at a depth higher than expected yet both are essentially a failure of the drilling margin or, if you will, a failure in the perception of a drilling margin, yet simply and exactly a failure.

Managing a drilling margin as the last barrier is extremely complex since even in development well drilling we do not know everything yet we must focus on this task and ignore the fail-safe in terms of risk tolerance for the sake of focus on our objective of maintenance of the drilling margin which is Drilling Process Safety 101. Guarding the last barrier while drilling or the “drilling margin” should be the focus and the use of the "execution" tools: downhole tools like LWD, PWDs, FPWDs, etc. reading any indications of changes in the drilling margin and others on surface like gas units, cuttings indications, and surface indications of the drilling margin like ROP, WOB, etc. and before all of this the PPFG prediction itself, that designates the pre-drill drilling margin. Kick indications are not execution tools either yet are simply indicators of failure of the last barrier while drilling, the drilling margin, and the first signs that the "fail safe" must be used immediately as a failure mitigation of the failed drilling margin.

The BOPE is the “Fail Safe” and failure to predict pressure and depth of sands requires GEO accuracy and synergy with engineering. The PPFG defines the barrier and the adequacy of the barrier is further designed by engineering by kick tolerance estimations pre-drill and yet even the term "kick tolerance" and "kick intensity" belies the issue with our mindset in tolerance for kicks, in designing casing seats and thus drilling margins we imply that we are tolerant of a kick of certain intensity. The leading indicators of an erosion of the drilling margin needs to be our focus in drilling process safety as the execution tool and although the fail safe performance of the BOPE is a function of the mostly lagging indicators of the failure of the drilling margin detecting these lagging indicators ASAP decreases the risk of the failure of the "fail safe" BOPE and therefore must always be diligently watched and also diligently engineered for improvements.

As we go into deeper water and deeper formations we increase interactive complexities tighter coupling of operational synergies and our "fail-safe" gets closer to the bubble points of the gases in our muds from sands with higher gas to oil ratios and our response time shortens further still exactly as we need more of it. BOPE isn’t an execution tool used to overcome bad and unsafe drilling practice yet a “fail safe” only used after a failure in drilling operations to maintain the drilling margin.

Remember, if you know the story of Macondo, that the higher ups in the command chain were dancing and otherwise distracted and not aware of or perhaps not knowing that leading indicators in process safety were signaling poor performance and escalating risk and ultimately disaster ahead. They were oblivious because they were only observing personal safety indicators that were signaling them that things were going great in fact they were awarding the team a safety award based on personal safety and absolutely oblivious to the process safety indicators that we all agree would have signaled them to shut the operation down completely and would have been the end of the dancing and unconcerned email chatter. They were indeed conveying frustration within the team and this in itself would make another excellent leading indicator of problems within the process safety realm. This is the way to go not focus on prescriptive mitigations of symptoms of poor performance and yet to focus on the cause; the operator and shutting them down due to risk escalated past a certain threshold of acceptability.
Don't handcuff the operator along the way stifling their freedom to innovate and yet only after exceeding a certain threshold of process safety defined risk escalation. Process safety is the answer to allow regulations to be objective oriented and still preventative of disasters brought on by being oblivious to leading indicators of risk escalations that prescriptive regulation do not and cannot address. In the absence of sufficient checks and balances that Drilling Process Safety affords, adding time and cost that does not immediately appear necessary to the safety of the well might not be judged fairly.

If we establish significant steps of hazard thresholds, perhaps green, yellow and red lights, that alert the government and officials with all organizations that there is significant danger in the process these higher ups that would not have made the mistakes these subordinates did make and were unsupervised in making them then certainly we are protecting containment considerably. The escalating hazard levels; green, yellow, red and be triggered after certain objectives were not met; staying with the drilling margin (avoiding kicks), setting casing seats at planned depths, time estimations within error margins, expressions of frustration within the team, etc.. Would possibly be better to have five different colors, green, blue, yellow, Orange and red.

This is how we do this, setup up a hazard alert system based on clear criteria of process safety indicators. The last escalation initiates an immediate "stand down". The regulations become objectives that if not met trigger higher levels of hazard warnings as indicators of the deterioration of process safety. Innovation is preserved and warning signs of escalating risk are noticed, documented, accounted for, responsible for triggering a higher level hazard warning that will either get the attention of the most experienced and skilled within the company or alert the government for the need for an impending intervention and stand down. This system must be simple yet effective in both prevention of blowouts and preservation of innovative operational, engineering and technical excellence in the most difficult drilling situations.

Ultimately this drilling process safety is simply guiding supervisors and the chain of command on how to supervise.

Next though has to be developing a clear and complex algorithm for the hazard escalations and de-escalations with the buy in from all involved. Easy! The objectives are already documented before each well begins in the EP and APD. The scoring of how well the objectives are met and escalation and de-escalation can be done both within an organization and by the government. That would ensure both are paying attention to the risk register. Of course if there is a clearly defined algorithm both the government and company would go by then the engineer in all of us would be satisfied and yet if the risk register was assessed, mitigated and negotiated at each point in time there would be scope and breadth of transparency and communication the industry and regulators have not enjoyed previously.

Procedural objectives would be divided into sections. Smaller objectives within each procedural section. The sections will be hole sections and flat spots. Obviously if the hole section is drilled and the casing set cemented and tested through LOT that whole section risk would “reduced”, according to the testing done on the casing and LOT, and the risk would be mostly assigned to the subsequent risks to be encountered in the next open hole section. Smaller objectives within a hole section would be: staying within the drilling margin: The LOT at the shoe and a safe
margin above the pore pressure estimate. Have new estimates of pore pressure updated in the procedures and conveyed to the rig within certain time limits. Have MOCs of changes to procedures conveyed to all involved within time limits. Have specifications of all equipment met or exceeded.

Have specifications of all personnel met or exceeded. Have communication protocols within teams met or exceeded. Have objections or hazard observances communicated throughout the team, assessed, mitigated and the mitigation communicated back throughout the team as an MOC to procedures, etc. within a certain time limit.

The risks/hazards thusly assessed and broadcasts throughout the team and on the morning reports, etc. will be called the Broadcast Risk of Operating Assessed Dynamically (BROAD). Details for how to assess risk pre-drill and dynamically will be added to the essay, “Drilling Process Safety – BROAD. A sample “Risk Register” of the stages of hazard risk escalation may look like:

0-10 **GREEN** Normal Broadcast Risk of Operating Assessed Dynamically (BROAD)– Proceed

10-25: **BLUE** Low BROAD – Proceed with increased caution

25-45: **YELLOW** Medium BROAD–Proceed w/hi caution & HAZOPS certified personnel

45-70: **ORANGE** Elevated BROAD–Proceed w/HAZOPS certified personnel & supervision

70-100: **RED** Highest BROAD – Stand down

A score can be raised by various mitigations to be determined. Once a hole section is finished the total average score of the smaller sections isn’t weighted as heavily as the passing score of the total hole section and yet the poor performance as indicated by the smaller section scores is not ignored yet can, according to some algorithm be a residual that will recognized improvement or register continual low smaller section scores escalating hazard registers at elevated levels. This all can be worked through on the procedural level by the engineer writing the procedure itself. Drilling procedures that outline objectives with minimal prescriptive mandates are more effective and lend themselves well to this type of process safety accounting scheme anyway.

The scoring doesn’t start with the procedure and the operations during the execution stage of the process it begins in the offices of the operating company in the very beginning of the initial phase with the geologists and geophysicists and engineers in the conceptualization and planning phase. Objectives in the early phases of the process would be related to meeting due diligence, thoroughness and review related goals. Examples of deductions in scoring would be for failure to conduct studies that were indicated as necessary by member(s) of the peer review, not meeting self (or other) imposed timelines or not adjusting them before time expiring, not documenting progress in a process management system (PMS), not procuring equipment with long lead times to match timeline requirements, etc. the list will need to be worked, vetted,
reworked, refined and ultimately blessed, bought into and rolled out as a Drilling Process Safety System (DPSS) within companies and perhaps adopted by regulatory in an effort to rid regulations of prescriptive measures and yet adopt more appropriate objective regulations supervised and enforced by the DPSS.

A DPSS like this will appease the regulatory side while appealing to the operators as being objective and allowing many paths, unprescribed by regulators unfamiliar with drilling or new innovations, to meet objectives and yet with clear understanding of the importance of meeting project specific objectives (outline already in EP and APD documents) and scoring operators as to how they are currently meeting objectives as appropriate indicators of the overall process safety of the project. The registration of measures of risk thus take account of and warn of increases and decreases in risk levels in a manner that will prompt higher levels of diligent supervision as needed in response to escalated levels of risk of loss of containment as represented by the risk register.

Appeals to cutting "red tape" of prescriptive regulations for operators, appeals to preventing accidents for the public and the regulators.

If line of sight decisions need to be vetted then having them peer reviewed (calls to superiors) and definitions of what a "line of sight" decision is in the procedure can be made. Once again the objective is set, peer review of line of sight decisions, and assessed along the way, scored, documented and forever apart of the combined total average score becoming clearly defined as a hazard level in the staged alerts. Line of sight decisions at higher hazard levels would require higher levels of superiors involved in the peer review of the line of sight decisions. Perhaps replacing the person making the line of sight decisions with a person certified to make them at the elevated hazard levels is done as well until the project is de-escalated to a lower hazard level, since it may not be possible to peer review all line of sight decisions.

A Balanced Focus on the True Dangers on a Drilling Rig and the need for Rationality

A teacher told my son that he thinks too much and I told him that she teaches too little.

There is a concept of cognitive ease that describes this behavior. We have a finite cognitive attention and a natural inclination toward cognitive ease. Our brains have sensors like in a cockpit that measure how much effort we must exert for thought based on our current situation. One of these dials measures cognitive ease and range from "easy" and go up to "strained". No major threats, no major news, no need to redirect effort and the dial will read "easy". "Strained" indicates that a problem exists which will require increased effort of system 2 thinking. Mental strain is a combination of current levels of effort and unmet demands. People in states of level 1 cognitive ease are comfortable that things are going well and are more superficial in their thinking, less vigilant and alert to problems and the need to redirect plans and think through the current situation than when in a state of cognitive strain. In cognitive strain people are in less comfort, less casual, more diligent and vigilant in thought and suspicious and less prone to errors. Because once a brain is "primed" to a certain thought, focusing attention on related tasks is cognitively easy. This is how "priming" the workplace with personal safety messages works and puts the focus on fingers and loads overhead and since we have a limited cognitive
attention bank and most tend to be susceptible to cognitive ease this focus may be at the expense of another focus, like downhole and the dangers of a blowout; process safety.

This is why others don't want to hear your suspicious thoughts of dangerous conditions or your thoughts of a non-standard action; it isn't easy. Their brains have not been "primed" with the new investigation procedure you suggested and so it causes cognitive strain they aren't rational enough to be willing to endure additional mental strain or perhaps they can't spare the attention resources due to allocation to other duties. This is why changes to procedures escalate risks, and this is why drilling process safety risk registers that go beyond an MOC are important. Rationality as a competence is important in team members as well and yet systems devoid of drilling process safety breed biases not to be seen in teams with these systems. One comment on rationality as a competence however, although it isn't rational to forego mental effort not all team members are judged on competencies of rationality yet mostly on experience, skill, knowledge and understanding and EQ qualities and yet as we are learning now that isn't enough to ensure they will make rational decisions in moments of cognitive strain. Exactly this range of rationality competence is the reason an elevated risk register may require a company man with an appropriately elevated rationality competence level. Of course this rationality competence is strongly a function of experience and training level in many cases it is a competency that should be carefully noted and tracked as a singular competence as we do skill, IQ, EQ and experience.

We need people with equal levels of IQ, EQ, and RQ and we must "prime" our drilling rigs with balanced messages of personal safety and process safety. Who wouldn't agree that our focus on our rigs must be at least partially on the wellbore and keeping reservoir fluids contained miles below in the sands? And yet how many posters on our walls and JSAs and Safety Moments are devoted to the dangers lurking below with only one barrier between us and disasters like Macondo? Those posters and JSAs are everywhere and they are only about keeping our hands away from pinch points and our hard hats on and looking upward for suspended loads. We must put an equal amount of emphasis on the loads lurking at the bottom of our wellbores. We must have equal posters on the dangers of kicks and blowouts and removal of barriers and having drill pipe on bottom and equal JSAs on keeping the well under control and Safety Moments on that same focus as well.

The DPSS and the Risk Register serve an important formalization; an omnipresent communication of the current state of risk to summon attention and decisions and appropriately extra precautions up to and including appropriate assignment of skilled company men to rigs and issuance of a "stop work" order. This thread of risk status communication would have been a stabilizing uniformity at a time of reorganization of personnel and chains of command and, as you summarized, summons managers to "where the focus should be" and thus frees up finite attention resources otherwise spent on delving into minute, low level, details in order to surmise the same information the green to red light rating system instantly communicates.

Appendix 1
In Drilling Process Safety 101, deviations from procedure would elevate the risk register for that hole section. It might be a sign that either the planning was off or the actual conditions were different than estimated. If the risk is elevated then the managers can step in and assert more authority and more experienced company men may be emplaced.

As we look at risk analysis (the topic of this thread) we must keep in mind that individuals have two forms of risk judgment, public and private, and these risk judgments are a function of where these individuals' lie on the scale of informational and reputational concern. The reputational component works through expressions of conviction, weakly or uncertainly held, possibly even feigned, that people produce in order to retain social approval and escape censure. Only the rare individual has no concern for the reputational component of his/her public risk judgment in the corporate setting. The influence of a particular company's value culture cannot be minimized in how it affects risk analysis of ongoing operations and can be set by seemingly random comments and temporary sentiments if said by a person held in a relatively high esteem or holding a relatively high position of authority or influence.

With this in mind the comments that set and/or reflect a tone of cavalier minimization of risk, and scorn for "concern of risk" hinting at a need to "stop work", can be monumental in either making a "stop work" culturally acceptable or not. The statement, "Who cares, it's done, end of story, we'll probably be fine" can be seen as exactly that type of statement that can, and does, set a precedent or at least reflect a prevalent corporate cultural value that says effectively, "Work will not be stopped over this concern...Minimize this risk...adopt the sentiment that 'we'll probably be fine'...we are not going to stop work over this...this is the prevalent corporate value...enough said". With this corporate value clearly in evidence via an email it is clear that most if not all individuals on the rig making decisions, ie. the company man, would have been strongly influenced to adopt a public risk judgment strongly against admitting risk has escalated in order to avoid corporate censure ("we'll probably be fine, its done, end of story") With this in mind and clear it is more than obvious the subsequent decisions and judgment on that rig drilling Macondo, specifically in failing to confirm the Negative test failed so as to "stop work", suffered from the cognitive bias "Backfire effect – when people react to disconfirming evidence by strengthening their beliefs".

We must keep in mind this is the case and is not overcome by strong public judgments of informational and reputational concern for "Personal Safety" since Macondo was a tragedy in "Process Safety" and completely independent from any corporate cultural value instilled into programs of "Personal Safety". While the company's "Personal Safety" corporate value was/is truly "Safety First" It's "Process Safety" value was clearly, "Will probably be okay". Tragic and yet simple in the flaw in logic whereas good intentions might have been in place and yet the details of any attempt at changing corporate values fell short due to a technical error and specification flaw in the subtle differences between personal and process safety.

Appendix 2 – Random Examples of Conditions That May Automatically Escalate a Drilling Process Safety Risk Register and Might Be Included In A Subsequently Devised System.

drill crew did not consider well control as a realistic event during the...displacement operation as the downhole barrier had been successfully negative pressure tested, and the displacement was set up as —an open circulating system nullifying pit monitoring. The advisory admonished rig management that —tested barriers can fail and risk awareness and control measures need to be implemented, —standard well control practices must be maintained through the life span of the well, and that well programs must —specify operations that induce underbalance conditions
in the well bore. As one Transocean executive noted after the incident, reading the advisory would —increase the awareness of anybody in the drilling industry.

Kick tolerances below a certain level should put a well construction project’s Risk Register into an elevated status.

Each day at a “tour change” the risk level will increase a bit.

Each day at report time and when the crew is in the “AM meeting or conference call” there will need to be a risk level increase.

Each time a regular company man or crew member is replaced temporarily while he/she attends training such as “Well Control School”, there will need to be a risk escalation.

Appendix 3 – Random Forum Discussions on Process Safety

First of all WITSML, is Wellsite Information Transfer Standard Markup Language and its a kind of RSS like how we get feeds from news services and RSS is made up of XML. The point is it is a standard feed and if it was standardized all feeds from the rig could be read easily by any number of portals receiving the feed. This isn't so much of a problem since most of the rig real time monitoring feeds use WITS and all the appropriate people in the office can get it. The BP problem? I don't understand except it being disinterest and disengagement and a part of the disconnect between Operations Management and Engineering Management since I can get these rig feeds on my Iphone, no problem, and never have had a problem. So let's talk about the disconnect between Ops and Eng since this is basically the rig and the office or aka field and engineering. We have discussed this in here before and about the source of the disconnect and how to perhaps mitigate the risk of communications breaking down between these two groups. My personal opinion is that all of the tests must be reviewed by an engineer, preferably in real time using the WITS based systems, and formally signed off on before the test is officially accepted and operations can move along. If this had been done Macondo would not have blown out since it is clear in the reports that the engineer had told the company man that there was something wrong with the test and the field guy, the company man ignored this and instead accepted the false science of some "bladder effect" that was a figment of an untrained mind, at least untrained in engineering and the theories that are accepted. We know these relationships between "rig" and "shore" are strained and the best thing for these relationships are formalities and protocols and systems that ensure that the top value is well containment and balanced with personal safety and this is recognized by both "rig" and "shore". This creates good relationships and communication and this is where improvement is needed.

As far as having systems in place that could characterize dynamic risk levels this is Drilling Process Safety and this can be done and here is a short essay/work in progress that illustrates them http://www.DrillScience.com/Drilling%20Process%20Safety%20101.pdf This is the type of system that Shell is hoping to implement and Peter Sharpe, VP of wells for Shell, was actually quoted in a speech as saying, "It wasn’t that I didn't understand the risks of a major well control incident. ... But it wasn’t until after Macondo that I realized I needed to strike a different balance between personal and process safety, that I needed to send different
messages about what was important to me." Let's make this point clear, there is no standard for "stopping work" over a process safety issue at this point and yet there is for a personal safety issue. We have a formal system to stop work over a trip hazard and yet nothing when we think the well will blowout. We have to implement process safety so that this value is placed before costs and so that people on the rig and the shore can demand standards of process safety are met and maintained and that work can be stop anytime they aren't. This will improve the relationships between the “rig” and “shore” and there is nothing else that can nor will. This hits on the cause of Macondo, imbalanced focus and unclear values, and the way to remedy this is to implement process safety measures and put personal and process safety values as a priority ahead of costs. This common value will dictate decisions and results will be immediately assessed and the current status of risk level on the rig will always be communicated formally. This is lacking and not just with BP and yet throughout the industry.

Can a WITSML be used to communicate a Drilling Process Safety Dynamic Risk Level System? Yes! That is exactly the answer.

Appendix 4 – Management Failure from Chief Council's Report

The management breakdown at Macondo affected many of the operational aspects of designing and drilling the well. The Chief Counsel's team observed at least the following management failures: (1) ineffective leadership at critical times; (2) ineffective communication and siloing of information; (3) failure to provide timely procedures; (4) poor training and supervision of employees; (5) ineffective management and oversight of contractors; (6) inadequate use of technology; and (7) failure to appropriately analyze and appreciate risk. Ultimately, the companies placed undue reliance on timely intervention and human judgment in light of their failure to provide individuals with the information, tools, and training necessary to be effective.

Appendix 5 – An example from Chief Council's Report Where Process Safety as Describe Above Is Essentially Being Stated As Being A System That Needed To Be In Place

Given the risk factors surrounding the primary cement job and other prior unusual events (such as difficulty converting the float valves), the BP Well Site Leaders and, to the extent they were aware of the issues, the Transocean crew should have been particularly sensitive to anomalous pressure readings and ready to accept that the primary cement job could have failed. It appears instead they started from the assumption that the well could not be flowing, and kept running tests and coming up with various explanations until they had convinced themselves their assumption was correct.

Appendix 6 – Commission Identified Factors of Conducting and Interpreting the NPT

The Commission has identified a number of potential factors that may have contributed to the failure to properly conduct and interpret the negative pressure test that night:

• First, there was no standard procedure for running or interpreting the test in either MMS regulations or written industry protocols. Indeed, the regulations and standards did not require BP to run a negative-pressure test at all.
• Second, BP and Transocean had no internal procedures for running or interpreting negative-pressure tests, and had not formally trained their personnel in how to do so.
• Third, the BP Macondo team did not provide the Well Site Leaders or rig crew with specific procedures for performing the negative-pressure test at Macondo.
• Fourth, BP did not have in place (or did not enforce) any policy that would have required personnel to call back to shore for a second opinion about confusing data.
• Finally, due to poor communication, it does not appear that the men performing and interpreting the test had a full appreciation of the context in which they were performing it. Such an appreciation might have increased their willingness to believe the well was flowing. Context aside, however, individuals conducting and interpreting the negative-pressure test should always do so with an expectation that the well might lack integrity.

Appendix 7 – Chief Counsel’s comments on Personal Safety and Process Safety and the need for Formal Compliance Authority in Process Safety

The Chief Counsel’s team does not presume to know whether the reorganization improved BP’s previous management structure, but it is clear that the way BP handled authority and accountability created confusion during the Macondo project. For example, the BP team did not know who was accountable for important practices associated with safety. After the blowout, Hafle told BP investigators that he had no idea who was accountable for ensuring compliance with BP’s standards on drilling safety. Sims told BP investigators, —this accountability is not well documented‖ and —it is more like ‘we are all accountable.’ Saying that everyone is accountable can be beneficial in certain instances, such as with respect to personal safety and —stop-job‖ authority, but can lead to a diffusion of personal responsibility for process safety. For example, BP has admitted that its internal engineering standards required the Macondo team to conduct a formal risk assessment of the annulus cement barriers in the well, and that such an assessment might have led the team to run a cement evaluation log. Yet nobody on the team appears to have brought up the relevant Engineering Technical Practice (ETP) on zonal isolation. There also appears to have been confusion about who was accountable for ensuring the adequacy of the cement slurry design, determining the risks attendant to changes in operations, and assessing the competence of personnel assigned to perform the negative pressure test. Though it is understandable that no one would wish to take ownership of the well after the blowout, the Chief Counsel’s team found many instances in which nobody was taking ownership before the blowout.

Appendix 8 – Shell’s Approach to Process Safety According to Exec. VP Peter Sharpe

We have taken this approach a step further and are implementing a similar system for the construction phase of our wells called electronic Well Construction Assurance Tool (eWCAT). This will allow us to measure compliance against our well control standards around competency of people, certification of equipment, quality of barriers, design derogation and so forth. Both systems provide key metrics to measure discipline, compliance and make risk and management of change visible