ASSESSMENT OF RESIDUAL RISK LEVELS ON BRENT BRAVO Sept. 1999 to Sept. 2003

Preamble

In reviewing this document the reader needs to bear in mind the robust disclaimer that Shell gave to newspapers and the BBC that 'The allegation made regarding operating with high-risk levels is untrue and we (Shell) absolutely refute this'.

Prior to the screening of the Frontline Scotland programme the BBC received a letter from Shell's lawyers accusing them of defamation because the BBC said that 'Shell "knowingly" operated their platforms at dangerously high-risk levels'. The reader should refer to the information also provided on the attached document Progress with Safety – fact or fiction.

What ironically these press releases ignore is that Shell admitted at Stonehaven Sheriff Court on 27th April 2005 to fundamental failures in health and safety management on Brent Bravo that caused the unlawful deaths of two men. One would have thought, that it was a statement of the bleeding obvious, that fundamental failures, a direct consequence of which caused the deaths of two men, constituted operating at high-risk levels!

In 1999 the PSMR audit also found that Brent Bravo was operating with risk levels that were probably in the intolerable region, or otherwise stated at levels unacceptable in modern society.

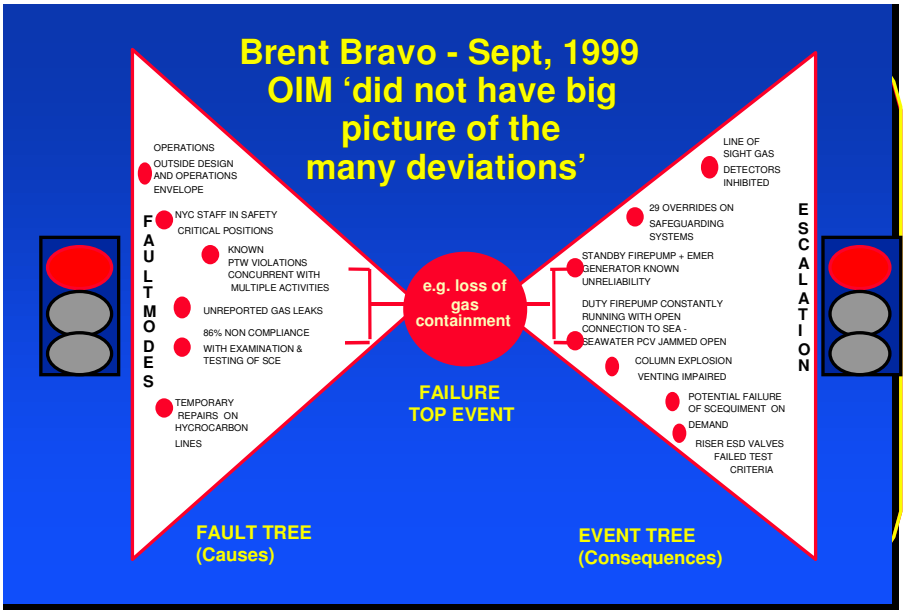
Shell's follow-up Internal Investigation in 2005 found no evidence that anything was done at the time to reduce these risk levels and the longer term programme of recommendations to change negative behaviours stalled in late 2000 with many actions outstanding.

In the document Progress with Safety is provided evidence, much of which is provided by the Regulator, and is independent of Shell, that the risk levels on Brent Bravo remained at a heightened level between September 1999 up to the time of the fatalities at September 2003. During this period, apart from a few months here and there, Shell were continuously in breach of the Offshore Installation Safety Case Regulations, on all of the 18 offshore installations for which data is available, this is irrefutable, a matter of fact. During the period late 1999 to end 2006 a total of 48 enforcement notices have been served on Shell and in addition on 5 occasions it has pled guilty to serious breaches of the relevant offshore regulations and associated mother legislation the UK Health and Safety etc at Work Act.

If installations operate in such a manner then *ipso facto*, the risks are above the ALARP levels and the author argues, remarkably above these levels

FIG1:

Brent Bravo Hazards and Effects



Summary of Hazards and Effects

The diagram Fig 1 is part of the proprietary Shell Hazard and Effects Management Process, (HEMP) known internally as the 'bow-tie' diagram.

They show on the left-hand side the barriers to prevent the top event occurring (the proactive barriers) and on the right-hand side the barriers that are designed to reduce the likelihood that if a top event does occur that this will escalate out of control (the reactive barriers).

It can be observed on Fig 1 that there were systemic weaknesses on both sides of the bow tie, impairing the proactive barriers on the LHS and the reactive barriers on the RHS of the diagram.

An offshore installation operating like this is so well removed from conventional risk levels as to fit the description of being operated continually in a dangerous condition.

Risks to the individual on Brent Bravo, known as the Individual Risk per Annum (IRPA), under these conditions were probably greater than 1 fatality per 10 years. The other commonly used risk measure is the Potential Loss of Life on an offshore installation (PLL). At its simplest the PLL is the product of the IRPA and the number of persons on board (POB) the installation. With a POB of 150+ this makes the PLL up 15 persons per annum.

This is a remarkably high figure! – so, how can it be justified?

In determining whether such a figure is credible you need to look at what are the hazards creating these risks. The hazards in general were not those associated with occupational work such as slips, trip and falls that in turn may have led to single fatality events. Rather, the hazards were those that could lead to top events such as fire or explosion.

These top events could effect the society of the installation, i.e. a significant amount of persons on board that installation, through the potential for multiple fatality events and damage to the primary and secondary structures maintaining the integrity of the installation, and coincidentally allowing significant losses of hydrocarbon liquids from vessels and pipelines with subsequent potential catastrophic damage to the local environment.

For example, in the electronic attachment (Progress with Safety) there is an situation described where the combination of an explosion in the utility shaft, concurrent with the venting for that shaft being impaired, could have had the potential of causing partial or complete structural collapse of the installation topsides onto the storage cells containing over 1 million barrels of oil.

As it was, two persons died in the utility shaft. See over the page

FIG 2

Brent Bravo Comparative Analysis 1999 c.f 2003

Where is the evidence of a significant improvement over the four year period?

On 4th September 1999	On 11th September 2003
ESD Valves not meeting performance criteria Operation of test separator in violation of design codes to augment oil production Many gas detectors were inhibited - unauthorised Unauthorised temporary repairs Skid deck covered by heavy equipment - explosion venting of utility shaft impaired PTW violations and deviation observed Standby Fire-pump 'only one run left on pump' Fire-main being used to supply cooling water to drilling, Seawater discharge valve to sea jammed open Two minor gas leaks - valve stems (not reported) Emergency Generator questionable reliability Low levels of safety critical maintenance compliance (14%) against falsely reported 96%	A Failed ESD Valves on the HP KO Drum contributed to deaths. The main Riser ESD valves had failed their leak-off tests but the Work Order for same was cancelled Operation of the Drains De-gasser Vessel test separator in violation of design contributed to deaths The post fatality Review found a number of fire and gas detectors (16) failed to danger There was at the time 33 temporary repairs on pipes of which 9, including the leaking temp repair that contributed to deaths, were not authorised PTW and leg entry procedures deviation contributed to the deaths Maintenance was being neglected, the Emergency Generator known to be of questionable reliability failed to start automatically and the UPS system failed when most required

How do you assess the risks of these combined deficiencies – the answer is you can't with any degree of accuracy, but

All you can say is that these deficiencies in 2003, remarkably similar to the deficiencies in 1999, were responsible for a double fatality major accident event *ipso facto*, the risk levels must have been dangerously high in 1999 also

Individual versus Societal (Catastrophic) Risks

I would like to dwell on this point. At the time of the 1999 Audit the team found it difficult to get the General Manager and the Oil Director to apparently understand how risky the continual operation of Brent Bravo was. As evidence of that statement they allowed this installation to continue in operation during the whole period from 4th September to the presentation on 22nd October with no actions being taken.

The General Manager would continually during his interview refer to the excellent safety record of Brent facilities. His measure for this was loss time incident frequency (LTIF), which was better than the industry standard.

On this basis he appeared in denial of the Audit findings and statements that the platform was operating at unacceptable risk levels.

He and the Oil Director did not seem to have the technical competence to generally understand the gravity of the findings and to therefore understand that LTIF was not a reliable measure in determining that the residual risk levels on an offshore installation were acceptable, or otherwise.

Perhaps I can explain this point with an example

In a preliminary report by the U.S. Chemical Safety Board into the BP Texas City Refinery Disaster they stated the focus of many of the Refinery initiatives over a prolonged period was on improving procedural compliance and reducing occupational injury rates, while catastrophic safety risks remained.

Earlier Audits of the refinery were complimentary about this performance as an indication to corporate headquarters that the site was being well managed with respect to health and safety. All this, despite the fact that the refinery had equipment of unsafe and antiquated design, and unacceptable deficiencies in preventative maintenance were tolerated."

Also most of the fatalities were inflicted on construction team members who occupied portacabins very near process equipment (coincidentally this equipment being the seat of the explosion). A flawed risk assessment said the risk to the occupants was tolerable because the portacabins would only be occupied for a few hours in a day!

In summary

- having a good safety record at the work-site level, slips, trips and falls etc, does not mean that catastrophic risks are being managed, and
- LTIF, sick bay visits etc is not a key performance measure that can be used reliably to ascertain that residual risk levels are as low as is reasonably practicable on an offshore installation, or anywhere else for that matter

What does operating in a dangerous condition mean, can it be quantified?

The legally stipulated residual risk levels As Low as is Reasonably Practicable (ALARP) numerated in the offshore installation Safety Case could only be achieved for Brent Bravo with all its safety systems in full operational condition such that the technical integrity of the that installation can be maintained at all times – as stated and described in its specific Safety Case

Society and industry tend to agree that the dividing line between tolerable and intolerable risk of those individuals that obtain commensurate benefits from the activity is around 10^{-3} per year.

The concept of Safety Case legislation was for a Duty Holder to demonstrate that risks were reduced to ALARP rather than a fixed level. Thus with expenditure on risk reduction projects etc by the Duty Holder, the Individual Risk Per Annum (IRPA) on Brent Bravo would have been in the broadly acceptable range of between 10^{-4} and 10^{-5}.

When I state that the risks on Brent Bravo were such as to make it a dangerous place to work you need to refer to the Fig 1 and Fig 2.

- Failure, or significant degradation of the proactive systems on the LHS of Fig 1 increases significantly the probability that an undesirable event, for example a loss of containment, will occur.

- Failure, or significant degradation of the reactive systems on the RHS of Figs 1 increases the potential of these undesirable events to escalate and cause damage to people and the asset.

Since risk is the product of the probability (P_e) that an undesirable event will occur, and the consequence of that undesirable event (C_e). The risk numbers per individual deficiency on the HEMP diagrams can be large due to the nature and gravity of these known deficiencies.

Risk per deficiency is P_e X C_e, and then these individual risks are additive such that Risk due to deficiency 1 is added to Risk due to deficiency 2 up to Risk due to deficiency n, where n is the number of identified deficiencies.

In this condition the item by item individual risks are subject to what I call the Sigma effect, in that the incremental risk from all the individual deficiencies are additive.

The difficulty in trying to assess the magnitude of these risks is that these risks may be tangible, for example

- the risks of operating the oil test separator outside its design parameters, but also

- Intangible, the combined effects of violation from procedures such as the Permit to Work, and how can that possibly be assessed?

All we can be sure of is that the Piper A initiating event was a failure of the PTW system, and that a causal factor in the deaths on Brent Bravo was failure to comply with the PTW system, in combination with failure to follow the rigorous leg entry procedures.

The bottom line is that any single one deficiency may on its own raise risk levels above ALARP, and even to threshold values, but the Sigma effect

compounds matters and raises the risks significantly, and to dangerously high levels.

There is simply no legitimate methodology for accurately assessing these risks.

Quantitative Risk Analysis (QRA) should only be used by convention to determine the residual risks on the installation by estimating the failure frequencies of competently designed, installed, commissioned and maintained safety systems using internationally accepted failure data from OREDA et al.

This is supported by the Shell International accepted standard on Quantitative Risk Assessment EP 95 – 0352 which clearly states that installations can not use QRA to justify operating in deviation from Company standards or applicable legislation applicable in the Country in which we are operating

In the case of a number of the systems on Brent Bravo, these were already in a failed state, or severely degraded with a probability of failing to function on demand approaching 1, or certainty.

With regard to the combined effect of deficiencies shown on both Fig 1 and Fig 2, the Temporary Refuge Impairment Frequency (TRIF) would also be high – my guess would be at least 10^{-1}, or some 100 times higher than the mandatory limit.

Does it matter how long the dangerous levels persisted?

Essentially in operating the Brent Bravo in the condition as observed in 1999 and 2003, and for the four years in between, and (coincidentally on the other 17 installations for which data was available in September 2003), the duty holder was gambling with the lives of the employees on the installation.

The dangerously high levels of risk pertained from day to day at a constant level but as time passed then the chance of the major accident event occurring increase with time (normally referred to as exposure time).

A simple example would be playing Russian roulette with a gun with a bullet in one chamber and with 5 empty chambers. Every time the player pulls the trigger the absolute probability that he will survive is 5/6. For each event it remains constant. However, the chance that the unfortunate player will be alive after 10 events is remarkably slim due to the multiplication rule of probabilities.

The implication of all this should be obvious. If conditions on Brent Bravo as observed in September 1999 did not improve, and improve significantly, then a major accident event would occur, the only question was when.

This message given by the Audit team to Directors of Shell Expro in 1999 could not have been clearer, something had to be done, and done immediately to reduce risks, but this did not happen. Not during the period 4th

September to 22nd October 1999 and from the 2005 internal investigation no evidence was forthcoming that anything was done thereafter.

By failing to act appropriately to the concerns raised by their 1999 Audit team the Oil and Managing Director failed to reduce the risks, and to remove the Managers responsible for personally accepting these risks on behalf of Shell per se.

This more than anything else allowed these risks to go unchecked (because the behaviours didn't alter) with the inevitable consequences that occurred on the 11th September 2003.

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In 1999, the SIEP Group Auditor leading the PSMR Audit

PS: this analysis was discussed and shared with the Head of OSD and Technical Director of HSE in the UK in Aberdeen on 31st August 2006. They raised no objections to the analysis and did not criticise its credibility.