



US CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

INVESTIGATION REPORT OVERVIEW

EXPLOSION AND FIRE AT THE **MACONDO WELL**

(11 Fatalities, 17 Seriously Injured, and Serious Environmental Damage)



DEEPWATER HORIZON RIG

MISSISSIPPI CANYON BLOCK #252, GULF OF MEXICO

APRIL 20, 2010

REPORT NO. 2010-10-I-OS

6/5/2014

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Dedication

The CSB dedicates this report to the eleven men who lost their lives as a result of the explosion and fire at the Macondo well on April 20, 2010.

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Preface

The impact of the Macondo incident was catastrophic: 11 workers died, 17 others were seriously injured, and a reported 5 million barrels of oil spilled into the Gulf of Mexico,^a making it was one of the largest environmental disasters in US history. The accident had far reaching effects on the lives of tens of thousands of people, from the families of those killed and injured to those whose livelihoods depend on the Gulf, as well as the broader oil and gas industry. The incident was the subject of other investigations, including those conducted by the National Commission, the National Academy of Engineering, the Department of Interior, the Joint Investigation Team (formed by the US Coast Guard and the Bureau of the Ocean Energy Management), the Deepwater Horizon Study Group, BP, and Transocean. These investigations publicly documented many facts about the incident and thoroughly examined several issues.^b

Consequently, the US Chemical Safety and Hazard Investigation Board (CSB) investigation generally does not address issues already well covered in the earlier reports. The CSB's particular experience in process safety, organizational factors/safety culture, and regulatory analysis has led the Agency to focus on topics that earlier investigations have not fully addressed or where further examination can yield additional safety lessons.

As with other major incidents,^c the Macondo blowout resulted from a complex combination of deficiencies: process safety safeguards and inadequate management systems and processes meant to ensure safeguard effectiveness, human and organizational factors that created an environment ripe for error, organizational culture focused more on personal safety and behavioral observations than on major accident prevention, and a regulatory regime unable to deliver the necessary oversight for the high-risk activities involved in deepwater exploration, drilling, and production.

Furthermore, Macondo raises regulatory concerns for the US just as the 1988 Piper Alpha disaster^d in the North Sea called into question the offshore regulatory regime in the United Kingdom (UK). As part of its Macondo investigation, the CSB held a public hearing in December 2010 on the international use of

^a The total volume of oil spilled has yet to be determined by the U.S. District Court in the multidistrict litigation, but estimates range from approximately 5 million barrels to 3.2 million barrels. In *Re: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010*, U.S. Br. 1, Jan. 27, 2014, ECF No. 12237; BP Br. 29, Jan. 24, 2014, ECF. No. 12227.

^b For example, the National Commission's Chief Counsel Report thoroughly explored the issues surrounding the cement used in the well. See these reports: National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Deep Water: The Gulf Oil Disaster and the Future of Offshore Drilling*. Washington, DC: US Government Printing Office, January 2011.

^c Highly visible incidents with far-reaching economic and industry effects in which lives were lost include the Piper Alpha offshore accident (1988), the Columbia space shuttle disaster (2003), and the BP Texas City refinery explosion (2005).

^d On July 6, 1988, explosions and fire on this North Sea oil production platform killed 167.

performance-based regulatory regimes offshore, such as the safety case regime.^a And the dialogue on needed improvements to the US regulatory framework has continued since that hearing. Multiple oil and gas regulatory agencies in the US met in September 2012 to discuss the attributes and feasibility of implementing new regulatory frameworks for the energy sector both on and offshore.^b Further, the US National Academies of Science initiated a study on safety and health for the onshore and offshore oil and gas sectors.^c These events represent a serious interest in fundamentally changing how the entire US energy sector manages major accident prevention. The aim of the CSB Macondo incident investigation is to focus on the most important technical, organizational, and regulatory topics so that the safety improvements necessary to help prevent a similar incident may be implemented in the United States.

^a The safety case regulatory regime is typically defined as a combination of prescriptive elements that describe specific activity-based actions and goal-setting elements that require companies to demonstrate to the regulator that risks of an operation have been reduced to as low as reasonably practicable (ALARP). The CSB's multi-volume Macondo investigation report will fully explore various regulatory frameworks and their distinctive attributes (including those of the safety case).

^b Expert Forum on the Use of Performance-Based Regulatory Models in the US Oil and Gas Industry, Offshore and Onshore, 77 Fed. Reg. 50,172 (August 20, 2012).

^c Letter from Senator Jeff Bingaman, Chairman of Committee on Energy and Natural Resources, and Senator Patty Murray, Chairman of Health, Education, Labor and Pensions' Subcommittee on Employment and Workplace Safety, to Hilda Solis, Secretary of US Department of Labor, April 27, 2012.

Investigation Overview

Incident Synopsis

On April 20, 2010, a multiple-fatality incident occurred at the Macondo oil well approximately 50 miles off the coast of Louisiana in the Gulf of Mexico. The incident occurred during temporary well-abandonment^a activities on the Deepwater Horizon (DWH) drilling rig. Control of the well was lost, resulting in a blowout—hydrocarbon gas and liquid rapidly and forcefully released from the well at rig level. The hydrocarbons found an ignition source on the drilling rig and ignited. The resulting explosions and fire led to the deaths of 11 individuals, serious injuries to 17 others, the sinking of the rig, and massive marine and coastal damage from a reported 5 million barrels of released hydrocarbons.^b This incident is one of the worst environmental disasters in US history.

Scope of the Investigation

The CSB examines the Macondo incident from a process safety perspective, integrating into the US offshore sector fundamental safety concepts, such as the hierarchy of controls, human factors, and inherent safety. While these concepts are not new in the petrochemical world or in other offshore regions around the globe, they are not as commonplace in the US outer continental shelf.

The CSB also was specifically requested to examine how safety might have been affected due to issues pertaining to corporate culture and decision-making, management of organizational change, contractor oversight and shared responsibilities for major accident prevention, and for similarities to past CSB investigations, including the 2005 BP Texas City explosion.^c

Thus, the CSB Macondo investigation goes beyond previously released reports on the accident, providing information not fully covered elsewhere, including:

- The publication of new findings concerning the failures of a key piece of safety equipment—the blowout preventer (BOP)—which was, and continues to be, relied upon as a final barrier^d to loss of well control. These key findings emerged through a comprehensive examination of the full set

^a Temporary abandonment consists of securing the integrity of the well and removing all equipment above the seafloor wellhead. Once this has been accomplished, the well would be left in a safe condition until required for production, at which time a production installation would be located over the well.

^b The total volume of oil spilled has yet to be determined by the U.S. District Court in the multidistrict litigation, but estimates range from approximately 5 million barrels to 3.2 million barrels. In *Re: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010*, U.S. Br. 1, Jan. 27, 2014, ECF No. 12237; BP Br. 29, Jan. 24, 2014, ECF. No. 12227.

^c The CSB was explicitly called upon by the US Congressional Committee on Energy and Commerce to conduct an investigation because the Committee "believe[s] CSB's past work on BP puts it in a unique position to address questions about BP's safety culture and practices," making specific requests to explore several organizational issues that may be causal to the event. (Letter from Henry A. Waxman, Chairman, and Bart Stupak, Subcommittee Chairman of the Energy and Commerce Committee, to CSB Chairman John Bresland, June 8, 2010).

^d In this context, barriers are the technical, operational and /or organizational elements that individually or collectively ensure that major accidents, such as well blowouts, do not occur. The failure of all these barriers contributed to causing the Macondo incident.

of testing data of the blowout preventer, which was not available at the time of previously published reports on the incident. These findings underscore existing design and testing limitations of blowout preventers that might otherwise remain undetected.

- A discussion of the treatment of safety critical elements in the existing post-Macondo US offshore regulatory regime with comparisons to the treatment of such equipment in other offshore regions. This comparison demonstrates that, while the US regime implemented many positive changes after the Macondo accident, there exists further opportunities for improvement in the management of all safety critical elements.
- A comprehensive comparison of the attributes of other regulatory regimes to the existing framework and the safety regulations established in the US offshore since Macondo. This comparison reveals significant limitations of the post-Macondo US regulatory regime when compared to its international counterparts, leaving industry and the public vulnerable to another major accident.
- In-depth analysis of needed safety improvements on a number of organizational factors, including but not limited to industry's approach to risk management, corporate governance of safety management for major accident prevention, workforce involvement through the lifecycle of hazardous operations, the dependence on human actions to maintain safe operations without a sufficient focus on the management of human factors in offshore operations, and the need for leading process safety indicators that allow for active monitoring of safety critical equipment and systems.

Various volumes of the CSB Macondo Investigation Report will include recommendations as relevant to the evidence and analysis.

Organization of the Report

The CSB investigation of the Macondo incident covers technical, organizational, and regulatory factors that contributed to the April 20, 2010, event. Due to the span of issues examined, the report has been divided into multiple volumes published separately as they are completed.

Volume 1 recounts a summary of events leading up to the Macondo explosions and fire on the rig pertinent to the CSB's incident analysis, providing descriptive information on drilling and well completion activities.

Volume 2 explores several technical findings related to the functioning of BOP, a subsea system that was intended to mitigate or prevent a loss of well control.^a This volume examines the failures of the BOP as a safety critical piece of equipment and explores deficiencies in the management systems meant to ensure that the BOP was reliable and available as a barrier on April 20. Thus, the CSB presents a technical examination of the BOP with two purposes: (1) to discuss key findings related to functionality, availability, and reliability of the BOP as a well control device and safety-critical barrier, and (2) as a

^a The BOP is not the most critical barrier to loss of well control, yet, as will be explored in Volume 2, industry had placed great reliance on the effectiveness of BOPs for preventing major well accidents. The BOP was also a key piece of physical evidence available to the entities that investigated the accident. Much of the physical evidence was not retrieved or was lost with the sinking of the rig, while other physical evidence, including the downhole cement, remains thousands of feet under the seabed.

conduit for exploring gaps in the post-Macondo US regulations and good practice guidance. The CSB concludes that the functioning of the BOP is important to analyze, as it is emblematic of an inadequate framework for the management of safety critical elements in the US offshore sector. The Agency explores how safety critical elements are managed and regulated in other global offshore regions to illustrate ways in which the US can further advance offshore safety.

Volume 3 builds upon the evidence and analysis of the second volume by delving into the role of the regulator in the oversight of the offshore industry as more generally revealed from the Macondo accident. It discusses failures that existed at the time of the event, as well as the remaining challenges that exist today, four years later. The limitations of the current regulatory regime in the US are compared to international models. Recommendations seek to give the US offshore regulator the capability of continually driving improvements to prevent major accidents.

The fourth and final volume of the CSB Macondo Investigation Report explores additional safety issues, including corporate governance, safety performance indicators, organizational behavior, and safety culture, and it issues recommendations pertaining to these topics.

Conduct of the Investigation

In the course of its investigation, the CSB conducted numerous interviews; collected almost one million documents from 24 companies and parties, including all evidence from the National Commission on the BP Deepwater Horizon Oil Spill and the federal court multi-district litigation; gathered data from post-accident investigations activities, including testing of a critical piece of safety equipment (the BOP); and sponsored independent testing of an exemplar BOP component for further analysis. Through the duration of its investigation, the CSB investigative staff and Board met with regulators, industry, and workforce representatives in the United Kingdom, Canada, Australia, and Brazil for information gathering purposes. The CSB also conducted two public hearings. The first event, held in Washington, DC, in December 2010, focused on international regulatory approaches used to prevent major accident events^a offshore. Former and current regulatory officials as well as workforce and industry personnel participated in panel discussions on the challenges and benefits of various regulatory models. In July 2012, the CSB held a second public hearing on safety performance indicators for major accident prevention. The CSB Chairman and Board Members heard testimony from leading regulatory, industry, and workforce representatives, and CSB staff released preliminary findings of the Agency's Macondo investigation.^b

The Agency worked with experts in petroleum engineering, corporate governance, safety performance indicators, sociology, public policy, regulatory enforcement, and organizational culture to assist with the

^a Major accident events (MAEs) have been defined for offshore drilling operations by governing regulations in UK, Norway, and Australia. While each definition differs slightly, MAEs are generally described as a fire, explosion, or release of a hazardous chemical substance that involves the death or serious injury to multiple individuals or severe environmental damage. (UK HSE, Safety Case Regulations, Interpretation, Section 2(1) "major accident," http://www.legislation.gov.uk/ukxi/2005/3117/pdfs/ukxi_20053117_en.pdf; Norway PSA, "Guidelines Regarding the Management Regulations" (December 20, 2012), Section 9, "major accident," <http://www.ptil.no/management/category406.html#p17>; and Australia NOPSEMA, *Offshore Petroleum and Greenhouse Gas Storage Act 2006*, Chapter 1.5 Definitions, "major accident event," <http://www.comlaw.gov.au/Details/F2010C00422/Html/Text#param5>.

^b Transcripts for both events are available at the CSB's website on the Macondo investigation, www.csb.gov.

analysis. Former and current heads of various regulatory regimes in the US and internationally were also consulted for their expertise.

Challenges to the CSB's Mission and Investigative Efforts

The CSB is an independent federal agency charged with investigating industrial chemical accidents. Its mission is to independently investigate significant chemical incidents and hazards and effectively advocate the implementation of the resulting recommendations to protect workers, the public, and the environment. Like its sister agency, the National Transportation Safety Board, the CSB as a federal agency focuses more on national and industry-wide issues beyond the confines of the existing regulatory framework rather than solely on company-specific policies. The CSB looks for new opportunities to improve safety, not just for the companies involved, but for the broader chemical industry and the regulators that provide oversight. Despite its safety mission, the CSB often faces roadblocks and delays. The Macondo case was no exception. Indeed, it was one of the most challenging experiences in Agency history.

Unlike most CSB investigations that begin within 24 – 48 hours of an incident occurring, the Agency's inquiry into the April 20, 2010, Macondo event did not commence until July 2010, after receiving requests from Congress to analyze the incident in a manner similar to its inquiry into the 2005 BP Texas City refinery explosion. This late start was the first of many impediments along the way. While most of the involved companies, including BP, cooperated with the CSB investigation, a primary one did not. Transocean, the drilling contractor with the most witnesses on the drilling rig, refused to acknowledge the Agency's jurisdiction and failed to respond fully to subpoena requests for documents and interviews. The CSB pursued enforcement actions in federal court, a multi-year endeavor that expended significant Agency resources.^a It was also blocked from fully participating in portions of equipment testing, so it had to examine the data *ex post facto*. The CSB's limited ability to influence the testing procedures precluded it from conducting further testing that would have spawned a more thorough understanding of primary evidence. Additional Congressional funding was not provided for such a major undertaking; thus, the CSB had to conduct the largest investigation in its history with its usual operating budget and staffing resources. All of these obstacles challenged the speed and depth of the Agency's exploration in vital safety issues. Nevertheless, the CSB was able to comprehensively examine numerous technical, organizational, and regulatory issues.

The Agency urges industry, regulators, the offshore workforce, and the public to use this multi-volume investigation report to prevent future catastrophic accidents.

^a Ultimately, a federal district court ordered Transocean to comply with the CSB subpoenas. *United States v. Transocean Deepwater Drilling, Inc.*, 2013 WL 1345246 (S.D. Tex., March 30, 2013). Transocean has appealed this decision, and at the time of publication of this report a court decision on the appeal is pending.

CSB Investigation Reports are formal, detailed reports on significant chemical accidents and include key findings, root causes, and safety recommendations. CSB Hazard Investigations are broader studies of significant chemical hazards. CSB Safety Bulletins are short, general-interest publications that provide new or noteworthy information on preventing chemical accidents. CSB Case Studies are short reports on specific accidents and include a discussion of relevant prevention practices. All reports may contain include safety recommendations when appropriate. CSB Investigation Digests are plain-language summaries of Investigation Reports.

The U.S. Chemical Safety and Hazard Investigation Board (CSB) is an independent Federal agency whose mission is to ensure the safety of workers, the public, and the environment by investigating and preventing chemical incidents. The CSB is a scientific investigative organization; it is not an enforcement or regulatory body. Established by the Clean Air Act Amendments of 1990, the CSB is responsible for determining the root and contributing causes of accidents, issuing safety recommendations, studying chemical safety issues, and evaluating the effectiveness of other government agencies involved in chemical safety.

No part of the conclusions, findings, or recommendations of the CSB relating to any chemical accident may be admitted as evidence or used in any action or suit for damages. See 42 U.S.C. § 7412(r)(6)(G). The CSB makes public its actions and decisions through investigation reports, summary reports, safety bulletins, safety recommendations, case studies, incident digests, special technical publications, and statistical reviews. More information about the CSB is available at www.csb.gov.

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