Macondo – What Happened? And What Can We Learn?

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Finding Petroleum – Post Macondo Technologies
The Geological Society, 17 May 2011

Macondo – Presentation Structure

- The Macondo Blowout
- The BP Investigation Report
- The Report to the President
- Industry Analysis and Response
- In Summary, the Issues and the Opportunities

The Macondo Blowout – What Happened

The build up to the blowout and the operational actions to control it for the subsequent three months.

20 April 2010 - The Macondo Blowout

ref, The BP Accident Investigation Report

- 6 October – Marianas spudded well, Horizon re-entered on 6 February

- 1200 - successful positive pressure test of 9 7/8x7 in casing at 18,304 ft
- 1800 – following anomalous pressures, reconfigured system for repeat negative pressure test
- 2000 – having concluded erroneously that the negative pressure test was good, BOP was opened and riser was circulated to seawater and temporary abandonment commenced – influx underway
- 2131 – pumps shut down to discuss unexpected pressure readings
- 2140 – mud overflows onto rig floor – serious well control situation
- 2145 – reported attempts to shut well in, gas alarms
- 2149 – explosion and fire
- 2150 – emergency shut down failed, abandon rig commenced

- 22 April – Deepwater Horizon sank

Subsequent Well Control Activities

ref, Deepwater Horizon Study Group, University of California, Berkeley

- Closing the BOP blind/shear rams and variable pipe rams with ROV intervention (failed)
- Capturing oil spewing from the broken riser on the sea floor with containment device, then insertion tube (partially successful)
- Shearing off the bent over and ruptured riser and drill pipe and installing Top Hat and LMRP (partially successful)
- Killing the well by injecting heavy mud and LCM into the BOP (failed).
- Removing the remnant riser at the BOP top and bolting on a sealing cap with a BOP above (succeeded)
- Pumping heavy kill mud into the well to reduce pressure at the well head, followed by cement to permanently seal off flow paths (succeeded).
- Two relief wells had been drilled to provide bottom kill capability. The first was able to intersect the well and permanently seal the Macondo well.

Wide Ranging Consequences

- 11 people killed, 17 people injured
- Consequential life changing effects on families, friends, co-workers, etc
- Estimated 4.9 million barrels of crude oil released to the sea
- Significant damage to marine and wildlife habitats and fishing and tourist industries
- Huge financial costs for operator, $20 billion plus, partners and the contractors involved, and shareholders
- Significant costs for the industry generally arising from the moratorium and increased regulation
- Significant long term litigation exposure for primary companies and their employees
- Long term reputation damage for industry, the companies and everyone involved
- Increased regulation, oversight and enforcement

Deepwater Horizon Accident Investigation Report - The BP Accident Investigation Report

BPs Internal Investigation published in September 2010

The BP Investigation Report Findings

ref, the BP Accident Investigation Report, September 2010

- **The annulus cement barrier did not isolate the hydrocarbons**
  - Weaknesses in cement design and testing, QA and risk assessment
- **The shoe track barriers did not isolate the hydrocarbons**
  - Hydrocarbon ingress was through the shoe, not through a failure in the production casing or up the annulus and through the seal assembly.
  - Potential failure modes to explain how the shoe track cement and the float collar allowed hydrocarbon ingress have been identified
- **The negative-pressure test was accepted although well integrity had not been established**
  - The Transocean rig crew and BP well site leaders reached the incorrect view that the test was good and that well integrity was OK
- **Influx was not recognized until hydrocarbons were in the riser**
  - The rig crew did not recognize the influx and did not act to control the well until hydrocarbons had passed through the BOP and into the riser

The BP Investigation Report Findings

ref, the BP Accident Investigation Report, September 2010

- **Well control response actions failed to regain control of the well**
  - If fluids had been diverted overboard, there may have been more time to respond, and reduced consequences
- **Diversion to the mud gas separator resulted in gas venting onto the rig**
  - The design of the system allowed diversion of the riser contents to the MGS although the well was in a high flow condition, overwhelming it
- **The fire and gas system did not prevent hydrocarbon ignition**
  - The HVAC system probably transferred a gas-rich mixture into the engine rooms, creating a potential source of ignition
- **The BOP emergency mode did not seal the well**
  - Rig audit findings and maintenance records found weaknesses in the testing regime and maintenance management system for the BOP

The BP Report Recommendations

ref, The BP Accident Investigation Report, September 2010

- **Review, update and clarify procedures and engineering technical practices**
  - Cementing, BOP configuration, casing design, pressure testing, well control, well integrity incident reporting, risk management and MOC
- **Strengthen technical capability and competency**
  - Cementing, deepwater well control training, BOPs and control systems and in in-house drilling and completions competency programmes
- **Strengthen rig audit, cement service QA and BOP design and assurance process**
  - include closure and verification
- **Integrity monitoring system for the well integrity, well control practices and critical rig equipment**
  - Establish lead and lag indicators and HAZOP reviews of critical systems including surface gas and drilling mud systems

Decisions Made That Increased Risk

ref, Deepwater Horizon Study Group, University of California, Berkeley

- Uncemented well drilling liner overlaps
- Delayed installation of the casing hanger seal assembly lock-down
- Single long string casing instead of liner and tieback
- Minimum positive pressure test on cemented production casing
- To not use recommended casing centralizers
- Partial bottoms-up circulation to remove well debris before cementing
- To run underbalance test with most of the drill pipe out of the well instead of running a full string to total depth
- Failure to perform CBL on basis of cement lift pressures and absence of fluid losses during cementing
- To not cement the annulus between production casing and drilling liner
- To place sole reliance on float equipment and shoetrack cement to isolate bottom of production casing
- To displace drilling mud from riser before setting plug in production casing

Deepwater, The Gulf Oil Disaster and the Future of Offshore Drilling – The Report to the President

January 2011, National Commission on the Spill and Offshore Drilling

The Root Causes of the Accident

ref, National Commission on the Spill and Offshore Drilling, January 2011

- The root causes are systemic and, absent significant reform in both industry practices and government policies, might well recur. The missteps were rooted in systemic failures by industry management (extending beyond BP to contractors that serve many in the industry) and also by failures of government to provide effective regulatory oversight of offshore drilling
- Most, if not all, of the failures at Macondo can be traced back to underlying failures of management and communication
- Better management of decision making processes within BP and other companies, better communication within and between BP and its contractors, and effective training of key engineering and rig personnel would have prevented the Macondo incident
- BP and other operators must have effective systems in place for integrating the various corporate cultures, internal procedures, and decision making protocols of the many different contractors involved in drilling a deepwater well

The Root Causes of the Accident

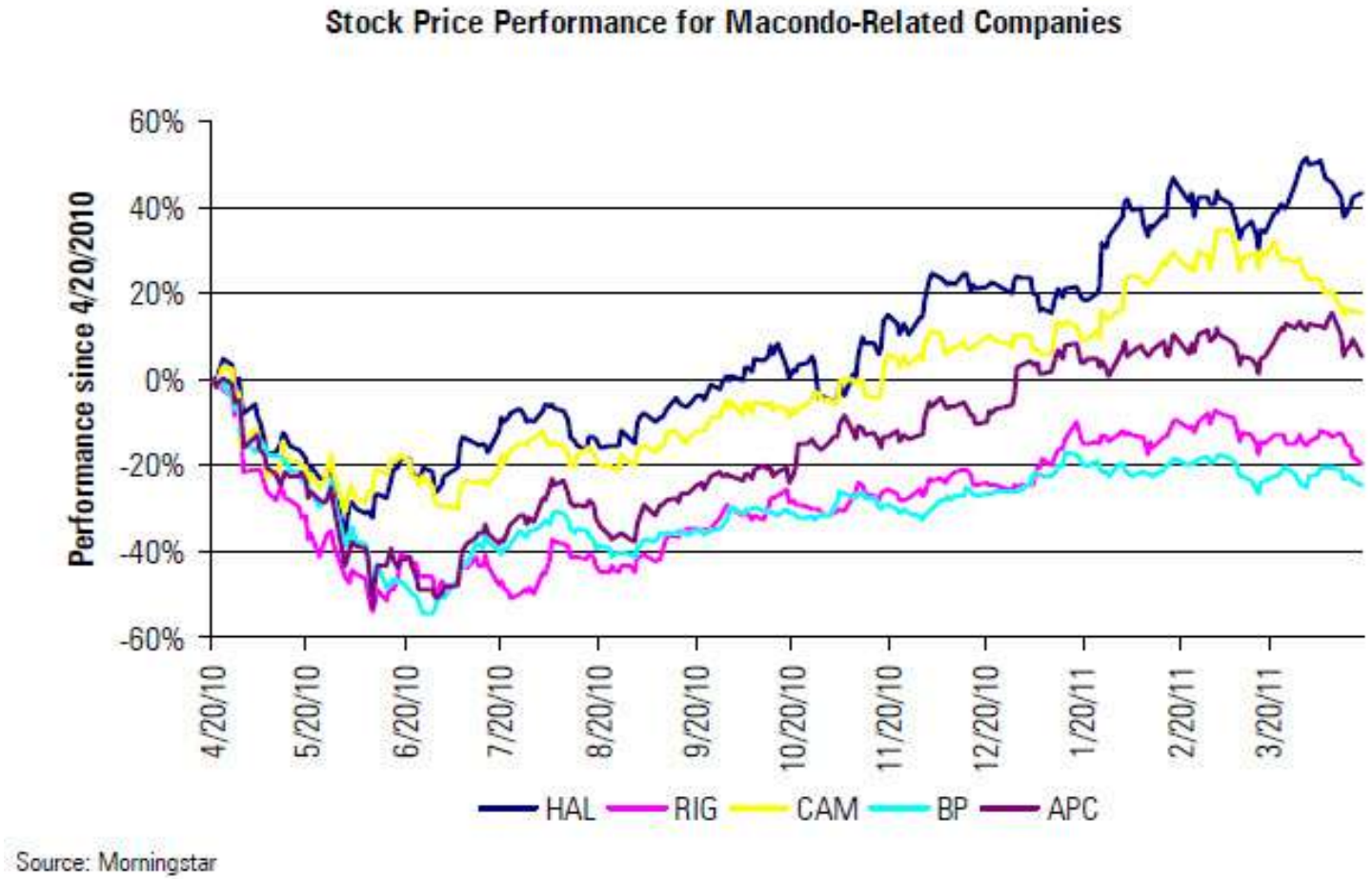
ref, National Commission on the Spill and Offshore Drilling, January 2011

- Overarching management failures by the industry
  - BPs management process did not adequately identify or address risks created by late changes to well design and procedures
  - Halliburton and BPs management processes did not ensure that cement was adequately tested.
  - BP, Transocean, and Halliburton failed to communicate adequately
- Regulatory failures
  - MMS regulations were inadequate to address the risks of deepwater drilling
  - Efforts to expand regulatory oversight, tighten safety requirements, and provide funding to equip regulators with the resources, personnel, and training needed to be effective were either overtly resisted or not supported by industry, members of Congress, and several administrations
  - MMSs cursory review of the temporary abandonment procedure mirrors BPs apparent lack of controls governing certain key engineering decisions.

Far Reaching Changes to Regulations

ref, National Commission on the Spill and Offshore Drilling, January 2011

- The Minerals Management Service (MMS), was the federal agency responsible for overseeing the well's drilling and operation
- Nineteen days after the rig sank, Secretary of the Interior Ken Salazar announced his intention to strip MMSs safety and environmental enforcement responsibilities away from its leasing, revenue collection, and permitting functions
- A week later, he announced MMS would be reorganized into three separate entities with distinct missions:
  - Bureau of Ocean Energy Management;
  - Bureau of Safety and Environmental Enforcement;
  - Office of Natural Resources Revenue
- By June 19, the Secretary had discarded the "MMS" name altogether
- Like the Deepwater Horizon, MMS had ceased to exist. The rig's demise signals the conflicted evolution— and severe shortcomings—of federal regulation of offshore oil drilling in the United States, and particularly of MMS oversight of deepwater drilling in the GOM



Source: Morningstar

The Macondo Blowout - Industry Analysis

A vast amount of information is available analyzing the incident, sources include, companies directly and indirectly involved, government and state institutions, NGOs, industry groups, universities and the media.

The OGP Safety Committee Workshop

Global Industry Response Group (focus outside US)

Well design, operation and subsea response group

- Central database of well incidents and quarterly peer group analysis
- Drilling standards advocacy
- Work with API and manufacturers to identify R&D and technology needs
- Set up task forces on technology, learning, standards and practices
- Set up capping toolbox
- International deployment of dispersant hardware
- Studies into need and feasibility of containment solutions
- Development of procedures for operational issues in capping and containment from blowouts

Oil spill preparedness and response group

- Education for better use of dispersant
- Environment effects of subsea use of dispersants, approval protocols and supply chain
- Dispersant effectiveness monitoring
- Airborne dispersant delivery systems
- Response philosophy and strategy verification - assessing response preparedness, risk assessment, regulations and benefits of real time exercises
- Communications – IT and technology developments
- Mobilising and managing responders
- Surveillance and plume modeling

Industry Leaders Speak On Macondo

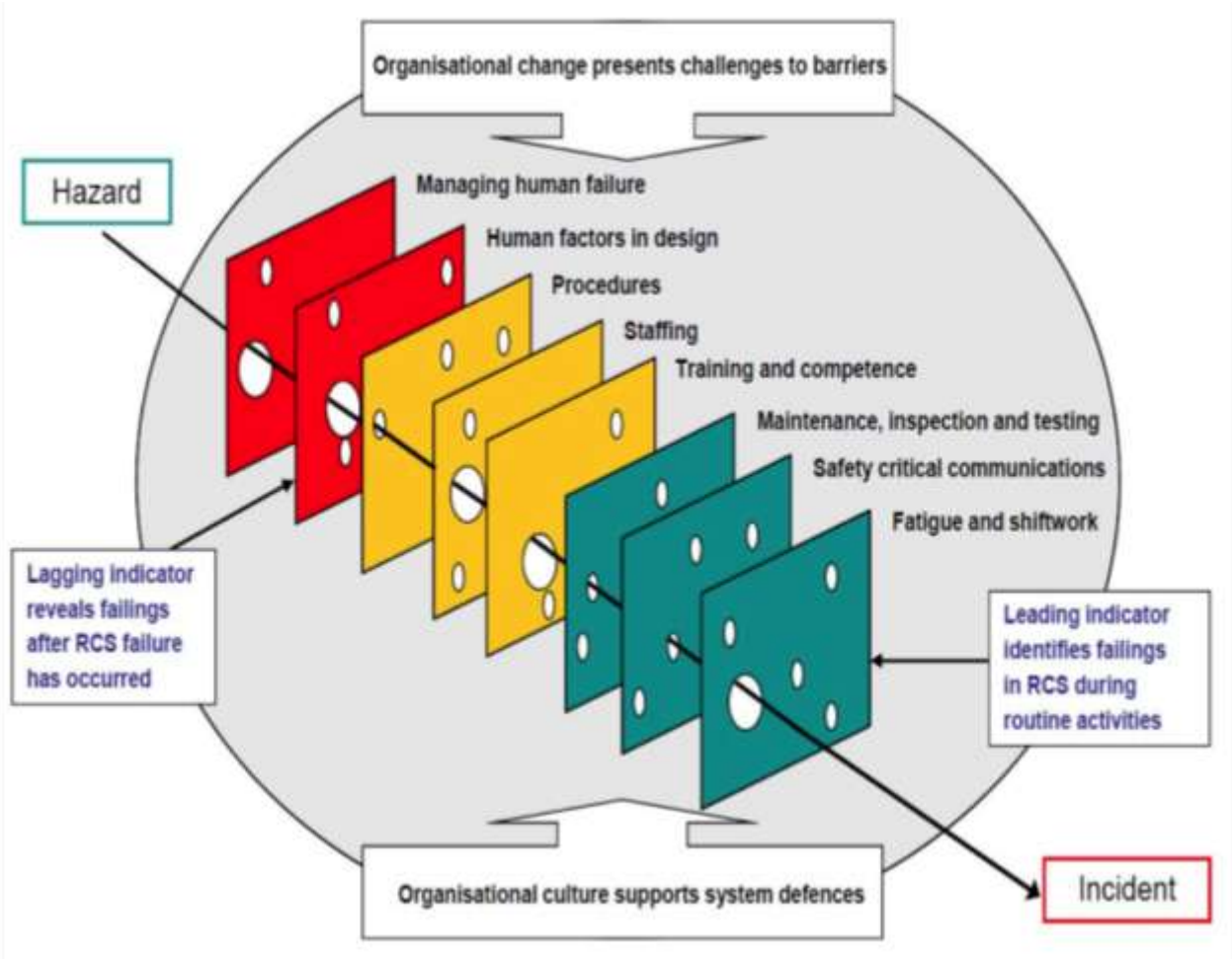
ref, IADC Drilling Contractor Magazine - Safety, People, Automation

- **Mike Diehl, VP Pride International**
  - Drilling contractors have focused on keeping the equipment running,
- **David Williams, Chairman Noble Corporation, (late 2010)**
  - Companies are submitting drilling permits, the government says they will be approved when they meet the guidelines, but they don't really know what the guidelines are; so nothing is happening
- **Mark Mitchell, GVP Drilling Optimization, Weatherford**
  - Challenges. Many complex and uncertain geological plays are undrillable by conventional means; the regulatory environment is dynamic; oil company in-house resources are are limited; the gap between process technology and knowledge is diverging

Industry Leaders Speak On Macondo

ref, IADC Drilling Contractor Magazine - Safety, People, Automation

- **Dan Rabun, Ensco, IADC VP**
  - Equipment and rig designs exist to meet challenges, but these things are not necessarily integrated
- **Peter Sharpe, Wells EVP Shell International**
  - First priority is a high reliability organisation in both personal and process safety – zero major process safety events
  - Well integrity management system and well construction assurance tool – transparency to drive compliance with standards
  - Rigorous three year minimum well engineering training programme with mandatory examinations - 20% failure rate
  - Working on containment technology, BOP functionality, instrumentation and artificial intelligence for process safety



In Summary, the Issues and the Opportunities

March 2100, Deepwater Horizon Study Group, University of California, Berkeley

In Summary, The Issues Seem To Be:

Issues for E&P Operators:

- Pushing technology boundaries
- Hostile environments
- Huge costs and benefits, competitive
- Complex wells and processes
- Under resourced in core skills
- Policy and standards application
- Management failures and staff competence
- Ability to integrate and project manage
- Inadequate technical specialisations
- Informed buyer of diverse services
- Human factors remain huge issue
- Risk assessment and QA inadequate
- Contingencies and response capability
- Ability to deliver cost, quality, HSE

Issues for Contractors:

- Independent contractor
- Executing operators plan
- With mixed priorities
- Complex equipment and systems
- Limited automation and fail safe
- Maintenance backlogs, complacency
- Mechanical failures
- Management failures and staff competence
- Training priorities and issues
- Integrity management is critical
- Assurance processes must improve
- Inconsistent practices and service QA
- Accidents, near misses and incidents
- Industry is highly competitive

Business Imperatives and Opportunities

- Well construction risks are diverse and potentially significant, probabilities are not well understood, consequences potentially enormous
- Operators and contractors need to invest in people, systems, standards, technology, assurance, compliance
- Governments need to invest in regulators, standards, contingency planning and emergency response; and they need to invest in the industry
- The actions arising from Macondo are not new; from a ten year old investigation:
  - Management should re-communicate their expectations of conformance with company policies, systems and practices and assess compliance
  - Contractors should review and update well control training and competency assurance processes for all personnel
  - Contractors should implement auditable integrity monitoring systems including verification and closure
  - New projects should be systematically assessed for the presence of well control risks and contingency arrangements should be put in place
- Enormous opportunities exist for competent service providers

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