THE HUMAN AND ORGANISATIONAL CAUSES OF THE BLOWOUT ON THE DEEPWATER HORIZON

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Introduction[1]

The blowout in the Gulf of Mexico on the evening of 20 April 2010 caught everyone by surprise, although it shouldn't have.

The *Deepwater Horizon*, a huge floating drilling rig, had just completed drilling an ultra-deep exploratory well. It was operating in water that was 1.5 kms deep and it had drilled to 4 kms below the sea floor - total depth 5.5 kilometres below sea level. This was an impressive achievement, although it was by no means the deepest well that the *Deepwater Horizon* had drilled.

Drilling was a long way behind schedule, but the job was finally finished, and with a sense of relief, crew were preparing for departure. Suddenly, drilling fluid began spewing out of the top of the derrick, covering the deck and landing on a supply vessel stationed nearby. This mud was accompanied by volatile oil and gas. Gas alarms sounded, and the vessel's engines began revving as gas reached the engine room. Almost immediately, there was an explosion, followed shortly by another. The *Deepwater Horizon* became an inferno with flames roaring into the night sky, causing chaos and panic.

Dazed and injured workers converged on the lifeboats which were progressively lowered into the sea. Some were so afraid that they jumped 40 metres to the sea below. The supply vessel had backed off a short distance when the mud began raining down; it launched its own rescue craft to pick up survivors in the water and took on board all the people in lifeboats. Of the 126 people who had been on board the *Deepwater Horizon*, 115 were rescued. Eleven perished in the explosions and fire. Fire-fighting vessels rushed to the scene and poured water onto the *Deepwater Horizon* but the fire was uncontrollable, and two days later the rig sank.

This was not only a disaster in terms of loss of life. It was 87 days before the well was finally capped and the flow of oil stopped. Containment efforts were unable to prevent oil reaching the shores of several States around the Gulf of Mexico, doing untold damage to the environment and to the livelihood of Gulf residents.

The *Deepwater Horizon* was working under contract to the operating company, BP, whose shares lost half their value shortly after the accident. At one point it seemed possible that BP might not survive. Two years later the share price was still nearly 25 per cent below its pre-blowout level. The ultimate cost to BP was about US$65 billion.[2]

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On the day of the disaster, all seemed normal. The oil and gas reservoir at the bottom of the well was under very high pressure, and the well needed to securely plugged with cement before departure, to prevent a blowout. Pumping cement 5.5 kilometres to the bottom of a well was a difficult job requiring considerable finesse, but eventually the cementing team concluded that the cement had arrived at its intended location. They thereupon announced that the operation had been a success. This was true only in a very limited sense. Although the cement had reached its intended destination, there were other ways in which it might nevertheless fail, which could only be ruled out by subsequent testing. But this was overlooked, and it was assumed from this point onwards that the well had been successfully plugged.

This assumed success meant that, among other things, the team was able to dispense with a particular cement evaluation test (the cement bond long), and contractors who had been on standby to perform the test were sent ashore on an 11am helicopter flight. At 8pm another test - a well integrity test - was completed, and the crew mistakenly declared this test was sound and that the well had passed the test. Finally, in the hour before the well erupted there were indications that it was about to fail, but these indications were missed because no one was monitoring the well. So it was that the blowout came as a complete surprise.

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Two questions will be addressed in the following sections:

- Why did the cement job fail?
- Why did no one realise that the cement job had failed?

The paper concludes with a discussion of the system of defence in depth and how it failed in this case.

The failure of the cement job

Apart from technical reasons, which are not discussed in the paper, there were numerous human and organisational factors that contributed to the failure of the cement job.

(1) Prior to finishing the well, the engineers took various decisions that increased the risk of cement failure. They recognised this, but saw the risk as commercial, and not safety related. This was a plausible idea only on the assumption that, if the cement job failed, they would *know* it had failed, and they would then be able to fix the problem. In fact, they were unaware that the cement had failed, and in this way the commercial risk became a safety risk - a blowout risk. The failure to recognize that commercial risk could also create safety risk lies at the heart of their poor decision making.

(2) One of the reasons for this failure to think carefully about safety risk was the very meaning that safety had for BP drilling operations. Since the BP Texas City refinery disaster of 2005, there was a distinction between personal and process safety, as major lesson from Texas City was that process and personal safety need to be measured and managed differently. But in BP drilling operations, the whole concept of process safety and major accident risk more generally tended to disappear from view, leaving only a focus on personal or occupational safety.

A management walk-around on the rig on the day of the accident illustrated this state of mind with devastating clarity. The executives involved in this walk-around were focused exclusively on personal safety; there was no discussion of major hazard risk, in particular the risk of blowout. It is a truism that the culture of an organisation is determined by its leadership. From this point of view, it is entirely unsurprising that the engineers were as blind to major hazard risk as they were.

Moreover, the activities of the engineers had no obvious implications for personal safety. As a result, neither personal nor process safety was relevant for them. Safety, per se, was simply not on their agenda as they went about designing the cement job.

(3) The blindness to major hazard risk is not unique to BP drilling operations, but there was a particular reason for it in this context. The concept of process safety was developed for process industries - refining and the like - where the issue is keeping dangerous substances contained in pipes and tanks, particularly substances that can cause major fires and

explosions. On the other hand, in drilling operations the most serious hazard is a blowout. The fact is that process safety, narrowly understood, is *not* directly applicable to drilling operations, and needs to be adapted to deal with blowout risk. At the time, BP had not recognized the need to make this adaptation. So it was that major hazard risk tended to disappear from view, as far as the engineers were concerned.

(4) Cost pressure was another factor that contributed to the safety risk blindness of the BP engineers. There was enormous pressure on both engineers and line managers to keep costs to a minimum. The most obvious manifestation of this pressure was in their performance agreements. These agreements specified production and cost reduction goals, both for line managers and for engineers, and bonuses depended on how well these goals were met. This provided a strong incentive to take what were seen as commercial risks, which, if they paid off, would result in considerable cost reductions.

This cost pressure was not entirely unconstrained. Apart from production/cost reduction targets, performance agreements also included personal injury reduction targets. BP managers were very focussed on personal safety, at least partly because of the injury reduction incentives contained in the company's bonus system. But this focus on personal safety in bonuses did not extend to blowout risk. In the years immediately preceding the blowout BP had been moving hesitantly towards including indicators of process safety in performance agreements. This culminated in 2010 when a numerical indicator of process safety was finally included in the performance agreements of top managers. That indicator was number of losses of primary containment, defined in such a way as to emphasise oil and gas releases. But BP had made the mistake of seeking a single indicator of process safety across all its operations and had not recognized that process safety indicators need to be relevant to the major hazards faced by particular operations or sites. The rate of gas leaks, or more generally losses of primary containment (LOPC), does *no*t measure how well a drilling operation is managing its risk of blowout. Accordingly, seeking to drive down this rate will not reduce the risk of blowout. In short, there was nothing in the performance agreements or the incentive system to focus attention on the risk of blowout. The result was that the pressure to cut costs was unconstrained by any countervailing pressure to attend to the most significant major accident risk faced by drillers[3].

(5) BP's decentralized organisational design was a further factor that contributed to the lack of engineering rigour during the cement job. BP's well engineering team reported to line

management at a low level within the overall organisational structure. This meant that they were subordinated to these line managers and their cost concerns, and it meant that their performance agreements were designed by these relatively low-level and cost-focused line managers. This inevitably tended to corrupt good engineering judgement. BP had recognized this problem and was slowly reorganizing itself so as to make engineers answerable to higher level engineering managers, in a process known as centralizing the engineering function. But these changes were too late to make any difference before the blowout. After the blowout, BP went much further in imposing centralized control over its operations, which suggests that the company itself saw its decentralized organisational structure as one of the most significant causes of the accident[4]. Ten years later in 2020, BP had apparently forgotten this lesson and began dismantling its centralised control of major accident risk. It is possibly only coincidence, but two years later the company suffered a major refinery accident in the US.[5]

(6) Regulatory co-dependence was a further contributing factor. Regulators tended to rely on BP engineers, assuming that they would have the necessary expertise to design and construct wells safely. On the other hand, BP engineers, who wanted to modify a design in a way that they knew would increase the risk of failure, relied on the regulator to authorize, or alternatively reject, whatever change they were proposing. Furthermore, they assumed that if an authorisation was forthcoming, the proposed course of action must be acceptable. This was a process that meant that neither the regulator nor the operators accepted full responsibility for safe well design. So it was that the regulator rubber stamped a number of last-minute changes that increased the risk of cement failure, without ensuring that there was any commensurate increase in attention to the detection of cement failures.

(7) Finally, consensus decision-making was a problem. Decisions tended to be made by groups, and the test of whether the decision was a good one seemed to be whether everyone was “comfortable” with it. This meant that in practice, no one person really took responsibility for decisions.

The failure to realise the cement job had failed

BP failed to recognise that the cement job had failed until it was too late. There were several points after the completion of the cement job at which this discovery might have been made. The most dramatic of these was the well integrity test.

The well integrity test involved temporarily reducing the pressure in the well to see if hydrocarbons would begin flowing upwards. That is indeed exactly what happened, which meant that the well was not sealed against the high-pressure reservoir and would begin to blow out as soon as the rig released its downward pressure in the well immediately prior to departure. However, the team doing the test misinterpreted the results and concluded that the well was secure. How could this have happened? Most analysts concluded that the problem was that BP had not developed sufficiently detailed procedures for carrying out the test. While this is true, it does not account for the fact that no one recognised the unambiguous evidence of failure that confronted them. A series of factors came into play.

(1) First and foremost, the group was subject to powerful confirmation bias because the cement job had already been declared a success. In these circumstances they were not *testing* whether the well was safe, they were *confirming* that it was. This is a subtle but vital distinction. It meant that when they got results suggesting otherwise, they repeated the test in various ways until finally they got a result that could be interpreted as a success, at which point, it was mission accomplished.

(2) Furthermore, the team had a very limited idea of what they were doing - their mental model was deficient. In particular, although they conducted the test in various ways, the results should have been identical. They weren't. The team failed to understand that this was a serious anomaly.

(3) Their limited mental model of what was going on was a result of their limited professional competence, and of the fact that there were no professional engineers on site able to provide advice on what was happening.

(4) Next, they were able to rationalize the different test outcomes as being a result of a so-called "bladder effect". Experts deny that such an effect exists but in the minds of those present the bladder effect helped them *normalize* the discrepancy between the results.

(5) Finally, those in the group who remained doubtful of the interpretation that was being placed on the results were silenced by a powerful groupthink process, in which the informal group leaders, who happened to be *Deepwater Horizon* drillers, prevailed over the formal decision makers, the BP staff men.

So it was that the team came to the conclusion that the well had passed the integrity test when in fact it had failed.

Notwithstanding this disastrous misunderstanding, the team might have discovered that the cement job had failed if they had been monitoring the well when hydrocarbons from the reservoir began flowing upwards in the final hours before departure. But they were not monitoring the well, as we shall see.

The failure of defence-in-depth

One of the striking things about this accident was the failure of the system of defence in depth. Defence in depth works on the assumption that the various defences are independent of each other. But if the defences are not independent, the system will not give the expected reduction in level of risk.

In fact, the defences were highly interdependent. Some defences were undermined by the belief that if they failed, later defences would operate as intended. Later defences failed because of the belief that earlier defences had been effective. The image that comes most readily to mind is of falling dominos. Once one fell, all the others collapsed. Here is a summary of this interdependence.

1) Risks were taken with the first barrier, the cement job, on the assumption that the well integrity test would pick up any problems and that, if necessary, the blowout preventer (BOP) would operate as a last line of defence. The BOP was a large piece of equipment sitting on the sea floor that could be activated by the operators and was intended to shear through the drill pipe and seal the well.

2) The cement evaluation tool was not used because the cement job was believed to have been successful. This barrier was always intended to be conditional in this way. Strictly

speaking it was not part of the system of *independent* barriers. Nevertheless, it fits the pattern of a barrier rendered ineffective by the belief that an earlier barrier had been successful.

3) The well integrity test was undermined by the announcement that the cement job had been successful. This gave rise to a powerful confirmation bias on the part of the testers that led them to dismiss the indications of failure that they were getting.

4) The team effectively stopped monitoring the well in the last hours before the blowout, because of the earlier declarations that the cement job had been successful and that the well had passed the integrity test.

5) When operators tried to activate the BOP, after hydrocarbons erupted on the deck of the *Deepwater Horizon*, it failed. It failed because it was designed on the assumption that operators would be monitoring the well vigilantly and would activate the device long before well fluids gushed out onto the rig. The monitoring failure therefore contributed directly to the failure of the blowout preventer.

Evidently, this was a failure of the very system of defence in depth. There are some important lessons here. First, there is a general tendency for people to regard a single effective defence as good enough and to drop their guard if they believe that such a defence is in place. The reality is that no one defence can be relied on, and all must be made to work as effectively as possible. A second lesson is that some defences may assume the successful operation of earlier defences. This was particularly the case with the BOP. This conditionality needs to be widely advertised. If everyone had realized that the effective operation of the BOP depended on vigilant monitoring, the crew may not have had such blind faith in the BOP as a line of last defence. The need to take seriously the idea of defence in depth is perhaps the single most important lesson emerging the *Deepwater Horizon* tragedy.

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[1] This article is based on the author's book, *Disastrous Decisions* (CCH:Sydney, 2012), where detailed references will be found. Major sources for the book were:
Bureau of Ocean Energy Management, Regulation and Enforcement, 2011 *Report Regarding the Causes of the April 20, 2010 Macondo Well Blowout*. US Department of the Interior;
National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, *Deepwater: The Gulf Oil Disaster and the Future of Offshore Drilling, Report to the President*. January 2011;
Chief Counsel for the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011, *Report*. Washington

[2] https://www.maritime-executive.com/article/bp-s-deepwater-horizon-costs-reach-65-billion

[3] OGP, (2018) *Report No 456: Process Safety –Recommended Practices on Key Performance Indicators,* p15

[4] Hopkins, Andrew (2019) *Organising for Safety: How Structure Creates Culture.* (*CCH: Sydney*)

[5] BP faces growing scrutiny over latest fatal accident in US" *Financial Times* 29/9/2022