UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

TELEPHONE: (510) 643-8678
TELEFAX: (510) 643-8919
E-MAIL: bea@ce.berkeley.edu
HTTP://www.ce.berkeley.edu/

CENTER FOR CATASTROPHIC RISK MANAGEMENT
DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
212 McLAUGHLIN HALL
BERKELEY, CALIFORNIA 94720-1710

May 18, 2010

Failures of the Deepwater Horizon Semi-Submersible Drilling Unit

Testimony of Professor Robert Bea

Based on currently available information (provided by approximately 50 informants) and analyses (400 hours) of that information has provided the following preliminary insights into the failures of the Deepwater Horizon Drilling Unit on and after April 20, 2005.

Summary

Based on the evidence I have been able to develop and analyze, this disaster appears to have been preventable if progressive international guidelines and practices were followed.

Lessee – BP PLC

As the lessee, BP PLC bears the primary responsibilities for operational Quality (serviceability, safety, compatibility, durability), Reliability (likelihood of realizing desirable Quality) and Stewardship of these public resources and protection of the environment.

Regulatory – DOI MMS

As the Federal regulator, the DOI MMS bears the primary responsibilities for oversight of the operations of BP PLC. This responsibility is to assure that adequate and acceptable Quality and Reliability are developed during the life-cycle (concept, design, construction, operation, maintenance, decommissioning) during development of this precious and vital public resource and for protection of the environment.

How Did This Happen?

This is an extremely hazardous environment – equal to that of exploration of the Moon and Mars. USCG Admiral Thad Allen described this environment as the "Tyranny of Depth and Distance." I would add 'Darkness'. These are the 'Natural Hazards' of the pressures, forces, movements of the water and the seafloor, and extremely low and high temperatures of the deep ocean environment.

Previous studies of more than 600 catastrophic failures (costing more than US $1 Billions) has provided a simple equation for these catastrophes: A + B = C. 'A' are natural hazards. 'B' are human fallibilities that include hubris, arrogance, greed, and sloth. 'C' is a catastrophe sooner or later.

These studies show approximately 80% of the failures are rooted in Extrinsic Uncertainties (human and organizational performance, knowledge acquisition and utilization). The remaining 20% of the failures are rooted in Intrinsic Uncertainties (natural variabilities, analytical model limitations). Approximately 80% of these failures develop during the system operating and maintenance phases. The studies show that more than 60% develop during the design phase (including concept development). Based on the information currently available to the author, the failures of the Deepwater Horizon drilling unit is an excellent example these findings.

Based on the information available to the author, BP PLC and the DOI MMS failed to:

- properly evaluate and manage the likelihoods of failure (Pfs),
- properly evaluate and manage the consequences of failure (Cfs), and
- abide by the legal Standards of Care, National Environmental Protection Act, and the Public Trust Doctrine.

Based on the information available to the author, BP PLC and the DOI MMS failed to properly assess and manage the natural hazards. The public, resources and environment were and are being severely punished.

Seven Steps to Failure to Contain (Blowout, Pf)

Based on the information available to the author, the Deepwater Horizon failure developed due to:

- improper well design (configuration of well tubulars),
- improper cement design (segmented discontinuous cement sheath),
- flawed Quality Assurance and Quality Control (QA / QC) – no cement bond logs, ineffective oversight of operations,
- bad decision making – removing the pressure barrier – displacing the drilling mud with sea water 8000 feet below the drill deck,
- loss of situational awareness – early warning signs not properly detected, analyzed, or corrected (repeated major gas kicks, lost drilling tools, lost circulation, changes in mud volume and drill string weight),
- improper operating procedures – premature off-loading the drilling mud (weight material not available at critical time), and
- flawed design and maintenance of the final line of defense – the shear rams of the Blow Out Preventer (BOP).

Based on the information available to the author, the BP PLC and DOI MMS:

- drilling and well completion operations did not meet industry standards,
- operations were 'Faster and Cheaper', but not 'Better' – the operation records clearly show excessive economic and schedule pressures resulted in compromises in the Quality ad Reliability of this deepwater oil and gas development system, and
- did not develop effective, collaborative, and constructive interactions to assure that the Pf due to blowout was acceptable and desirable.

Three Steps to the Failure to Respond (Containment, Clean-up, Secure, Cf)

Based on the information available to the author, BP PLC and the DOI MMS did not develop or implement effective measures for:

- well control after loss of containment – blowout,
- capturing the loss of control materials (gases, oil, water),
- clean-up of the loss of control materials in the open ocean (booms, skimmers, burning, dispersants).

Because BP PLC and the DOI MMS believed that the potential Cfs 'insignificant', they were not prepared for the failures associated with the Deepwater Horizon operations (prevention, containment). The consequences of these deeply flawed assessments and decisions were catastrophic to life, property, resources, the industry, and the environment. Based on the information available to the author, BP PLC and the DOI MMS had no effective plans, measures, or preparations for mitigating the Cfs.

Based on the information available to the author, BP PLC and the DOI MMS had ineffective QA/QC of BP PLC plans, operations, and maintenance. Diligent and effective efforts are required to correctly detect, analyze, and rectify important flaws during the life-cycle of 'cutting edge' systems and operations.

Violation of The Laws of Public Resource Development

Based on the information available to the author, BP PLC and the DOI MMS did not:

- properly or effectively assess and manage the Risks (Pfs and Cfs) associated with the development of precious and vital public resources. Pfs and Cfs were not acceptable to the US public and environment. This is a violation of the first principle of Civil Law,
- satisfy the legal Standard of Care (SOC) in design, construction, operation, and maintenance of this deepwater drilling and development system (due diligence was not demonstrated),
- meet the requirements of the National Environmental Protection Act (NEPA), and
- satisfy the Public Trust Doctrine.

This catastrophic failure resulted from multiple violations of the laws of public resource development.

How Can This Be Prevented?

The likelihoods of failures such as the failure of the Deepwater Horizon and the subsequent containment and clean-up operations can be reduced to desirable and acceptable levels by developing and implementing a leading, collaborative, and diligent Life-Cycle Risk Based Management (LC RBM) government and industrial regime to explore and develop a precious and vital public resource – offshore oil and gas reserves (life-cycle Safety Case regime).

The industrial LC RBM should be based on Pfs and Cfs assessed using qualitative and quantitative methods that develop and maintain Pfs and Cfs that are acceptable to the public, government and comply with the legal SOC, NEPA and the Public Trust Doctrine. Proactive, Reactive, and Interactive methods must be used to assure development of acceptable and desirable Pfs and Cfs during the life-cycle of the activities. These methods are founded on continuous effective efforts to reduce the likelihoods and severity of malfunctions, and increase the likelihoods of effective detection, analysis, and correction of malfunctions.

The OCS Lessees and the DOI MMS should develop and sustain:

- a technically superior, challenging, collaborative, and diligent program of life-cycle QA/QC based on effective and timely detection, analysis and correction of defects and flaws,
- High Reliability Organizations that effectively practice High Reliability Management (planning, organizing, leading, controlling) in all segments of the operations. This will require organizational Commitment (to develop acceptable Pfs and Cfs throughout the life-cycle), Capabilities (technical and managerial superiority), Cognizance (awareness of hazards and uncertainties that threaten acceptable Pfs and Cfs through the life-cycle), Culture (balancing production and protection), and Counting (development of acceptable costs, benefits, and profitability),
- programs of international industry – government – academia collaborative Research and Development projects and Public Outreach to help educate the public,
- long term collaborations with international regulatory agencies to enable realization of continuous improvements and implementation of best practices in regulations of deepwater oil and gas exploration and production, and
- effective deepwater oil and gas development Technology Delivery System (TDS) that effectively engages the public interests, the responsibilities of the governments (of, by, and for the people), the technology of industry and commerce, and the stewardship of the environment.

These recommendations do not address the hardware, equipment, and structural elements associated with ultra deepwater exploration and production developments – the 'engineering technical' elements associated with these systems. These recommendations are based on analyses of the performance of previous systems summarized earlier. The primary challenge that must be developed as a first priority are the human and organizational aspects. Experience clearly shows that if we are able to develop the 'right stuff' – High Reliability Organizations and Management, then systems (comprised of hardware, structures, operating personnel, operating and oversight organizations, procedures, cultures, and interfaces among the foregoing) that have acceptable reliability and quality characteristics will be realized. We must have the right stuff to realize the right things.

Professor Robert Bea, PhD, PE

Deepwater Horizon Study Group
Center for Catastrophic Risk Management