U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

INVESTIGATION REPORT
VOLUME 3

DRILLING RIG EXPLOSION AND FIRE AT THE MACONDO WELL

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

DEEPWATER HORIZON RIG

MISSISSIPPI CANYON 252, GULF OF MEXICO

APRIL 20, 2010

KEY ISSUES:

- HUMAN FACTORS
- ORGANIZATIONAL LEARNING
- SAFETY PERFORMANCE INDICATORS
- RISK MANAGEMENT PRACTICES
- CORPORATE GOVERNANCE
- SAFETY CULTURE

REPORT NO. 2010-10-I-OS

4/12/2016

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Acronyms and Abbreviations

ALARP	As Low As Reasonably Practicable
AMF	Automatic Mode Function
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BOP	Blowout Preventer
BSEE	Bureau of Safety and Environmental Enforcement
BSR	Blind Shear Ram
CCPS	Center for Chemical Process Safety
CEO	Chief Executive Officer
COS	Center for Offshore Safety
COSO	Committee of Sponsoring Organizations
CRM	Crew Resource Management
CSB	US Chemical Safety Board
DAFW	Days Away From Work
DAFWC	Days Away From Work Case
DAFWCF	Days Away From Work Case Frequency
DART	Days Away from Work, Restricted duty, and Transfer situations
DAWFC	Days Away from Work Case Frequency
DNV	Det Norske Veritas
DOI	Department of Interior
DWH	Deepwater Horizon
DWOP	Drilling and Wells Operation Practice
EDS	Emergency Disconnect System
EHS	Environmental Health and Safety
EPA	Environmental Protection Agency
ERM	Enterprise Risk Management

ETP	Engineering Technical Practices
FAA	Federal Aviation Administration
FRC	Financial Reporting Council
GDP	Group Defined Practice
GHSER	Getting HSE Right
GRI	Global Reporting Initiative
HAZID	Hazard Identification
HAZOP	Hazard and Operability Study
HIPO	High Potential Incident
HPDO	High Potential Dropped Objects
HRO	High Reliability Organization
HSE	Health Safety Executive
HSSE	Health, Safety, Security and Environment
HTO	Human, Technology and Organization
IADC	International Drilling Contractors Association
INPO	Institute of Nuclear Power Operations
IOGP	International Association of Oil & Gas Producers
ITL	Information to Lessee
LCM	Loss Circulation Material
LMRP	Lower Marine Riser Package
LOPA	Layers of Protection Analysis
LOPC	Loss of Primary Containment
LTA	Lost Time Accident
LTI	Lost Time Incident/Lost Time Incident rate
MAE	Mary Accident Event
MAHRA	Major Accident Hazard Risk Assessment
MHRA	Major Hazard Risk Assessment
MAP	Major Accident Prevention
MAR	Major Accident Risk
MBI	Marine Board of Investigation
MBO	Management by Objective

MGS	Mud-Gas Separator
MHRA	Major Hazard Risk Assessments
MIA	Major Incident Announcement
MMS	Minerals Management Service
MOC	Management of Change
MODU	Mobile Offshore Drilling Unit
MSHA	Mine Safety and Health Authority
NAE	National Academy of Engineering
NOPSA	National Offshore Petroleum Safety Authority
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NPT	Negative Pressure Test
NRC	Nuclear Regulatory Commission
NSOAF	North Sea Offshore Authorities Forum
NTL	Notice to Lessee
NTS	Non-technical Skills
NTSB	National Transportation Safety Board
OCS	Outer Continental Shelf
ODE	Onshore Drilling Engineer
OECD	Organization for Economic Co-operation and Development
OIC	Operations Integrity Case
OIM	Offshore Installation Manager
OLF	Norwegian Oil Industry Association
OMS	Operating Management System
OOC	Offshore Operators Committee
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PMAA	Performance Monitoring Audit and Assessment
PSA	Petroleum Safety Authority
PSM	Process Safety Management
QHSE	Quality, Health, Safety and Environment
RAT	Risk Assurance Tool

RIF	Recordable Injury Frequency
SASB	Sustainability Accounting Standards Board
SCE	Safety Critical Element
SCTA	Safety Critical Task Analysis
SEC	Securities and Exchange Commission
SEEAC	Safety, Ethics and Environment Assurance Committee
SEMS	Safety and Environmental Management System
SHAPE	Safety and Health in Amec Process & Energy
SHE	Safety, Health, and Environment
SIC	Serious Injury Case
SID	Standing Instructions to the Driller
SINTEF	Norwegian: Stiftelsen for industriell og teknisk forskning
SIS	Safety Instrumented Systems
SMS	Safety Management System
SOP	Standard Operating Procedure
SPE	Society of Petroleum Engineers
SPI	Safety Performance Indicator
SPU	Strategic Performance Unit
TPSR	Total Potential Severity Rate
TRIR	Total Recordable Injury Rate
TSTP	Task Specific THINK Procedure
UK	United Kingdom
US	United States
USCG	United States Coast Guard
WAD	Work as Done
WAI	Work as Imagined
WBM	Water Based Material
WCID	Well Construction Interface Document
WLCPF	Well Lifecycle Practices Forum
WSL	Well Site Leader

Volume 3

Human, Organizational, and Safety System Factors of the Macondo Blowout

Volume 3 – Introduction

In 1988, the offshore oil and gas industry experienced its deadliest accident when an explosion aboard the Piper Alpha oil production platform took the lives of 167 individuals. In its aftermath, a major incident investigation revealed a number of issues concerning the management of major accident risk offshore.[1] Twenty-five years later, the Piper Alpha disaster was described as "the lens through which we [the offshore industry] view our safety efforts."[2] The Macondo incident serves to check the focus of that lens, as the blowout illuminates the increasing complexity of offshore operations, technologies, and drilling environments. To that end, the CSB's investigation of the Macondo incident revisits some of Piper Alpha's lessons and introduces new ones related to human performance, organizational learning, safety performance indicators, risk management coordination, and corporate cultures that promote safety.

The risk management policies of both BP and Transocean promote an incident-free workplace. BP's 2008 major corporate safety Operating Management System (OMS) framework states, "Our goals are simply stated: no accidents, no harm to people, and no damage to the environment."[3] In Transocean's 2009 Health and Safety Policy statement, the company commits to operating in an "incident-free workplace—all the time, everywhere."[4] ExxonMobil,[5] Shell

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[1] Department of Energy. *The Public Inquiry into the Piper Alpha Disaster; Presented to Parliament by the Secretary of State for Energy by Command of her Majesty*. November, 1990.

[2] Oil & Gas UK. *Health & Safety Report 2014;* 2014; p 1. http://oilandgasuk.co.uk/wp-content/uploads/2015/05/HS087.pdf (accessed December 20, 2015).

[3] Internal Company Document, BP. *The BP Operating Management System Framework, Part 1, An Overview of OMS*, Issue 2, November 3, 2008, p 24, BP-HZN-2179MDL0033320, see Exhibit 2352 http://www.mdl2179trialdocs.com/releases/release201302281700004/Lynch_Richard-Depo_Bundle.zip (accessed October 7, 2015).

[4] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, General, BP-HZN-2179MDL00132067, see Exhibit 4942 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[5] ExxonMobil, Commitment to Safety, http://www.exxonmobile.com/USA-English/EMPCo/healthsafetyenvironment_safety.aspx (accessed December 8, 2014).

Global,[6] Total,[7] ConocoPhillips,[8] and Chevron[9] have similarly stated "zero incident" risk management goals, but zero incidents for a day, month, or even years do not preclude a company from an incident tomorrow. Preventing incidents requires a shift in focus from past successes to current risk reduction activities. Ultimately, risk reduction efforts must be continually accounting for inevitably changing circumstances (e.g., the drilling environment, technology, knowledge, and workforce).

While the Macondo blowout occurred under the direction of Transocean and BP, it affected the offshore industry worldwide,[10] demonstrating that risk management for preventing major accident events (MAEs) continues to challenge the offshore industry despite the numerous lessons from the Piper Alpha incident.[11] For example, almost five years after the Macondo blowout, audit findings from one of the offshore US regulators, Bureau of Safety and Environmental Enforcement (BSEE), suggest that some companies use their safety and environmental management system (SEMS) programs[12] to document regulatory compliance rather than to actually manage risks.[13] In fact, post-incident CSB analyses of Transocean and BP risk management policies at the time of the blowout reveal that many of the policies would have satisfied current SEMS requirements. Yet the companies did not effectively implement these policies to manage the major accident risks of the Macondo well, and the companies were not held accountable by the regulator to ensure that they managed safety as their company policies stipulated. Beyond BP and Transocean, the CSB found a lack of US offshore industry regulations and guidance for human factors, process safety indicators, and corporate governance. Volume 3 of the CSB Macondo investigation report addresses the insufficient focus on managing major hazard risk throughout the lifecycle of the Macondo well, beginning with the well's initial design, through execution of the project, which included several modifications, and finally during temporary abandonment planning and execution. The CSB's report:

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6 Shell Global, Safety, http://www.shell.com/global/environment-society/safety.html (accessed December 8, 2014).

7 Total, Industrial Safety: Our Objectives and Ambitions, http://www.total.com/en/society-environment/industrial-safety/our-objectives-and-ambitions (accessed December 8, 2014).

8 ConocoPhillips, Our Safety Commitment, http://www.conocophillips.com/sustainable-development/safety-health/Pages/our-safety-commitment.aspx (accessed February 8, 2015).

9 Chevron, Workforce Health and Safety, http://www.chevron.com/corporateresponsibility/approach/workforce/ (accessed December 8, 2014).

10 E.g., Oil & Gas UK. *Guidelines on BOP Systems for Offshore Wells, Issue 2;* Oil & Gas UK: Great Britain, May, 2014; p 182.; House of Commons Energy and Climate Change Committee. *UK Deepwater Drilling-Implications of the Gulf of Mexico Oil Spill;* HC 450-1; The Stationery Office Limited: London, Great Britain, January 6, 2011.; International Association of Oil & Gas Producers. *Deepwater Wells: Global Industry Response Group Recommendations;* Report No. 463; May, 2011.

11 E.g., Walker, S. *Review of the Cullen Recommendations - are they still relevant?*, Oil & Gas UK's Piper 25 Confernece, Aberdeen, Scotland, June, 2013.; Hackitt, J. *Piper Alpha – honouring the legacy and adapting for the future*, Oil & Gas UK's Piper 25 Confernece, Aberdeen, Scotland, June, 2013.; Fryan, R. *Piper Alpha 25*, Oil & Gas UK's Piper 25 Confernece, Aberdeen, Scotland, June, 2013.

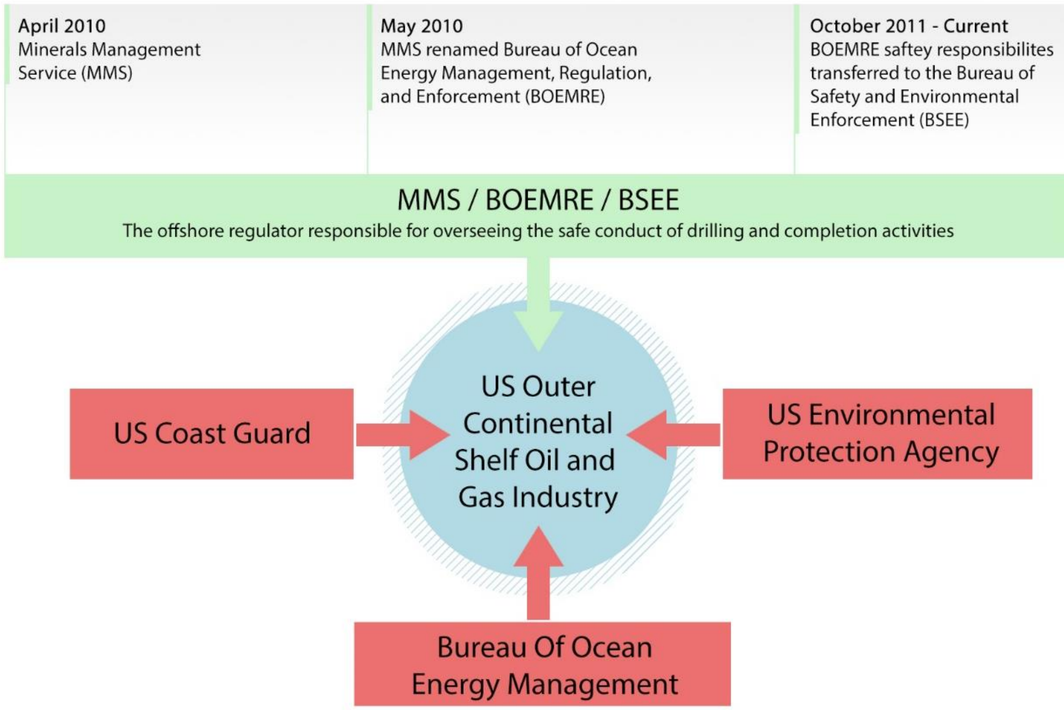
12 30 C.F.R. §250.1900 Subpart S, Safety and Environmental Management Systems (2015).

13 Bureau of Safety and Environmental Enforcement. *BSEE Priorities Regarding SEMS*, Offshore Technology Conference, Houston, TX, 2015; http://www.bsee.gov/uploadedFiles/BSEE/BSEE_Newsroom/Speeches/2015/OTC%202015%20Mtg%20SEMS%20Presentation.pdf (accessed December 19, 2015).

1. Identifies instances where crewmember's actions were relied upon for successful and safe well operations, but neither BP nor Transocean effectively defined performance expectations, nor did they support the crew with a rigorous human factors management system.
2. Demonstrates that both BP and Transocean possessed safety management system policies meant to manage major accident hazards, but they did not effectively implement these policies because of:
    a. Inadequate incorporation of human factors into safety management practices and hazard assessments;
    b. Ineffective organizational learning from previous incidents;
    c. Unclear roles and responsibilities, separately and jointly, for managing major accident risk; and
    d. Insufficient fulfillment of internal company requirements to reduce risk to as low as reasonably practicable (ALARP).
3. Advances the importance of actively monitoring the effectiveness of barrier and safety management systems.
4. Illuminates the influence of oversight from corporate board of directors and shareholders on risk management.
5. Illustrates the current gaps in US regulations and guidance that do not incorporate recognized process safety concepts, including human factors, ALARP, and effective management of safety critical elements.
6. Lays the necessary foundation for carefully examining the strong oversight and influence required of the regulator in pushing companies to effectively implement what they claim they are doing to manage major accident risk and in driving them toward continual risk reduction.

[CALL-OUT BOX START]

Throughout Volume 3, the CSB refers to "the regulator" or "offshore regulations" to indicate either MMS or BSEE and their respective safety regulations for drilling and completions activities on the outer continental shelf. As indicated in the figure below, MMS evolved into BSEE after the Macondo incident occurred. In reality, several regulatory bodies oversee the offshore oil and gas industry including the US Coast Guard (USCG), the Bureau of Ocean Energy Management (BOEM), and the Environmental Protection Agency (EPA), but the CSB generally limits its discussion to MMS and BSEE.



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Moving Beyond the Blowout Preventer

Volume 2 of the CSB Macondo investigation report introduces safety critical elements (SCEs), also called safety barriers, as equipment or tasks that provide the highest level of protection against MAEs, and, conversely, whose failure increases the risk of an MAE.[14] In that volume, the CSB uses the blowout preventer (BOP) as the vehicle to explore targeted risk reduction by describing the steps required for maintaining SCE effectiveness to ensure risk of an MAE is as low as reasonably practicable.[15]

[14] CSB Macondo Investigation Report, Volume 2, Section 4.2.3.1, pp 58.

[15] CSB Macondo Investigation Report, Volume 2, Figure 5-1, p 63.

Historically, safety barriers have been identified as physical in nature, intended to separate and protect people and the environment from hazards.[16, 17] Physical barriers, such as the downhole cement and BOP installed at the Macondo well, have been closely assessed post-incident for their contribution to the blowout.[18] But focusing on solutions to these technical failures cannot prevent future incidents without giving equal attention to failures of less visible, non-physical barriers and support systems.

The safety barrier concept must extend beyond physical safeguards. For example, a blowout preventer should establish a physical barrier to prevent the flow of hydrocarbons from the well to the drilling rig, yet the BOP can accomplish this only if the crew detects the kick soon after ingress and activates the appropriate BOP component in time for it to seal the well. Beyond the crew's actions, companies must appropriately manage several organizational factors to ensure the BOP will successfully function as a barrier, including:

- proper selection of a BOP with capabilities appropriate to control the well being drilled;
- maintenance and care to ensure the BOP can function as designed;
- a crew's capabilities in identifying the need to close the well;
- active monitoring of the BOP and its associated safety systems to ensure its effectiveness as a barrier when summoned; and
- company procedures and cultural practices that directly influence a crew's actions.

This brief dissection of the BOP as a physical barrier illustrates how its success depends upon a barrier system[19] that incorporates operational/human and organizational elements.

In the United States, Macondo precipitated numerous industry and government publications to address issues such as safe drilling operations, well containment and intervention capability, and oil spill response capability.[20] The focus of these US regulations, standards, and guidance has primarily been on the reduction of physical threats and improvements in managing technical barriers such as those related to this incident. In contrast, new US regulations and guidance aimed at advancing our understanding and management of human performance—the operational barriers—have been limited. This volume explores opportunities in the US for further improvements.

Volume Overview

Because Deepwater drilling is highly dependent on the actions of the well operations crew, Volume 3 of the CSB Macondo investigation report begins by exploring four specific phases of activity by the crew

[16] Sklet, S. Safety Barriers: Definitions, Classification, and Performance. *J. Loss Prevent. Proc.* 2006, 19, 494.

[17] The weight of a column of fluid that fills the hole being drilled (wellbore) and the riser is the primary barrier used to control pore pressures and prevent kicks during drilling and completion activities; for more detail, see Volume 1 of the CSB Macondo Investigation Report, Section 4.2.3.1, p 19.

[18] CSB Macondo Investigation Report, Volume 2.

[19] "A barrier system describes how a barrier function is realized or executed…A barrier element is a component or a subsystem of a barrier system that by itself is not sufficient, to perform a barrier function..." Sklet, S. Safety Barriers: Definitions, Classification, and Performance. *J. Loss Prevent. Proc.* 2006, pp 19, 494.

[20] Joint Industry Task Force (JITF). *JITF Executive Summary ;* March 13, 2013, p 1. http://www.api.org/~/media/files/oil-and-natural-gas/exploration/offshore/executive-summary-final-031312.pdf (accessed October 2015, 2015).

leading up to the blowout and subsequent explosions. These phases provide a framework for analyzing the human and organizational factors contributing to the April 20, 2010, incident. From there, this volume reviews several human factors issues relevant to the incident (Chapter 1.0).

Volume 3 extends beyond human factors and safety system performance to organizational learning of offshore incident investigations (Chapter 2.0) and major challenges facing industry in this endeavor, as demonstrated by several well control incidents. Chapter 3.0 illuminates successful personal safety program initiatives that BP and Transocean have not adequately applied to process safety. Chapter 3.0 then describes advances in safety performance indicators and suggests offshore process safety indicators appropriate for rig, company, industry, and regulatory levels. Chapter 4.0 details how several of BP's and Transocean's MAE risk management policies could have made a positive impact on work completed at the Macondo well, but safety roles and responsibilities were unclear, and ultimately neither company applied their policies. Since BP's and Transocean's boards of directors did not have sufficient oversight for process safety issues and major accident prevention, Chapter 5.0 reviews corporate governance good practice, as well as the influence that shareholders, SEC reporting requirements, and the regulator might have on ensuring boards of directors remain focused on potential MAEs. Ultimately, the organizational behaviors and practices of BP and Transocean demonstrated a focus on personal safety without an equal attention to managing barriers and safety management systems meant to prevent MAEs, and both companies exhibited behaviors more akin to a minimal safety compliance approach (Chapter 0). With limited safety management regulatory provisions and oversight for the drilling operation, they did not abide—nor did any government authority require them to abide—by their own, more stringent corporate risk management policies. And in many respects, their documented policies still meet or exceed the current regulatory requirements for risk management.

In demonstrating that the deficiencies outlined in this volume continue to exist offshore in the Gulf of Mexico (GoM), the CSB identifies opportunities for further strengthening industry management of major accident hazards and the role of the regulator in this endeavor. The facts and findings described in Volume 3, as well as in Volumes 1 and 2, provide the bridge to Volume 4; this final volume illustrates how the regulatory changes since Macondo, while greatly significant, do not go far enough to put the onus on industry to effectively reduce risk, nor do they sufficiently provide the mechanisms for the regulator to proactively assure effective industry management and control of major hazards.

1.0 Human Factors

Chapter 1.0 Overview

This chapter provides an analysis of the human factors pertinent to the incident to shed light on the reasoning behind the decisions and actions of those immediately involved in the drilling and temporary abandonment process at Macondo. The chapter describes the current industry dependence on human actions to maintain safe operations and details a significant gap in effective management of human factors in offshore operations.

In the aftermath of a catastrophe, the individuals immediately involved in the activities that precipitated the event often receive much of the focus and subsequent blame, due largely to the ease of drawing causal lines between those activities and the negative outcomes. This holds true for Macondo, where much attention has been on the incorrect interpretation of the well data during the negative test[21] and well displacement, the delayed response to hydrocarbons entering the well, and the diversion of the well fluids to the mud gas separator instead of off the sides of the rig away from potential ignition sources and the people on board.[22] Beyond Macondo, human "errors" have also been linked to numerous major accidents from a wide variety of environments, including Chernobyl (nuclear), Herald of Free Enterprise (passenger ferry),[23] Clapham Junction (railroad),[24] Piper Alpha (offshore production facility),[25] and Texas City (onshore refinery).[26, 27]

Pointing to human failure "is hardly surprising…every operational, inspection and maintenance task is carried out by a skilled technician and the successful outcome relies on error-free performance."[28] But we should expect human performance variability, and in fact it is normal and necessary.[29] Humans are valuable because of their flexibility—their ability to adapt and troubleshoot within workplace conditions

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[21] The negative test is defined in Section 1.2.2 and discussed at length throughout Chapter 1. The negative test is also referred to as 'negative flow test' and 'negative pressure test,' depending upon which variable is measured/observed as part of the test procedure. The CSB will use the general 'negative test' for the remainder of this volume.

[22] The diverter system and mud gas separator are described in detail in Section 1.3.

[23] On March 6, 1987, a vehicle and passenger ferry capsized immediately after leaving its Belgian port when its bow door was left open, killing 193 people.

[24] Poor maintenance and human fatigue were deemed causal in this December 20, 1988, multi-train collision that resulted in 35 deaths and 500 injuries.

[25] On July 6, 1988, 167 individuals died from explosions and fire on this North Sea oil platform. A number of human factors issues were identified pertaining to procedures, the permit to work process, shift handover, communication, and training, among others.

[26] Several human factors were identified as contributory to the March 23, 2005 BP Texas City refinery explosions and fire leading to 15 deaths and 180 injuries. These included workload/staffing, distraction, fatigue, poor/inadequate instrumentation, and human-computer interface design of the unit control board.

[27] Energy Institute, Guidance on Human Factors Safety Critical Task Analysis, 1st ed., March 2011, p 1.

[28] Hamilton, I. Human Error: in the loop; *The Chemical Engineer*, 2012**,** *854,* p 40.

[29] Shorrock, S. Humanistic Systems; 'Human error': The handicap of human factors, safety and justice, http://humanisticsystems.com/2013/09/21/human-error-the-handicap-of-human-factors-safety-and-justice/ (accessed October 7, 2015).; Hollnagel, E. *Barriers and Accident Prevention;* Ashgate: 2004.

that can be "vague, shifting, and suboptimal."[30] For every catastrophic incident, humans have achieved countless other successful outcomes because of their variability and ingenuity in the face of unexpected situations. As such, humans remain a critical component of any high-hazard system and play a direct and indispensable role in preventing or mitigating a major accident event.

Human intervention is essential throughout the entire lifecycle of a drilling operation, where reliance on successful human performance begins with the initial hazard analysis to assess and design the well, and it continues through the plans and procedures developed and subsequently modified in response to the real-time well conditions. This reliance places a heavy dependence upon the decisions and actions of the well operations crew[31] which can 1) increase or decrease the risk of a well kick, and 2) compromise or strengthen the effectiveness of various technical barriers[32] intended to minimize the potential for a blowout.

Official inquiries into the Macondo incident concluded that the well operations crew and rig management made decisions and took actions that they should not have,[33] and some called for more technical competency training.[34] Yet improving human performance goes far beyond simply retraining individuals on the technical aspects of offshore operations. As Sidney Dekker expresses in his book *The Field Guide to Understanding Human Error*, "Accidents are seldom preceded by bizarre behavior … Mishaps are the result of everyday influences on everyday decision making, not isolated cases of erratic individuals

[30] Shorrock, S. Humanistic Systems; 'Human error': The handicap of human factors, safety and justice, http://humanisticsystems.com/2013/09/21/human-error-the-handicap-of-human-factors-safety-and-justice/ (accessed October 7, 2015).

[31] While the well operations crew members often get credit for making decisions and taking direct action to conduct the drilling activities, a number of management and engineering personnel play a role in the decision-making/action-taking process through various means, such as providing leadership instruction, guidance, and technical analysis of the well. The complexity of these relationships provides support for improved methods of non-technical skills development, which is covered in Section 1.7 of this chapter.

[32] Technical barriers are physical in nature, such as the BOP or drilling mud, either of which can be used to physically stop the flow of hydrocarbons from a well. The CSB Macondo Investigation Report, Volume 2, chapters 2 and 4 provide further details on physical, operational, and organizational barriers.

[33] BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010; pp 10.; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Deep Water The Gulf oil Disaster and the Future of Offshore Drilling;* 2011; pp 115, 120-122.; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; Sections 4.6 – 4.8.; US Coast Guard. *Report of the Investigation into the Circumstances Surrounding the Explosion, Fire, Sinking and Loss of Eleven Crew Memebers Aboard the MODU, Deepwater Horizon;* 2011; pp 12.; National Academy of Engineering and National Research Council of the National Academies. *Macondo Well – Deepwater Horizon Blowout: Lessons for Improving Offshore Drilling Safety;* The National Academies Press: Washington, D.C., 2011; pp 3, 19.

[34] BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010; pp 183-184.; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; pp 162.; Bureau of Ocean Energy Management, Regulation, and Enforcement. *Report Regarding the Causes of the April 20, 2010, Macondo Well Blowout;* 2011; pp 8, 210.

behaving unrepresentatively." [35, 36] Furthermore, human performance is often only deemed erroneous in the aftermath of a negative outcome. The CSB's investigative work frequently finds a history of *acceptable* performance leading up to an incident that was never considered erroneous or critiqued until catastrophe happened. (See Call-out Box.) Indeed, "There is almost no human action or decision that cannot be made to look flawed or less sensible in the misleading light of hindsight."[37] Overall, the performance failures identified post-incident do not point to worker competency per se, but to a variety of situational, contextual, and organizational variables that influence even a highly competent person's decision-making.

[CALL-OUT BOX START]

Performance Judged "Good" or "Bad" Depending on the Outcome

Error-free performance is unattainable, largely because the performance decision or action is subjectively judged erroneous or error-free based on the outcome. After an incident, the decisions and actions of those immediately involved in the event are invariably criticized. Personnel have broken rules, not followed procedures, and made "illogical" decisions. However, the CSB has frequently found that decisions and actions labeled as "poor" post-incident were previously accepted, and sometimes even rewarded.

The BP Texas City refinery explosion (2005)[a] is one such example. On the day of the incident, process parameters were exceeded during unit startup. In fact, process parameters were deviated in the 18 previous startups of that unit. Sometimes these startups led to a hydrocarbon release into the unit, but none resulted in explosions and fatalities. These deviations were not assessed, nor were steps taken to prevent future deviations. Up until the day of the incident, the deviations to procedures were considered acceptable to protect the unit equipment and achieve successful unit startup.

[a] *US CSB, Refinery Explosion and Fire: BP Texas City, Section 3.1.1, http://www.csb.gov/bp-america-refinery-explosion/.*

[CALL-OUT BOX END]

"As a discipline, human factors is concerned with understanding interactions between people and other elements of complex systems. Human factors applies scientific knowledge and principles as well as lessons learned from previous incidents and operational experience to optimize human wellbeing, overall system performance and reliability. The discipline contributes to the design and evaluation of organisations, tasks, jobs and equipment, environments, products and systems."[38]

Thus, drilling organizations—like any entity conducting high-hazard operations—must incorporate human factors into safety management practices. They must consider human strengths and limitations

[35] As in any CSB incident investigation, unless evidence suggests intentional criminal acts, it is assumed that the crew members were evaluating the information at hand and responding without any malicious intent toward themselves, their coworkers, and the facility/organization.

[36] Dekker, S. *The Field Guide to Understanding Human Error;* Ashgate: 2006; pp 18.; James Reason and others make similar statements, e.g., see Reason, J. *Human Error;* Cambridge University Press: 1990.

[37] Department of Transport. *Investigation into the Clapham Junction Railway Accident;* Her Majesty's Stationary Office: London, 1989, p 147.

[38] International Association of Oil & Gas Producers. *Human Factors Engineering in Projects, Report No. 454;* August 2011.

when designing a task and implement safety management systems to support the work activities of those conducting the hazardous operations.[39] They must explicitly identify the performance expectations of the human-dependent controls, and continually assess those controls to ensure they are sufficient and can be reliably maintained or executed.

This chapter provides specific evidence of the lack of effective integration of human factors into the design, planning, and execution of drilling and completions activities at the Macondo well, and it illustrates a demonstrable gap in US offshore regulation and guidance to incorporate more robust management of human factors. Specifically, this chapter shows:

- The organizational influence on human performance;
- The importance of human factors engineering considerations for safety critical system design and usage;
- The still unresolved risk of gas-in-riser situations that place unrealistic expectations on well operations crews;
- The need for development and use of non-technical skills,[40] including communication, teamwork, and decision-making, by the operator, drilling contractor, and other well services providers;
- The gap between work-as-imagined (WAI) by well designers, managers, or regulatory authorities and work-as-done (WAD) by the well operations crew; and
- The importance of assessment of safety critical tasks and identification of controls that could maximize the likelihood of successful human performance.

[39] Volume 3 offers multiple examples throughout of how multiple safety management system programs, including those for management of change, procedures, and incident investigations, can support successful human performance.

[40] Non-technical skills have been defined as "the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance." [Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008; pp 1.] Non-technical skills will be discussed more fully in Section 1.7 of this chapter.

1.1 Macondo Temporary Abandonment Personnel

To set the context of this analysis, Table 1-1 provides a review of the individuals immediately involved in the temporary abandonment activities.

Table 1-1. Well Control Personnel on Board the Deepwater Horizon Rig on April 20, 2010, that are discussed in this volume*

Position	Employer	No. On Board/ No. on Duty at time of blowout	Detail
Well Site Leader (WSL)	BP	2 / 1	Considered the "Company Man," this person represents the operator/leaseholder; there was also a third WSL on board who was a trainee
Offshore Installation Manager (OIM)	Transocean	1	Manages all aspects of the rig, including well, crane, and marine operations
Senior Toolpusher	Transocean	1	Supervises well operations; conducts a variety of administrative tasks associated with the well operations; assists the OIM
Toolpusher	Transocean	2 / 1	Supervises well operations/rig floor; advises and assists the driller
Driller	Transocean	2 / 1	Operates drilling equipment; using visual observation of rig floor and down hole data, monitors and responds to well conditions
Assistant Driller	Transocean	4 / 2	Assists the driller in operating the drilling equipment and monitoring/responding to well conditions
Mud Engineer	M-I Swaco	2 / 1	Also called a drilling fluids specialist, this person is responsible for ensuring the drilling fluid (mud) meets design specifications necessary for the well operation
Mudlogger	Sperry-Sun	2 /1	Monitors well (down hole) conditions and video feed of flow on rig to assist the driller

There are a number of additional personnel with responsibilities associated with well operations, such as the Subsea Supervisor, Floorhands, Derrickhands, and Cementers. However, these positions do not play a prominent role in the analysis presented within this volume. There are also a number of personnel on shore that provide technical and managerial support, such as the Onshore Drilling Engineer, who is discussed in Section 1.7.2.

Besides these 16 individuals, 110 others representing 13 companies were on board the rig on April 20, 2010, most of whom (79) were Transocean personnel.[41] On official duty at the time of the blowout were 9 of the 16 well operations crewmembers identified in Table 1-1. The drillers operated drilling equipment and monitored the well from the driller's cabin (or shack) on the drill floor. The senior toolpusher supervised the toolpushers and the drillers' activities. The mudlogger was housed in the mudlogger's shack, a separate location one flight of stairs away from the drillers. Both the Offshore Installation Manager (OIM) and Well Site Leader (WSL) oversaw resources and operational performance.

1.2 Macondo Temporary Abandonment Activities: Four Phases

By April 20, 2010, the Macondo crew completed exploratory drilling activities at the well after discovering several potential oil and gas producing zones.[42] This success meant that the Macondo well would likely be converted from an exploratory well to a producing one at some future date, so the Deepwater Horizon (DWH) crew began the process to temporarily abandon the well.[43]

As part of this process, and before leaving the well site, the DWH crew pressure tested the well to ensure there were no leaks and the hydrocarbon bearing zones were sealed. After the crew successfully conducted a positive pressure test of the well,[44] BP's temporary abandonment plan called for a negative test[45] followed by displacement of the drilling mud from the riser with seawater. For the human factors analysis, this chapter divides this process into four phases:

- Presetting of the diverter system route;
- Displacement of the drilling mud from the drillpipe and upper wellbore;
- Monitoring of pressure in the underbalanced well; and
- Displacement of the riser.

Dividing the activities of the crew into these four phases provides an opportunity to explore the contextual framework in which the crew was operating, which changed with each phase. This chapter discusses the implications of this dynamic framework on the human factors that influenced the crew's collective understanding of the real-time conditions of the well.

[41] Table 1-2 from Volume 1 of the CSB Macondo Investigation Report provides additional details on the personnel on board.

[42] The CSB Macondo Investigation Report, Volume 1 details Macondo exploratory drilling activities.

[43] A production facility would return later to extract the oil and gas from the well.

[44] See Volume 1, Section 2.2.1 for more details about pressure testing a well. During a positive pressure test, a well is pressured up and then held in this condition to see if the pressure is maintained, indicating no leaks in the casing. If a decrease in pressure is observed, regulations require that either the well be re-cemented, the casing repaired, or additional casing installed to ensure the well is sealed.

[45] See Volume 1, Section 2.2.1 for more details about pressure testing a well. A negative pressure text simulates the underbalanced condition of the well upon abandonment by displacing some of the heavy drilling mud from the well and closing the BOP to isolate the bottom of the well from the hydrostatic pressure exerted by fluids above the BOP.

1.2.1 Phase 1: Presetting of the Diverter System Route

The diverter system is one of the pieces of equipment on a drilling rig designed to limit oil and gas from inundating the rig floor during excessive flow[46] from the riser by routing the well fluids to a safer location. Using a control panel, the Deepwater Horizon crew could preset the route to one of two locations (Figure 1-1), either the mud gas separator (MGS, an atmospheric separating vessel), located on the rig, or overboard. The standard preset route was to the MGS; this was the route preset on April 20, 2010.[47] In this configuration, if the crew wanted to change the route before or during an emergency, they needed to complete a multi-step process to divert overboard (additional details in Section 1.3).

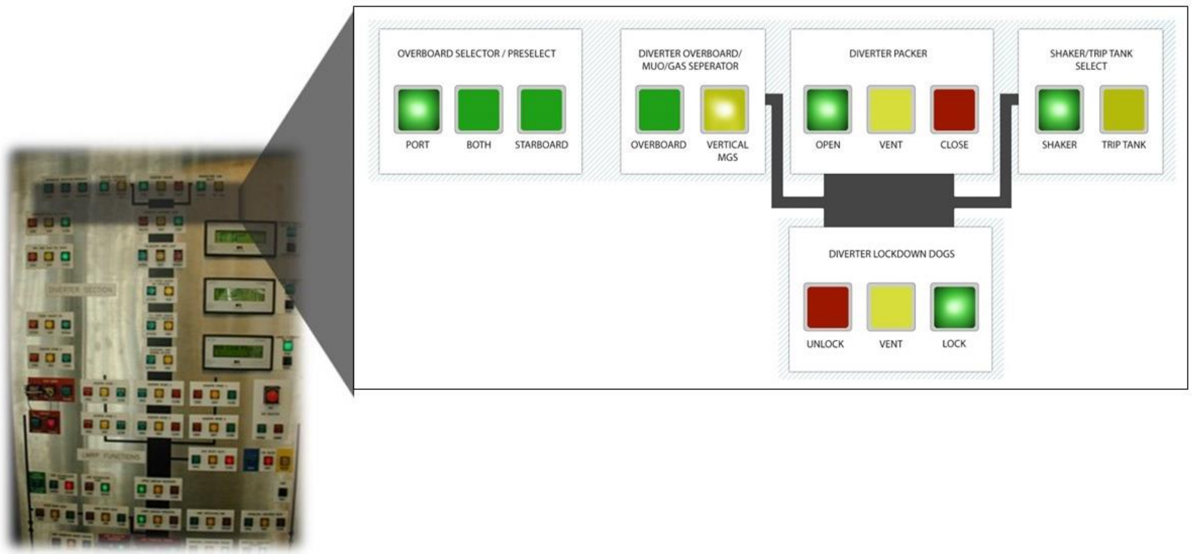

Figure 1-1. Control panel (left) and partial close-up of control panel on the Deepwater Horizon found in the driller's cabin[48] and on the bridge of the rig. These controls were used to preset the diverter.

1.2.2 Phase 2: Displacement of the Drilling Mud from the Drillpipe and Upper Wellbore

During a negative test, the crew purposely underbalances the well to simulate the condition that will exist once the well is abandoned. Generally, the primary barrier used to prevent the flow of hydrocarbons (oil and gas) from the reservoir is a column of heavy fluid that fills the wellbore and the riser and essentially "pushes" back on the hydrocarbons. When a well is abandoned, some of the fluid column is replaced with

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[46] Excessive flow could be the result of a blowout or, if the BOP is closed, a release of gas from the riser. Initially, the Macondo explosion was the latter because the BOP successfully sealed the well just prior to the explosion occurring with the well blowout evolving after the initial explosion. See Volume 2, Section 2.5, p. 30 and Appendix 2A, p 23.

[47] Internal Company Documents, Transocean. *Interview Final Memo*, June 2, 3,4, and 11, 2010, Interviews with Drillers, Assistant Drillers, OIM, TRN-INV-00000180, TRN-INV-00000698, TRN-INV-00002791, and TRN-INV-00003448, TRN-I NV-00004242.

[48] The driller's cabin, on the drill floor, contains the primary control panel. Hearing before the Deepwater Horizon Joint Investigation, May 26, 2010, p 19.

lighter sea water, and the well may become underbalanced, meaning the weight of the fluid column may not be sufficient to keep hydrocarbons from entering the wellbore. If the hydrocarbon bearing zones in the well are sealed by additional barriers (e.g., cement), the well will not flow despite being underbalanced. By simulating the underbalanced condition and observing the pressure in the well, the crew is able to test the integrity of the well in a controlled manner before removing the fluid column barrier.

At Macondo, between 3:00 p.m. and 5:00 p.m., the crew displaced drilling mud from the drillpipe and upper wellbore by pumping a dense spacer[49] material (Figure 1-2, left) followed by seawater to push the drilling mud out of the drillpipe and the upper wellbore.[50] The intent was to move this mud and all of the spacer material until they were both above the BOP (Figure 1-2, right). Then they closed the BOP to isolate the well from the hydrostatic pressure[51] generated by the liquids above the BOP. Had the crew suspected any problems with the well at the end of this activity, they had the option to open the blowout preventer to reestablish the drilling mud barrier in the well.

[49] As defined by Schulmberger Oilfield Glossary (http://www.glossary.oilfield.slb.com/Terms/s/spacer_fluid.aspx), "Any liquid used to physically separate one special-purpose liquid from another. Special-purpose liquids are typically prone to contamination, so a spacer fluid compatible with each is used between the two…Spacers are used primarily when changing mud types and to separate mud from cement during cementing operations." Ultimately, cement could be negatively affected if it is contaminated by the synthetic based oil drilling mud.

[50] There was also a small amount of freshwater used during displacement that is not depicted in Figure 1-2. See footnote 36 in Appendix 2A of the Macondo Investigation Report Volume 2 for more detail.

[51] Hydrostatic pressure is exerted by liquid at a given point as a result of the weight of the column of fluid above it. See Volume 1, Section 2.1 for more description.

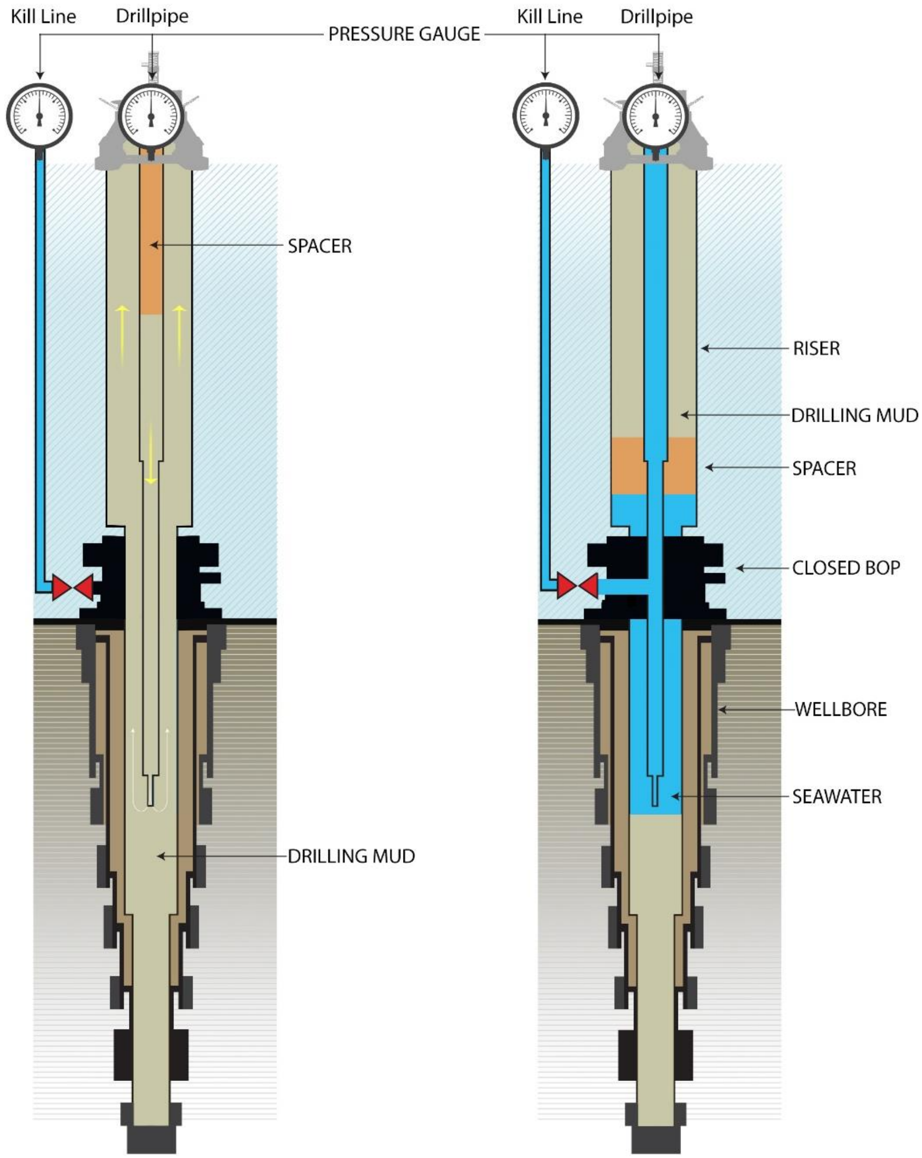

Figure 1-2. On the left, the well as spacer material is pumped into the well, beginning to push drilling mud out of the riser. On the right, the intended well configuration for the negative test.

After closing the BOP, the crew released a predictable amount of trapped pressure in the well by bleeding fluid (seawater) from the drillpipe.[52]

[52] The trapped pressure is commonly illustrated using a u-tube model. See more details in Section 1.4 and Appendix 2A from Volume 2 of the CSB Macondo Investigation Report.

1.2.3 Phase 3: Monitoring Pressure in the Underbalanced Well

The crew declares a negative test successful, assuming the hydrocarbon bearing zone at the bottom of the well has been sealed, after crewmembers observe no flow or pressure increase from the underbalanced well upon releasing the initial trapped pressure. Various methods are possible to accomplish the negative test; indeed, at least six negative test procedures were used on the DWH between August 2007 and April 2010.[53] They generally fell into two main categories:

1. displacing the drillpipe with the pipe end no deeper than 500 feet below the sea floor (at Macondo the bottom of the drillpipe was approximately 3,000 feet below the seafloor);[54] and
2. displacing a choke/kill line, a pipe that runs from the BOP to the rig, with the blind shear rams of the BOP closed.

Initial BP temporary abandonment plans for the Macondo well proposed displacing the kill line (Figure 1-3, left).[55] Under this configuration, only the kill line could be used to conduct a negative test, but BP determined this approach did not create enough underbalance pressure to simulate the abandonment condition of the well.[56] Instead, BP determined that drillpipe needed to be lowered into the well to displace the upper wellbore with seawater to create the necessary underbalance conditions. Ultimately, the negative test procedure employed at Macondo actually displaced both the drillpipe and the kill line, enabling the crew to observe pressure from the underbalanced well from either the kill line or the drillpipe (Figure 1-3, right).

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[53] Internal Company Document, Transocean. *Memorandum: Investigation of the Negative Test and Riser Displacement Procedures (Preliminary Report)*, July 26, 2010, TRN-INV-00847616, see Exhibit 5007 http://www.mdl2179trialdocs.com/releases/release201302281700004/Roller_Perrin-Depo_Bundle.zip (accessed October 7, 2015).

[54] Internal Company Document, BP. *Form MMS - 124 Application for Permit to Modify*, April 16, 2010, Temporary Abandonment Procedure, BP-HZN-MBI00127909, http://www.mdl2179trialdocs.com/releases/release201304041200022/TREX-00570.pdf (accessed October 7, 2015).

[55] See Appendix 2A, p 61, of the CSB Macondo Investigation Report Volume 2 for more details.

[56] BP intended to set a surface cement plug at 3,300 feet below the seafloor which increased the necessary negative test requirement. Displacing the kill line created only 1,844 psi pressure differential while displacing the upper wellbore would simulate an underbalance pressure of 2,371 psi, see Appendix 2A, Section G, pp 61-62.

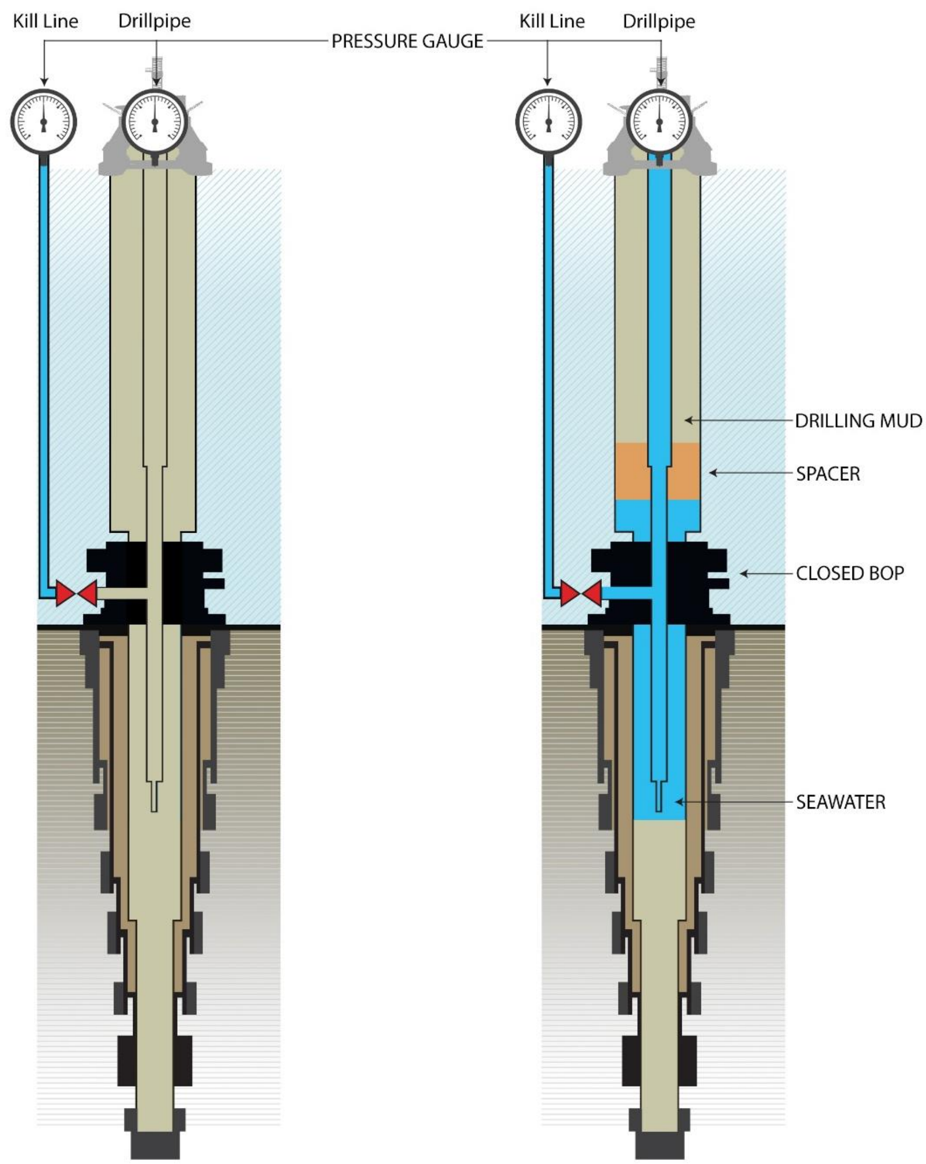

Figure 1-3. Initial negative test configuration for the Macondo well called for only displacing the kill line (left), but the final configuration had both the kill line and the drill pipe displaced with sea water.

However, the actual conditions of the well after displacement did not match the plans and expectations of the crew. The spacer material used during the displacement of the drillpipe and upper wellbore was not fully pushed above the BOP, reducing the pressure that would appear on the kill line. Also, some spacer was positioned across the kill line in the BOP, likely enabling the dense material to enter and plug the line (Figure 1-4). Section 1.4 explores the reasons for the under-displacement.

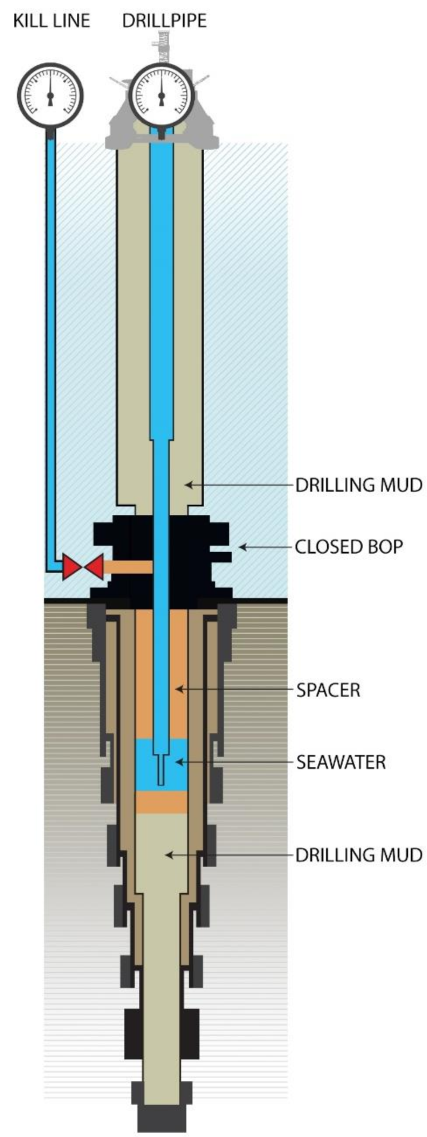

Figure 1-4. Actual well conditions, with spacer positioned across the BOP, which likely lead to plugging of the kill line.

During the 3 hours between when the crew first closed the BOP to begin the negative test and they deemed the test successful, indicating the well was sealed, they observed pressures or flow from the drillpipe and the kill line four times. Pressure on the drillpipe rose after each of the four observations,[57]

[57] CSB Macondo Investigation Report, Volume 2, Appendix 2A; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; pp 147-159.

but flow from the kill line eventually ceased. The zero flow from the kill line and zero pressure continued for 30 minutes, so the crew considered this as evidence that the well was sealed.

1.2.4 Phase 4: Displacement of the Riser

Acceptance of the negative test as successful indicated the Deepwater Horizon crew believed the well had been sealed. The crew proceeded to open the BOP and displace the remaining drilling mud from the Macondo well in preparation of setting a surface cement plug.[58] With the drilling mud removed (Figure 1-5), the open blowout preventer was the only physical barrier against flow into the well (a kick). The ability of the blowout preventer to act as this barrier was contingent upon human detection of the kick and timely activation of the BOP.

[58] Cement plugs are portions of cement put into a wellbore to seal it. “Surface” is typically used to refer to the shallowest cement plug used in a well. See Volume 1, Section 2.0 for more details.

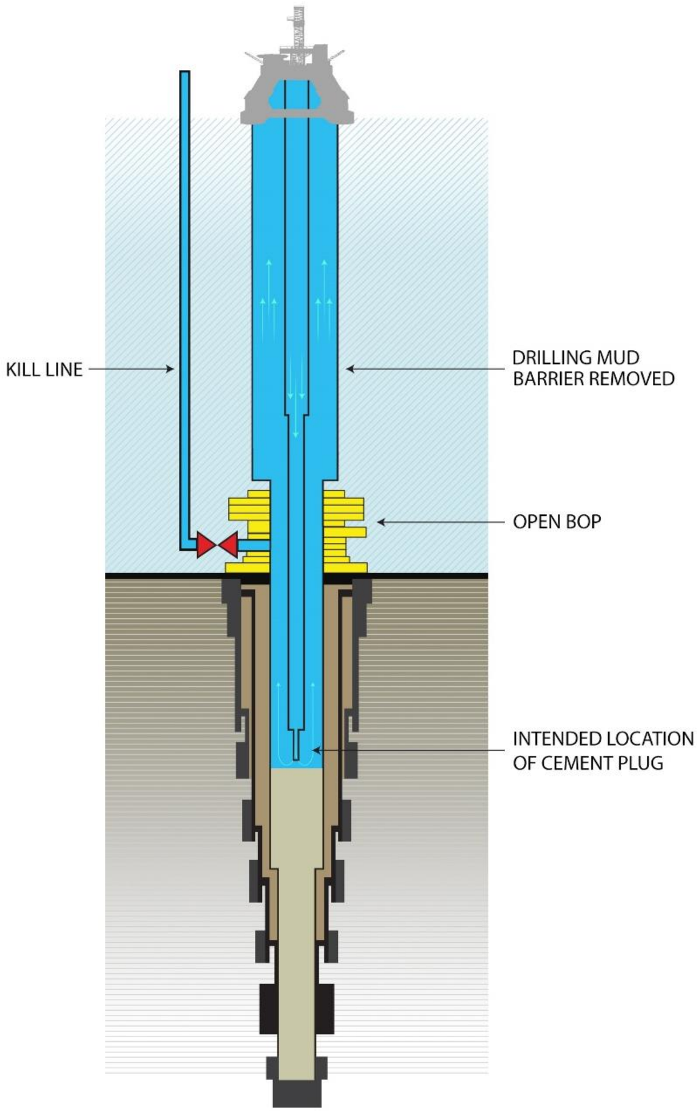

Figure 1-5. During the final displacement of the well, the remaining drill mud above the drillpipe is replaced with seawater.

During the process of displacing the riser, a mixture of seawater, drilling mud, and hydrocarbons erupted onto the drilling rig, which the crew immediately tried to divert to the mud gas separator (MGS). Within a minute after diverting, mud overwhelmed the MGS and erupted out of it and multiple other locations. From the time well fluids released onto the deck until the first explosion, the crew had 9 minutes to understand what was happening, determine the best well control responses, and implement them.[59]

[59] Volume 2, pp 29-30 describes the sequence of well control actions completed by the crew.

1.2.5 Human Performance at Macondo

Within the four phases of temporary abandonment crew activity, this chapter analyzes a number of human performance actions (Table 1-2) to give context for the actions and decisions in the hours leading up to the incident and to explore potential mitigating approaches or controls.

Table 1-2. Identified human performance actions/decisions during the four phases of temporary abandonment leading up to the blowout

PHASE OF CREW ACTIVITY	HUMAN PERFORMANCE ACTIONS AND DECISIONS OF INTEREST POST-INCIDENT
Phase 1: Preset of the Diverter System Route	The diverter system route was preset to flow out of the well to the Mud Gas Separator (MGS). Once well fluids erupted from the well onto the deck, the crew did not successfully complete the multi-step process necessary to reroute the well fluids overboard (Section 1.3).
Phase 2: Displacement of the Drilling Mud from the Drillpipe and Upper Wellbore	The crew did not achieve the intended well conditions during the displacement of the drillpipe and wellbore; some spacer material remained below the closed BOP. The under-displacement likely led to plugging of the kill line, impacting pressure readings used by the crew to assess well integrity (Section 1.4).
Phase 3: Monitoring Pressure in the Underbalanced Well	The crew incorrectly rationalized pressure and flow indicators observed from the kill line and the drillpipe during the negative test. Thus, they considered the well sealed (Section 1.5).
Phase 4: Displacement of the Riser	During completion of the displacement process, the well experienced an influx of reservoir fluid. For almost an hour, the crew did not detect hydrocarbons flowing into the well and eventually up the riser toward the rig (Section 1.6).

[CALL-OUT BOX START]

Doing What Made Sense at the Time

Some investigation reports described "significant" and "obvious" anomalies in the real-time data available to the crew during the hours leading up to the blowout with assertions or implications that the crew should have recognized and acted upon these anomalies.[a] But how obvious were these indicators? Any declarations of what the control system data indicated about the Macondo well were constructed from extensive post-incident modeling of the well flow conditions and with hindsight as to the consequences of each decision or action taken by the crew. In the moment, no one person would have had the benefit of such comprehensive knowledge. These individuals were doing what made sense to them at the time. Each individual's understanding of the well conditions was shaped by a complex interplay between the various communication tools used to share information about the well (verbal *communications, control board systems, procedures) and the individual's knowledge, experience, judgment, and biases.*

[a] BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010; pp 42; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Deep Water The Gulf oil Disaster and the Future of Offshore Drilling;* 2011; pp 115, 177-179.

[CALL-OUT BOX END]

1.3 Phase 1 – Organizational Influence on Human Performance

During drilling and completion activities at a well, gas and oil can pass above a BOP before it is closed. This creates a gas-in-riser event that can progress to a "riser gas blowout," identified as such to indicate that the wellbore is sealed and the only source of gas is in the riser. This is a hazardous situation because riser gas migration toward the rig may be nearly undetectable and can rapidly change from a seemingly stable condition to an extremely high flow rate, releasing large amounts of gas on the drilling rig that can ignite and explode.[60]

For Macondo, the April 20, 2010, incident progressed from a gas-in-riser event ultimately to an uncontrolled blowout after the crew's well control actions and the physical well barriers (e.g., the BOP and diverter system) were unable to mitigate the hazardous conditions created once hydrocarbons entered the riser. The BOP as a barrier is analyzed in Volume 2. The diverter system, analyzed here, was activated by the crew as well fluids released out of the riser onto the rig. The system was preset to route well fluids to the mud gas separator, rather than overboard; it was quickly overwhelmed and hydrocarbons blew onto the rig floor. Post-Macondo, Transocean now requires well operations crews to preset the diverter system route overboard,[61] thus removing aspects of manual human intervention with an engineering control. However, the organizational decision to preset the diverter route to overboard increases the likelihood of discharges into the sea that might otherwise have been controlled through use of the MGS. Therein lies a risk to drift back to the original practice as, over time, the rig operator receives environmental penalties for discharges that, with hindsight, are determined to have been preventable. Furthermore, the decision to eliminate the manual intervention requirement does not fully resolve an underlying hazard for a diverter system to fail under high load even if it has been reset to direct well fluids overboard. Ultimately, as this section shows, there is a danger of inappropriately placing blame on human performance for a technical problem the offshore industry does not fully understand.

Through an examination of the diverter system design and the evolution of its purpose and use offshore, this section demonstrates that unrealistic expectations were placed on the crew to send well fluids overboard once they entered the riser. Furthermore, a review of the actions of the Deepwater Horizon

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[60] For example, see the MMS Zapata Lexington report, U.S. Department of the Interior/Minerals Management Service. Investigation of September 1984 Blowout and Fire Lease OCS-G 5893, Green Canyon Block 69 Gulf of Mexico, Off the Louisiana Coast; OCS Report 86-0101; Minerals Management Service: 1986; http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Panel-Investigation-Reports/86-0101-pdf/ (accessed October 7, 2015).

[61] Internal Company Document, Transocean. *Well Control Handbook*, Issue HQS-OPS-HB-01, Revision 00, July 22, 2011, Handling Gas in the Riser, Exhibit 5781, http://www.mdl2179trialdocs.com/releases/release201302281700004/Braniff_Barry-Depo_Bundle.zip (accessed October 7, 2015).

crew illustrates the strong influence that organizational policies, historic operational practices, and technical design have on human performance, including:

- The economic and regulatory consequences for diversion of well fluids overboard;
- The operational decision to preset the diverter system route to send flow from the well to the MGS, which was standard practice for Transocean and occurred far before the temporary abandonment activities commenced;
- The design of the diverter system and the multi-step process to redirect well fluids overboard;
- The reliance by all involved parties on the subjective judgment of the well operations crew to determine whether the well flow would be too great for the MGS to handle; and
- The time available to the crew to respond in a chaotic and stressful situation.

1.3.1 Diverter Dual Role: Operational and Emergency Mitigation Device

During drilling and completion operations, drilling fluids returning from the well are routed to a variety of equipment so that they may be processed and recycled for future drilling. As part of that process, the diverter system can direct well fluids containing flammable gas to the MGS where the gas is segregated from the drilling mud and vented away from the drill floor (Figure 1-6).[62] This might occur, for instance, in response to a well kick that the BOP has contained. The influx is then circulated though the MGS, a standard practice acknowledged in both BP and Transocean well control manuals.[63] Less frequently, the diverter system is also used as an emergency mitigation system meant to limit the amount of oil and gas inundating the rig floor from a riser gas event by directing the well flow overboard, thus minimizing the chance that flammable gases could find an ignition source on the rig.[64]

[62] Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, Well Control Equipment, BP-HZN-2179MDL0033106, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015).

[63] Internal Company Document, BP. *Well Control Manual: Volume 2 Fundamentals of Well Control*, Issue 3, BPA-D-002, 2000, Mud Gas Separator, pp 6-4-3, BP-HZN-2179MDL00336730. See Exhibit 2390 http://www.mdl2179trialdocs.com/releases/release201302281700004/Frazelle_Andrew-Depo_Bundle.zip (accessed October 7, 2015); Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, BP-HZN-2179MDL00330980, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015).

[64] Internal Company Document, BP. *Well Control Manual: Volume 2 Fundamentals of Well Control*, Issue 3, BPA-D-002, December 2000, Blowout Preventer Equipment, BP-HZN-2179MDL00336706, see Exhibit 2390 http://www.mdl2179trialdocs.com/releases/release201302281700004/Frazelle_Andrew-Depo_Bundle.zip.; Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, Equipment for Handling Gas in the Riser, BP- BP-HZN-2179MDL00330974, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015).

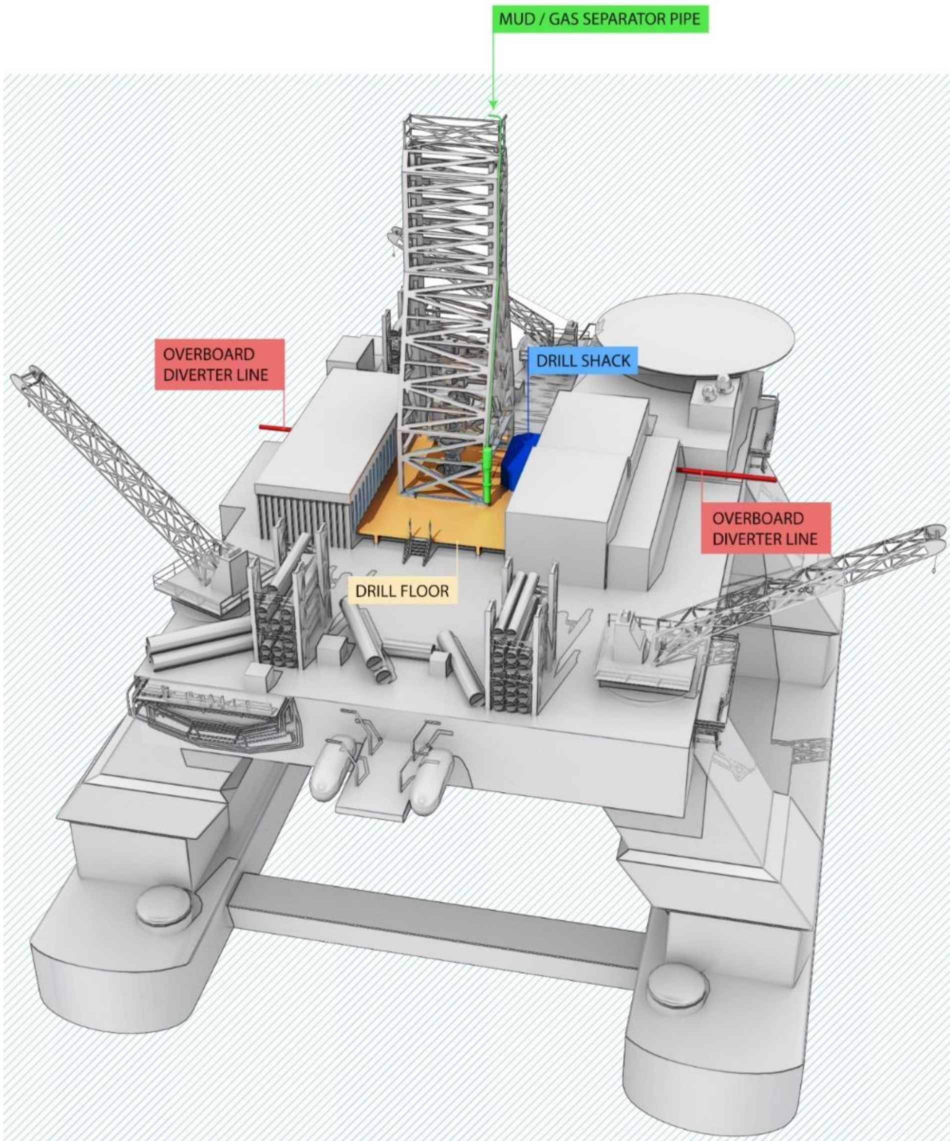

Figure 1-6. The diverter system on a rig can be routed to direct well fluids containing flammable gas to the mud gas separator (green) so that gas can be vented away from rig floor or drilling fluids can be directed routed overboard (red).

1.3.2 Organizational Policy and Practice Influence Human Performance

Transocean's Well Control Handbook (2009) at the time of the incident did not identify criteria for determining the diverter route during various well operations, and the handbook remained neutral on the preferred route.[65] Historically, Deepwater Horizon rig personnel reported that use of the diverter system

[65] Transocean Well Control Handbook: "If the riser is flowing, divert the flow overboard. If so equipped, the flow can be diverted through a gas handling system or MGS," and "if the flow rate increases, be prepared to open up the diverter line to send the mud overboard." Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, BP-HZN-2179MDL00330975 and BP-HZN-

to send well fluids overboard was rarely, if ever, needed because the MGS successfully handled previous well control situations,[66] and that the mud gas separator route was the standard arrangement on the Deepwater Horizon.[67]

Diverting overboard has a number of consequences. For one, drilling mud is expensive and on-site mud supplies may be limited, so use of the MGS allows salvaging the mud.[68] Also, discharging oil-based drilling mud overboard is legally restricted by both the EPA and BOEM, so sending material into the ocean can result in a citation for violating environmental regulations.[69] This well-known consequence was one that crewmembers knew to avoid where possible.[70] Such knowledge applies pressure on the well operations crew to default toward avoiding the higher probability environmental risk rather than the low probability, but high consequences of overwhelming the MGS.

MGSs are designed to handle the circulated fluids and gas contained by a BOP in response to a well kick, and the diverter is intended to redirect manageable influxes of well fluids, not a blowout. Alignment of a diverter is a matter of (a) rig configuration, which is inherent to the rig selected by the oil company operator for a particular campaign, and (b) a well's risk assessment, which the oil company operator develops to address a geotechnical risk assessment.[71] Well control procedures should address predicted exit flow rates from kick scenarios in the well's risk assessment to avoid overwhelming the MGS. Transocean's 2009 well control handbook indicates it is "essential to verify that the [mud gas separator] system is capable of handling the maximum amount of fluid and gas that could be produced by the well in the case of a severe kick. The relevant information of the well to be drilled should be obtained from the Operator and should be compared to the system capacity according to the Company [Transocean]."[72]

2179MDL00330976, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015).

[66] CSB interview; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling interview.

[67] Internal Company Documents, Transocean. *Interview Final Memo*, June 2, 3,4, and 11, 2010, Interviews with Drillers, Assistant Drillers, OIM, TRN-INV-00000180, TRN-INV-00000698, TRN-INV-00002791, and TRN-INV-00003448, TRN-I NV-00004242.

[68] Internal Company Document, BP. *Well Control Manual: Volume 2 Fundamentals of Well Control*, Issue 3, BPA-D-002, December 2000, Mud Gas Separator, see Exhibit 2390, BP-HZN-2179MDL00336730, http://www.mdl2179trialdocs.com/releases/release201302281700004/Frazelle_Andrew-Depo_Bundle.zip.

[69] 30 C.F.R. 250.300 Pollution Prevention; 30 C.F.R. 122 EPA Administered Permit Programs: The National Pollutant Discharge Elimination System; see also Memorandum of Understanding Between the Environmental Protection Agency and the Department of the Interior Concerning the Coordination of NPDES Permit Issuance with the Outer Continental Shelf Oil and Gas Lease Program http://www.bsee.gov/uploadedFiles/BSEE/Newsroom/Publications_Library/001_1984-MOU.pdf (accessed Feburary 26, 2016).

[70] Internal Company Document, Transocean. *Interviewing Form: OIM*, October 13, 2010, TRN-INV-00001864, see Exhibit 3801 http://www.mdl2179trialdocs.com/releases/release201304041200022/Harrell_Jimmy-Depo_Bundle.zip (accessed October 7, 2015). National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling interview.

[71] The Australian offshore regulator provides useful guidance on well risk assessments http://www.nopsema.gov.au/assets/Guidance-notes/GN1602-Well-operations-management-plan-content-and-level-of-detail-Rev-0-December-2015.pdf (accessed Feburary 26, 2016).

[72] Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, Well Control Equipment, BP-HZN-2179MDL00331068,

MGSs are not usually designed for the fluid and gas that occur from a riser gas event or blowout, largely because those rates can be impractically large. In reality, limited information is available to the crew to discern when a situation exceeds the MGS capabilities or how quickly the situation may progress. (See Section 1.3.4 for more detail.) The Transocean well control handbook in effect at the time of the Macondo blowout implied that the crewmembers should observe the riser flow and that they would have sufficient time to react to a potentially hazardous situation: "if the riser is flowing [as the result of a kick], divert the flow overboard. If so equipped, the flow can be diverted through a gas handling system or MGS … If the flow rate increases, be prepared to open up the diverter line to send the mud overboard."[73]

The dual purpose of the diverter system and internal Transocean diverter/MGS policy created a significant human factors dilemma for the Deepwater Horizon crew. They were placed into a position of deciding if a gas-in-riser event was controllable, if the MGS could safely separate flammable gas from the well fluids, if the situation exceeded the capabilities of the system, and if they needed to divert mud overboard.

Training strongly influences responses in emergency situations. The Transocean Well Control Handbook required each crew to conduct a diverter drill at the beginning of every tour to "improve the crew's reaction time and prove the operation of all diverter system equipment."[74] However, a senior Transocean toolpusher from the Deepwater Horizon stated he was unaware of any drills to simulate gas in the riser and the required decision-making response, including changing the diverter flow path.[75] As previously stated, testimony from DWH personnel suggests that training and typical practice emphasized well fluid diversion through the MGS. An Assistant Driller with Transocean for 6 years and with over 23 years offshore experience reported that he was taught to always divert to the MGS if mud came out of the riser before diverting overboard and to do this only if the MGS became overwhelmed.[76]

Yet gas-in-riser is a hazardous situation because riser gas migration toward the rig may be nearly undetectable in the early stages and can rapidly change from a seemingly stable condition to an extremely high flow rate, resulting in a release of large amounts of gas on the drilling rig that can ignite and explode.[77] BP's well control manual cautions:

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http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015).

[73] Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, Specific Environments, BP-HZN-2179MDL00330976, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015).

[74] Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, Preparation and Prevention, BP-HZN-2179MDL00330825, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015).

[75] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013 pp 1894-95, http://www.mdl2179trialdocs.com/releases/release201303051200006/2013-03-05_BP_Trial_Day_6_PM-Final.pdf (accessed October 7, 2015).

[76] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling interview.

[77] For example, see the MMS Zapata Lexington report, U.S. Department of the Interior/Minerals Management Service. Investigation of September 1984 Blowout and Fire Lease OCS-G 5893, Green Canyon Block 69 Gulf of

> "Free gas in the riser represents one of the most dangerous situations on a rig from a standpoint of personnel safety… [A] small influx of free gas can expand as it approaches the surface to produce very significant gas volumes at surface. History has shown that this gas could unload violently as it approaches the surface…It is not out of the realm of possibilities that this slow migration of gas in the riser could go unnoticed as the other activities are taking place, and the gas will begin to unload before anyone notices it. These conditions are the most dangerous."[78]

The Macondo blowout demonstrates that such a situation can quickly evolve into a dire emergency because, while gas flowed into the well for almost an hour without detection, only minutes passed between when it entered the riser and drilling mud shot across and above the drill floor.[79] Add to that crisis the crew's scant experience in sending well fluids overboard due to the rarity of riser gas events,[80] as well as the trained habit and actual practice to initially send fluids and gas to the MGS.

[CALL-OUT BOX START]

Diverter Safety System Adapted for Operational Purposes – An Example of Organizational Drift

Use of the diverter as an operational tool for routing drilling fluids to the MGS was a secondary development to its original design purpose of diverting well fluids and gas overboard during shallow gas blowouts.

A recommendation in the early 1980s was to develop a dedicated additional device, now commonly called a "riser gas handler," for installation below the telescopic joint at the top end of the riser. This location was chosen to avoid subjecting surface equipment (e.g., slip joint seals, diverter seals) to pressures that would exceed their design capabilities.[a, b] *This device was not intended to divert a well blowout fueled by a formation in the well, but to safely handle gas that had gotten into the riser above a closed BOP. In this manner, the riser gas handler allows for the circulation of a gas-in-riser event to a mud pit on the rig rather than diverting the riser fluids overboard. However, the riser gas handler has had only limited acceptance, and has been installed on few rigs.*

Years later came the recognition that a system capable of circulating the well fluid/mud through the MGS to remove small amounts of gas would allow for salvaging of the expensive drilling mud and would reduce environmental releases. The diverter system was then adapted to achieve this purpose. A line was installed upstream from the diverter line outlet valve, permitting mud from the riser to circulate through the MGS to remove residual gas. The diverter system aboard the Deepwater Horizon matched this design.

Post-incident, the Norwegian Oil Industry Association (OLF) recommended eliminating the use of the diverter as a tool for routing drilling fluids to the MGS.[c] *To eliminate the possibility of overloading the MGS, OLF specifically recommended updating language of its relevant standard [Norsok D-001] to clarify that the diverter system's function is safety and that it is designed to handle gas in the riser above*

Mexico, Off the Louisiana Coast; OCS Report 86-0101; Minerals Management Service: 1986; http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Panel-Investigation-Reports/86-0101-pdf/ (accessed October 7, 2015).

[78] Internal Company Document, BP. *Well Control Manual: Volume 2 Fundamentals of Well Control*, Issue 3, BPA-D-002, December 2000, Blowout Preventer Equipment, BP-HZN-2179MDL00336706, see Exhibit 2390 http://www.mdl2179trialdocs.com/releases/release201302281700004/Frazelle_Andrew-Depo_Bundle.zip.

[79] CSB Macondo Investigation Report, Volume 2, pp 29-30.

[80] CSB Interview: National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling interviews.

the BOP by routing all hydrocarbons overboard and, ideally, downwind. As such, OLF recommended that any connection between the diverter system and the MGS should be designed out of the system, except for possibly a connection from the downstream end of the choke manifold to the MGS. Others followed suit, resurrecting the riser gas handler approach.[b]

[a] Hall, J. E.; Roche, J. R. Diverter for deepwater drilling risers permits kick control; *Oil & Gas Journal* 1985**,** pp 116-119.
[b] E.g., Kozicz, J. R. Development of a marine riser gas managment system; *Society of Petroleum Engineers* 2012**,** January.
[c] Norwegian Oil Industry Association (OLF). *Deepwater Horizon Lessons learned and followu-up;* May, 2012; Reccomentation no. 8, pp 16.

[CALL-OUT BOX END]

1.3.3 Diverter System Design Required Multi-Step Process to Divert Fluids Overboard

With presetting the Deepwater Horizon diverter flow to the MGS, the system design required the crew to take a two-step action to send flow overboard.

The crew could use the diverter system from one of three locations: a Diverter Control Panel on the drill floor,[81] a Driller Control Panel in the driller's cabin,[82] and a duplicate of the Driller Control Panel, called the OIM Control Panel, on the bridge.[83] While the drill floor diverter control panel used toggle switches, the driller, who has primary responsibility for well control operations from the driller's cabin,[84] and the OIM control panels used pushbuttons. As indicated in Figure 1-7, at the top left of the panels were three sets of pushbuttons to select:

- the overboard flow path (starboard, portside, or both);
- the overboard or MGS flow path; and
- an open or closed position of the diverter.[85]

[81] Cameron Controls, *Assembly*, *Diverter Control Panel*, Sheet 1 of 6, Drawing No. SK-122358-21-04, Rev D01, March 23, 2000.

[82] The driller's cabin, shack, or doghouse (as it is informally called) was located on the drill floor; this location was where the drillers and assistant drillers monitored and controlled well conditions through control system panels that they could manipulate to operate various drilling equipment, including the BOP and diverter. Information on the Driller Control Panel can be found here: Cameron Controls, *Assembly Drawing, Driller Control Panel*, Sheets 2 and 4 of 11, Drawing No. SK-122106-21-04, Rev F01, January 7, 2000.

[83] Cameron Controls, *Assembly Drawing*, *Toolpusher Remote Control Panel*, Sheets 2 and 4 of 11, Drawing No. SK-122107-21-04, Rev E01, May 16, 2000.

[84] Hearing before the Deepwater Horizon Joint Investigation, May 26, 2010, p 19.

[85] These buttons were actually hydraulic fluid switches, meaning they physically redirected the flow of hydraulic fluid to manipulate the position of the diverter. Pushing the 'VENT' button for the diverter packer seen in Figure 1-7 removes hydraulic pressure from the diverter packer.

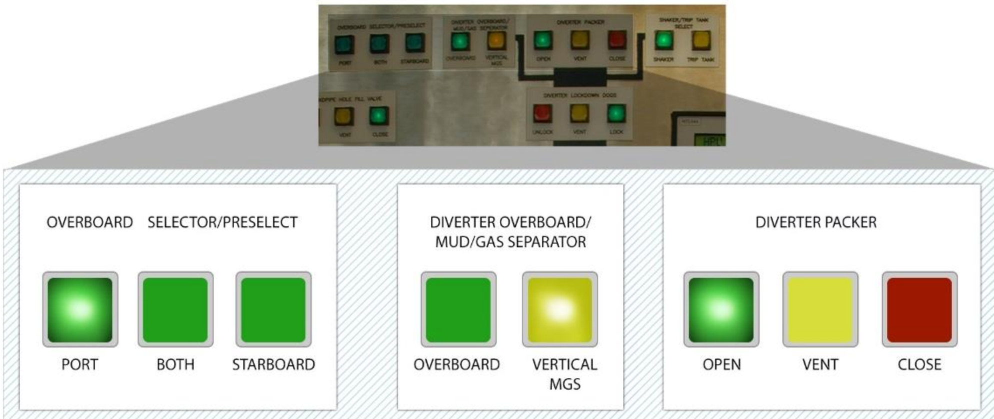

Figure 1-7. Control panel and partial close-up of control panel on the Deepwater Horizon found in the driller's cabin and on the bridge of the rig.

When the diverter was closed, the system always maintained an open pathway, either overboard or to the MGS to not shut in the pressure from the well. This route was chosen by selecting either OVERBOARD or VERTICAL MGS (Figure 1-8).

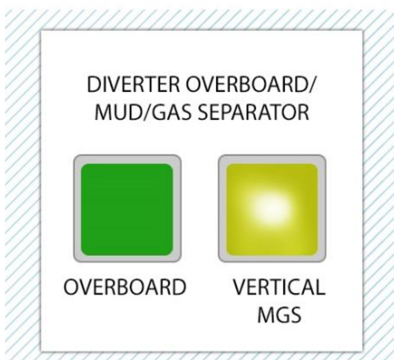

Figure 1-8. Control Panel Pushbuttons to preset route to MGS or overboard

Regardless of which vent pathway was opened (overboard or vertical MGS), one of the OVERBOARD SELECTOR/PRESELECT pushbuttons would remain lit (Figure 1-9), as it indicated only the pre-selection of the overboard valves that would open if the OVERBOARD button were subsequently selected.

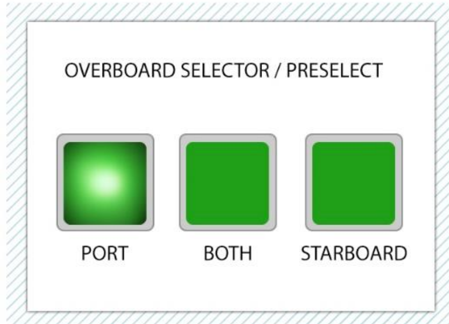

Figure 1-9. Control Panel Pushbuttons to preselect the overboard route

Thus, pressing the OVERBOARD button would close the diverter and fluids would flow through either the portside, starboard, or both overboard lines as determined by the OVERBOARD SELECTOR/PRESELECT pushbuttons.

This design is not ideal from a human factors perspective, as a crewmember could hit the one button that closes the diverter but miss the second step of changing the diverter route from MGS to overboard. Sound human factors engineering design suggests that opportunities for omission (skipping of steps) be designed out of a system when possible.[86] Adding an automated feature to the diverter control system is one way to achieve this goal. At least one Deepwater Horizon Well Site Leader believed the diverter had an automated function that would divert flow overboard upon detection of increased pressure within the MGS,[87] a design used on other rigs in the Gulf of Mexico.[88] However, post-incident analysis revealed that the Deepwater Horizon diverter did not have such functionality.[89]

Because the individuals who activated the diverter system did not survive the incident, no one can sufficiently explore whether this design hindered performance of the well operations crew on the day of the Macondo blowout. A draft 2002 Transocean Deepwater Horizon procedure for using the diverter when gas is in the riser lists 10 steps in addition to activating the control system buttons to send flow overboard, including stipulations that the crew must fully shut in the well, determine wind direction,[90] and

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[86] HSE. *Inspectors Toolkit: Human Factors in the Management of Major Accident Hazards;* October, 2005, p 14. http://www.hse.gov.uk/humanfactors/topics/toolkit.pdf (accessed January 15, 2016).

[87] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling interviews.

[88] CSB Interview; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling interview.

[89] Internal Company Document, Transocean. *Investigations: Mud Gas Separator Control*, Janurary 14, 2011, TRN-INV-03405410.

[90] If the decision was to divert overboard, the operator had to choose which side would be best to divert (based on wind direction), and then redirect the diverted flow away from the MGS and over the side chosen. However, with dynamically positioned (DP) rigs, such as the Deepwater Horizon, the side chosen is less of an issue, as the DP system maintains the rig's position so that it is headed into the wind. Thus, deciding which side to divert would be less of an issue; in fact, the preference would be to choose the both-sides option.

call the Bridge to verify wind direction and clear boats from the discharge location.[91] Whether this procedure was meant to be used on the day of the incident, the speed at which a gas-in-riser event can evolve makes following a 10-step procedure unrealistic.

From a human factors perspective, the question operators and drilling contractors need to ask is: how reliable is the human action to change the diverter location during reasonably anticipated emergency scenarios, such as a riser blowout? The speed at which a gas-in-riser event can evolve implies that crews may simply not have time to assess a situation before it is already out of control. Perhaps even more fundamental, consider Transocean's observation concerning diverting fluids from the Macondo blowout overboard: "it is impossible given the magnitude of the blowout to know if the diverter packer would have kept flow diverted overboard and if the gas ignition could have been prevented."[92] It is impossible to a large degree because no adequate engineering tools/software exist to model the complex gas migration and 2-phase flow of gas and liquids in a riser.[93] And various industry tests have given inconsistent results, highlighting the complexity of the phenomenon.[94] Safety or performance concerns of existing riser gas handling designs should be identified, corrected, and reconciled.

Ultimately, it would be unfair to cast blame on the Deepwater Horizon crew for diverting to the mud gas separator when the diverter system might have failed regardless. Post-Macondo, Transocean now requires well operations crews to preset the diverter system route overboard,[95] thus removing aspects of manual human intervention with an engineering control. Considering the design limitation of the diverter system, a solution such as this, meant to remove the 'choice' to divert overboard, may actually lead to a false sense of security when in fact that hazard remains. This problem highlights the need for a hazard analysis that correctly identifies the uncertainty of the gas in the riser scenario.

1.3.4 Needed Improvements in Detecting Gas Influx Prior to Reaching Riser

The decision to send flow overboard assumes the crew detects gas in the riser and recognizes when the gas volume will not exceed the rig's surface handling capability (e.g., diverter system, mud gas

[91] Internal Company Document, Transocean. *Deepwater Horizon Dverter Procedure with Gas in Riser*, TRN-I NV-00697095 attachement to Email from Deepwater Horizon OIM, Transocean, to Deepwater Horizon Toolpusher, Transocean, Subject: Horizon Dovierter Procedure, June 3, 2002, TRN-I NV-00697094.

[92] Transocean. Macondo Well Incident: Transocean Investigation Report Volumes I; June, 2011, p 193.

[93] Sonnenmann, P. IADC workgroup conducting studies to better understand, manage gas-in-riser events. *Drilling It Safely*, July 9, 2015, http://www.drillingcontractor.org/iadc-workgroup-conducting-studies-to-better-understand-manage-gas-in-riser-events-35793 (accessed October 7, 2015).

[94] Hauge, E.; Godhavn, J. M.; Molde, D. O.; Cohen, J. H.; Stave, R. S.; Toftevaag, K. R. *Analysis of Field Trial Well Control Results with a Dual Gradient Drilling System,* Offshore Technology Conference 2015, Houston, TX, May 4-7, 2015; OTC-26056-MS.; Tarvin, J. A.; Hamilton, A. P.; Gaynord, P. J.; Lindsay, G. D. *Gas Rses Rapidly Through Drilling Mud*, IADC/SPE Drilling Conference, Dallas, TX, Fedbruary 15-18, 1994; IADC/SPE 27499.; Gonzalez, R.; Shaughnessy, J.; Grindle, W. Industry Leaders Shed Light on Drilling Riser Gas Effects; *Oil & Gas Journal* 2000**,** *July 17*, pp 42 - 46.; Johnson, A.; Rezmer-Cooper, I.; Bailey, T.; McCann, D. *Gas Migration: Fast, Slow, or Stopped*, SPE/IADC Drilling Conference, Amsterdam, February 26, 1995; SPE/IADC 29342.

[95] Internal Company Document, Transocean. *Well Control Handbook*, Issue HQS-OPS-HB-01, Revision 00, July 22, 2011, Handling Gas in the Riser, Exhibit 5781, http://www.mdl2179trialdocs.com/releases/release201302281700004/Braniff_Barry-Depo_Bundle.zip (accessed October 7, 2015).

separator). Such predictions are a challenge, as evident by Macondo and other incidents discussed below. Generally, it is not possible to predict surface flow rates of a gas-in-riser event, a necessary parameter for determining when to unload overboard.[96] Any gas that enters into the riser can migrate toward the drilling rig, much as a bubble rises in water. The rate of migration depends on many factors and cannot be reliably predicted or even readily detected until the gas nears the surface. A gas bubble may disaggregate into a harmless foam, but it can also become unstable and rapidly erupt onto the rig floor. How severely depends on the size of the original bubble, or the amount of dissolved gas in the oil or oil-based mud. In a severe case, it may overload a closed surface diverter system. This tragically happened at Macondo, where the contents of the 5,000-foot riser (calculated to be initially 20-50% full of gas and oil, or more) erupted onto the rig floor only 2-3 minutes after the BOP was sealed.[97]

[CALL-OUT BOX START]

Free Gas in the Riser Recognized by BP as "Most Dangerous" to Rig Personnel in the Gulf of Mexico

"As is intuitively obvious, the possibility of free gas getting into the riser in very deepwater locations is quite high and is probably the one event that is most dangerous to rig floor personnel. This is of particular concern in the Gulf of Mexico due to the preponderance of shallow geopressured formations."

Internal Company Document, BP. *Well Control ManualV of Well Control*, Issue 3, BPA-D-002, December 2000, Blowout Preventer Equipment, BP-HZN-2179MDL00336706, see Exhibit 2390 http://www.mdl2179trialdocs.com/releases/release201302281700004/Frazelle_Andrew-Depo_Bundle.zip/

[CALL-OUT BOX END]

In a separate riser unloading[98] event that occurred a little over a year before the Macondo incident on a Transocean semi-submersible off the coast of West Africa,[99] issues arose concerning the use of the diverter while gas was in the riser. Similar to Macondo, the crew did not detect the situation until mud and gas began releasing out of the riser onto the rig. However, in this instance, the crew was able to shut in the well and the gas vented and dispersed before it found an ignition source.

In December 2009, the Transocean-owned rig, Sedco 711, also experienced a riser blowout; well ingress went undetected by the crew until hydrocarbons were releasing onto the rig. However, similar to the West Africa incident, the crew was able to close the well and the released flammable material did not ignite.[100]

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[96] Sonnenmann, P. IADC workgroup conducting studies to better understand, manage gas-in-riser events. *Drilling It Safely*, July 9, 2015, http://www.drillingcontractor.org/iadc-workgroup-conducting-studies-to-better-understand-manage-gas-in-riser-events-35793 (accessed October 7, 2015).

[97] CSB Macondo Investigation Report, Volume 2, Appendix A, pp 6, 21, 23.

[98] The sudden and uncontrolled release of the riser contents (e.g., drilling mud, gas, etc.) onto the rig caused by expanding gas in the riser.

[99] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 19, 2013 pp 4593, http://www.mdl2179trialdocs.com/releases/release201303191200014/2013-03-19_BP_Trial_Day_14_AM-Final.pdf (accessed October 7, 2015).; Internal Company Document, Transocean. *EAU Incident Investigation Report - M.G. Hulme, Jr. Well Control Incident - Riser Unloading*, OER-MGH-09-005, March 26, 2009, TRN-INV-01143039, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05650.pdf (accessed October 7, 2015).

[100] Internal Company Document, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, TRN-MDL-02840790, see Exhibit 5749

(Chapter 2.0 discusses these incidents in more detail.) Transocean identified riser unloading events as "the biggest concern" when identifying areas for well control improvement.[101] And with wells being drilled in deeper water, the requisite riser length continues to increase, suggesting the increased potential for severe riser unloading if gas flows above the BOP. The well operations crew needs tools to understand well conditions before a riser unloading situation develops. Yet these incidents demonstrate the challenges to detecting hydrocarbon ingress into the well before the gas enters the riser.

Appendix 2A of Volume 2 discusses the existence of two BOP pressure transducers on the Deepwater Horizon BOP that could have allowed the crew to cross-check the conflicting pressure readings between the drillpipe and the kill line. While it is not known if they were functional or used on the day of the incident, they were used during well control operations the previous month.[102] Neither the BP nor the Transocean well control manual referenced their use in operations and there were no signal processing or alarms associated with the sensor data.[103] If these sensors are incorporated into well monitoring activities, they (or similar other devices) may provide early indication of gas entering the riser.

Macondo and other delayed kick detection incidents support the need for improvements in kick detection capabilities and assessments of the reliability of those capabilities during emergency situations. Indeed, riser unloading events, while not common, are serious near-misses and can result in rig and environmental damage, as well as death.[104] As such, the CSB recommends industry further study riser gas unloading scenarios, testing, and modeling to improve understanding of this behavior and better manage the risk of large riser gas events.

1.4 Phase 2 – Seemingly Insignificant Decisions can have Great Impact in Complex Systems

In the previous section, examples from Macondo demonstrate the impact of organizational policies and practices on human performance. This section explores another characteristic of complex highly-interconnected systems—how minute indiscriminate decisions and behaviors of apparently no consequence when performed individually can coalesce into an unanticipated outcome.[105] Put another

http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip (accessed October 7, 2015).

[101] Internal Company Document, Transocean. *Annual Report - 2009 Well Control Events & Statistics 2005 to 2009*, pp 7, TRN-INV-00760060, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05649.pdf (accessed May 22, 2015).

[102] Bureau of Ocean Energy Management, Regulation, and Enforcement. Report Regarding the Causes of the April 20, 2010, Macondo Well Blowout: Volume II Appendices; 2011; pp F-57 to F-61.

[103] CSB Macondo Investigation Report, Volume 2, Appendix A, pp 5, 39-40.

[104] See Chapter 2 and U.S. Department of the Interior/Minerals Management Service. Investigation of September 1984 Blowout and Fire Lease OCS-G 5893, Green Canyon Block 69 Gulf of Mexico, Off the Louisiana Coast; OCS Report 86-0101; Minerals Management Service: 1986; http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Panel-Investigation-Reports/86-0101-pdf/ (accessed October 7, 2015).

[105] This phenomenon is a "routine byproduct of the characteristics of the complex system itself." Dekker, S. *Drift into Failure: From Hunting Broken Components to Understanding Complex Systems;* Ashgate Publishing: Burlington, VT, 2011; pp 14 & 159.

way, local decisions can have global impact.[106] At Macondo, introducing spacer material into the well and inadvertently placing it across the kill line of the BOP may have led to plugging of the kill line during the negative test, causing the zero pressure reading that the crew accepted as indication of a secure well.[107] In the moment, local decisions and actions taken by rig personnel and management pertaining to initial displacement may have seemed inconsequential, but they contributed to the positioning of the spacer across the kill line in the BOP:

- Onshore BP personnel chose an unusual spacer type and used a large volume when displacing drilling mud from the riser to avoid hazardous waste management fees and environmental penalties.
- BP did not perform a risk assessment of the atypical spacer before its use; while conduct of risk assessment in itself does not guarantee that the risks will be managed, the act of conducting a risk assessment provides the opportunity for identification and control of those risks.
- The morning of the displacement, one of the BP Well Site Leaders on the rig and an onshore BP Drilling Engineer requested a well fluids specialist, a third-party contractor, to prepare the displacement procedure based upon previous displacements conducted on the rig. No others played a role in developing the procedure, no pressure and volume parameters were identified to gauge successful completion of the procedure, and no effective verification for accuracy of the procedure occurred before it was rolled out to the crew.
- As was customary, a drilling fluids specialist from M-I SWACO assumed the Horizon’s pump efficiency was 96.1%, but the actual pump efficiency was closer to 90%, resulting in a smaller-than-planned volume of sea water to be pumped into the well.
- During troubleshooting efforts for the negative test, the Deepwater Horizon crew noticed that the riser was not full; a judgment was made that an annular preventer was leaking and the crew mitigated the perceived problem.

The independent local decisions regarding hazardous waste management, the informal and casual procedural development for the displacement process, and the judgment made concerning the riser fluid level seemed inconsequential to the successful completion of the temporary abandonment process, but with hindsight these decisions clearly had significant ramifications for the temporary abandonment.

BP chose to use Lost Circulation Materials (LCM)[108] as the spacer material between the drilling mud and the sea water to displace the mud from the well.[109] By doing so, BP was able to discharge the 450 barrels of leftover LCM overboard without environmental legal obligations and removed any need to pay for its

[106] Dekker, S. Drift into Failure: From Hunting Broken Components to Understanding Complex Systems; Ashgate Publishing: Burlington, VT, 2011; pp 158-172.

[107] *BP Report*, Appendix Q, 3: concluded “Solids from the spacer could have plugged the kill line, or the viscosity or gel strength of the spacer could have been too high to allow pressure to be transmitted through the kill line.”

[108] Lost Circulation Material (LCM) is a class of drilling fluids designed to plug the fractured walls in the wellbore so that drilling mud is not lost into the formation.

[109] E.g., CSB Macondo Investigation Report, Volume 1, pp 27; Transocean. *Macondo Well Incident: Transocean Investigation Report Volumes I and II;* June, 2011; pp 28.; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; p 147.

disposal onshore.[110] The company never tested the LCM material for this application, had no operational reason for using it, and not assess the potential risks of using this spacer. Similar to routing the diverter line to the MGS, management was influenced by the potential risk of regulatory environmental penalties, which dictated the actions of the crew.

On the morning of April 20, 2010, a drilling fluids specialist from M-I SWACO[111] on the Deepwater Horizon received two different calls from a BP Well Site Leader and a BP Drilling Engineer to discuss the displacement procedures the crew had been using to conduct its negative tests.[112] The drilling engineer conveyed that they would be displacing the well more than normal, so the fluids specialist wrote a procedure that included the details he had been communicated (Table 1-3). At a 3:00 p.m. pre-job safety meeting (also referred to as a THINK drill),[113] the fluids specialist reviewed the procedure with the crew and reported no one raised any concerns.[114] The fluids specialist possessed only a general knowledge of conducting a negative test, and the procedure he provided to the crew addressed only the types and volumes of fluids that would be used during the displacement process. The procedure did not address the negative test other than to indicate that it would occur.[115]

Table 1-3. Selected steps from the M-I SWACO displacement procedure used at the Macondo well on April 20, 2010.[116]

	Macondo Displacement Procedure Steps (verbatim from M-I SWACO document)	***CSB Interpretation of the Procedure Steps and Explanatory Information***
1	Before displacing to seawater, conduct a THINK DRILL with all.	*Refers to Transocean's THINK planning and risk management process (see Section 1.8.3).*
2	Build 425 bbl WBM spacer in pit #5, and use Duo Vis to thicken up.	*"WBM Spacer" refers to the water-based material that was used to separate drilling mud from seawater during the displacement of the well. Leftover lost circulation*

[110] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; pp 151, The *Chief Counsel's Report* noted that BP would avoid hazardous waste disposal obligations stipulated by the Resource Conversation and Recovery Act.; Hearing before the Deepwater Horizon Joint Investigation, July 19, 2010, pp 67, 79, 90.

[111] As a drilling fluids specialist, he was in charge of the properties of the drilling fluids, maintaining an inventory of what the rig had, and communicating what the rig would need. The drilling fluids specialist would also mix lost circulation material like that used in the spacer material; Hearing before the Deepwater Horizon Joint Investigation, July 19, 2010, pp 39-41,

[112] Hearing before the Deepwater Horizon Joint Investigation, July 19, 2010, p 42.

[113] See Section 1.8.4 for more details concerning THINK Drills; Hearing before the Deepwater Horizon Joint Investigation, July 19, 2010, pp 43, 55.

[114] Hearing before the Deepwater Horizon Joint Investigation, July 19, 2010 pp 43, 55.

[115] Section 1.8.3 details Transocean's polices concerning procedure development, including that for a negative test.

[116] Internal Company Document, MI SWACO. *BP/Deepater Horizon Rheliant Displacement Procedure "Macondo" OCS-G 32306*, BP-HZN-BLY00094818, see Exhibit 0052 http://www.mdl2179trialdocs.com/releases/release201302281700004/Lacy_Kevin-Depo_Bundle.zip.

		material was used as a 16-pound-per-gallon (ppg) dense spacer at Macondo. Duo Vis is a thickening ingredient.
3	Capacities: • Choke 100 bbls/794 strokes; • Kill 100 bbls/794 strokes; • Boost 73 bbls/579 strokes; • Drill pipe 196 bbls/1555 strokes; • Casing/Riser w/drill pipe annular 1817 bbls/14,420 stks. • Total displaced volume for hole and drill string, 2012 bbls/15,968 strokes • Pump Output 0.126 bbls/stk	*'Stks' refers to the number of strokes on the pump pushing the material into the well. The displacement procedure assumed one pump stroke gave 0.126 bbls of fluid which is 96.1% volumetric efficiency of the theoretical value. This was the customary assumption for this rig.*[117] *However, analyses of subsequent real time data shows that the actual efficiency was less, about 89-91%.*[118] *As a consequence, less seawater was actually pumped than planned, leaving spacer in and below the BOP.*
4	Displace choke, kill, and boost lines, and close lower valves after each. Zero stroke counter.	
5	Pump 425 bbl WBM spacer from pit # 5 down drill pipe followed by seawater.	
6	Pump 775 bbls or 6150 stks. Spacer should be above the upper annular.	*This step does not indicate if a total of 775 bbls should be pumped or if an additional 775 bbls is intended. It becomes clear during a later step this is intended to be the cumulative total (spacer + seawater).* *This procedure and its 775 bbl. value erroneously do not include 30 bbl. of freshwater of pit wash that was reportedly planned and likely pumped just after the spacer. Analysis of real-time data indicates that the driller actually used 775+30 = 805 bbls for this step.*[119] *This additional 30 bbl. volume is necessary for the calculated volumes to place the spacer above the BOP.*
7	Close annular and conduct negative test. After successful negative test, open bag.	*"Bag" refers to the annular BOP.*

[117] Transocean. Macondo Well Incident: Transocean Investigation Report:Volume II; June, 2011; Appendix G, pp 41, 57, 63.

[118] CSB Macondo Investigation Report, Volume 2, Appendix A, pp 5 & 12.; Transocean. *Macondo Well Incident: Transocean Investigation Report:Volume II;* June, 2011; Appendix G, pp 41, 57, 63.

[119] BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010; pp 83. CSB Macondo Investigation Report, Volume 2, Appendix A, pp 9 footnote 36 and pp 14; CSB Macondo Investigation Report, Volume 2, Appendix A, pp 5, 12.; Transocean. *Macondo Well Incident: Transocean Investigation Report:Volume II;* June, 2011; Appendix G, pp 57.

8	When WBM spacer returns at 15,968 stks…Compliance Engineer will take a sample for Static Sheen test…	*Sheen test: A sample of the returning well fluids is added to water and a visual determination is made if it causes a sheen, indicating synthetic oil based mud is still present and the returning fluids from the well cannot be disposed into the sea. An acceptable sheen test indicates that the displacement volumes were adequate, and such was the report to the driller.*[120]

Unknown to the crew, the volumetric efficiency of the rig's pump during the displacement was less than that assumed in the procedure, as noted in step 3. As a result, not enough seawater was pumped to displace all the spacer fluid above the BOP as intended. In hindsight, displacing all of the atypical spacer above the BOP was critical to minimize the possibility of plugging the kill line. Moving forward, a proactive measure may be to incorporate a safety factor on the target strokes to displace the spacer above the BOP.

At the end of the displacement (step 6), the drillpipe had 2,300 psi of trapped fluid pressure (see call-out box). If all of the spacer had been placed above the BOP as intended, the crew should have observed only ~1,600 psi of trapped pressure.[121] The high pressure reading could have warned the crew of the under-displacement, but the crew would have needed to be predisposed to look for this data and use it to deduce the conditions of the well, yet they weren't given that information and had no *a priori* reason for suspecting a problem.

Further, two pieces of evidence indicate that the well lost integrity during the initial displacement for the negative test. The loss of integrity would have further contributed to the under-displacement of spacer fluid, slowly taking fluid out of the well and reducing the displacement volume.[122] First, just after the crew closed an annular preventer[123] to isolate the well from the hydrostatic pressure of the riser, the real-time Deepwater Horizon data indicates the drillpipe pressure began to drop, implying a loss of well integrity.[124] Second, after closing the annular and initially attempting to bleed trapped pressure, the crew noticed that the riser was not full and assumed that the annular preventer was leaking riser fluid back into the well, causing drillpipe pressure to rise.[125] No witness testimony indicates the crew considered the

[120] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; pp 179.

[121] CSB Macondo Investigation Report, Volume 2, Appendix 2A, p 14.

[122] CSB Macondo Investigation Report, Volume 2, Appendix 2A, p 10.

[123] Annular preventers are rubber components of a BOP that are designed to seal around virtually any object that passes through them as well as an open hole when no drillpipe is present. See Section 2.1 in Volume 2 for figures and further description.

[124] The leak possibilities were in either the casing or the wiper plug in the lower shoe. The CSB could find no evidence or technical reason why either of these should have leaked, but a leak assumption was necessary to model the real-time data. For the well data simulations found in Appendix 2A of the CSB Volume 2 Macondo report, it was assumed that the leakage occurred at the casing shoe, but leakage at the casing crossover (12,488 ft.) also provided a good data match. CSB Macondo Investigation Report, Volume 2, Appendix 2A, p 14.

[125] Witnesses at the Hearings before the Deepwater Horizon Joint Investigation Team gave contradictory recollections; Hearing before the Deepwater Horizon Joint Investigation, May 28, 2010 pp 115, 133, "During the

possibility that well integrity had been compromised, and for at least two reasons the crew would have been predisposed to accept the leaking annular theory:

- The well had successfully passed a positive pressure test earlier in the day; and
- It is "not uncommon" to see an annular leak.[126]

Performing a visual check of the riser once the mud-displacing pumps were stopped, but before the annular preventer was closed for the negative test, could have provided a means to confirm if well integrity was secure or if remedial steps were necessary before proceeding with a negative test. However, witness testimony indicates such a visual check did not occur until after the crew began to troubleshoot the pressure increases in the well. Once the crew became aware of the drop in riser level, a decision was made to increase the annular closing pressure and fill the riser with more drilling mud; it stayed full, thus reinforcing the assumption of an annular leak.[127] A procedure providing the expected drill pipe pressure at the end of the initial displacement and a maximum acceptable value would have helped the crew detect the displacement shortfall.

negative test they felt like they lost approximately 60 barrels of mud through the annular." A Transocean Subsea Supervisor also recalled that a BP well site leader spoke to a Transocean driller on shift who observed, "We didn't lose no mud through the annular.' He say it U-tubed. Where it U-tubed to, I don't know;" Hearing before the Deepwater Horizon Joint Investigation, August 25, 2010 pp 271-272. August 25, 2010, pp 271-272.

[126] As a Transocean Senior Toolpusher and BP Wellsite Leader later described, I 2016.02.17 Day 2 Afternoon p 179, 2016.02.18 Day 3 Afternoon p 561.

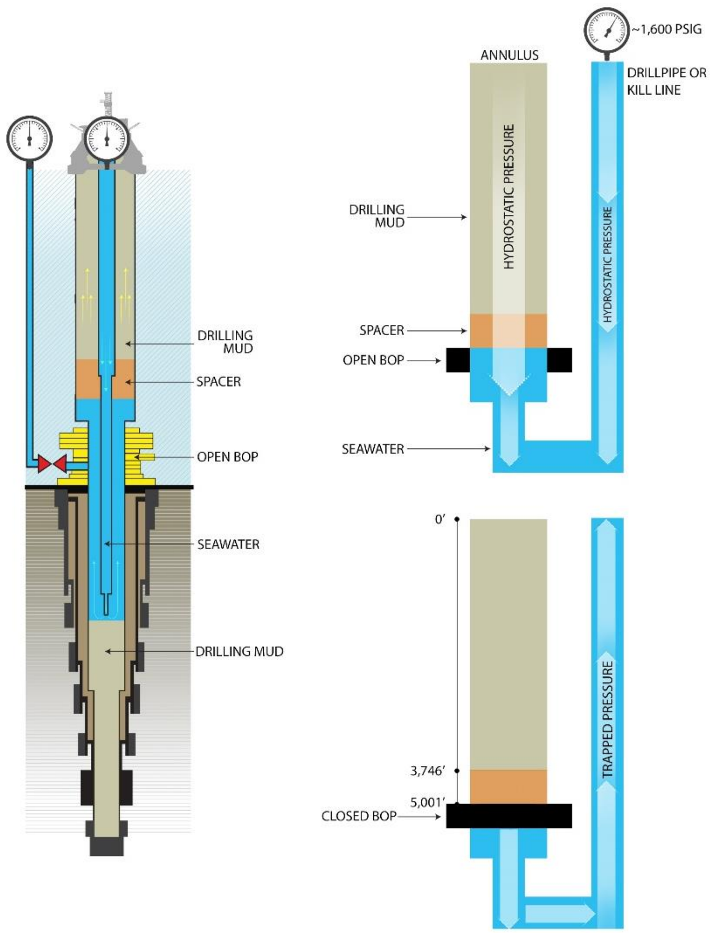
[127] Hearings before the Deepwater Horizon Joint Investigation Team, May 28, 2010, pp. 279 -280.

[CALL-OUT BOX START]

As described in Section 1.2.3, depending on the configuration of a negative test, the well pressure can be monitored from either the drillpipe, the kill line,[a] or in some instances both.

The pressure a crew observes after displacing drilling mud from a well can be illustrated by using the u-tube model seen here. The drillpipe, or the kill line, containing only relatively light seawater, is shown on one side of the u-tube.[b] On the other side, the annulus contains some seawater, but also much heavier drilling mud and spacer material. The heavier annulus material pushes down through the u-tube and up on the drillpipe seawater, increasing the drillpipe pressure, commonly called u-tube pressure, which can be predicted before fluid conditions in a well change.[c]

Similar to trapping gas in an inflated balloon, pressure will remain in a pipe if it is shut in. When the crew at Macondo closed the BOP, the u-tube pressure was trapped in the well until the crew intentionally released it from either the drillpipe or the kill line in preparation for the negative test.



[a] The kill line is a pipe that runs from the BOP to the rig.

[b] Hydrostatic pressure is height of the fluid column multiplied by the density of the fluid.

[c] The u-tube pressure is the hydrostatic pressure exerted by seawater in the drillpipe subtracted from the hydrostatic pressure generated in the annulus from the drilling mud and spacer material. Planned u-tube pressure at Macondo was ~1,600 psig.

Calculated hydrostatic pressures:
Drilling mud: 3,746 ft * 14.2 ppg * 0.052 = 2,766 psi
Spacer material: 1,255 ft * 16 ppg * 0.052 = 1,044 psi
Seawater: 5,001 ft * 8.55 ppg * 0.052 = 2,223 psi
where 0.052 is a units constant to convert feet-pounds per gallon (ppg) to pounds per cubic inch (lbs/in^3)

[CALL-OUT BOX END]

The issues covered in this section reveal numerous assumptions of the operator, drilling contractor, and other well service providers concerning the ability of the crew to accurately understand the conditions of the well throughout displacement. In reality, this status was inferred from the various indicators available and, as demonstrated here, incorrectly so. This evidence further supports the need for improved tools for accurate interpretation of well conditions, and this knowledge gap must be recognized when making decisions about well status throughout the drilling and temporary abandonment process.

1.5 Phase 3 – Evidence of Confirmation Bias

After displacement of the drillpipe, the crew took steps to conduct the negative test by bleeding and observing pressure and flow from the well several times over three hours (striped portion of Figure 1-10). After closing the annular, (~5:00 pm) the crew bled trapped pressure from the drillpipe, but subsequently observed it rise. They then noticed the low riser level, increased closing pressure on the annular, refilled the riser, and bled pressure from the drillpipe again (~5:25 pm). Afterwards, the crew again observed drillpipe pressure rise.

Shift change was officially at 6:00 pm for the toolpushers and WSLs.[128] The night shift WSL came on duty. After discussions (addressed in more detail shortly) among the Transocean well operations crew and both BP well site leaders, the decision was made to change the procedure to test on the kill line stipulated in the drilling permit submitted to MMS.[129] The crew bled pressure from the kill line (5:50 p.m.) until the pressure was zero in the kill line. The crew next pumped seawater into the kill line to ensure it was full (6:35 p.m.) and then observed no flow on the kill line for 30 minutes.[130] Despite this, pressure on the drillpipe remained. As the timespan in solid green illustrates in Figure 1-10, about an hour and a half passed without further actions by the crew, as discussions of the pressure on the drillpipe ensued.

Purportedly, the night toolpusher[131] offered an interpretation of the drillpipe pressure that justified the observed pressure. Post-incident, this theory, termed the bladder effect, annular compression, and annular compaction,[132] could not be supported. While it is in dispute whether the entire on-duty well operations

[128] The mud engineers also have shift change at this time, although they play a support role in the well operations. The drillers did not change out at this time; their shift change was at noon and midnight. (USA v. Robert Kaluza, Docket No. 12-CR-265, February 7, 2016, pp 153:5-154:3; USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, p 304:`6-18.)

[129] “CSB2010-10-I-OS-948944 MC252_APM_TA_Approval.pdf,” Temporary Abandonment Procedure_RevA.doc, BP-HZN-BLY00269182; USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 320:20-21, 323:7-9, & 328:22-329:5.

[130] USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 358:12-360:1

[131] The toolpusher plays a supervisory role within the drill crew, advising and assisting if the driller runs into a problem; Internal Company Document, Transocean. *Field Operations Policies & Procedures Manuel*, Issue 01, Revision 00, HQS-POP-PP-01, August 8, 2009; USA v. Robert Kaluza, Docket No. 12-CR-265, February 17, 2016, p 92:11-19.

[132] The bladder effect/annular compression theory is detailed in various places in the *Chief Counsel's Report*. The theory purported that the weight of the heavy drilling mud and spacer material pressed against the annular preventer which in turned pressed against the fluids below the preventer, forcing them up the drillpipe; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; pp 157, 162, and 229-30 (amongst others). USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 326:1-17 & 366:2-17 & 550:6-553:15

crew and both Well Site Leaders on the rig accepted this rationale,[133] ultimately, they proceeded with displacement. Continuation of the temporary abandonment process signified their acceptance of the negative test results and their belief that well integrity was secure.

Why would the WSLs and well operations crew continue with the displacement despite the pressure reading on the drillpipe? Not all of these individuals survived to explain their rationale. Yet from those who did, along with the evidence available, it can be reasonably assumed that they would have not proceeded with the displacement had they believed a blowout to be a real possibility.[134] But they did proceed, removing the fluid barrier from the well.

[133] USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 366:8-11 & 439:23-440:11 & 472:9-15 & 554:1-8.

[134] There exists a difference between real-time operational risk awareness by those conducting the work in the moment and risk awareness in the "back-office" sense by those removed from the actual operational setting. McLoed offers a useful discussion of the difference. [McLoed, R., 2015, *Designing for Human Reliability in the Oil, Gas and Process Industries*, Elsevier, Ltd.: Oxford, UK, pp 30-32.]

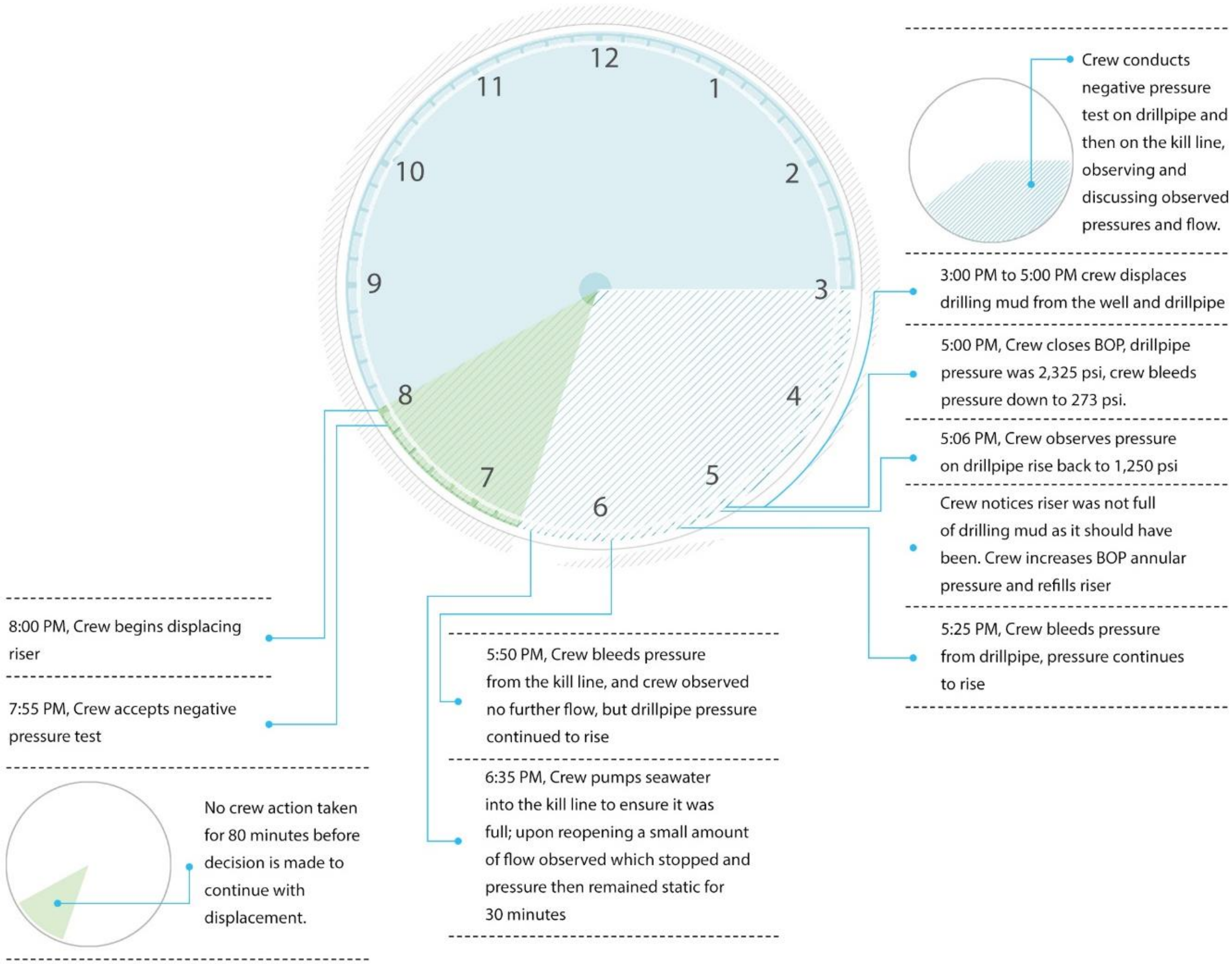


Figure 1-10. Crew Activities during Temporary Abandonment beginning at 3:00 p.m. on April 20, 2010

Several facts, experiences, and rational justifications explain why the well operations crew proceeded:

- Up to the point of the blowout, challenges of the well throughout the drilling process were successfully overcome, including: 1) multiple losses of well control events throughout the drilling of the well in which the crew was able to regain control of the well[135] and 2) changes to the drilling plans to accommodate those challenges (e.g., drill depth, casing choice). The ability to regain control of the well numerous times prior could have reinforced a mentality that success was inevitable.
- The crew explained away or remediated several anomalies during the cementing process.[136]
- Various personnel deemed successful the bottom-hole cement job—the primary physical barrier set in the well to prevent loss of well control and the major operational task of temporary abandonment.[137]
- The positive pressure test conducted earlier in the day to verify casing integrity (i.e., no leaks from inside the well to the outside) was successful. While this test does not verify the integrity of the bottom hole cement job, it represents another successfully completed step in temporary abandonment.
- A rationale for the loss of riser fluid was provided.
- The well operations group purportedly discussed, and at least partially accepted, a rationale for the drillpipe pressure. The individual purported to have provided the rationale was considered highly competent in skills directly applicable to this situation—"[he] makes quality decisions on a consistent basis," "has always been a recognized leader on the Deepwater Horizon, and uses his experience to help others."[138] The professional respect for this individual, as well as the backing

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[135] Numerous 'lost returns' events on February 17, March 2, 3, 21, 31, April 3, 4, and 9, 2010, well kicks on October 26, 2009 and March 8, 2010, and a ballooning event on March 25, 2010; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; Figure 4.2.8, p 59.

[136] These included issues with converting the float valve assembly, a device that allows cement to be pumped into a well and then to prevent flow back up the casing once pumping ceased. Ultimately, much higher pressure was required to convert the float valves. Additionally, the anticipated cement circulation pressure was lower than predicted, but the eventual conclusion was that the lower-than-expected pressure actually reflected a broken pressure gauge. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; Chapter 4.3, p 67.

[137] Email from Cementing Engineer, Halliburton, to Cementing Engineer, Halliburton, Subject: 9.875" x 7" Casing Post Job, "We have completed the job and it went well," April 20, 2010, HAL 0011208, see Exhibit 0708 http://www.mdl2179trialdocs.com/releases/release201302281700004/Stringfellow_William-Depo_Bundle.zip (accessed October 7, 2015).; Email from Drilling Engineer, BP, to Drilling Engineering Team Leader, Senior Drilling Engineer, Wells Team Leader, BP, Subject: Nitrogen Cement Team, "the Halliburton cement team … did a great job," April 20, 2010, BP-HZN-MBI00129141.; Foamed Casing Post Job Report from Macondo stated that the cement job was "pumped as planned" and that full returns were seen throughout the process; Internal Company Document, Halliburton. *9.875" x 7" Foamed Production Casing Post Job Report,* April 20, 2010, HAL_0011210, Exhibit 0708 http://www.mdl2179trialdocs.com/releases/release201302281700004/Stringfellow_William-Depo_Bundle.zip (accessed October 7, 2015).

[138] Internal Company Document, Transocean. *2009 Senior Supervisor Performance Appraisal - Performance Appraisal and Development Plan,* October 31, 2009, TRN-MDL-08076982, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-52649.pdf (accessed October 7, 2015).

by others of the rationale as something plausible,[139] and even seen before,[140] gave the crew comfort that the theory was valid.

- The night shift WSL recalled participating in approximately 50 previous negative tests; to his knowledge, never had one failed.[141]
- They had conducted the negative test according to the drilling permit, seeing no flow for 30 minutes,[142] an indication of a successful negative test.[143]

It is reasonable to assume that these facts, experiential knowledge, and justifications convinced the crew that successful completion of the well was inevitable. This information strongly indicates that the well operations crew and WSLs were subject to confirmation bias,[144] a one-sided case-building process of unconscious selectivity in gathering and using evidence that supports one's beliefs.[145] Acceptance of an explanation or decision despite indications otherwise is more likely when a recognized leader supports the position, a lot at stake, and an alternative scenario would be costly.[146] (See also Section 1.7.1.) Thus, the situation predisposed the crew to interpret the negative test as successful on April 20, 2010.

[CALL-OUT BOX START]

Shift Change of Supervisory Personnel

Shift change for both the toolpushers and the WSLs was scheduled to occur at 6:00 p.m. on April 20, which coincided with the time the well operations crew were conducting and discussing the negative test.[147] Changing out were the toolpusher, identified as the rig floor supervisor of the drilling operations, and the WSL, the designated decision-maker for the well operations.[148] The day toolpusher reported that

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[139] USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 326:7-17, 554:1-6; Hearing before the Deepwater Horizon Joint Investigation, July 20, 2010 pp 90-91, 153.

[140] Internal Company Document, BP. *Notes from Bob Kaluza Interview*, April 28, 2010, BP-HZN-MBI00021276, see Exhibit 0005 http://www.mdl2179trialdocs.com/releases/release201302281700004/Daigle_Keith-Depo_Bundle.zip (accessed October 7, 2015).

[141] USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp. 282:13-15, 294:2-6.

[142] USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, p. 358:12-360:1; CSB2010-10-I-OS-629100 2013-03-05 BP Trial Day 6 AM, p.1682:13-17.

[143] USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp. 166:21-22, 358:12-360:1

[144] This analysis is in alignment with Hopkins, A. *Disastrous Decisions;* CCH Australia: Australia, 2012; p 40.

[145] Nickerson, R. S. Confirmation Bias: A Ubiquitous Phenomenon in Many Guises; *Review of General Psychology* 1998**,** *2* , pp 175-176.

[146] The logical extension of this argument would suggest that if integrity is lost but not acted upon, as was the case with Macondo, the result could be significantly costlier. However, research on confirmation bias demonstrates that people influenced generally weigh more heavily data that supports and affirms their beliefs. Nickerson, R. S. Confirmation Bias: A Ubiquitous Phenomenon in Many Guises; Review of General Psychology 1998, p 176.

[147] Vidrine 5/7/10 interview notes by Guillot, Anderson, and Wetherbee, BP-HZN-MBI00021427. The mud loggers also had shift change at this time, but they were in support roles more than supervisory. CSB2010-10-I-OS-629100 2013-03-05 BP Trial Day 6 AM, p 1676:4-8.

[148] TREX-07532 Telephone interview of Wyman Wheeler, June 4, 2010, p.4; USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 319:12-13, 348:17.

he left his shift approximately 20 minutes after his replacement arrived the evening of April 20;[149] *if his time estimates are accurate, he would not have been in the drill shack for a significant portion of the discussion about the negative test that occurred during the day shift and the next steps for the night shift crew. There were also understanding gaps between the day and night WSLs, which were not realized until those conversations were deconstructed post-incident.*[150] *It can be argued that because the drill crew does not change out at the same time, the potential for communication gaps is lessened. But this situation reveals an opportunity to review shift change procedures and practices for all safety critical positions and to assess whether training in (non-technical) communication skills is warranted (see Section 1.7).*

[CALL-OUT BOX END]

[CALL-OUT BOX START]

Subsea supervisor testimony offered during the Joint Marine Board investigation provides insights into the general mindset of a crew during these final stages of drilling and abandoning a well:

> *When you run that last string of casing and you have got it cemented, it's landed out and a test was done on it, then you say this job, we are at the end of it. Everything is going to be okay. Now I'm telling you this, not from a supervisor, not from the well-site leader's office, but from the working men that are out there, we have finished this well. You are thinking ahead to your next job. You're moving on.*
>
> Hearing before the Deepwater Horizon Joint Investigation, July 20, 2010, p 63.

[CALL-OUT BOX END]

1.5.1 Potential Influence of Distraction and Fatigue

A variety of performance shaping factors[151] contributed to the decisions and actions of the crew, some of which have already been discussed. Two additional factors have been prominently raised in review of the incident: fatigue and distraction of those carrying out temporary abandonment. While the CSB does not find conclusive evidence to assert that these factors played a causal role in the blowout, the agency cannot rule them out. Both are briefly covered here.

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[149] TREX-07532 Telephone interview of Toolpusher, June 4, 2010, p.4. US District Court, Eastern District of Louisiana, MDL-2179, March 5, 2013, Day 6 morning session, p 1676.

[150] The night WSL asserted that he likely would have changed his decisions/actions on the night of April 20 if he had this information at the time. USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 371:21, 73:13.

[151] Performance shaping factors, also called performance influencing factors, are the characteristics of the job (e.g., nature, workload, procedures, environment), individual (e.g., skills, attitude, personality, mental state) and organization (e.g., culture, leadership, resources) that influence human performance. (UK HSE, Performance Influencing Factors, http://www.hse.gov.uk/humanfactors/topics/pifs.pdf)

1.5.1.1 Fatigue

Fatigue can negatively affect workplace performance by increasing errors, delaying responses, and clouding decision-making.[152] Complex task decision-making that requires innovative and flexible thinking is also sensitive to fatigue.[153] "Fatigued people are less able to respond to unusual or emergency conditions effectively. They are also more likely to take risks."[154] The following facts are known about the Macondo blowout:

- Transocean implemented 21-day hitches (called "3 and 3") across all North American Division rigs in October 2009; prior to that time, both 14- and 21-day hitches were used. The analyses conducted, and rationale given, by Transocean to switch its Gulf regional fleet from a 14-day hitch to a 21-day hitch expressly focused on schedule predictability, interchangeability of crews from rig to rig, more time for crew training, and financial savings.[155] Missing from the analysis is consideration of sleep science.
- Limited research exists on performance impacts resulting from offshore 21-day hitch durations in comparison two 14-day hitches;[156] however, general sleep science shows detrimental performance effects increase as periods of consecutive shift work increase,[157] and most North Sea operations[158] in both UK and Norwegian waters implement 14-day hitches followed by 14 - 28 days of onshore rest.[159]

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[152] Rogers, A.S., Spencer, M.B., and Stone, B.M., 1999. Report 245/Validation and Development of a Method for Assessing the Risks Arising from Mental Fatigue, prepared by the Defence Evaluation and Research Agency Center for Human Services, for the HSE, U.K; Lerman, S. et al., Fatigue Risk Management in the Workplace, ACOEM Presidential Task Force on Fatigue Risk Management, Journal of Occupational and Environmental Medicine, 54(2), February 2012, p 1; and UK HSE, Human Factors, Specific Topic 2: Managing Fatigue Risks, http://www.hse.gov.uk/humanfactors/topics/specific2.pdf, p 1, accessed March 21, 2016.

[153] Rogers, A.S., Spencer, M.B., and Stone, B.M., 1999. Report 245/Validation and Development of a Method for Assessing the Risks Arising from Mental Fatigue, prepared by the Defence Evaluation and Research Agency Center for Human Services, for the HSE, U.K. Rosekind, M., Gander, P., et al., 1996. "Managing Fatigue in Operational Settings I: Physiological Considerations and Countermeasures," Behavioral Medicine, Vol. 21, p 157-165.

[154] Energy Institute, *Improving Alertness through Effective Fatigue Management,* 2006, p 1; this document has been superseded by *Managing Fatigue using a Fatigue Risk Management Plan*, 1st ed., 2014, https://www.energyinst.org/technical/human-and-organisational-factors/human-factors-fatigue (accessed March 26, 2016).

[155] April 20, 2011, response by Transocean to CSB subpoena requests for records and information on Transocean's 21-day on/off work schedule.

[156] HSE, *Offshore Working Time in Relation to Performance, Health and Safety: A review of Current Practice and Evidence, RR772,* 2010, p 23 & 51.

[157] Rosekind, M., Managing work schedules: an alertness and safety perspective, in *Principles and Practice of Sleep Medicine,* eds. By Kryger, M, Roth, T., & Dement, W. Philadelphia, PA, 2004, pp 682 & 686.

[158] The exceptions most commonly include those working in remote UK waters, e.g., West of Shetland.

[159] Parkes, K., Shift schedules on North Sea oil/gas installations: a systematic review of their impact on performance, safety and health, *Safety Science, (50)*, 2012, pp 1638.

- Historical accident and injury data from the North Sea suggest that the ratio of fatalities and severe injuries to less severe injuries was markedly higher for hitches longer than 14 days in comparison to those of lesser quantity.[160]
- Research shows that schedules rotating 'backwards' from night to day shifts (as opposed to rotating 'forward' from day to night shifts),[161] and that make this switch in the middle of the hitch,[162] are more likely to negatively impact performance by causing fatigue as the body readjusts to a new sleep-wake schedule.
- Workers reported in a Lloyds Register culture/climate review that the 21-day hitch was causing fatigue, particularly during the final week.[163]
- The driller and one assistant driller working the evening of April 20 were on shift 20 of their 21-day hitch; the second assistant driller was on shift 19 of 21; each shift was 12 hours, not including any overage worked to conduct shift turnover.
- The day shift toolpusher was on day 20 of his hitch; his shifts were also 12 hours.
- The toolpusher on the evening of April 20 was only on day 6 of his hitch, but he was scheduled to leave the Deepwater Horizon the next day for another offshore facility; he would not be returning to the Horizon, where he spent approximately half his life for almost the last decade.[164]
- The BP Well Site Leaders were on a 14-day hitch; they were scheduled to have their swing-shift rotation at 2:00 a.m. on April 21.

To determine causality, investigators require sufficient evidence that identifiable fatigue factors[165] were present at the time of the incident and that fatigue-related performance loss contributed to or caused the

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[160] Parkes, K. (University of Oxford). *Psychosocial Aspects of Work and Health in the North Sea Oil and Gas Industry, 1996 – 2001*, Sudbury: Health and Safety Executive, 2002, pp 38.

[161] HSE, *Offshore Working Time in Relation to Performance, Health and Safety: A review of Current Practice and Evidence, RR772,* 2010, pp 33-35; Rosa, R. and M. Colligan. *Plain Language about Shift Work,* Cincinnati: US Department of Health and Human Services (Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health), July 1997, p 9.

[162] Parkes, K. (University of Oxford). *Psychosocial Aspects of Work and Health in the North Sea Oil and Gas Industry, 1996 – 2001,* Sudbury: Health and Safety Executive, 2002, pp 7, 37-38; HSE, *Offshore Working Time in Relation to Performance, Health and Safety: A review of Current Practice and Evidence, RR772,* 2010, pp 32-33; Parkes, K., Shift schedules on North Sea oil/gas installations: a systematic review of their impact on performance, safety and health, *Safety Science, (50)*, 2012, pp 1647.

[163] "On their last week, they seem like they are in another world," and "On the last week, you are so tired that you feel like a robot" were two quoted responses. TREX-04261, *Lloyd's Register Safety Management Systems and Safety Culture/Climate Reviews: Deepwater Horizon* closing meeting on March 16, 2010, TRN-INV-00016761 and *Lloyd's Register EMEA Aberdeen Energy, Safety Management and Safety Culture/Climate – Deepwater Horizon,* May 11, 2010, p.16. TRN-HCEC-00090589.

[164] US District Court, Eastern District of Louisiana, MDL-2179, March 5, 2013, Day 6 morning session, p 1737.

[165] Fatigue factors are physiological aspects of an individual's sleep/wake cycle that underlie fatigue. Rosekind, M., Gregory, K., et al., 1993. "Analysis of crew fatigue factors in AIA Guantanamo Bay aviation accident, Appendix E," to Aircraft Accident Report: Uncontrolled Collision with Terrain, NTSB/AAR-94/04, Washington, D.C.: NTSB.

accident.[166] Fatigue factors include acute sleep loss and cumulative sleep debt,[167] continuous hours of wakefulness, circadian rhythm disruptions, and potential medical sleep conditions.

This analysis cannot go further due to the lack of specific information pertaining to the sleep and wake cycles of the individuals involved, many of whom suffered fatal injuries as a result of the incident or were not made available to the CSB for interviews. Without such information, the CSB cannot draw strong connections between fatigued mental states and explicit performance detriments demonstrated by the individuals. The CSB does not know how the well operations crew spent their off time in the days leading up to the blowout, what portion of that time they spent sleeping, and whether their sleep was of high quality. Yet the CSB does know that the night shift toolpusher and WSL were more likely to be fatigued due to their 6:00 p.m. – 6:00 a.m. schedules. The CSB can surmise that leaving the MODU after almost a decade would take an emotional toll on the toolpusher, which may amplify the effects of fatigue;[168] however, the evidence available does not provide sufficient information to make that claim.

Overall, sufficient information is not available for a causal connection to the blowout. Yet, the facts outlined here raise sufficient concern for the offshore industry to address fatigue as a safety issue. Testimony from Steve Newman, then the Transocean CEO, confirmed Transocean also implemented 28-day hitches.[169] Some offshore workers may prefer extended hitches for the equivalent-in-length non-work periods. But management has the responsibility to effectively manage the risks inherent in the work, and working hours, shift patterns, and hitch length are within its span of control. Reasons for implementing long hitches include limitations on the number of personnel that can be accommodated on the offshore facility and reductions in the number of shift changes, which minimize opportunities for error that could arise from more frequent staff change-outs.[170] An additional benefit is reduced helicopter traffic, which has also been recognized as a major offshore risk. Thus, a safety management system is necessary to assess the risk of fatigue and to establish and maintain policies and practices to effectively reduce those risks. API Recommended Practice 755 is voluntary US onshore guidance for developing and implementing a fatigue risk management system, but its scope is expressly applicable to shift workers commuting daily to the worksite.[171]

[166] This two-step methodology was employed by the NASA Fatigue Countermeasures Program and the National Transportation Safety Board (NTSB) to assess operator fatigue in accidents, and it has been used in NTSB investigations of pipeline and transportation incidents. As the tasks of the well operations crew, pilots, board operators, and drivers parallel each other in that they all deal with issues of critical decision-making, attending to/monitoring technological systems, reacting quickly to abnormal conditions, and rectifying deviations from normal conditions, the methodology is appropriate and applicable to offshore well operations events.

[167] Acute sleep loss is the amount of sleep lost from an individual's normal sleep requirements in a 24-hour period. Cumulative sleep debt is the total amount of lost sleep over several 24-hour periods. If a person who normally needs 8 hours of sleep a night to feel refreshed gets only 6 hours of sleep for five straight days, this person has a sleep debt of 10 hours.

[168] "…combinations of stressors may act additively or combine to produce multiplicative effects on health and safety outcomes." HSE, *Offshore Working Time in Relation to Performance, Health and Safety: A review of Current Practice and Evidence*, *RR772*, 2010, pp 9-10.

[169] US District Court, Eastern District of Louisiana, MDL-2179, March 19, 2013, Day 14 morning session, p.4666.

[170] UK HSE, Guidance for Managing Shiftwork and Fatigue Offshore, Information Sheet No. 7/2008, http://www.hse.gov.uk/offshore/infosheets/is7-2008.htm (accessed February 14, 2011).

[171] API, Recommended Practice 755: Fatigue Risk Management Systems for Personnel in the Petroleum and Petrochemical Industries, 2007, p.1. The CSB notes that it has identified a number of ways this recommended

1.5.1.1 Distraction

Testimonies from witnesses suggest that the executive tour was only in the drill shack (and thus capable of interrupting/distracting those involved in the well operations) for about 5 minutes. The OIM and senior toolpusher, who were on the tour, were asked to stay within the drill shack to help the drill crew, and they did so for about 15 minutes more. The senior toolpusher stated that he did not play a role in the decision-making occurring with the shack concerning the negative tests and that he actually stepped out of the shack to discuss some next steps in temporary abandonment with the assistant driller.[172] The drill crew and WSLs continued to discuss the negative test and well data for some time after the tour group left, suggesting that they were focused on the work and not distracted by the executive group. However, without more detailed evidence of what was said, by whom, in what manner, and to what extent within that drill shack, the CSB cannot determine with any level of certainty how the tour might have impacted the flow of communication and the analysis of the well data/negative tests.

1.6 Phase 4 – Troubleshooting, Multiple Activities, and Communication Gaps Obscure Well Conditions

After accepting the negative test results at 7:55 p.m. (Figure 1-11), the crew continued with displacement of the riser. The crew engaged in multiple activities during this time, including a sheen test, several mud and well fluid transfers into and out of various locations, and displacement pump shutdowns and restarts (Figure 1-11). Unbeknownst to the people on the Deepwater Horizon, at ~8:50 pm, reservoir fluids began to flow into the well. Between 8:50 p.m. and 9:08 p.m., when the crew stopped displacing the riser to conduct the sheen test, the influx rate into the well was approximately 9 bpm (barrels/minute), and the pit gain on the rig was about 60 barrels over 16 minutes.[173] The crew did not detect this influx. Post-incident, the senior toolpusher noted that the number of pre-calculated strokes (step 8, Table 1-3) on the pump used to displace the riser correlated with the visual sheen test results, indicating that the drilling mud in the riser had been displaced and the spacer had reached the rig.[174, 175] In short, "everything looked good."[176]

practice could be further improved. See http://www.csb.gov/assets/1/7/Fatigue_Evaluation_for_Public_Comment_3_11_20131.pdf.

[172] USA v. Robert Kaluza, Docket No. 12-CR-265, February 17, 2016, pp 162:25, 163:12.

[173] The computer simulation found in Appendix 2-A indicates that by 9:09 p.m. about 9 bpm were flowing into the well, and the pit gain on the rig was about 60 barrels over 16 minutes. These conditions should have been sufficient to be observable on the rig, but the crew was not predisposed to look for them.

[174] Internal Company Document, Transocean. *Senior Toolpusher Interviewing Form*, May 28, 2010, TRN-MDL-00493745, http://www.mdl2179trialdocs.com/releases/release201304041200022/TREX-50296.pdf (accessed October 7, 2015).

[175] Subsequent analysis by both Transocean and the CSB indicates that the spacer had not yet reached the surface at 9:08 p.m. A possible explanation for the successful sheen test may be that spacer bypassed some of the drilling mud, giving a false displacement indication. If a sheen were detected, it would have been an indication of an incomplete displacement, that the actual pump efficiency was lower than assumed; *Macondo Well Incident: Transocean Investigation Report:Volume II;* June, 2011; Appendix G, Figure 44, p 103; CSB Macondo Investigation Report, Volume 2, Appendix A, Figure 9, p 20.

[176] Internal Company Document, Transocean. *Senior Toolpusher Interviewing Form*, May 28, 2010, TRN-MDL-00493745, http://www.mdl2179trialdocs.com/releases/release201304041200022/TREX-50296.pdf (accessed October 7, 2015).

As a backup to the well operations crew, the Sperry Sun[177] mudloggers aboard the rig were hired by BP to monitor surface instruments that provided drilling and well information and to raise concerns for any abnormalities.[178] Sperry Sun had installed its own flow meter on the rig to monitor returns from the well, but apart from this particular device, the mudlogger monitored the same data as the drillers.[179] Yet, prior to resuming the displacement, the mudlogger was not privy to all the discussions about whether to accept the negative test. He was not with the well operations crew in the drill shack; instead, he was in a separate windowless office approximately 15 feet from the perimeter of the rig floor.[180] He surmised that the negative test was successful only because displacement of the drillpipe was occurring.[181] While he did leave his monitoring post to go to the restroom in the hour before blowout, this purportedly occurred sometime between 8:50 p.m. and 9:15 p.m., when fluid transfer movements were either impacting or were perceived to be impacting the flow-out meter.[182]

If an organization is relying upon individuals to monitor and troubleshoot an operational process, it must make efforts to ensure they have enough information to do so. The mudlogger might have had the same raw data available to him as the driller, but the information was contextually incomplete—he was not a part of the conversations concerning the negative test results and their implications for the well, nor was he fully abreast of the fluid transfers,[183] yet he was relied upon as the independent layer of protection for kick detection.[184] In actuality, during temporary abandonment, he was a dependent layer, able to interpret well conditions only from the data that was available to him.

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[177] A subsidiary of Halliburton; see Volume 1, Section 1.1, for description of various well service providers contracted by BP.

[178] Hearing before the Deepwater Horizon Joint Investigation, December 8, 2010, pp 267; Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, p 18.

[179] The mudlogger reported that Transocean had its own HiTech Profibus system, the data of which was shared with the mudloggers, but not necessarily communicated in the same format; Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 116. For a more detailed analysis, see Hopkins, A., February 2011, *A working paper prepared for the CSB: the failure of monitoring prior to blowout,* available at the Macondo investigation page of the CSB.gov website.

[180] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013 p 3494, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

[181] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 28, 158.

[182] Starting around 9:08 p.m., when the overboard line was opened, the mudlogger's ability to see flow out of the well was impaired; Hearing before the Deepwater Horizon Joint Investigation, December 8, 2010, pp 189.; Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 212, 216.

[183] The mudlogger reported calling the drill shack several times to understand the data he was seeing from his control station. Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013 pp 3603, 3605-2606, 3527-3828, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

[184] Internal Company Document, BP. *BP Incident Investigation Team - Notes of Interview with Mark Hafle*, July 8, 2010, BP-HZN-BLY00144213, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-04447.pdf (accessed October 7, 2015).; Hearing before the Deepwater Horizon Joint Investigation, December 8, 2010, p 267; Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, p 18.

Once the sheen test was accepted, the crew diverted overboard the fluids returning from the well, bypassing the pit volume monitoring system, which is the prime means for the crew to detect flow anomalies from the well. A pressure anomaly was observed at ~9:31 p.m., but instead of checking the well for flow—which would be the anticipated course of action if well influx was suspected—the crew shut down the displacement pumps and began troubleshooting valves and lines at the surface.[185] Within nine minutes of shutting down the pumps, oil and gas erupted a mixture of seawater, drilling mud, and hydrocarbons up onto the drilling rig floor.

The actions of the crew, summarized in Figure 1-11, depict a group that was neither idle nor complacent in the minutes leading up to the blowout at 9:40 p.m. Rather, the crew demonstrated that they knew something was amiss, and they were actively trying to understand the situation by examining surface valves and lines. The crew's performance of these surface checks suggests their perception of only minor problems, such as a valve leak, not a catastrophic gas-in-riser situation.

[185] CSB Macondo Investigation Report, Volume 2, Appendix 2-A, p 11.

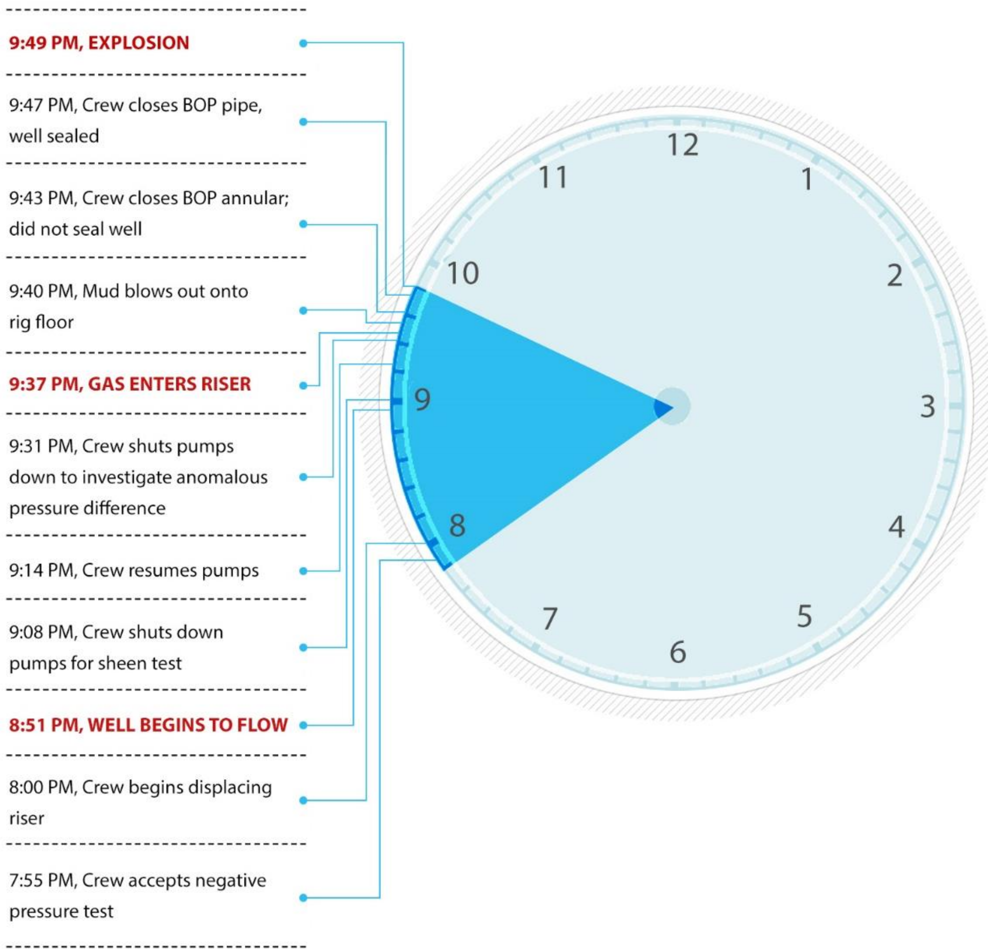

Figure 1-11. Crew activities and actions during final displacement of the riser

The crew was predisposed to interpret the pressure anomaly as unrelated to cement integrity because of a perceived "successful" completion of the well. In summary, "as operations continue, the resulting anomalies remain undetected or are satisfactorily accounted for until matters evolve to a point where events demolish the reality inside which the crew is operating."[186]

1.7 Competency and Non-technical Skills

The human factors contributing to the Macondo incident almost automatically raise questions about competency of the personnel involved, and more fundamentally about the meaning of competency. More job-specific training is often the recommendation in the aftermath of a catastrophic incident, as was the

[186] Thorogood, J. *The Macondo Inflow Test Decision: Implications for Well Control and Non-technical Skills Training*, SPE/IADC Drilling Conference and Exhibition, London, March 17-19, 2015; SPE/IADC-173123-MS, p 8.

case in Macondo.[187] Traditional training typically consists of teaching crews to manage conditions based on plans (rules, procedures, policies). As such, post-incident investigations often focus on the need to improve those skills (i.e., knowledge of procedures and ability to execute them), and steps are taken to revise procedures and manuals so that individuals will be prepared for those specific unanticipated conditions when they arise.

This approach faces two challenges. First, task-specific or technical competency training does not guarantee error-free performance. A highly skilled, technically competent person can make glaring human errors.[188] For example, an expert surgeon may amputate a patient's right limb with technical precision only to realize later that the left one was to be removed.[189] Second, within complex systems, "rules, regulations, policy or procedures cannot be written to address all the situations that people may face,"[190] precisely because these systems can have emergent properties that are inherently unpredictable.[191] Consequently, "expertise is required to recognize when the unexpected is present or may arise."[192] Thus, technical competency is only one aspect of an individual's performance capabilities, and other non-technical skills (NTS) are necessary to prepare individuals to manage the natural variability inherent within the complex system. Non-technical skills are meant to enhance human performance reliability in high-demand and high-risk work environments (e.g., the hospital operating room, the nuclear plant control room), [193] where innovation and adaptation by people are needed to successfully operate within imperfect systems.[194]

Akin to crew resource management (CRM)[195] skills used in aviation, NTS are "the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task

[187] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Deep Water The Gulf oil Disaster and the Future of Offshore Drilling;* 2011; p 122.; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011, pp 162, 185.

[188] Health and Safety Executive. *Reducing Error and Influencing Behaviour;* HSG48; 2009; pp 12-17. http://www.hseni.gov.uk/hsg_48_reducing_error_and_influencing_behaviour.pdf (accessed October 7, 2015).

[189] This scenario is based upon the example given in Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008; p 10.

[190] Pupulidy, I. Novices, Experts & Errors: Toward a Safer Fire Ground; *Wildfire* 2015**,** *24 (1),* p 33.

[191] Dekker, S. Drift into Failure: From Hunting Broken Components to Understanding Complex Systems; Ashgate Publishing: Burlington, VT, 2011; pp 155-160. Weick, K.; Sutcliffe, K. Managing the Unexpected: Resilient Performance in an Age of Uncertainty, 2nd ed.; John Wiley & Sons, Inc: San Francisco, CA, 2007.

[192] Pupulidy, I. Novices, Experts & Errors: Toward a Safer Fire Ground; *Wildfire* 2015**,** *24 (1),* p 33.

[193] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 1.

[194] Pupulidy, I. Novices, Experts & Errors: Toward a Safer Fire Ground; *Wildfire* 2015**,** *24 (1),* p 33.

[195] Crew Resource Management (CRM) is defined as "a management system which makes optimum use of all available resources—equipment, procedures and people—to promote safety and enhance the efficiency of … operations." The focus of CRM training is on cognitive and intrapersonal skills. (Civil Aviation Authority. *Crew Resource Management (CRM) Training, Guidance for Flight Crew, CRM Instructors and CRM Instructor Examiners;* CAP 737; Chapter 1, Sections 2.1 and 2.2.)

performance."[196] As defined in Table 1-4, they focus on situation awareness, decision-making, communication, teamwork, leadership, and stress and fatigue management.[197]

Table 1-4. Non-technical skill categories, definitions, and example behaviors associated with each[198]

Skill Category	Definition	Types of Behaviors
Situation awareness	Developing and maintaining a dynamic awareness of the situation and the risks present during a wells operation, based on gathering information from multiple sources from the task environment, understanding what the information means, and using it to think ahead about what may happen next.	• Gathering information • Understanding information and risk status • Anticipating future developments
Decision-making	Diagnosing the situation and reaching a judgment to choose an appropriate course of action.	• Identifying and assessing options • Selecting and communicating an option • Implementing and reviewing decisions
Communication	Exchanging (transmission and reception) of information, ideas and feelings, by verbal (spoken, written) or non-verbal methods.	• Briefing and giving feedback • Listening • Asking questions • Communicating assertively
Teamwork	Working in a group, in any role, to ensure joint task completion, including coordination, cooperation and conflict resolution. A core concept of CRM training is not necessarily to strengthen any particular team but rather to make individuals more effective in whichever team they are working in.[199]	• Understanding own role with the team • Coordinating tasks with team members/other shift • Considering and helping others • Resolving conflicts
Leadership	Directing, managing, and supporting a team in order to accomplish tasks for set targets.	• Planning and directing • Maintaining standards • Supporting team members

[196] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 1.

[197] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 1.; IOGP. *Crew Resource Management for Well Operations;* 501; April, 2014; pp 12. http://www.ogp.org.uk/pubs/501.pdf (accessed October 7, 2015).

[198] Except where specifically footnoted, this information is extracted and compiled from IOGP *Crew Resource Management for Well Operations;* 501; April, 2014; pp 12-15. http://www.ogp.org.uk/pubs/501.pdf (accessed October 7, 2015).

[199] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008; p 93.

Stress and Fatigue Management	Mitigating the effects of stress and fatigue.	• Identifying signs of stress and fatigue • Coping with effects of stress and fatigue

Aviation provides perhaps the most notable example of focused effort to develop individuals' non-technical skills, where this effort came to fruition after recognition that aviation accidents were not primarily the result of technical problems or lack of technical knowledge of the crew, but due to the crew's inability to understand their situation and respond appropriately.[200] The Tenerife runway collision that killed 538 individuals in 1977 is one of the more well-known examples. The black box recordings of the two cockpits and air traffic control communications provide unique insight into non-technical aspects of their interactions that might have contributed to the event. The transcript of these communications reveals usage of vague and nonstandard language, hesitation by lower ranked individuals to assertively question higher ranked personnel, unclear communication of decisions among teams, and an insufficient verification of understanding verbal messages.[201] United Airlines also experienced a significant accident in 1978, in which similar interpersonal behaviors were identified as contributory, and in 1979 the National Transportation Safety Board issued a recommendation requiring flight crew training in resource management skills.[202] Two years later, United initiated the first US crew resource management program.[203]

The offshore oil and gas industry does not have the benefit of black box recorders to examine critical interactions between its well control personnel for both assessment and further improvements. Yet Macondo provides a unique set of data to explore potential non-technical skill gaps—the behavior and actions of the both on and offshore crew and management in the hours leading up to the gas release onto the rig underscore the importance of non-technical skills development in offshore high-risk operations.

Three specific examples from the activities leading up to the blowout are (1) the 80 minutes when the toolpusher, driller, well site leader, and others discussed pressure discrepancies between the drillpipe and kill line, (2) when the well site leader mentioned those discrepancies to the onshore drilling engineer, and (3) the interactions of the mudlogger with others from the well operations crew in monitoring the well. An analysis of these situations is presented here to demonstrate that systematic application of various NTS could have altered the interactions between rig personnel for the better.

[200] Civil Aviation Authority. Crew Resource Management (CRM) Training, Guidance for Flight Crew, CRM Instructors and CRM Instructor Examiners; CAP 737; Chapter 1, Section 1.1 and 2.2.

[201] An annotated transcript of these communications is available here: http://www.pbs.org/wgbh/nova/space/final-eight-minutes.html (accessed December 7, 2015).

[202] NTSB, Aircraft Accident Report: United Airlines, Inc., Douglas DC-8-54, N8082U, Portland, Oregon, December 28, 1978 (NTSB-AAR-79-7), 1979, Washington, DC.

[203] Helmreich, R. L.; Merritt, A. C.; Wilhelm, J. A. The evolution of crew resource management training in commercial aviation; *International Journal of Aviation Psychology* 1999**,** *9(1)*, p 19.

1.7.1 Case Study for NTS: Pressure Discrepancies between Drillpipe and Kill Line

Despite its limitations,[204] the evidence and testimony from surviving witnesses provides sufficient information to perform a simple assessment of when the toolpusher, driller, well site leader and others discussed the pressure discrepancies between the drillpipe and kill line. (See the solid green shaded portion of Figure 1-10.) The well operations crew, less the mudlogger, spent 80 minutes discussing the negative test results and their implications. This discussion suggests that the crew did, in fact, recognize that the well data they were examining were atypical enough to warrant further observations and consideration. Yet, the survivors' testimonies reveal a lack of discussion about the possibility of well integrity loss—as if the crew could not conceive this possibility. Why? What can be done to help crews recognize when they are falling into such a mental trap? Table 1-5 highlights evidence suggesting the well operations crew exhibited ineffective use of non-technical skills.

Table 1-5. Multiple Interpersonal Behaviors and Interactions amongst Well Operations Personnel Demonstrate Need for Non-technical Skills

Testimony Illustrating Interpersonal Behaviors of the Well Operations Crew	**Relevant Non-technical Skills (using options listed in** Table 1-4**)**
An experienced and highly-esteemed toolpusher explained the negative test results as something that "happens all the time," [205] and the driller confirmed that he had seen these results before.[206]	• Situation awareness (gathering information, understanding information and risk status, anticipating future state/developments); • Decision making (identifying and assessing options); • Implementing and reviewing decisions
Other crewmembers questioned the bladder effect explanation but ultimately agreed with the rationale.[207]	• Teamwork (resolving disparate opinions/conflict);

[204] There is limited testimony pertaining to the negative tests, and even where testimony exists, witnesses tend to contradict each other. The individuals most involved in the negative test discussion either refrained from giving testimony to the CSB and other post-incident civil and criminal hearings, or they did not survive the incident.

[205] The Toolpusher, who had significant on-the-job experience and received noteworthy remarks in his performance review as "extremely competent" and someone who "does all within his level of authority to prevent exposure to potentially compromising situations." Internal Company Document, Transocean. *2009 Senior Supervisor Performance Appraisal - Performance Appraisal and Development Plan*, October 31, 2009, TRN-MDL-08076982, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-52649.pdf (accessed October 7, 2015).

[206] Internal Company Document, BP. *Notes from Bob Kaluza Interview*, April 28, 2010, BP-HZN-MBI00021276, see Exhibit 0005 http://www.mdl2179trialdocs.com/releases/release201302281700004/Daigle_Keith-Depo_Bundle.zip (accessed October 7, 2015).

[207] Hearing before the Deepwater Horizon Joint Investigation, July 20, 2010 pp 90-91; Internal Company Document, BP. *Notes from Don Vidrine Interview*, April 27, 2010, BP-HZN-MBI00021424, see Exhibit 0006 http://www.mdl2179trialdocs.com/releases/release201302281700004/Pleasant_Christopher-Depo_Bundle.zip (accessed October 7, 2015).

	• Communication (asking questions; being assertive); • Situation awareness (understanding information and risk status)
The day shift WSL deferred to the toolpusher, saying "if you have seen this so many times before, it must be true."[208]	• Situation awareness (understanding information and risk status); • Decision-making (identifying and assessing options; • Implementing and reviewing decisions); • Communication (asking questions)
The night shift WSL coming on duty during the middle of the negative test process was teased for questioning the annular compression rationale.[209]	• Teamwork (resolving disparate opinions/conflict, understanding role within team); • Communication (asking questions; being assertive); • Situation awareness (understanding information and risk status); • Leadership (planning and directing)
The same WSL focused on performing the negative test as stated in the permit submitted to the regulator. When the test on the kill line was conducted, as stipulated in the permit, there was no flow for 30 minutes which he took as confirmation that the well was secure.	• Situation awareness (understanding information and risk status); • Decision-making (identifying and assessing options; • Implementing and reviewing decisions); • Communication (asking questions)
The night shift WSL reported looking for changes in the pressure readings rather than the absolute pressure in the well. As a result, although 1400 psi was indicated on the drillpipe, it remained stable, which he stated indicated to him that no gas was coming up the well.[210]	• Situation awareness (understanding information and risk status); • Decision-making (identifying and assessing options, implementing and reviewing decisions); • Communication (asking questions)
There was a lack of explicit coordination with the mudlogger and a need for the well operations crew and mudlogger to	• Situation awareness (gathering information; understanding information and risk status);

[208] Internal Company Document, BP. *Notes from Bob Kaluza Interview*, April 28, 2010, BP-HZN-MBI00021277, see Exhibit 0005 http://www.mdl2179trialdocs.com/releases/release201302281700004/Daigle_Keith-Depo_Bundle.zip (accessed October 7, 2015).

[209] Internal Company Document, BP. *Notes from Don Vidrine Interview*, April 27, 2010, BP-HZN-MBI00021424, see Exhibit 0006 http://www.mdl2179trialdocs.com/releases/release201302281700004/Pleasant_Christopher-Depo_Bundle.zip (accessed October 7, 2015).

[210] Internal Company Document, BP. *Notes from Don Vidrine Interview*, April 27, 2010, BP-HZN-MBI00021424, see Exhibit 0006 http://www.mdl2179trialdocs.com/releases/release201302281700004/Pleasant_Christopher-Depo_Bundle.zip (accessed October 7, 2015).

articulate their expectations for the mudlogger's monitoring role throughout the displacement stages.[211] (See also Sections 1.6 and 1.7.1.1.)	• Decision-making (identifying and assessing options; communicating the options chosen); • Communication (giving feedback; asking questions; being assertive); • Teamwork (understanding role within team; coordinating tasks with team members)

Decision-making is a two-stage cognitive process: (1) what is the problem (situation assessment) and (2) what shall I do?[212] The situation assessment of the negative test was inaccurate. "If the situation assessment is incorrect, then it is likely that the resulting decision and selected course of action that is taken in response will not be suitable."[213] This can occur when "conditions change so insidiously that the operators do not update their situation assessments often enough", and when "the current situation has altered to some extent from the expected situation and that remedial actions are required to return to the planned path."[214] "Sources of failure in team decision-making, according to Orasanu and Salas (1993), include poor communication, logical errors, inadequate situation assessment and pressure to conform."[215]

The evidence described in Table 1-5 suggests that improvements in non-technical skills of personnel involved in offshore well operations decision-making and implementation would benefit major accident prevention.[216]

1.7.1.1 Role of Mudlogger

During displacement of the riser, communication was inadequate. The mudlogger was identified post-incident as a perceived independent layer of protection, yet he was not privy to all pertinent information to fulfill this protective role. Indeed, there was not a shared situation awareness of the well, in part because the mudlogger was separate from the well operations crew and unaware of the rig activities that impacted his understanding of the data he was meant to monitor.

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[211] Both explicit coordination and articulated expectations are characteristics of highly effective teams. See Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 109.

[212] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 45.

[213] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 46.

[214] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p, 46.

[215] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p, 113. IOGP. *Crew Resource Management for Well Operations;* 501, April 2014, p, 12. http://www.ogp.org.uk/pubs/501.pdf (accessed October 7, 2015).

[216] Others have analyzed the effectiveness of non-technical skills usage at Macondo. For example, Roberts, Flin and Cleland examined the well operation crew's situational awareness via content analysis of eight official investigation reports of the event as well as eight transcripts from two court hearings. See Roberts, Flin & Cleland. Everything was fine: An analysis of the drill crew's situation awareness on Deepwater Horizon. *Journal of Loss Prevention in the Process Industries (38),* 2015, pp 87-100.

Communication in offshore operations, like any high-hazard work environment, is vital for successful completion. Figure 1-12 shows the various communication channels expected to be effectively functioning during drilling and completion activities.

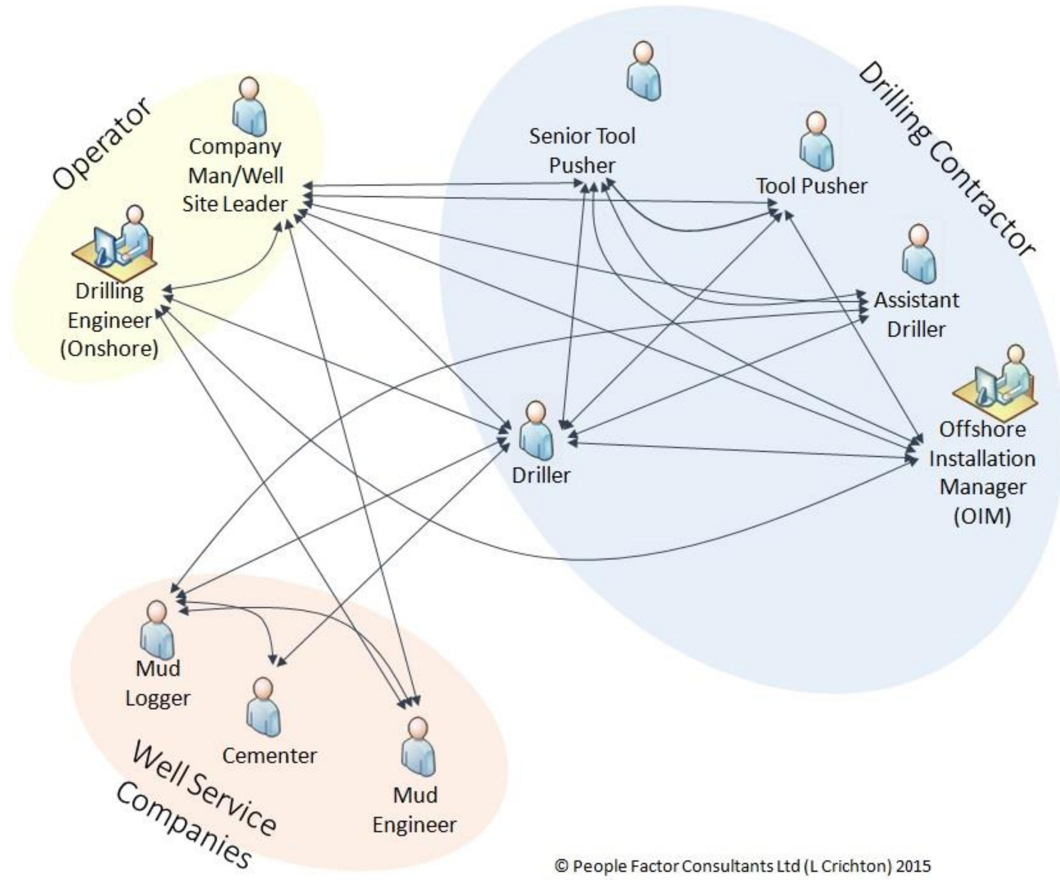

Figure 1-12. Intricate Communication Routes of Well Operations Personnel

Both mudloggers gave testimony post-Macondo that they were uncomfortable with the multiple fluid movements and transfers between pits and off the rig.[217] While the day mudlogger voiced concerns, the transfers continued.[218] The night shift mudlogger confirmed that he did not speak up about this discomfort.[219] Considering the hierarchical organizational structure of the rig, the well service provider, as a client of the operator (i.e., BP), is perceived to be below that of the driller and assistant driller who are primary members of well control operations crew. A hesitation to be assertive with concerns by "lower"

[217] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 31-32; Internal Company Documents, BP. *Interview with Service Data Mudlogger,* May 26, BP-HZN–BLY00161924.

[218] Internal Company Documents, BP..

[219] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 31, 181.

ranking individuals was a critical interpersonal behavior that CRM was meant to counter in the aviation industry.

Four transfers occurred between 9:10 p.m. and 9:35 p.m., and the displacement went to two pits. The night shift mudlogger attributed these fluid transfers to some of the data he was seeing.[220] There is some conflicting testimony by the mudlogger regarding if and how often he communicated with others from the well operations crew (e.g., the assistant driller, a mud engineer) concerning the rig activities and well data in the hours leading up to the release of mud onto the rig (Table 1-6). However, various purported exchanges between him and other well operations crew evinces a need for improved communications, including adequate feedback that the verbal messages and their implications were understood, as well as sufficiently shared situation awareness of the well and rig conditions among the entire well operations crew.

Table 1-6. Summary of communications between Mudlogger and Other Well Operations Crewmembers the evening of April 20, 2010

Date and Source of Testimony	**Transcript excerpts and information concerning the Mudlogger's communication with others from the well operations crew**
December 7, 2010 Joint United States Coast Guard/Bureau of Ocean Energy Management Investigation	When he noticed that the mud pumps were being brought online in a "staggering" manner during the final displacement[221] and called an assistant driller to find out why, the assistant driller said, "That's the way we're going to do it this time."[222] He also spoke with the mud engineer when he noticed a gain in one of the active pits, although he could not recall the time. The mud engineer informed him that "they were moving mud out of some sand traps."[223] No other communications with the well operations crew during his shift were identified.[224]
March 13, 2013	Based upon examination of the data post-incident, at around 9:13 p.m.[225] he noticed that the mud pumps were being brought online in a "staggering" manner.[226] He called an assistant driller to find out why, and the assistant

[220] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 218-219.

[221] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, p 177.

[222] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, p 216 and re. the staggering of the pumps, see p 177.

[223] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 178-179.

[224] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 177-178.

[225] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013 p 3606, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

[226] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013 p 3605,

United States District Court, Eastern District of Louisiana, Civil Action no. 10-MD-2179 "J"	driller "said, we're just doing it like that. He abruptly hung up."[227] Within minutes,[228] he noted a spike in the standpipe pressure.[229] He called again to inquire, and was told that the crew, "had a valve lined up wrong, and we blew a pop-off, and we're sending a crew down there."[230] No other information was provided to him regarding the matter.[231] Earlier in his shift, around 8:30 p.m., the mudlogger called the mud engineer regarding a slow gain he was detecting in the active pit, and the engineer said that "they were flushing out one of the sand traps into the active pit."[232] Prior to that time, no one informed the mudlogger that this activity was to be undertaken.[233] Overall, he was not informed about the fluid movements occurring onboard the rig the evening of April 20.[234]

http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

227 Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013 pp 3605, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

228 Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013, p 3606, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

229 Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013, pp 3606-3607, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

230 Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013, pp 3605-3606, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

231 Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013, p 3606, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

232 Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013, p 3527-3528, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

233 Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013, p 3528, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

234 Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013, p 3603, http://www.mdl2179trialdocs.com/releases/release201303131200011/2013-03-13_BP_Trial_Day_11_AM-Final.pdf (accessed October 7, 2015).

The testimony highlighted in Table 1-6 illustrates the challenges faced by the mudlogger. Communication is more difficult when the parties are not co-located. The mudlogger was only a short distance from the driller's cabin, but he was not privy to the same visual[235] and verbal information, nor to the context of that information.

Good practice guidance created post-Macondo identifies the mudlogger as "top priority" support personnel within the wells operations team (along with the roughneck and derrickman). As such, mudloggers should receive NTS training along with the driller, assistant driller, toolpusher, company man (i.e., WSL), drilling supervisor, rig manager, superintendent, and well services supervisor.[236] Improvements in team communication, both in training and in everyday application of this non-technical skill, between the various wells operations personnel would be beneficial. If the mudlogger had the requisite NTS, the limited access to well information that hindered his ability to act as an independent layer of protection might have been overcome.

1.7.2 Case Study for NTS: Conversation between Well Site Leader and Onshore Engineer

This section dissects the purported phone conversation between the on-rig Well Site Leader (WSL) and the onshore Drilling Engineer (for simplicity, in this section referred to as ODE). Much focus was given to this conversation in the aftermath of the incident, as it was deemed a critical opportunity when the crew could have identified loss of well control and taken actions to secure the well.

The conversation was noted in interview summary write-ups conducted shortly after the incident,[237] before many of the facts of the incident were known (Table 1-7). In the months after Macondo, both individuals took legal positions that protected them from giving sworn testimony at various civil and criminal legal proceedings. The CSB was unable to interview either individual directly, thus must restrict its analysis to the one existing trial deposition[238] and the summaries of others. Nevertheless, the CSB

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[235] Hearing before the Deepwater Horizon Joint Investigation, December 7, 2010, pp 122.

[236] IOGP. *Crew Resource Management for Well Operations;* 501; April, 2014; Table 1, pp 6. http://www.ogp.org.uk/pubs/501.pdf (accessed October 7, 2015).

[237] BP Well Site Leader was interviewed by the BP Investigation Team on April 23 and 27, 2010, May 7 and 12, 2010; Internal Company Documents, BP. *Interview of Donald Vidrine, Well Site Leader on the Horizon Rig*, April 23, 2010, TRN-MDL-00265598, see Exhibit 3572 http://www.mdl2179trialdocs.com/releases/release201304041200022/Kaluza_Robert-Depo_Bundle.zip (accessed October 7, 2015) and *Notes from Don Vidrine Interview*, BP-HZN-MBI00021424, 21427, 21429, see Exhibit 0006 http://www.mdl2179trialdocs.com/releases/release201302281700004/Pleasant_Christopher-Depo_Bundle.zip (accessed October 7, 2015). BP Senior Drilling Engineer was interviewed by the BP Investigation Team on May 2, 2010 and July 8, 2010; Internal Company Documents, BP. *Interview of Mark Hafle - Sr. Drilling Engineer*, May 2, 2010, see Exhibit 0300, http://www.mdl2179trialdocs.com/releases/release201302281700004/Martin_Brian-Depo_Bundle.zip (accessed October 7, 2015) and *BP Incident Investigation Team - Notes of Interview with Mark Hafle*, July 8, 2010, BP-HZN-BLY00103037, see Exhibit 0296 http://www.mdl2179trialdocs.com/releases/release201302281700004/Cowie_James-Depo_Bundle.zip (accessed October 7, 2015).

[238] USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016.

identifies opportunities for NTS improvement by examining the description of the phone conversation from the perspective of both individuals.

Examining the conversation between the WSL and the ODE from each perspective gives clues as to the individuals' situation awareness of the well conditions and the perceived purpose of the call. The WSL appears to be focused on the cement plug and the method for setting it.[239] When the ODE suggests something may not be right with the negative test results, the WSL seems to dismiss conversation about the negative test, trying to refocus the ODE on the cement plug. The WSL reiterates that the negative test was redone and the results were good. There is ambiguity about whether the pressure difference between the drillpipe and kill line was a problem only initially or with all negative tests. The WSL was seeking one-way communication (seeking info on setting the surface plug), not seeking feedback and advice on the negative test.[240] The purpose of the phone calls and the respective roles of the WSL and ODE are ambiguous and varied—sometimes to inform and other times to obtain information, advice, or instruction.

[239] In his February 18, 2016, testimony, the WSL states that he does not recall why he called the ODE, but he knows it was not to discuss the negative test. USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 470:17-471:6.

[240] The WSL confirms the purpose of the call as informational in his February 18, 2016 testimony. USA v. Robert Kaluza, Docket No. 12-CR-265, February 18, 2016, pp 471:7-472:24, 511:12-19.

Table 1-7. Interview statements concerning conversation between the on-rig Well Site Leader (WSL) and the onshore drilling engineer (ODE); names have been replaced with title abbreviations

Interview	Excerpts from Interview Notes/Summaries	Assessment of the Interpersonal Behaviors being described and the Identified Potential Non-technical Skills Failures
WSL Interview April 27, 2010	Called ODE to discuss surface plug. [Later in the testimony] ODE called back while displacing @ +/- 9 p – not sure why he called – curious about how things going.[241]	Reveals uncertainty about the purpose of the call – communication (briefing, asking questions); – teamwork (understanding role, coordinating tasks)
	Called ODE to discuss surface plug, said still watching stripping tank, dripping had stopped and everything looked fine.[242]	Purpose of call appears to be for the WSL to inform only, not seek counsel. – teamwork (understanding roles)
WSL statements as summarized by various interviewers (same interview)	ODE calls to check. He tells ODE negative test was squirrelly. Told ODE no problems.[243] The 1400 psi was the difference between the mud in the riser. This was annular compression – they (toolpusher, etc) said it does that all the time. If we have 1400 psi on the drill pipe we should see it on the kill line? Let's bleed it off and see—the kill line was bled then stopped.	Problem noted ("squirrelly" results), but not explored fully by either party – situation awareness (gathering information, understanding information and risk status, anticipating future states) – communication (briefing and giving feedback, listening, asking questions, being assertive [on the part of the ODE]) – leadership (planning, directing, supporting)
	I then went to call ODE. When I came back they were still watching the stripping tank and the dripping had stopped. Everything looked fine. [Later in the testimony] I talked to ODE about the 1400—said that if there had been a kick in the well we would have seen it.[244]	Information is shared between the WSL and ODE implies that the possibility of a kick is not absent from their mindsets ("if there had been a kick in the well, we would have seen it"), but further discussion on this point is absent by either party.

[241] Internal Company Document, BP. *Steve R. Notebook*, BP-HZN-MBI00021407, see Exhibit 4953 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[242] Internal Company Document, BP. *Interview Notes Don Vidrine*, BP-HZN-MBI00021424, see Exhibit 4953 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[243] Internal Company Document, BP. *Interview Notes Don Vidrine (Kent C. handwritten notes)*, April 27, 2010, BP-HZN-MBI00021415, see Exhibit 4953 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[244] There are several sets of notes from the various interviews conducted by BP post incident; according to testimony given in the Multi-District Litigation hearing, the following document is a compilation of all interviewers' notes from the April 27, 2010 interview: Internal Company Documents, BP. See Exhibit 0303, http://www.mdl2179trialdocs.com/releases/release201302281700004/Martin_Brian-Depo_Bundle.zip (accessed October 7, 2015); Testimony given in the U. S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, February 21, 2011 pp 34-35, see Martin Designations, http://www.mdl2179trialdocs.com/releases/release201302281700004/Martin_Brian-Depo_Bundle.zip (accessed May 22, 2015);

		– situation awareness (gathering information, understanding information and risk status, anticipating future states) – communication (briefing and giving feedback, listening, asking questions, being assertive [on the part of the ODE]) – leadership (planning, directing, supporting)
ODE Interview May 2, 2010 ODE statement as summarized and compiled by various interviewers	While watching monitors of rig activity while he worked he received a call at 8:52 pm from WSL. Loss the phone connection—he called WSL back. WSL asked if they were going to test the plug? ODE asked WSL, "What's going on?" WSL said the day crew screwed up the inflow test and he had to go up and run another test. ODE asked WSL if everything was OK? WSL replied that nothing came out of the kill line. ODE said good night and hung up the phone.	Problem with negative test raised as a tangential item to the main purpose of the call, to ask the ODE about the surface plug. The WSL was not calling to seek counsel on the negative test, but shared info when prompted by ODE. Based on limited information shared and the manner of the exchanges, it appears the WSL provides answers to ODE's questions to inform. When the ODE asks about the test problem, The WSL shares very little information, and the ODE does not probe for additional information. The ODE does not request a follow-up. – situation awareness (gathering information, understanding information and risk status, anticipating future states) – communication (briefing and giving feedback, listening, asking questions, being assertive) – teamwork (understanding role); – leadership (planning, directing, supporting)
ODE Interview July 8, 2010 ODE statement as summarized and compiled by various interviewers	Later, on April 20, 2010, WSL called ODE at 8:52 p.m. to talk about how to test the surface plug and whether they should apply a pressure test or a weight test. ODE noted that WSL also talked to him about the negative tests. WSL told ODE that the crew had zero pressure on the kill line, but that they still had pressure on the drillpipe. ODE said he told WSL that you can't have pressure on the drillpipe and zero pressure on the kill line in a test that's lined up properly. ODE said that he told WSL he might consider whether he had trapped pressure in the line or perhaps he didn't have a valve properly lined up. WSL told ODE that he was fully satisfied that the rig crew had performed a successful negative test. ODE said he didn't have the full context for what had transpired during the tests and it wasn't clear to him whether WSL was talking	Purpose of the call was to discuss the surface plug; discussion of negative test was tangential to that purpose. When sharing the observed pressure data from the negative test, the ODE identifies a problem ("you can't have pressure on the drill pipe and zero pressure on the kill line in a test that is properly lined up"), and identifies a potential solution. Yet the WSL rejects the suggestion of a problem ("fully satisfied"). ODE accepts judgment of WSL, assuming lack of context. He was at an onshore location separate from the crew, not part of the immediate team

Internal Company Document, BP. *Interview Notes Don Vidrine (Kent C. handwritten notes),* April 27, 2010, BP-HZN-MBI00021419-00021420, see Exhibit 4953 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

	about the first or second negative tests. WSL told him he watched the kill line for 30 minutes and didn't see a drip come out of it, so ODE assumed that WSL had concluded that it was not a problem.[245]	conducting the work. ODE admits to lack of clarity but did not explore the issue further. WSL provides ODE with evidence (lack of flow for 30 minutes on kill line) to further support is judgment. – situation awareness (gathering information, understanding information and risk status, anticipating future states) – communication (briefing and giving feedback, listening, asking questions, being assertive [on the part of the ODE]) – teamwork (understanding role—was ODE meant to verify well data/decisions or only provide counsel when requested?) – leadership (planning, directing; supporting)

[245] Internal Company Document, BP. *BP Incident Investigation Team - Notes of Interview with Mark Hafle*, July 8, 2010, BP-HZN-BLY00103032, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00296.pdf (accessed October 7, 2015).; Testimony given in the U. S. Districk Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 9, 2013, pp 16-23, http://www.mdl2179trialdocs.com/releases/release201304090900024/2013-04-09_BP_Trial_Day_24_PM-Final.pdf (accessed May 22, 2015).

The WSL and ODE faced a number of challenges to effective communication the night of April 20, 2010. The offshore-onshore arrangement for this work team hinders its ability to have a shared understanding of the contextual aspects of the work environment and engenders a lack of awareness of each other's roles and responsibilities.[246] While the ODE had access to rig-based data on the well, it is not clear to what extent the ODE perceived, comprehended, or analyzed that data. In theory, such shared computer systems are meant to improve communication and understanding, but research shows that "information exchange is often less complete and the discussion more biased."[247]

Interestingly, post-incident the ODE stated that he couldn't determine if the well was flowing from the data at his disposal because he didn't know what was occurring on the rig, and he criticized the mudlogger company for less-than-desirable well monitoring performance. Yet the ODE had the same Sperry Sun software and rig data available to monitor as the mudlogger.[248] Along the same lines as the drilling engineer, the mudlogger was not fully abreast of what was occurring on the rig during the time he was expected to monitor the well for flow. Additionally, when returns were routed overboard, the volume of fluids leaving the well could not be monitored.[249]

Other seemingly ancillary factors may also have influenced the conversation between the WSL and ODE. For example, whether the individuals were relative strangers or long-time acquaintances could influence the tone and style of the discussion, as well as unspoken agreements about the purposes of such calls. A less formal, more casual informational conversation would be more typical of the latter, even when organizational hierarchies may suggest otherwise. In this case, however, the organizational hierarchy within BP was such that the ODE did not have direct line management accountability over the WSL.[250] He was not meant to instruct or give orders but to counsel, and it appears that this counsel could be freely given or solicited; thus, neither party expected the ODE to explicitly probe or verify the decisions of the WSL. As far as they were both concerned, the point of the call was to discuss the next steps in the temporary abandonment process, and the discussion of the negative test was incidental to the call.

This organizational arrangement may not be atypical for industry. The onshore drilling engineer, while identified as part of the larger group of well operations team, is not included in the top 17 wells roles

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[246] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 77.

[247] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 77.

[248] Internal Company Document, BP. *BP Incident Investigation Team - Notes of Interview with Mark Hafle*, July 8, 2010, BP-HZN-BLY00103037, see Exhibit 0296 http://www.mdl2179trialdocs.com/releases/release201302281700004/Cowie_James-Depo_Bundle.zip (accessed October 7, 2015), and Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, February 10, 2011, see Corser designations Vol 1, pp 83-84, http://www.mdl2179trialdocs.com/releases/release201302281700004/Corser_Kent-Depo_Bundle.zip (accessed October 7, 2015).

[249] The Senior Toolpusher noted: "There was no way to monitor the volume of what was dumped overboard;" Internal Company Document, Transocean. *Senior Toolpusher Interviewing Form*, May 28, 2010, TRN-MDL-00493744, http://www.mdl2179trialdocs.com/releases/release201304041200022/TREX-50296.pdf (accessed October 7, 2015).

[250] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011, p 31.

examined for CRM applicability in the latest offshore guidance.[251] This suggests that the role of the ODE in such a situation had not been identified as a critical opportunity for decision-making input into well operations.

In the aftermath of Macondo, assertions have been made that this conversation should have led to a decision to shut-in the well. If communication between shore engineering support is to be designated a useful barrier for the mitigation of well influx, then roles and responsibilities for both parties must be explicitly defined. The development and incorporation of NTS into everyday practices within the work environment often includes improved protocols for communication, decision-making, and role clarity that would improve performance for a wide range of interpersonal relationships.

1.7.3 Integration of Non-technical Skills

To improve team interactions and counter situations such as in the examples above, the aviation industry (and other high-hazard industries, such as nuclear) introduced crew resource management into the everyday operational performance of flight crews. In 2006 the NTSB placed CRM improvements on its Most Wanted List, and five years later the Federal Aviation Administration (FAA) published the final rule to require CRM training for all crewmembers, including pilots and flight attendants.[252]

In the oil and gas industry, the concept of non-technical skills is not completely foreign. The UK offshore regulator, the Health Safety Executive (HSE), honed in on the importance of non-technical skills for line management personnel when it conducted a 2010 human and organizational factors inspection of four Transocean rigs in the North Sea. The HSE identified an absence of training for supervisors, including OIMs and senior/say toolpushers, in interpersonal leadership capabilities, finding that a number of these supervisors were put in managerial positions "with no skills or training to support them in this role."[253] The inspection noted that interviews with personnel revealed "there is no training once staff are promoted above driller level … This reinforces the view that training is focused on technical skills, rather than management or non-technical skills."[254] These inspection findings are relevant when considering that some of the primary decision-makers on the negative test results were the Transocean toolpushers and OIM, as well as the BP Wells Site Leaders.[255] Transocean and BP are not unique. Industry has acknowledged needed improvements in the non-technical skills of offshore facility personnel. In its report on the lessons learned from the Deepwater Horizon, OLF suggested CRM be considered for well activities on the Norwegian Continental Shelf.[256] And various international industry associations have

[251] IOGP. *Crew Resource Management for Well Operations;* 501; April, 2014, Table 1, p 6. http://www.ogp.org.uk/pubs/501.pdf (accessed October 7, 2015).

[252] NTSB, We are safer, http://www.ntsb.gov/safety/mwl/Pages/was2.aspx, (accessed October 9, 2015)

[253] HSE, Specialist Inspection Report, Offshore Division Human and Organizational Factors Team. *Transocean-Human & Organizational Factors Intervention;* July - October, 2009, pp 4.

[254] HSE, Specialist Inspection Report, Offshore Division Human and Organizational Factors Team. *Transocean-Human & Organizational Factors Intervention;* July - October, 2009, pp 23-25, 27.

[255] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Deep Water The Gulf oil Disaster and the Future of Offshore Drilling;* 2011, pp 107-109.

[256] Norwegian Oil Industry Association (OLF). *Deepwater Horizon: Lessons learned and follow-up;* May, 2012; Section 2.3.9, pp 29-30, recommendation No. 29.

since developed non-technical skills training guidance, [257] while some companies are exploring methods of incorporating such skill development into the curriculum of their offshore personnel. Yet, at this time, no US regulatory requirements or guidance for such training have been established.

It has been suggested that an organization that embodies the characteristics of an HRO (high reliability organization) encourages and continually develops the non-technical skills expertise of its personnel.[258] Training, practice, and assessment of people's NTS must be an integral part of everyday activity. "[T]he level of transfer will depend on the prevailing organizational culture at the worksites …. The training instructions have to be reinforced at the worksite, where observation and constructive feedback on well crewmembers' non-technical skills should become part of the normal way of operating at the worksite. The language of CRM should become part of everyday worksite discussions."[259] Furthermore, "the course content should be informed by an ongoing human factors analysis of task performance during well operations, especially in relation to the detection and management of control problems."[260]Finally, communication training should be an inherent component of each module of CRM training, and standard communication terminology and phraseology should be embedded within technical training so that good communication practices are intimately associated with the technical aspects of the work.[261]

[CALL-OUT BOX START]

Non-technical Skills and Organizational Culture

In the post-Macondo world, increasing personnel proficiency in NTS is critical for those working in the dynamic and high-hazard offshore work environment. However, training on NTS is not enough. Like so many other safety system components, inculcating non-technical skills will be successful only if the organization itself places importance on it. Evolving to high levels of operational discipline will promote NTS usage in everyday activity.[a]

[a] Thorogood, J. L.; Crichton, M. T. Threat-and-error management: the connection between process safety and practical action at the worksite; *SPE Drilling & Completion* 2014**,** *December*, pp 465-471.

[CALL-OUT BOX END]

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[257] IOGP produced two guidance documents, *Crew Resource Management for Well Operations;* Report No. 501, April, 2014. http://www.ogp.org.uk/pubs/501.pdf (accessed October 7, 2015) and *Guidelines for Implementing Well Operations Crew Resource Management training*, Report No. 502, December 2014; http://www.iogp.org/pubs/502.pdf (accessed October 7, 2015); Oil & Gas UK published *Guidelines on Competency for Wells Personnel, Issue 1* (January 2012); the Energy Institute developed *Guidance on Crew Resource Management (CRM) and Non-technical Skills Training Programmes, 1st ed.,* 2014. Also, the International Association of Drilling Contractors offers a resource database of both technical and non-technical competencies for a wide array of offshore job positions, see http://www.iadc.org/knowledge-skill-and-ability/.

[258] Thorogood, J. L.; Crichton, M. T. Threat-and-error management: the connection between process safety and practical action at the worksite; *SPE Drilling & Completion* 2014**,** *December*, pp 465-471.

[259] IOGP. *Crew Resource Management for Well Operations;* 501, April, 2014, p 19. http://www.ogp.org.uk/pubs/501.pdf (accessed October 7, 2015).

[260] IOGP. *Crew Resource Management for Well Operations;* 501, April, 2014, p 19. http://www.ogp.org.uk/pubs/501.pdf (accessed October 7, 2015).

[261] Flin, R.; O'Connor, P.; Crichton, M. *Safety at the Sharp End;* Ashgate Publishing: Hampshire, England, 2008, p 87.

Drilling is increasing in complexity as wells are drilled at greater and greater depths with high degrees of coordination between various companies (operators, drilling contractors, multiple well service providers) with specialized expertise. Such complexity impairs predictability of all potential safety challenges; thus, risk assessments of such operations will likely not identify all of the possible scenarios. Variability is inevitable, and NTS or CRM training will help prepare personnel and management to be resilient to that variability.

1.8 Work-as-Imagined Versus Work-as-Done: The Operator/Drilling Contractor Gap

Offshore drilling and well completion involves the complex interaction of multiple employers, including the leaseholder/operator (e.g., BP) and drilling contractor (e.g., Transocean), and other essential service providers (e.g., Sperry Sun[262]). In offshore drilling operations, the drilling contractor brings the infrastructure (drilling rig), supplies the majority of the workforce, and has more direct control over the primary operations (drilling) and emergency response (well control). The operator, though, is responsible for the well's design and drilling program, which form the basis for establishing safe drilling operations, and should account for site-specific conditions that could increase the risk or complexity of the contractor's various drilling and well control operations.

Successful execution of a drilling program requires that the operator and the drilling contractor actively work to bridge the gap between work-as-imagined (WAI) in the drilling program and work-as-done (WAD) by the well operations crew. [263] In essence, WAI describes what well designers and managers expect will or should happen at the well, while WAD is what the well operations crew actually does. There is a natural gap between WAI and WAD because it is not possible to write a drilling program that foresees all circumstances and covers every detail, or that crewmembers can follow exactly as written.[264] Reality and necessity require that well operations crews continually adjust to accommodate current work conditions in order to achieve the desired work goals.

To minimize that gap between WAI and WAD in offshore drilling, the operator and drilling contractor generally rely upon the knowledge and experience of their well site leaders and well operations crew, but they should also focus on building a resilient process that can "adjust its functioning prior to, during or following changes and disturbances so that it can sustain required operations under both expected and unexpected conditions."[265] Ideally, the safety management systems of the operator and drilling contractor will reinforce one another (and sometimes overlap) to continually develop a workforce adept in technical and non-technical skills, evaluate various well and rig specific scenarios, create rig/well specific

[262] See Volume 1, p 9 for a description of other well service providers hired by BP to help drill the Macondo well.

[263] Dekker, S., Chronicling the Emergence of Confused Consensus: Work as Imagined versus Work as Actually Done, chapter 7, pp 86-90, within Hollnagel, E., Woods, D.D., and Leveson, N., eds., *Resilience Engineering: Concepts and Precepts,* Ashgate Publishing: Hampshire, England, 2006.

[264] Dekker, S., Chronicling the Emergence of Confused Consensus: Work as Imagined versus Work as Actually Done, chapter 7, p 86, within Hollnagel, E., Woods, D.D., and Leveson, N., eds., *Resilience Engineering: Concepts and Precepts,* Ashgate Publishing: Hampshire, England, 2006.

[265] Hollnagel, E. Prologue: The Scope of Resilience Engineering. In *Resilience Engineering in Practice: A Guidebook;* Hollnagel, E., Paries, J., Woods, D. D., Wreathall, J., eds.; Ashgate: Surrey, UK, 2011, p xxxvi.

procedures, and identify risk reduction measures. If done effectively, this process would help maximize drilling contractor or operator practices that lead to a more resilient process which can adapt to and successfully manage the evolving risk of a drilling operation.

Numerous Macondo investigation reports commented on the minimal detail provided to the Deepwater Horizon crew for the negative test and temporary abandonment procedures,[266] but it is important to review the operational structures in both companies that permitted the situation to evolve as it did. To deconstruct the gap between WAI and WAD that occurred at the Macondo well, this section explores BP's development and communication of the temporary abandonment plan, the Deepwater Horizon's displacement and negative test procedures, and both companies' management of change programs. By exploring these topics, the CSB demonstrates how to minimize the WAI and WAD gap.

This analysis highlights the following key findings:

- BP's development of the Macondo Temporary Abandonment (TA)[267] plan occurred without a formal process, creating conditions for a TA design that lacked assessment of decisions, including review of internal policies and standards for quality control;
- BP sent a final written "Forward Plan" to the Transocean well operations crew concerning the TA plan on April 16, 2010, and those instructions lacked any mention of the negative test. Ultimately, a drilling fluids specialist from M-I SWACO provided written negative test instructions to the well operations crew on the afternoon of April 20.[268]
- Post-incident, BP described the negative test procedure as "broad, operational guidelines" and that it expected the Deepwater Horizon rig crew to use "the method consistent with their regular practice on prior wells."[269] The broad nature of the procedure implies that the Transocean drilling team and BP well site leaders would deal with any problems occurring during the TA plan by employing their knowledge, experience and skills. Missing from the process were tools that could have minimized the gap between WAI and WAD, such as written work plans or safety critical procedures.

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[266] National Academy of Engineering and National Research Council of the National Academies. *Macondo Well – Deepwater Horizon Blowout: Lessons for Improving Offshore Drilling Safety;* The National Academies Press: Washington, D.C., 2011, p 32.; BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010; pp 85.; Transocean. *Macondo Well Incident: Transocean Investigation Report Volumes I and II;* June, 2011; pp 85-86.; USCSB, 2014. *Explosion and Fire at the Macondo Well, Gulf of Mexico, April 20, 2010,* Report No. 2010-10-I-OS, Appendix 2-A, p 42, http://www.csb.gov/assets/1/19/Appendix_2_A__Deepwater_Horizon_Blowout_Preventer_Failure_Analysis1.pdf (accessed October 7, 2015), June 2014.

[267] While the Macondo TA plan included choices on the production casing design (e.g., long string vs. liner, Sizes/grades of pipe, etc.) and other abandonment features (e.g., BOP/riser retrieval, rig clean-up, surface cement plug etc.), for purposes of the CSB analysis in this Volume, the TA plan discussion will be limited to the negative test and displacement of the well. The CSB previously discussed the placement of the surface cement plug; Volume 1, pp 18, 25.

[268] See discussion in Section 1.4 and summary of instruction in Table 1-3 for more details.

[269] BP. Deepwater Horizon Accident Investigation Report; September 8, 2010, p 85.

- Transocean did not enforce its own policy to utilize written Standing Instructions to the Driller, which a previous Transocean incident investigation noted should “raise awareness and […] highlight” underbalanced conditions in a well when a single barrier is present.[270]
- The lack of safety critical task identification or incorporation of hazard controls in the TA procedures provided to the Deepwater Horizon crew did little to emphasize or optimize crew performance;
- Transocean did not follow its corporate policies to meaningfully engage the workforce in managing risks posed by an activity through identifying effective barriers. (1) Transocean did not develop written safety critical procedures for negative tests and displacement of a riser, even though internal Transocean policies required them for the Macondo well. (2) Generic Deepwater Horizon safety critical procedures for displacement and negative tests did not identify potential major accident events like loss of well control or a blowout. Most of the identified hazards focused on personal safety or relatively minor spills of drilling mud on the rig and overboard. (3) Transocean was unable to identify an operational safety critical procedure that addressed the lineup of the diverter system for either normal or non-normal (i.e., emergency) operating conditions.

1.8.1 BP’s Development and Communication of the Temporary Abandonment Plan

BP manages the development and delivery of a well through a five stage-gate process that incorporates peer review by sub-surface specialists (geologists and geoscientists) as well as engineering and operational specialists from the Drilling and Completions (D&C) business unit.[271,272] Approval to move through the various stages is a formal process supported by documented risk assessments and assurances. BP policies and standards in the *Drilling and Wells Operation Practice* (DWOP)[273] and related

[270]*Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, Exhibit 5749, TRN-MDL-02840797, http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip (accessed October 7, 2015).

[271] BP operations are divided into business units like the Gulf of Mexico Drilling & Completions or the Gulf of Mexico Exploration & Appraisal units. Individual business unit leaders oversee operations and performance of the units.

[272] Internal Company Document, BP. *Gulf of Mexico SPU: Drilling Engineering BtB Stage Gate Process (Well Level)*, Revision 1, November 30, 2009, Introduction, BP-HZN-2179MDL00284917, see Exhibit 1515 http://www.mdl2179trialdocs.com/releases/release201302281700004/Cocales_Brett-Depo_Bundle.zip (accessed October 7, 2015).

[273] The DWOP is “a summary of the key elements of the DC&W [Drilling Completion & Wells] Engineering Technical Practices. It also encompasses a number of standard practices that are not the subject of the ETPs. Where any potential conflict or lack of detail exists, the ETP has primacy. It is important to note that the ETPs may contain important requirements over and above those summarised in this document and therefore conformance solely with this document does not ensure conformance with the ETPs or STPs [Site Technical Practicies] derived from those ETPs;” Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, BP-HZN-BLY000332264, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

Engineering Technical Practices (ETPs)[274] define the process. The DWOP and ETPs outline practices for drilling and well operations intended to minimize harm to people and the environment as well as to prevent accidents that could have a high negative impact either financially or to the company's reputation. It follows that compliance to these policies and standards should reduce the risk of a drilling operation to levels that BP management deems acceptable.

The risks of a well can be broadly divided into two categories: those created or controlled through design and those created or controlled through execution of the design plan (referred to here as operational risk). Major design risks that could affect the safety and well-delivery schedule generally emerge early in the well-planning process. For example, drilling is easier and safer if the well design can avoid hazards such as natural pockets of gas or seafloor faults.[275,276] For hazards that cannot be designed out of the well, mitigation measures affecting operational practices at the well can be adopted.[277] For instance, design engineers of the Macondo well indicated that traditional kick tolerances were not practicable in deepwater wells like Macondo. As a result, they requested a dispensation from BP's accepted kick tolerance[278] as defined in the DWOP, and they indicated that the drilling contractor's well control operations at Macondo would instead rely on upon other emerging technologies.[279]

For development wells,[280] where the geology is known with a high degree of confidence, the subsequent completion or temporary abandonment program may be developed, reviewed and approved either as part

[274] BP developed written ETPs to ensure wells are designed, drilled, completed and maintained to consistent standards.

[275] As defined by *The Free Dictionary* (http://www.thefreedictionary.com/geological+fault), a fault is "a crack in the earth's crust resulting from the displacement of one side with respect to the other."

[276] CSB interviews.

[277] For example, there can be a pre-spud exercise known as "drilling the well on paper" to inform the crew of the well-specific hazards; e.g., Hearing before the Deepwater Horizon Joint Investigation, August 24, 2010 p 16.

[278] BP defines kick tolerance as the maximum volume of a kick influx that can be safely shut in and circulated out of the well without breaking down the formation at the open hole weak point;" Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, "This document contains the practices that have been agreed by BP management as current and relevant for drilling and well operations.", BP-HZN-BLY00034543, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[279] The request indicated, "Slow pump rates have previously been proven successful in circulating out influxes [kicks]. If unable to circulate out influx at reduced rates, bullhead techniques may be required;" Internal Company Document, BP. DCMOC-09-0048, Kick Tolerance less than 25 bbls with a 1.0 ppg kick intensity, July 10, 2009, BP-HZN-CSB00175983. The engineers completing the request cited BP's own well control manual which states, "Traditional kick tolerance calculation is based on circulating the kick out. Deepwater drilling is subject to particular complications due to tight mud weight/fracture margins and high chokeline friction pressures which would render some wells non-drillable in compliance with policy. In such event, a different approach can be adopted based on keeping the problem downhole and utilising bullhead techniques or other emerging technologies." The well control manual does not specify the "emerging technologies" it is referring to; Internal Company Document, BP. *Well Control Manual: Volume 1 Procedures and Guidelines*, Issue 3, BPA-D-002, December 2000, Deepwater Drilling Considerations, 1-5-10, BP-HZN-2179MDL00336023, see Exhibit 2389 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[280] Wells drilled in a previously explored area where the geology of the field has been documented and has been shown to be suitable for production of oil and gas.

of the main program itself or as a separate document. However, for exploration and appraisal wells, as in Macondo, the outcome is not known a priori and the well may require production flow testing[281] before either temporary or permanent abandonment. Under these circumstances, detailed planning is postponed to avoid wasted effort until the outcome is known.[282] Being exploratory in nature, the Macondo well was drilled to collect data about the geology and quality of the oil and gas at its location.[283] BP's permit to drill highlighted the need to wait for an evaluation of the geology to determine final plans for the well, including whether it would ultimately be abandoned or converted to a production well.[284] Consequently, BP did not develop a temporary abandonment plan for the well during the initial five stage-gate process.

As completion of the well neared, BP personnel developed a temporary abandonment program (Table 1-8) in a process that generally aligned with the common company process. They:[285]

- completed a high level risk assessment for the well;
- delayed the TA program preparation until the well was reasonably well configured;
- followed the general process of TA program preparation, working out options and preparing, discussing, and finalizing a draft program;
- created a well design that conformed with policies described in the DWOP and ETPs, but the DWOP and ETPs did not address all temporary abandonment issues such as location of a surface cement plug[286] or negative test;
- expected teams to deal with unforeseen operational risks that materialized by employing their knowledge, experience, and skills.

Herein though lay an operational gap in BP's well development process of the Macondo well. The Temporary Abandonment program was not reviewed through the stage-gate process, and it was not

[281] Well testing helps determine the how much and how fast a well will produce; Dyke, K. V. In *Fundamentals of Petroleum;* 4th ed.. The University of Texas at Austin, p 161.

[282] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 30, 2011; see Little designations Vol 3, p 35, http://www.mdl2179trialdocs.com/releases/release201302281700004/Little_Ian-Depo_Bundle.zip (accessed October 7, 2015).

[283] USCSB, 2014. *Explosion and Fire at the Macondo Well, Gulf of Mexico, April 20, 2010,* Report No. 2010-10-I-OS, Volume 1, p 13 http://www.csb.gov/file.aspx?DocumentId=679 (accessed October 7, 2015).

[284] BP's Application for Permit to Drill a New Well stated, "A decision on the way forward will be made following evaluation of the [12-1/4" x 14"] open hole interval. The well will either be P&A'd or temporarily abandoned for future completion. Once the final evaluation program is complete, a decision will be made as to whether to sidetrack, TA well, or PA the well." If the well proved commercially viable, data concerning the well's geology and hydrocarbon properties would be collected and used to create a production plan; alternatively, if the well was not viable, the data would be gathered to determine why the commercial predictions failed; Internal Company Document, BP. Form MMS 123A/123S Application for Revised New Well, October 29, 2009, 11; see Exhibit 1336 http://www.mdl2179trialdocs.com/releases/release201302281700004/Paine_Kate-Depo_Bundle.zip (accessed October 7, 2015).

[285] Internal Company Document, BP. *Gulf of Mexico SPU: Drilling Engineering BtB Stage Gate Process (Well Level),* Revision 1, 2200-T2-DO-RP-0003, November 30, 2009, Introduction, BP-HZN-2179MDL00284914, see Exhibit 1515 http://www.mdl2179trialdocs.com/releases/release201302281700004/Cocales_Brett-Depo_Bundle.zip (accessed October 7, 2015).

[286] Cement plugs are portions of cement put into a wellbore to seal it. "Surface" is typically used to refer to the shallowest cement plug used in a well.

normal practice to do so.[287] After the initial draft of the TA program, changes to the negative test and final well design, including the location of the surface cement plug,[288] were addressed through the Management of Change process (see Section 1.9), while others were addressed by "Ops Notes." There was no formal process for approving Ops Notes, which could consist simply of short emails. (See Table 1-8.)[289] As a result, the development of the Macondo TA plan occurred without a formal process that included a structured document complete with revision history and a signature page. This created conditions for an incomplete and unauditable development of the TA design that lacked formal documentation or assessment of decisions, including review of internal policies and standards to provide quality control.

Table 1-8. Description of the development and communication of the Macondo TA program.

Communication date	Email Subject (If Applicable)	Sender	Recipient	CSB Characterization of Communication
4/14[290]	Forward Ops	BP Drilling Engineer	BP Well Site Leader	Brainstorming session for the temporary abandonment plan.
4/15[291]	Updated Procedure	BP Drilling Engineer	BP Well Site Leaders and trainee Wells Team Leader Senior Drilling Engineer Operations Engineer	*Macondo Drilling Production Interval* for the final section of the well; a 21-page document describing the temporary abandonment program.

[287] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 30, 2011; see Little designations Vol 3, pp 35-39, http://www.mdl2179trialdocs.com/releases/release201302281700004/Little_Ian-Depo_Bundle.zip (accessed October 7, 2015).

[288] BP stated that the surface cement plug was designed "in accordance with common industry practice," but BP did not address surface cement plugs in either the DWOP or ETPs; BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010, p 92. See Volume 1, pp 18 and 25 for additional information on surface cement plugs.

[289] Internal Company Document, BP. *Horizon - Onshore/Offshore Communication Process*, BP-HZN-BLY00096591, see Exhibit 7312 http://www.mdl2179trialdocs.com/releases/release201302281700004/Cowie_James-Depo_Bundle.zip (accessed October 7, 2015); Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 30, 2011; see Little designations Vol 3, pp 35-39, 44, http://www.mdl2179trialdocs.com/releases/release201302281700004/Little_Ian-Depo_Bundle.zip (accessed October 7, 2015); Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 22, 201; see Sprague designations Vol 2, p 71, http://www.mdl2179trialdocs.com/releases/release201302281700004/Sprague_John-Depo_Bundle.zip (accessed October 7, 2015).

[290] Email from Drilling Engineer, BP, to Well Site Leader, BP, Subject: Forward Ops, April 14, 2010, BP-HZN-MBI 00126982, http://www.mdl2179trialdocs.com/releases/release201303141200012/TREX-00537.pdf (accessed October 7, 2015).

[291] Email from Drilling Engineer, BP, to Various, BP, Subject: Updated Procedure, April 16, 2010, Attachment: GoM Exploration Wells MC 252 #1ST00BP01 - Macondo Prospect - 7 x 9-7/8 Interval, BP-HZN-2179MDL00249965, http://www.mdl2179trialdocs.com/releases/release201303141200012/TREX-00545.pdf (accessed October 7, 2015).

			Drilling Engineering Team Leader M-I SWACO Drilling Fluids Specialist	
4/15[292]	N/A	BP Senior Drilling Engineer	BP Drilling Engineering Team Leader Drilling & Completions Operations Manager Engineering Manager	Management of Change for the production casing at Macondo that also mentions the final cement job, but not the negative test
4/16[293]	N/A	BP Regulatory Representative	Minerals Management Service (MMS)[a]	Application for Permit to Modify: BP's submittal of its Temporary Abandonment plan to MMS. The plan is described on a single page in 8 steps.
4/16[294]	none	BP Well Site Leader	Numerous Transocean Personnel including the well operations crew and the OIM	A one-page summary of the *Macondo Drilling Production Interval*; it is missing any reference to the negative test.
4/18 ~11AM[295]	Negative Test	BP Drilling Engineer	BP Wells Team Leader	Brainstorming session of negative test options, as stated in the email, "The way we currently have it set up is the standard we have been using, but this one is slightly different because the plug is so deep…"
4/18 5PM[296]	RE: Negative Test	BP Drilling Engineer	BP Wells Team Leader	Agreement to displace drillpipe with seawater to the wellhead and conduct the negative test
4/20 ~7:30AM[297]	N/A	BP Drilling Engineer and BP Well Site Leader	M-I SWACO Drilling Fluids Specialist	Phone calls from BP personnel to inquire about standard DWH displacement procedure and to provide details about the temporary abandonment plan to the M-I SWACO Drilling Fluids Specialist.

292 Internal Company Document, BP, *Production Casing for Macondo*, DCMOC-10-0069, April 14, 2010, BP-HZN-MBI00143259. http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-02659.pdf (accessed January 28, 2015).

293 Internal Company Document, BP. *Form MMS - 124 Application for Permit to Modify*, April 16, 2010, Temporary Abandonment Procedure, BP-HZN-MBI00127909, http://www.mdl2179trialdocs.com/releases/release201304041200022/TREX-00570.pdf (accessed October 7, 2015).

294 Internal Company Document, BP. *Forward Plan*, April 16, 2010, BP-HZN-2179MDL00002043, see Exhibit 2337 http://www.mdl2179trialdocs.com/releases/release201304041200022/Taylor_Carl-Depo_Bundle.zip (accessed October 7, 2015).

295 Email from Drilling Engineer, BP, to Wells Team Leader, BP, Subject: Negative Test, April 18, 2010, BP-HZN-BLY00070087, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-001816.pdf (accessed October 7, 2015).

296 Email from Drilling Engineer, BP, to Wells Team Leader, BP, Subject: RE: Negative Test, April 18, 2010, BP-HZN-BLY00070087, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-001816.pdf (accessed October 7, 2015).

297 Hearing before the Deepwater Horizon Joint Investigation, July 19, 2010, pp 271-272.

4/20 10AM[298]	Ops Note	BP Drilling Engineer	BP Well Site Leaders Well Site Leader trainee Wells Team Leader Senior Drilling Engineer Operations Engineer Drilling Engineering Team Leader	Modifications of temporary abandonment plan.
4/20 3PM[299]	N/A	M-I SWACO drilling fluids specialist	The well operations crew	BP/Deepwater Horizon displacement procedures used on the day of incident Added a large volume of 16 ppg spacer (significant change). See Section 1.9.1 for details.

[a] US offshore safety regulator at the time of the Macondo accident until June 18, 2011.

1.8.2 Gap between 'Work as Imagined' and 'Work as Done' at the Macondo Well

At the Macondo well, the gap between the work-as-imagined (WAI) by the planners and the work-as-done (WAD) at the rig site needed to be bridged by the BP operations engineers onshore and the knowledge and experience of the BP WSLs and Transocean well operations crew on the rig. Post-incident, BP described the final temporary abandonment plan as "broad, operational guidelines" and that it expected the Deepwater Horizon rig crew to use "the method consistent with their regular practice on prior wells."[300] In effect, the well operations crew would deal with any problems that occurred during the TA plan employing their knowledge, experience and skills. Missing from the process though were tools that could have minimized the gap between WAI by BP and WAD by Transocean, such as written work plans or safety critical procedures.

As indicated in Table 1-8, BP did not include Transocean in the discussions to develop the temporary abandonment plan, and while BP provided the crew with a written displacement procedure, it did not give them negative test instructions. (See Section 1.4.) The practice on the Deepwater Horizon was for BP to provide the OIM and well operations crew a "Forward Plan" that described upcoming critical operations.[301] On April 16, 2010, BP sent a Forward Plan describing the temporary abandonment

[298] Email from Drilling Engineer, BP, to Numerous, BP, Subject: Ops Note, April 20, 2010, BP-HZN-2179MDL00060995, http://www.mdl2179trialdocs.com/releases/release201303141200012/TREX-00097.pdf (accessed October 7, 2015).

[299] BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010; Appendix P: BP/Deepwater Horizon Rheliant Displacement Procedure "Macondo" OSC-G 32306.

[300] BP. Deepwater Horizon Accident Investigation Report; September 8, 2010; pp 85.

[301] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, July 14, 2011; see Taylor designations pp 65, http://www.mdl2179trialdocs.com/releases/release201304041200022/Taylor_Carl-Depo_Bundle.zip (accessed October 7, 2015).

activities,[302] but it was missing any reference to the negative test. The OIM bridged what was possibly a simple documentation oversight,[303] a potential gap in WAI versus WAD at Macondo, which he described post-incident: "I told [the BP Well Site Leader] it was my policy to do a negative test before displacing with seawater."[304] Worth noting is that the OIM indicated it was "his" policy and did not refer back to a corporate Transocean policy.[305] It is unknown if a different OIM would have had the same "personal" policy.

A corrected Forward Plan was not sent; consequently, the April 16, 2010, communication is the last documented daily instruction the rig received (see Table 1-8). A BP Well Site Leader trainee on the Deepwater Horizon commented post-incident that the issuance of daily instructions depended upon the Well Site Leader and that the DWH Well Site Leader likely relied on verbal discussions in daily meetings to communicate information.[306]

Transocean described written Standing Instructions to the Driller (SID) as a key communication tool with the customer (in this case BP), and that the SID should be developed with the customer representative and communicated to the drillers at the beginning of each shift.[307] The SID is supposed to include well hazard descriptions, focusing on the next 12 hours of well operations. In a company advisory issued just weeks before the Macondo blowout, Transocean noted that a SID should "raise awareness and […] highlight" underbalanced conditions in a well when a single barrier is present.[308] Despite Transocean's SID

[302] Internal Company Document, BP. *Forward Plan*, April 16, 2010, BP-HZN-2179MDL00002043, see Exhibit 2337 http://www.mdl2179trialdocs.com/releases/release201304041200022/Taylor_Carl-Depo_Bundle.zip (accessed October 7, 2015).

[303] Concerning the omission, the DWH OIM stated "[they] didn't have no problem [with performing a negative test]. They just left it out of the [forward] plan;" Hearing before the Deepwater Horizon Joint Investigation, May 27, 2010 pp 116.

[304] Hearing before the Deepwater Horizon Joint Investigation, May 27, 2010 pp 26.

[305] The Transocean Well Control Handbook in place at the time of the incident did not address negative tests; Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, BP-HZN-2179MDL00330768, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015). After the incident, Transocean updated its handbook which now states "prior to displacing kill weight fluid from the wellbore/riser, a negative/inflow test must be performed. This test must expose all barrier components to a pressure equal to or lower than the pressure it will be exposed to during or after the displacement is complete;" Internal Company Document, Transocean. *Well Control Handbook*, Issue HQS-OPS-HB-01, Revision 00, July 22, 2011, Well Planning Considerations, see Exhibit 5781 http://www.mdl2179trialdocs.com/releases/release201302281700004/Braniff_Barry-Depo_Bundle.zip (accessed October 7, 2015).

[306] Internal Company Document, BP. *Interview of Lee Lambert*, April 29, 2010, see Exhibit 2157, http://www.mdl2179trialdocs.com/releases/release201304041200022/Harrell_Jimmy-Depo_Bundle.zip (accessed October 7, 2015).

[307] Internal Company Document, Transocean. *Field Operations Policies & Procedures Manuel*, Issue 01, Revision 00, HQS-POP-PP-01, August 8, 2009, Performance Management: Rig and Well Operation Management, TRN-CSB-0002380.

[308] More specifically, advisory sites a 'mechanical barrier,' but the circumstances of the incident were such that the crew was relying on a tested barrier, lowering their risk perception of the operation. Internal Company Document, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, Exhibit 5749, TRN-MDL-02840797, http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip

requirements and the recent advisory, there is no evidence that SIDs were used on the Deepwater Horizon as envisioned in corporate policies. This underscores a missed opportunity to bridge gaps between the operator and the drilling contractor.

While SIDs could support communications between the operator and the drilling contractor, they do not replace the need for safety critical procedures. The consistent development and appropriate use of written operating procedures are key to managing the risk of a hazardous operation. Procedures are not safety barriers on their own, and using them does not guarantee that work-as-done will be completed as imagined. But procedures facilitate reliable and informed human performance from one individual to another or even by the same individual by documenting the intended steps of a task.[309]

1.8.3 Transocean Procedural Development Policies

Transocean requires rig supervisors and managers to work with the lease holders to assess rig-specific and site-specific conditions that could increase the risk or complexity of various drilling operations.[310, 311] Transocean asserts that the planning has both commercial and safety purposes. From a commercial standpoint, the planning enables Transocean and the lessees to identify critical milestones for a well and potential impact that planned Transocean activities might have on well delivery. Planning improves the safety of well operations by:[312]

- identifying risk reducing controls by elevating various well and rig-specific scenarios;
- eliminating assumptions that could negatively impact safety during operations;
- encouraging a multidisciplinary team approach to ensure best industry practices; and

(accessed October 7, 2015). See also Chapter 2.0 describing this incident (also referred to as Sedco 711) and other previous incident investigations.

309 Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007, p 246.

310 Internal Company Document, Transocean, *Performance and Operations Policies and Procedures Manual-Level L1A*, Issue #1, Revision # 00, April 19, 2010, Section 2 (Planning and Reporting), Subsection 1 (Well Construction Planning), TRN-MDL-00607022. http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip Exhibit 1474 (accessed January 28, 2015). Despite the late revision date on this document, testimony given by several individuals in the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179 indicated that the policies described in this document were in effect at Macondo. For example, see Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 26, 2011; see Rose Designations Vol 2, pp. 25, 28-29, http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed January 28, 2015).

311 Internal Company Document, Transocean. *Field Operations Policies & Procedures Manuel*, Issue 01, Revision 00, HQS-POP-PP-01, August 8, 2009, Performance Management: Rig and Well Operation Management, TRN-CSB-0002274 – TRN-CSB-0002320.

312 Internal Company Document, Transocean, *Performance and Operations Policies and Procedures Manual-Level L1A*, Issue #1, Revision # 00, April 19, 2010, Section 2 (Planning and Reporting), Subsection 1 (Well Construction Planning), TRN-MDL-00607018, see Exhibit 1474 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed January 28, 2015).

- considering lessons learned from previous wells or other installations.

These interactions are intended to contribute to the development of procedures for safety critical tasks.[313]

Transocean has a formal method, the THINK Planning Process, for well operations crews to develop, communicate, and monitor tasks.[314] THINK is a planning and risk management tool that begins with task development and identification of associated task hazards. The THINK process requires users to communicate hazards they identify to other crewmembers and to establish controls to mitigate them. The complexity of a task determines the depth of assessment and formality of the THINK plan.[315] According to company policy, for a low risk job, THINK can be a mental process by an individual or a verbal conversation between multiple people, while a more complex or higher risk job requires a written THINK plan that supervisors must assess for completeness and quality. However, THINK does not define how to determine the complexity of the task or the severity of the risks, it implies a subjective determination by the employee. Thus, if crewmembers perceive the task to be well understood or minimally risky, the potential is significant for individuals not to perform the necessary task analysis, risk assessment, and procedural development for safety critical activities.

When a planned activity involves safety critical tasks, Transocean requires a written Task Specific THINK Procedure (TSTP).[316] Transocean identified 106 key operations that require a written TSTP prior to the Macondo blowout,[317] including temporary abandonment activities and negative tests like those that

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[313] Internal Company Document, Transocean, *Health and Safety Policies and Procedures Manual-Level L1*, Issue #3, Revision # 7, December, 15, 2009, Section 4 (Safety Policies, Procedures and Documentation), Subsection 6.3 (Evaluating and Improving), TRN-MDL-00046866, see Exhibit 1449 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip, Exhibit (accessed October 8, 2014).

[314] THINK is a five step process that involves planning, inspecting, identifying, communicating, and controlling risk; Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 25, 2011; see Rose Designations Vol 1, pp. 32, http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed January 28, 2015); Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Preface, BP-HZN-2179MDL00132055, see Exhibit 4942 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[315] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Section 4 (Safety Policies, Procedures and Documentation), Subsection 2.1 (THINK Planning Process), BP-HZN-2179MDL00132217, see Exhibit 4942 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[316] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Section 4 (Safety Policies, Procedures and Documentation), Subsection 2.1 (THINK Planning Process), BP-HZN-2179MDL00132224, see Exhibit 4942 http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[317] Internal Company Document, Transocean, *Transocean HSE Review*, April 10, 2008, TRN-INV-00705442; Email from Deepwater Horizon Offshore Installation Manager, Transocean, to Deepwater Horizon Toolpusher, Transocean, Subject: FW: List of Critical TSTPs and Maintenance Tasks; Basic 106 TSTPs, June 5, 2007, TRN-INV-02063839; Internal Company Document, Transocean, *List of TSTPs and Critical Maintenance Activities*, TRN-INV-02063841.

occurred at Macondo at the time of the incident.[318] All crewmembers involved in a critical task or potentially affected by it are supposed to participate in developing the Task Specific THINK Procedure, which requires individuals or groups to:[319]

- review and discuss the Task Specific THINK Procedures prior to commencing the task;
- confirm the control measures for all task steps within the procedure;
- ensure personnel understand their responsibilities to carry out the steps;
- understand the hazards and the consequences of those hazards; and
- ensure the expected results are understood prior to commencing the activity.

Transocean also requires a Task Risk Assessment for all critical task steps in a TSTP to ensure that risks related to specific task steps are as low as reasonably practicable.[320] The Task Risk Assessment is intended to provide a greater level of risk assessment and to clearly identify potential consequences for each step so that crewmembers and/or management can verify control measures to prevent or mitigate an undesired event.

In practice, the Deepwater Horizon well operations crew had access to a company database of TSTPs, but Transocean standards require the Rig Manager[321] to review the TSTP and any risk analyses, including Task Risk Assessments or those conducted by a customer, such as an Operator like BP, to ensure they remain relevant for the proposed operation at a specific well.[322] The Vice President of Quality, Health, Safety and Environment described the use of the TSTP database:[323]

> "… we have a database with [TSTPs] … we call it the THINK database … They are rig specific, because every rig is a little different … people can go into that database and they can see the task

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[318] Internal Company Document, Transocean, *Performance and Operations Policies and Procedures Manual-Level L1A*, Issue #1, Revision # 00, April 19, 2010, Section 3 (OPS—Drilling Related), Subsections 5 and 6 (Simultaneous Drilling and Production Operations, Well Testing/DST), TRN-MDL-00607137 and TRN-MDL-00607142, see Exhibit 1474 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 8, 2014).

[319] Internal Company Document, Transocean, *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Section 4 (Safety Policies, Procedures and Documentation), Subsection 2.1 (Risk Management), TRN-MDL-00046636, see Exhibit 1449 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip, (accessed October 8, 2014).

[320] Internal Company Document, Transocean, *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Section 4 (Safety Policies, Procedures and Documentation), Subsection 2.1 (Risk Management), TRN-MDL-00046637, see Exhibit 1449 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip, (accessed October 8, 2014).

[321] The Rig Manager is a shore-based position with responsibilities for the personnel, training, and operational performance of the offshore facility/rig; the Offshore Installation Manager has direct line accountability to the Rig Manager. (CSB2010-I-OS-743597 Paul Johnson Testimony – Aug 23 2010.pdf, p.5-6.)

[322] Internal Company Document, Transocean, *Performance and Operations Policies and Procedures Manual-Level L1A*, Issue #1, Revision # 00, April 19, 2010, Section 3 (OPS—Drilling Related), Section 3 (OPS—Drilling Related), Subsection 6 (Well Testing/DST), TRN-MDL-00607142, see Exhibit 1474 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 8, 2014).

[323] Hearing before the Deepwater Horizon Joint Investigation, May 26, 2010, pp. 219-220.

specific THINK procedure for another rig doing the same job and they might want to compare it with that.

But we do warn that every time we do a job, the conditions are changed. The weather conditions may be different. The experience of the crew may be different. You have to take into account that every time you do it, it may not be exactly the same as the last time."

1.8.4 Lack of Written Transocean Procedures and Work Instructions at Macondo

An expert hired by BP post-incident to review the negative test activities at Macondo commented, "The rig crew does not have to be told how to run a negative test. This should be a routine operation that fits within their training."[324] This sentiment does not address the fact that procedures are more than a set of instructions; they are tools for competent, motivated individuals to plan, coordinate, verify, and assure performance will achieve the intended results.[325] Minimizing the difference between WAI and WAD requires the participation of the individuals actually performing the work.

Companies and their workforce may employ various methods and parameters for conducting a negative test and, as the Macondo incident demonstrates, both individual variations and the interpretation of the data can be critical. Good practice guidance asserts that safety critical tasks demand an error assessment process because of their potential to cause or mitigate a major accident event.[326] It is not about the competency of the individual performing the task, as even the best employees will not be able to achieve positive performance outcomes all of the time.[327]

On the morning of the incident, there was a safety meeting to hold a THINK drill before displacing drilling mud from the well. THINK drills are an opportunity to discuss the proposed job, including the TSTP, assign crewmembers tasks, and discuss potential hazards.[328] Witnesses described the THINK drill on April 20, 2010 as covering the basic steps to be completed that day,[329] as described in the M-I

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[324] Bourgoyne, A. T. *Expert Report - In RE: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010;* United States District Court Eastern District of Louisiana MDL No. 2179, Section J Judge Barbier; Magistrate Shushan: October 7, 2011; pp 52. http://www.mdl2179trialdocs.com/releases/release201304080900023/TREX-08173.pdf (accessed October 7, 2015).

[325] Health and Safety Executive. *Reducing Error and Influencing Behaviour;* HSG48; 2009; pp 10. http://www.hseni.gov.uk/hsg_48_reducing_error_and_influencing_behaviour.pdf (accessed October 7, 2015).

[326] Energy Institute 1st ed., Guidance on Human Factors Safety Critical Task Analysis, March 2011, pp 1.

[327] Health and Safety Executive. *Reducing Error and Influencing Behaviour;* HSG48; 2009; pp 10. http://www.hseni.gov.uk/hsg_48_reducing_error_and_influencing_behaviour.pdf (accessed October 7, 2015).

[328] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013 pp 1972, http://www.mdl2179trialdocs.com/releases/release201303051200006/2013-03-05_BP_Trial_Day_6_PM-Final.pdf (accessed October 7, 2015).

[329] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 10, 2013, p 8274, http://www.mdl2179trialdocs.com/releases/release201304101200025/2013-04-10_BP_Trial_Day_25_PM-Final.pdf (accessed October 7, 2015); Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 5, 2013 p 1946,

SWACO displacement procedure (Table 1-3), and only generally addressing the types and volumes of fluids that were to be used.[330] In practice, a TSTP is to be used as a basis for a THINK drill, but the M-I SWACO procedure was not a TSTP. Instead, there was a presumptive role the M-I SWACO procedure would play in managing the risks associated with displacement and the negative pressure, even though it did not include a hazard analysis of the proposed steps. A TSTP, or in this case a procedure, that fails to identify the well-specific hazards and controls for a given operation yields a weak THINK drill, which does not adequately inform the crew about the hazards associated with their tasks.

The DWH crew completed numerous negative test procedures between August 2007 and April 2010, and each should have triggered development and use of a TSTP that reflected the real-time conditions of the well.[331] However, the CSB could identify only one TSTP for a negative test (Figure 1-13), which Transocean refers to as a "negative flow test." This TSTP fails to describe or prompt users of the TSTP to identify the location of the drillpipe in the well, the displacement of the drillpipe, or the use of spacer material. Consequently, while this generic document represents a starting point from which a procedure could be developed in the manner described in Section 1.8.3, it is insufficient for a negative test like that conducted at Macondo on April 20, 2010.

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http://www.mdl2179trialdocs.com/releases/release201303051200006/2013-03-05_BP_Trial_Day_6_PM-Final.pdf (accessed October 7, 2015).

[330] Internal Company Document, MI SWACO. *BP/Deepater Horizon Rheliant Displacement Procedure "Macondo" OCS-G 32306*, BP-HZN-BLY00094818, see Exhibit 0052 http://www.mdl2179trialdocs.com/releases/release201302281700004/Lacy_Kevin-Depo_Bundle.zip.

[331] Internal Company Document, Transocean. *Memorandum: Investigation of the Negative Test and Riser Displacement Procedures (Preliminary Report)*, July 26, 2010, TRN-INV-00847616, see Exhibit 5007 http://www.mdl2179trialdocs.com/releases/release201302281700004/Roller_Perrin-Depo_Bundle.zip (accessed October 7, 2015).

Transocean SedcoForex

DEEPWATER HORIZON

START TO BE ACCOUNTABLE

PLAN	INSPECT	IDENTIFY	COMMUNICATE	CONTROL
List the step-by-step operational procedure for completing the task. State WHAT will be done - Do Not define HOW at this point. Be as general as possible and use specifics only when they are critical to the operation (e.g. weight, time, location, equipment, etc.). If it is impossible to list all of the essential steps of the operation here, use a second worksheet or break the operation into two or more sub-operations.	List WHAT equipment, materials and areas are to be inspected for each step of the operation. Be sure to include personal protective equipment. If the same equipment is used in more than one step, there is no need to repeat.	Brainstorm the potential hazards and risks associated with each operational step, piece of equipment, work area and all materials.	WHAT information needs to be communicated to WHOM? Ensure that all personnel performing the task understand how to perform the task safely, the hazards, risks, and controls required. Anyone else who might be affected by or might affect the task must clearly understand their role.	WHAT precautions should be taken to avoid risk of injury, environmental damage or property damage? How will the task be conducted to reduce the risk to an acceptable level as low as reasonably practical?

TASK SPECIFIC THINK PROCEDURE

Brief Description of Task: Negative flow test using choke and kill lines

PLAN	INSPECT	IDENTIFY HAZARDS	COMMUNICATE	CONTROL
1. Perform negative flow test.	• Choke manifold for proper alignment	Well fluids going to wrong place	• Driller and drill crew toolpusher	• A.D.s double check each other
2. displace choke and kill lines with sea water close in on fail safe valves line up to mini trip tank	• choke manifold for proper alignment	Wrong fluid going down hole. Valves closed and blow relief valves	• Driller, A.D.s, drill crew, derrick man, sub sea tool pusher	• Derrick man and assistant cross check line in pit room and ad. Cross check
3. Space out close lower annular or the appropriate rams.	• Sub sea ensure right gallon count	Wrong space out damage rams	• Driller A.D.s,drill crew tool pusher,sub sea	• Sub sea controls and monitors gallon count
4. open well to surface open choke and kill line fail safe valves and remote choke to mini trip tank	• ensure flow path to poor boy and it is open and clear	Closed flow path will give false indication of no flow	• Driller,A.D. drill crew tool pusher and sub sea ,	• A.D.s cross check each other
5. check for flow	• ensure flow path is open	Same as above	• Driller AD.s drill crew toolpusher and sub sea.	• A.d.s cross check each other

Figure 1-13. Deepwater Horizon negative test Task Specific THINK Plan.[332]

[332] Internal Company Document, Transocean. *Deepwater Horizon Task Specific THINK Procedure: Negative flow test using choke and kill lines*, TRN-MDL-01995569,

A generic Deepwater Horizon TSTP for displacing the riser with seawater appears in Figure 1-14; this activity was being conducted at the time of the Macondo blowout. The hazards in the TSTP focus on minor spills of synthetic-based drilling mud onto the rig floor (and their becoming a personal safety slip hazard) or on going overboard. The TSTP does not address major accident hazards, such as the number or robustness of the barriers to prevent a kick or blowout while one of the primary barriers, the drilling mud, is being removed. It is also generic enough to be used in several circumstances and does not mention the importance of assessing cement integrity or the potential for kicks if the well is placed into an underbalanced state. Instead, the TSTP implies implicit trust that the casing/bottom hole cement barrier is good, so no additional barriers will be required. Despite multiple examples of tested barriers subsequently failing on Transocean rigs (see Section 2.0), there are no controls indicated in the TSTP, such as the prohibition of bypassing pressure, flow, or volume monitoring systems that could indicate a subsequent barrier failure any time the well is being circulated. Furthermore, Transocean was unable to identify an operational TSTP that included the line-up of the diverter system for either normal or abnormal (i.e., emergency) operating conditions.[333]

http://www.mdl2179trialdocs.com/releases/release201304041200022/TREX-04640.pdf (accessed October 7, 2015).

[333] Internal Company Document, Transocean. *Investigations - Daily Summary*, September 9, 2010, TRN-INV-01816603.

Transocean

START TO BE ACCOUNTABLE

TASK SPECIFIC THINK PROCEDURE

Brief Description of Task: Displace Riser With Sea H20

PLAN	INSPECT	IDENTIFY HAZARDS	ENVIRONMENTAL	COMMUNICATE	CONTROL
1. Hold pre-task meeting and task specific with all crewmembers and company reps involved.	• Area of meeting is free of disturbances and general rig traffic. ppe	• None	• None	• Lists roles and responsibilities during the meeting. Insure all members involved in the operation understand their roles accordingly. Issue out hand radios to persons involved after meeting.	• Meeting area to be controlled ie: if not involved in task then no need to be there.
2. Line-Up to take returns directly to mud pits bypassing the shakers via the Shaker man.	• Work areas, walkways, proper valve alignment, flow line cameras, proper operating hand radios and all personal protective equipment used during this task. ppe	• Improper communication between Driller and Shaker man, slipping on surfaces and or walkways, improper valve alignment, to many people entering in and out of shaker house during operation causing a distraction, improper valve alignment or spilling of mud in walkway causing a slip hazard.	• Improper valve alignment causing a spill overboard, hydraulically driven equipment malfunctioning at time of displacement on rig floor. Synthetic base mud being spilled in floor or walkways.	• Driller to shaker hand by use of audio box and hand held radios.	• Make sure the channel on the radios are being used and is not being interfered with by another source of activity.
3. Take returns into equalized mud pits 6-10 with returns starting in pit 6 first. Isolate #1 mud pump charging pump from synthetic base mud and line up on sea chest valve via derrick man.	• Valves being used and any unused valves are isolated. Sea chest lines, and phone communication between rig floor and mud pit room/mud pump room. All dump valves and master dump valves for pits. ppe	• Improper communication between driller and derrick man. Improper valve alignment causing trapped pressure.	• Same	• Driller to derrick man by way of telephone. Derrick man to double check all valves alignments with pump hand.	• Keep distractions in the pit room and the pump room to a minimum to maintain good communication between derrick man and pump man.
4. Lineup to displace choke line with seawater with #1 mud pump on #2 standpipe.	• Rig floor valves, standpipe valves, mud pump valves, sea chest valves, mud pump and personal protective equipment.	• Improper communication between driller, assistant drillers, floor hands and derrick man. Improper valve alignment causing trapped pressure or blown pop offs.	• Same	• Driller to assistant drillers, derrick man, floor hands and double-check all valve alignments.	• Keep distractions in the DWS to a minimum while the driller assigns duties.
5. Test choke, kill and boost lines 1000 psi over circulating rate.	• Same as above. • Ensure there is enough room in slugging pit in case pop off blows.	• High pressure testing on rig floor, moonpool and pump room. • Rupture in line. • Same as above.	• SOBM spill overboard from rupture in line. •	• Announcement of high pressure testing over PA system.	• Work permit in place. • Barriers in place to prevent people from entering area. • Good communication between derrickman and rig driller.
PLAN List the step-by-step operational procedure for completing the task. State WHAT will be done – Do Not define HOW at this point. Be as general as possible and use specifics only when they are critical to the operation (e.g. weight, time, location, equipment, etc.). If it is impossible to list all of the essential steps of the operation here, use a second worksheet or break the operation into two or more sub-operations.	**INSPECT** List WHAT equipment, materials, areas are to be inspected for each step of the operation, be sure to include personal protective equipment. If the same equipment is used in more than one step, there is no need to repeat.	**IDENTIFY** Brainstorm the potential hazards and risks associated with each operational step, piece of equipment, materials and work area.	**ENVIRONMENTAL IMPACT** Brainstorm the potential for environmental hazards and risks associated with each operational step, piece of equipment, materials and work area.	**COMMUNICATE** WHAT information needs to be communicated to WHO? Ensure that all personnel performing the task understand how to perform the task safely, the hazards, risks, and controls required. Anyone else who might be affected by or might affect the task must clearly understand his or her role.	**CONTROL** WHAT precautions should be taken to avoid personal, property or environmental damage? How will the task be conducted to reduce the risk to an acceptable level as low as reasonably practical?

Figure 1-14. Transocean Task Specific THINK Procedure addressing displacing a riser with seawater.

Managing safety critical task procedures through Transocean's TSTP process could provide Transocean the opportunity to assess more thoroughly the human performance expectations for the tasks at hand. For example, with the removal of physical well barriers, a question should arise concerning what tools and mechanisms are in place for crewmembers to quickly recognize and a gas in the riser situation. Such a process would benefit from the participation of individuals with expertise in assessing human performance and potential organizational influences. A human factors safety critical assessment of the diverter system design would include recognizing situational conflicts and identifying meaningful actions to resolve them. The Transocean well control handbook was updated post-Macondo to instruct the crew to preset the route overboard.[334] While using an engineering control eliminates the manual intervention

[334] Internal Company Document, Transocean. Well Control Handbook, Issue HQS-OPS-HB-01, Revision 00, July 22, 2011, Handling Gas in the Riser, Exhibit 5781,

previously required of the crew to change the diverter route if gas in the riser exceeds MGS capacity, this organizational decision to preset the diverter route to overboard may ultimately cause other problems. It increases the likelihood of discharges into the sea that might otherwise have been controlled through use of the MGS. Thus, there is a risk of organizational drift back to the original practice as, over time, the rig operator receives environmental penalties for discharges that, with hindsight, a regulator determines to have been preventable.[335] These tradeoffs and the potential influences they may have on decision-making are examples of what must be recognized as part of a human factors safety critical task assessment process (discussed in more detail in Section 1.10.2).

[CALL-OUT BOX START]

Lack of Assessment of Human Factors in Previous Transocean Incidents

The UK offshore regulator, the Health and Safety Executive (HSE) found a lack of a structured and systematic consideration of the human contribution to safety during in 2009 a multi-rig Human & Organizational Factors inspection. The HSE noted, "human failures and the range of factors that may influence human performance have not been adequately addressed in risk assessment or within incident investigations,"[336] and this was "particularly with respect to major hazard risk assessment."[337] In its 2003 Major Accident Hazard Risk Assessment (MAHRA), Transocean identified that a failure of the diverter system could result in a rig floor blowout with multiple injuries, fatalities, or loss of the rig.[338] The MAHRA listed prevention controls focused on the diverter equipment (testing, inspections, and maintenance), but did not address any vulnerabilities of manual activation of the diverter.

[CALL-OUT BOX END]

The CSB could not identify Macondo-specific TSTPs or formal Task Risk Assessments for any safety critical tasks, and Transocean did not conduct a qualitative risk assessment with rig management approval as part of developing temporary abandonment procedures. Despite all of its internal company policies, post-incident Transocean claimed that it was BP's responsibility to conduct a hazard analysis and develop the written negative test and temporary abandonment procedures used at the Macondo well.[339] Thus, at Macondo, the operator and drilling contractor each presumed the other was responsible for a proper negative test procedure. The crew was left to put together something to get the work done.

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http://www.mdl2179trialdocs.com/releases/release201302281700004/Braniff_Barry-Depo_Bundle.zip (accessed October 7, 2015).

[335] This also implies a powerful influence by a regulator on the organizational behaviors it intentionally (and sometimes unintentionally) encourages through its regulations. The role of a regulator in driving safety change is discussed in Volume 4 of the CSB Macondo Investigation Report.

[336] HSE, Specialist Inspection Report, Offshore Division Human and Organizational Factors Team. *Transocean-Human & Organizational Factors Intervention;* July - October, 2009, p 3.

[337] HSE, Specialist Inspection Report, Offshore Division Human and Organizational Factors Team. *Transocean-Human & Organizational Factors Intervention;* July - October, 2009, p 6.

[338] Internal Company Document, Transocean. *Major Accident Hazard Risk Assessment Deepwater Horizon*, Revision 01, August 29, 2004, TRN-MDL-01184777, http://www.mdl2179trialdocs.com/releases/release201303141200012/TREX-02188.pdf (accessed October 7, 2015).

[339] Transocean. Macondo Well Incident: Transocean Investigation Report Volumes I and II; June, 2011, p 78.

Nancy Leveson frames major accident causation and prevention in terms of a problem of control of a complex system.[340] When examining well engineering and operations from that perspective, two conclusions can be drawn. First, in an industry dominated by engineers, the design and planning aspects of preparing an operation are addressed in the management systems of the majority of organizations and reinforced by regulatory requirements. Second, by contrast, once the drilling program is signed off, there is a notable lack of guidance either within the industry at large or within operator organizations as to exactly how to execute the program at the rig site—in other words, how the plan will be translated into action.

This lack of control over bridging the gap between work-as-imagined and work-as-done, or absence of objective control mechanisms, extends beyond the simple requirement for operational, or procedural, discipline to the whole framework of communication command and control. Thorogood and Crichton addressed this question by suggesting that a company evaluate its organizational and workforce capabilities to conduct safe and efficient operations through documented management, training, and monitoring of eight elements:[341]

1. preparation of programs
2. generation of written work instructions
3. operations monitoring procedures
4. handling changes and deviations
5. decision-making protocols
6. operational discipline
7. mission rules
8. competency

1.9 Management of Change (MOC)

Experience shows that changes in the operating environment, systems, procedures, equipment, organization, and management personnel and practices represent some of the biggest challenges to effectively managing major hazard risks. Poorly managed change frequently results in serious failures, many of which are precursors to major accidents (or higher costs as well). A vital component of change management is an assessment of how those technical changes may influence human performance.

In the offshore drilling industry, these change management responsibilities do not reside with only one company. Due to the various specialties and coordination required to drill a well, all parties involved in a drilling operation should share them—leaseholder, drilling contractor, and other well service providers (third-party contractors).[342] The lease holder of a well is responsible for designing the well plan, but changes to a plan potentially have health, safety, and environmental consequences that could impact the drilling contractor's rig, crew, and others involved in the operation. Conversely, changes to the drilling

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[340] Leveson, N. G. *Engineering a Safer World;* Massachusetts Institute of Technology: Cambridge, MA, 2011.

[341] Thorogood, J.; Crichton, M. T. Operational Control and Managing Change: The Integration of Non-technical Skills With Workplace Procedures; *SPE Drilling and Completion* 2013**,** *28,* pp 203-211.

[342] Drilling a well requires third-party contracted support like cementing and well monitoring support services. See Volume 1, Section 1.1 of the CSB's Macondo report for more detail.

rig, equipment, materials, and personnel by the drilling contractor or well service providers may introduce new challenges to the safe execution of the well plan.

At Macondo, both BP and Transocean initiated or instituted multiple changes to the temporary abandonment activities that negatively affected the effectiveness of the safety critical barriers meant to prevent blowouts, and they did this without first assessing the hazards introduced by those changes, including human performance impacts.[343] As a result, they missed opportunities, often simple and relatively low cost, to implement effective human performance controls to prevent or mitigate unwanted consequences.

This section shows that BP and Transocean did not effectively manage changes with the temporary abandonment process, further supporting the conclusion that the companies did not identify safety critical steps in the temporary abandonment process as safety critical, nor did they recognize the impact of those changes on human performance. Ultimately, this section discusses how regulatory oversight was absent or ineffective in ensuring either BP or Transocean upheld internal management of change policies or that company policies effectively controlled for major accident hazards. (Section 3.5.2 describes indicators that owners and operators can use for internal company oversight.)

1.9.1 Management of Change: A Missed Opportunity

Table 1-9 identifies several changes to the Macondo temporary abandonment plan, highlighting the potential hazards introduced by the changes, and the actual human performance impacts of those changes.

Table 1-9. BP and Transocean instituted multiple changes to the temporary abandonment activities that had the potential to negatively affect well barriers without first assessing the hazards of those changes.

Scope of Change	**Potential Hazard**	**Human Performance Implications at Macondo**
Leftover circulation material was used as a spacer in the Macondo cement job design.	The lost circulation material (LCM) was never tested as a spacer, and its viscous, gelling nature made it susceptible to plugging lines used for the negative test. Also, its high density added complexity to the correct interpretation of the test pressures.	The LCM was under-displaced, leaving part of the spacer below the BOP and adversely affecting the test interpretation (Section 1.4).

[343] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011, p 107. http://permanent.access.gpo.gov/gpo4390/C21462-407CCRforPrint0.pdf (accessed October 7, 2015).; BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010, p 36.; Transocean. *Macondo Well Incident: Transocean Investigation Report Volumes I;* June, 2011, p 10.

Foamed cement[344] design for cement placed at the bottom of the well in an oil-base mud to seal the hydrocarbon bearing zone.	The design was both complex and challenging, increasing the risk of poor cement quality once installed at the bottom of the well.	The cement barrier failed to seal the well (Section 1.9.1). This was the primary barrier relied upon during displacement of the riser, but the crew was not made aware of the increased risk of a poor cement job.
Cement from a previous well was used for the foamed cement job at the Macondo well.	The cement had a defoaming additive that might have negatively affected foaming efforts for the Macondo well cement design, increasing the risk of poor cement quality once installed at the bottom of the well.	Cement barrier failed to seal the well (Section 1.9.1). This was the primary barrier relied upon during displacement of the riser, but the crew was not made aware of the increased risk of a poor cement job.

At the time of the Macondo incident, BP had internal MOC guidelines for the Gulf of Mexico and Drilling and Completions (D&C) Organization that covered administrative, organizational, and technical changes, as well as dispensations from BP's Drilling and Wells Operation Practice (DWOP) and BP-owned rig equipment.[345] Contractors, like Transocean, were to utilize their own MOC systems, which should include BP "as appropriate," and which BP reserved the right to audit.

BP's MOC guidelines required a justification statement to describe the rationale for a proposed change, such as the potential to improve safety, increase efficiency, or reduce costs. The scope of the change, including necessary resources, potential impacts, and interfaces, was also to be described. Assigned reviewers of an MOC were supposed to work as a team to ensure a "thorough technical evaluation and impact assessment."[346] Typical reviewers would be managers who were accountable for the overall impact of the proposed change. If a requested change was an exception to approved BP practices,[347] a

[344] Foamed cement is a mixture of cement slurry (cement, water, and other dry or liquid additives), foaming agent, and a gas that physically resembles a lightweight shaving cream.

[345] Internal Company Document, BP. *GoM Drilling and Completions D&C Recommended Practice for Management of Change*, Revision 0, 2200-T2-PM-PR-0001-0, March 31, 2009, see Exhibit 6291 http://www.mdl2179trialdocs.com/releases/release201302281700004/Daigle_Keith-Depo_Bundle.zip (accessed October 7, 2015).

[346] Internal Company Document, BP. *GoM Drilling and Completions D&C Recommended Practice for Management of Change*, Revision 0, 2200-T2-PM-PR-0001-0, March 31, 2009, pp BP-HZN-2179MDL00339810, see Exhibit 6291 http://www.mdl2179trialdocs.com/releases/release201302281700004/Daigle_Keith-Depo_Bundle.zip (accessed October 7, 2015).

[347] BP's used Engineering Technical Practices (ETPs), Site Technical Practice (STPs), and Group Practices to define minimum engineering and operations corporate standards.

dispensation to the DWOP, [348] or a change in well design, then an Engineering Authority (EA)[349] would also have to act as an approver for the change.[350]

Section 1.8.1 treats the lack of a hazard analysis on the temporary abandonment process as a flawed design process, but a secondary opportunity to complete a hazard analysis presented itself in a BP MOC that cited the bottom hole cement job. [351] Senior BP managers reviewed and approved the MOC, which listed risks such as fracturing the wellbore during cementing operations and noted the possible need to seek MMS approvals for resulting mitigation strategies if that risk materialized. The MOC did not discuss the inherent challenges of using foamed cement, including impacts it might have on well integrity and the need for increased vigilance by the rig crew for barrier failure.[352]

While industry guidelines address general cementing practices,[353] each cement job is dictated by specific well characteristics that vary throughout the drilling operation. Consequently, cement job designs are adjusted to accommodate real-time well conditions. Internal BP guidance for cementing complex wells states, "Due to unknown or unforeseen well conditions, the properties of the foam cement in the annulus[354] could end up being significantly different from the original design. The *sensitivity* of the design and the *associated risk* to the well should be *evaluated on a case-by-case basis* [italics original]."[355] The guidance lists several possible risks and specifically indicates that loss of well control or well kicks could result from circumstances leading to poor cement quality.[356] Post-incident BP noted that the foamed

[348] The DWOP is a document that BP management agrees contains current and relevant practices for drilling and well operations. These practices are intended to minimize harm to people and the environment as well as to prevent accidents that could have a high negative impact either financially or to the company's reputation.

[349] The EA is the top ranking decision-maker for engineering decisions in a business unit.

[350] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, May 4, 2011; see Grounds designations p 99, http://www.mdl2179trialdocs.com/releases/release201302281700004/Grounds_Cheryl-Depo_Bundle.zip (accessed October 7, 2015).

[351] Internal Company Document, BP. *Production Casing for Macondo, DCMOC-10-0069*, April 14, 2010, BP-HZN-MBI00143259, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-02659.pdf (accessed October 7, 2015).

[352] Internal Company Document, BP. *Production Casing for Macondo, DCMOC-10-0069*, April 14, 2010, BP-HZN-MBI00143259, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-02659.pdf (accessed October 7, 2015).

[353] API Standard 65, 2nd ed., Isolating Potential Flow Zones During Well Contruction-Part 2, December 2010.

[354] The annulus is the space between the drillpipe and wellbore. See Deepwater Drilling and Temporary Abandonment of the Macondo Well in Volume 1, p 20 of the CSB Macondo report for more details and diagrams.

[355] Internal Company Document, BP. Cementing in hostile environments: Guidelines for obtaining isolation in demanding wells, December 200263 BP-HZN-BLY00175616.

[356] The guidance lists cement channeling, low foam quality, and unstable foam—all possibilities BP listed in its investigation report as potential sources of cement failure at Macondo; BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010; pp 36.; Transocean. *Macondo Well Incident: Transocean Investigation Report Volumes I;* June, 2011, pp 34, 55.

cement design for Macondo was complex and that improved MOC could have raised awareness of the challenges to achieving a successful cement job.[357]

Beyond the foamed cement design, three substitutions or replacements occurred during the cementing process at Macondo. Leftover cement from a previous well was used and leftover lost circulation material was substituted as a spacer in the cement job design.[358] These changes were treated as "replacement in kinds"[359] without assessing whether they fulfilled necessary specifications or whether they could perform as anticipated. The substituted cement was designed for a non-foamed cement job and was being converted to a foamed design for Macondo,[360] but neither the crew nor management evaluated the conversion.[361] The lost circulation material was never tested as a spacer, and its viscous, gelling nature made it susceptible to plugging lines used for the negative test.[362]

Concerning other aspects of the TA program (e.g., the negative test, underbalancing the well), the BP Wells Team Leader responsible for initiating an MOC stated that he did not feel the changes were significant and that the team was experienced at conducting negative tests, so an MOC was not prepared.[363] Personnel experience is only one of many potential factors to consider in assessing and managing risk because wells can offer unique circumstances that even experienced crewmembers have not previously addressed. Furthermore, experience and competency do not preclude human error, so considerations of potential error must be part of the MOC process.

Transocean criticized BP for not preparing MOC documents to address the risks of the temporary abandonment operations,[364] but in its own investigation report Transocean failed to address the Deepwater Horizon's noncompliance with Transocean Corporate requirements. Transocean identified numerous scenarios for conducting formal MOC plans, including:[365]

- Change in people;
- Change in installation/facility specific procedures;

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[357] BP, Deepwater Horizon Accident Investigation Report; September 8, 2010, p 36.

[358] To avoid mixing the foamed cement and the synthetic-oil-based-mud, a spacer fluid is used in between the two fluids.

[359] A replacement in kind is a replacement component or procedure with the same specifications or effects as the original.

[360] The leftover cement contained a defoaming additive which could negate efforts to create a foamed cement.

[361] BP. Deepwater Horizon Accident Investigation Report; September 8, 2010, p 60.

[362] CSB, 2014, *Explosion and Fires at the Macondo Well, Gulf of Mexico*, April 20, 2010, Report No. 2010-10-I-OS, June 2014, Appendix 2-A, pp 17.

[363] Internal Company Document, BP. *BP Incident Investigation Team - Notes of Interview with John Guide*, July 1, 2010, pp BP-HZN-BLY00124225, see Exhibit 0153 http://www.mdl2179trialdocs.com/releases/release201302281700004/Paine_Kate-Depo_Bundle.zip (accessed October 7, 2015).

[364] Transocean. Macondo Well Incident: Transocean Investigation Report Volumes I; June, 2011, p 10-11.

[365] Internal Company Document, Transocean. *Company Management System*, Issue 04, Revision 05, HQS-CMS-GOV, November 30, 2009, Corporate Policies and Procedures, Level 1, TRN-MDL-00032841, see Exhibit 0925 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 7, 2015).

- Changes to safety systems or critical operating equipment;
- Changes to software and hardware;
- Equipment and structural changes, including non-original equipment replacement, upgrades or modifications; and
- Mobile Offshore Drilling Unit (MODU)[366] design and/or operating criteria.

Changes to installation/facility specific procedures included the negative test and temporary abandonment plans. The THINK Planning Process (Section 1.8.3)—the backbone of Transocean's MOC program—dictates how a plan for a task is developed. The plan should then be observed and monitored while it is executed using Transocean's START Observation and Monitoring Process. START (See, Think, Act, Reinforce, Track) is a tool to reinforce safe behavior, correct unsafe behavior, and ensure controls or barriers remain in place during implementation of a plan. Despite these requirements, Transocean did not generate MOCs (or TSTPs) while drilling the Macondo well. Chapter 4.0 further explores the lack of clarity concerning safety roles and responsibilities between the operator and drilling contractor, as influenced by US regulations, for safety critical activities.

1.9.2 MOC Regulatory Requirements and Good Practice Guidance

Management of Change is recognized as one of several vital components of an effective safety management system for hazardous operations.[367] While voluntary guidance recommended that leaseholders/operators develop and use an MOC process,[368] companies operating in the Gulf of Mexico at the time of the Macondo event were not required to have a formal MOC process as part of a larger major accident prevention program, nor did regulations require that these parties effectively coordinate their management of change activities.

1.9.2.1 Regulatory Requirements for an MOC Safety Management System

Offshore safety guidance in effect in the US at the time of the Macondo blowout, *Recommended Practice for the Development of a Safety and Environmental Management Program for Offshore* (API RP 75), recommended that MOC programs include the development of a written MOC procedure that contains design basis for the change; analysis of safety, health and environmental considerations for the proposed

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[366] As defined by US Code 2101 15(a), a MODU is "a vessel capable of engaging in drilling operations for the exploration or exploitation of subsea resources."

[367] Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007; Chapter 15.; International Association of Drilling Contractors, *Health, Safety and Environment Case Guidelines for Mobile Offshore Drilling Units,* Issue 3.6, January 2015, p 13.

While the CCPS guidelines were not expressly written for offshore operations, they have recently been effectively implemented in drilling and well operations. [Chajai, H.; Smith, C. *Defining and Improving Process Safety for Drilling and Well Services Operations*, IADC/(SPE) Drilling and Completion (SPE) Drilling Conference and Exhibition, 4-6 March 2014, Fort Worth, TX]. As such, they complement the IADC guidelines for assessing BP and Transocean policies in place at the time of the incident and BSEE's current MOC program requirements.

[368] API Recommended Practice, 75, 3rd (2004, reaffirmed 2008) ed., Recommended Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities, pp 9-10.

changes; revisions to operating procedures, work practices, and training; communication of the changes; and required authorizations to implement the change.

While API RP 75 was voluntary, both companies' MOC policies had requirements that incorporated or went beyond the recommendations contained within the RP. However, such MOC analyses were not performed for a number of changes at the Macondo well. (See previous section.) After the incident, the regulator codified industry good practices for MOC already stipulated within the corporate policies of BP and Transocean (Table 1-10).

Table 1-10. A comparison of best practice elements of an MOC program, current BSEE MOC requirements, and BP and Transocean's MOC programs in place at the time of the Macondo incident.

MOC Program Elements	**Required by Regulator at Time of Incident**	**Included in BP MOC Policies**	**Included in Transocean MOC Policies**	**Required by Regulator Post Macondo** ††
Write MOC procedures for changes to equipment, procedures, personnel, materials, and operating conditions		x	x	x
Review changes		x	x	x
Include technical basis in review		x	x	x
Include impact on safety, health, and the environment in review		x	x	x
Include time period for change in review		x	x	x
Approve procedure		x	x	x
Communicate change and train appropriately		x	x	x
Document changes to operating procedures		x	x	x
Identify, track, and implement changes through management system. Activities should be audited and used to improve dependability of MOC process.				x
Drive risk to as low as reasonably practicable through MOC process		implied†	x	

†BP's MOC guidelines do not explicitly state ALARP, but they do reference BP's OMS Exploration and Production Drilling and Well Operations Practice (DWOP), which states "all risks shall be managed to a level which is as low as reasonably practical" or ALARP; Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, pp A-9, BP-HZN-BLY00034504, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

††Specific requirements for an MOC program are addressed in 30 C.F.R. § 250.1912 (2015), while management's general responsibilities, which includes the improvement of the safety and environmental management system (SEMS) program, are addressed at 30 C.F.R. § 250.1909 (2015).

BSEE now requires leaseholders[369] to identify their MOC approval procedures and give both the technical basis for the change as well as an evaluation of the potential impacts on safety and health.[370] Companies now are required to communicate changes and document MOCs that result in procedural changes.[371] While BSEE requires companies to establish MOC program goals, there are no requirements to align risk tolerance expectations between BSEE and the companies its regulations cover, such as driving risk to as low as reasonably practicable (ALARP).[372]

1.9.2.2 Multi-party MOCs are an International Concern

At the time of the incident, no voluntary US industry guidance recommended how drilling contractors might provide critical reviews of their clients' designs or programs for the well to assure that the design/program did not put their equipment and personnel at an unacceptable level of risk. The multiparty environment of offshore oil and gas operations supports the need to coordinate any changes initiated by the various parties that have the potential to impact the safety of the crew, rig, equipment, and environment.

On a global level, after the Macondo blowout, there was a surge of industry recognition and appreciation for the interplay between leaseholder, drilling contractor, and well service providers. A 2013 multinational audit of offshore operators and drilling contractors in the North Sea raised as a primary concern the crucial need for improvements in the coordination and interface between client and driller, noting a "lack of clarity in the various levels of bridging and interfacing documentation/processes" as well as a "lack of effective gap analysis in the client and drilling contractor systems/documentation."[373]

In the US, the API published new voluntary guidance in November 2013 to address the need to develop a Well Construction Interface Document (WCID) that bridges safety and environmental management systems among the lease holder, drilling contractor, and other third-party contractors.[374] API's guidance specifically calls for the WCID to address MOC systems and risk assessment processes. Thus, while each company should have its own system for managing risk, the changes should be coordinated and

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[369] However, as discussed in Volume 4, Section 3.3 of the CSB Macondo Investigation Report, the key federal offshore safety management regulations that address MOC programs (the Safety and Environmental Management Systems Rule) issued in the wake of the Macondo incident do not directly cover contractors.

[370] 30 C.F.R. § 250.1912 (d) (1-2, 4) (2012).

[371] 30 C.F.R. § 250.1912 (a) (2) (2012).

[372] See Section 4.1 in this Volume and Section 3.1 in Volume 4 for further discussion on ALARP.

[373] North Sea Offshore Authorities Forum (NSOAF). *Multi-National Audit Human and Organisational Factors in Well Control 2012-2013*, pp 3-4; http://www.hse.gov.uk/offshore/nsoaf.pdf (accessed May 2016, 2015).

[374] American Petroleum Institute, Bulletin 97, 1st ed., *Well Construction Interface Document Guidelines*, November 2013, p 1.

communicated between all the potentially affected parties.[375] (The CSB further discusses the important role of bridging documents in effectively managing safety in Section 4.4.5.)

1.10 Inadequate Requirements for Incorporating Human Factors in US Offshore Operations

Before the Macondo incident, a company conducting US offshore drilling and completion operations was not required to maintain and implement a documented safety management program.[376] Thus, there were no requirements to incorporate human factors into such a program.[377] Also missing were any requirements for the safe management of critical tasks, operating procedures, and changes to the operational plan, process or the people conducting the work. US offshore lacked requirements for industry to incorporate good practice process safety principles, such as using the hierarchy of controls when deciding on the technical, operational and organizational barriers needed to prevent a major accident.

Despite this regulatory shortfall, the importance of human factors offshore did not go unrecognized by industry and regulators.[378] The following conclusion was noted at an April 2002 seminar to discuss human factors integration into oil and gas offshore operations: “Ignoring human factors will result in an increase not a decrease in incidents, lower safety performance and increased costs. Human factors are paramount to all aspects of offshore operations and essential in reducing human performance-related risks.”[379] Participants of this event included the US and UK offshore regulators (MMS and HSE, respectively), and major companies in industry, such as BP, Shell, and Exxon.

Several years later, in 2006, API published *Human Factors Tool for Existing Operations* to assist industry members in “incorporating human factors considerations into existing equipment and tasks.”[380] According to the guidance document, this tool is meant for use by those conducting the actual work—the rig crew or

[375] American Petroleum Institute, Bulletin 97, 1st ed., *Well Construction Interface Document Guidelines*, November 2013, pp 7-8.

[376] The SEMS Rule was promulgated in October 2010.

[377] Related the safe operation of a ship and pollution prevention, the US Coast Guard has had regulations since 1998 that require certain vessels, including self-propelled MODUs, to comply the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code). As a result, vessels must “have on board valid documentation showing that the vessel's company has a safety management system which was audited and assessed, consistent with the International Safety Management Code of IMO Resolution A.741(18);” 33 U.S.C. § 96.370 (a) (1) (2016). See also International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code), 62 Fed. Reg. 67492 (December 24, 1997).

[378] The USCG acknowledged the role of human factors in major accidents when introducing regulations requiring the ISM Code, “Recent casualty studies concluded that in excess of 80 percent of all high consequence marine casualties may be directly or indirectly attributable to the ‘‘human element.’’ […] The ISM Code offers a systematic approach to mariners with the policy and procedures needed to understand their duties and address the human element issues and risks that can prevent casualties from occurring.”; International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code), 62 Fed. Reg. 67492 (December 24, 1997)

[379] Demystifying Human Factors: Practical solutions to reduce incidents and improve safety quality and reliability, 2nd International Workshop on Human Factors in Offshore Operations, Houston, TX, April 8-10, 2002.

[380] API, *Human Factors Tool for Existing Operations*, API Human Factors Task Force, Regulatory Analysis & Scientific Affairs Department, February 2006, pp 1.

process unit operators and mechanics.[381] It provides a methodology for identifying both (1) latent human error conditions and (2) potential human errors immediately prior to commencing hazardous work.[382] The expectation is to use the information compiled through this process to identify needed safeguards, to determine the risks most likely to result in consequences, and to develop recommendations for the reduction or elimination of the hazards.[383] While the document suggests the tool requires little or no training, [384] a certain level of human factors expertise and authority to examine management system failures and cultural influences are likely needed to identify and accurately risk-rank the latent conditions that can contribute to human error scenarios. Furthermore, it does not emphasize the importance of considering human factors in the designing and planning phases of a hazardous operation/equipment lifecycle, and it fails to indicate where technical and operational barriers may be identified and implemented. And since the document is merely guidance, its use offshore is optional.

The emerging lessons of Macondo demonstrate the criticality of the human component within safe offshore operations. Yet, there remains a dearth of US regulatory requirements or national industry guidance aimed at improving human performance during safety critical offshore operations. In the aftermath of the blowout, the regulator and industry hastened numerous US task force initiatives to address issues such as safe drilling operations, well containment and intervention capability, and oil spill response capability,[385] but focused these initiatives on physical threats and technical barriers and controls. In comparison, at the time of the incident, international offshore regions with developed regulatory regimes provided both regulatory requirements and guidance on human factors, and made further advancements in managing human factors offshore. This section makes some global comparisons and identifies opportunities to further incorporate human factors into safety management practices within the US offshore.

1.10.1 After Macondo, Limited US Offshore Regulatory Requirements Remain for Including Human Factors

In the US, companies operating offshore are not required to demonstrate to the regulator that they are effectively managing safety critical tasks, nor must they incorporate human factors into the management of those tasks to reduce risk. The post-Macondo safety management regulation, *Safety and Environmental*

[381] API, *Human Factors Tool for Existing Operations*, API Human Factors Task Force, Regulatory Analysis & Scientific Affairs Department, February 2006, pp 2.

[382] API, *Human Factors Tool for Existing Operations*, API Human Factors Task Force, Regulatory Analysis & Scientific Affairs Department, February 2006, pp 2-3.

[383] API, *Human Factors Tool for Existing Operations*, API Human Factors Task Force, Regulatory Analysis & Scientific Affairs Department, February 2006, pp 3.

[384] API, *Human Factors Tool for Existing Operations,* API Human Factors Task Force, Regulatory Analysis & Scientific Affairs Department, February 2006, pp 1.

[385] Four Joint Industry Task Forces (JITFs) comprising of members from various industry associations were created post-Macondo to address critical offshore activities: operating procedures, equipment, subsea well control and containment, and oil spill preparedness and response. The aim of the JITFs was to further improve existing API standards and make recommendations to the regulator. [Joint Industry Task Force (JITF). *JITF Executive Summary ;* March 13, 2013; pp 1. http://www.api.org/~/media/files/oil-and-natural-gas/exploration/offshore/executive-summary-final-031312.pdf (accessed October 2015, 2015).]

Management Systems regulations (SEMS Rule [30 C.F.R. 250 Subpart S]), very minimally addresses human factors. It requires that "The factors (human or other) that contributed to the initiation of the incident and its escalation/control" be addressed in incident investigations [250.1919(a)(2)], yet that requirement is limiting and reactive, seeking only to assess human performance for its immediate causal ties to a given incident.

The American Petroleum Institute's *Recommend Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities* (API RP 75), which has been incorporated into the SEMS Rule by reference, suggests that human factors be "considered" in the following aspects of safety management: the design and implementation of the company's SEMS program; the design of new facilities or major modifications to those facilities; the development of operating procedures and safe work practices; the facility hazard analysis; and in regards to equipment accessibility for operation, maintenance and testing.[386] But *considered* is a weak requirement that does not suggest any action to incorporate human factors principles and best practice. A company could consider human factors issues, do nothing, and still meet the requirements outlined in the regulation. API RP 75 does not provide instruction on how to identify and assess human performance or implement controls for those potential performance failures that may impact safety critical task completion.

Furthermore, only one human factors standard, ASTM F1166-95,[387] is a related reference in API 75. The ASTM standard focuses on maritime facilities and equipment design, particularly on ergonomic design criteria and anthropometric considerations.[388] While this ASTM voluntary standard does provide guidance on a number of human performance principles,[389] it is not required of industry.

Application of the API tool remains voluntary. It has not been revised or amended since its creation, nor has it been incorporated by reference into the SEMS Rule or listed as a normative reference within API 75.

1.10.2 Good Practice Techniques and Guidance on Human Factors

Human factors technical standards and guidance applicable to the oil and gas industry exists, some of which have been referenced in this volume.[390] In addition to that guidance, a variety of tools and methods

[386] API Recommended Practice, 75, 3rd ed. (2004, reaffirmed 2008 and 2013), Recommended Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities, Sections 1.2.2, 2.3.5, 5.1, 6.1, 8.1 and 3.1.

[387] American Society for Testing and Materials (ASTM) F1166-95, Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities, 1995.

[388] ASTM F1166-95 (3.1.10) defines anthropometrics as the (1) study of the physical size, strength, and range of motion of the human body and the application of that data to the design of systems, equipment, workspaces, and tools to maximize human performance and safety in a work setting; and (2) measurement of human variability of body dimensions and strength as a function of gender, race, and regional origin.

[389] ASTM FM6611-95 Section 4.2.

[390] Further, McLeod provides a succinct summary of the most widely used guides pertaining to human factors engineering. See, McLeod, R., *Designing for Human Reliability: Human Factors Engineering in the Oil, Gas and Process Industries*, Elsevier, 2015, pp 348 – 356.

have been developed over the years to assess the human contribution to safety and operational success, ranging in name and complexity including, among others: [391]

- Human Factors Risk Assessment
- Human Reliability Assessment
- Human HAZOP
- Hierarchical Task Analysis
- Predictive Human Error Analysis
- Safety Critical Task Analysis (SCTA)

The SCTA is a proactive safety management activity of identifying human performance expectations, potential hindrances to those expectations, and controls to mitigate or eliminate those hindrances before safety-critical work commences.[392] Potential severe consequences of a blowout or gas in the riser scenario are the very hazards identified as particularly in need of more in-depth hazard assessment. An HSE technical report suggests that "only hazards with implications for kick and blow-out scenarios [be] considered [for safety critical task assessment], since these are considered to be the greatest sources of risk in well operations."[393] SCTAs are meant to assess failure mechanisms that extend beyond the span of control of the crew, into areas such as equipment design and mechanical integrity, as well as organizational factors that could influence decision-making, including production or time pressures. As such, these assessments often require the involvement of shore-based personnel as well as the crew.

The hierarchy of controls is one approach to test the sufficiency of the barriers for a safety critical task; in fact, it is considered a step in the human performance assessment process.[394] A foundational argument of the hierarchy of controls principle is that the most effective control minimizes or removes the hazard. If that is not possible, then one of the other progressive inherent safety strategies listed in Figure 1-15 may be used to manage those hazards and reduce risks associated with the operation.

[391] E.g., HSE, Human Factors Assessment of Safety Critical Tasks, OTO 1999, Report 095; Energy Institute, Guidance on Human Factors Safety Critical Task Analysis, March 2011; HSE, Inspector's Human Factors Toolkit, Identifying Human Failures, Core Topic 3.

[392] Energy Institute, Guidance on Human Factors Safety Critical Task Analysis, March 2011, p 1.

[393] HSE. Human Factors Assessment of Safety Critical Tasks, Offshore Technical Report - OTO 1999 092; July, 2000; p 14.

[394] HSE, Inspector's Human Factors Toolkit, Identifying Human Failures, Core Topic 3.

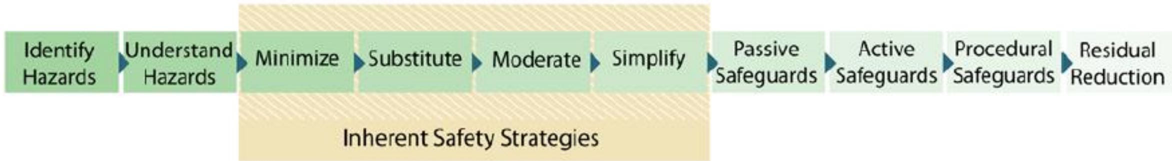

Figure 1-15. Illustration of the Hierarchy of Controls, including inherent safety strategies, for minimizing and eliminating hazards

[CALL-OUT BOX START]

Using the Hierarchy of Controls to Assess Human Performance Aspects of Safety Critical Tasks

- *Minimize: Can the consequences of the human failure be prevented (or mitigated), e.g., by additional barriers in the system?*
- *Substitute: Can the human contribution be removed, e.g., by a more reliable automated system?*
- *Moderate: Can human performance be assured by mechanical or electrical means? For example, the correct order of valve operation can be assured through physical key interlock systems or the sequential operation of switches on a control panel can be assured through programmable logic controllers. Actions of individuals alone should not be relied upon to control a major hazard.*
- *Simplify: Can the PIFs [Performance Influencing Factors] be optimised, (e.g., improve access to equipment, increase lighting, provide more time available for the task, improve supervision, revise procedures or address training needs)?*

- Energy Institute, *Guidance on Human Factors Safety Critical Task Analysis*: London. March 2011, p. 16.

[CALL-OUT BOX END]

1.10.3 International Offshore Regulatory Requirements and Guidance

The UK HSE requires consideration of human factors and offers guidance to its duty holders on the principles to which the regulator will assess the treatment of human factors.[395, 396] These principles include clearly describing the defined role of the human element in a hazardous operation/facility and demonstrating its reliability to perform the desired tasks; analyzing safety critical tasks and demonstrating (drawing upon recognized human factors good practice) that task performance can be delivered as expected; accounting for occupational factors, such as workload and shiftwork schedules; and analyzing human performance issues, such as work task feasibility, procedure design, training, and human-technology interfaces.[397] Furthermore, companies operating in the UK waters of the North Sea are

395 UK Health Safety Executive, Assessment Principles for Offshore Safety Cases (APOSC), March 2006, Forward.

396 HSE, Safety report assessment guide: Human factors and HSE, Assessment principles for offshore safety cases (APOSC); HSE, Human Factors Assessment of Safety Critical Tasks, Offshore Technical Report – OTO 1999 092 (July 2000), Section 3.2.1, p 32.

397 UK Health Safety Executive, Assessment Principles for Offshore Safety Cases (APOSC), March 2006, Principle 8, items 43 – 48.

expected to conduct qualitative analyses of human performance and demonstrate to the regulator they have identified potential performance consequences and the measures to counteract or mediate those consequences.[398] The UK HSE provides publicly-available guidance for its regulatory inspectors to both understand how to effectively analyze safety critical task performance and to audit companies' efforts at considering human performance variability and potential negative outcomes.[399]

In Australia, the regulator, NOPSEMA, asserts that the use of strategies that identify and optimize human factors will help industry reduce risk of a major accident, and using such strategies will help companies meet their obligations under the applicable Act and associated Regulations.[400] NOPSEMA stresses the importance of the hierarchy of controls, stating "The nature, number and scale of the controls should be such that they are robust, not easily defeated and the level of control is effective for the risks they are intended to manage, prevent or mitigate. A hierarchy of controls should be established, with those that eliminate or prevent MAEs given priority over those that reduce or mitigate the outcomes."[401]

The Norwegian offshore regulator, the Petroleum Safety Authority (PSA), asserts that the interaction among human, technology and organization—HTO—is central for accident prevention and the basic element in its petroleum industry Health, Safety and Environment regulations.[402] Section 13, *Work processes*, specifically states, "The interaction between human, technological and organisational factors shall be safeguarded in the work process."[403] As such, PSA emphasizes, among other human factors issues, the importance of the psychosocial and organizational factors, as well as HTO in safety critical systems.[404]

[CALL-OUT BOX START]

"Drilling and wells are examples of areas with great challenges in the interaction between people, technology and organisation. For example, the driller must maintain control of the well, lead the work on the drill floor and deal with technically advanced, screen-based solutions in the drilling cabin. It may

[398] HSE, Inspector's Human Factors Toolkit, Identifying Human Failures, Core Topic 3.

[399] HSE, Safety report assessment guide: Human factors and HSE, Assessment principles for offshore safety cases (APOSC); HSE, Human Factors Assessment of Safety Critical Tasks, Offshore Technical Report – OTO 1999 092 (July 2000).

[400] The Offshore Petroleum and Greenhouse Gas Storage Action (2006) and the Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations. National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), Resources: Human Factors, http://www.nopsema.gov.au/resources/human-factors/ (accessed July 31, 2015).

[401] NOPSEMA, Guidance Note N-04300-GN0060, The Safety Case in Context: An Overview of the Safety Case Regime, rev. 6, June 2013.

[402] Petroleum Safety Authority, HSE Management: HTO/Human factors, August 28, 2013, http://www.psa.no/hto-human-factors/category965.html (accessed January 23, 2016).

[403] Regulations Relating to Management and the Duty to Provide Information in the Petroleum Activities and at Certain Onshore Facilities (The Management Regulations), Last amended December 18, 2015, http://www.ptil.no/management/category401.html#_Toc280619401 (accessed January 24, 2016).

[404] Petroleum Safety Authority, HSE Management: HTO/Human factors, August 28, 2013, http://www.psa.no/hto-human-factors/category965.html. (accessed January 23, 2016).

thus be challenging to understand, operate and maintain an overview of all the incoming data – and simultaneously maintain control and overview of what is physically taking place on the drill floor."

Petroleum Safety Authority, HSE Management: HTO/Human factors, August 28, 2013, http://www.psa.no/hto-human-factors/category965.html, accessed January 23, 2016.

[CALL-OUT BOX END]

The International Association of Drilling Contractors (IADC) is a global industry association, of which Transocean is a member. The organization publishes the Health Safety and Environmental Case Guidelines (HSE Case Guidelines) for Mobile Offshore Drilling Units, such as the Deepwater Horizon, providing guidance for a harmonized global framework and methodology for the management of safety. Ten countries require use of the guidelines by force of regulation, and it is recognized as best practice in ten additional countries, some of which have regulations pending to require adoption of the guidelines.[405] The document, however, is only a voluntary standard in the US. Part 2 of the guidance contains HSE management objectives related to "procedural (human factors) controls."[406] The HSE Case Guidelines recommend that drilling contractors verify HSE critical activities and tasks, as well as the more typical physical safety critical equipment, stipulating, "Identification of Critical Activities or Tasks is essential to effectively manage major hazards or high risk hazards."[407] Part 4 of the Guidelines states, "A recognized best practice for risk optimization is to address each risk systematically according to a strategic hierarchy [of control]."[408] The HSE Case Guidelines also explicitly focus on the drilling contractor's management system, stating that it "needs to ensure that personnel policies, training, competencies, attentiveness and alertness, and other human factors allow individuals to perform their Critical Activities or Tasks effectively and efficiently,"[409] and that such factors be monitored periodically.[410]Onshore Regulatory Requirements and Industry Guidance

A number of US onshore regulations and standards address various aspects of human factors in downstream oil and gas operations, which are more robust than current offshore requirements. The federal onshore safety regulations applicable to oil and gas operations, *Process Safety Management of Highly Hazardous Chemicals (PSM),* stipulates that the required initial hazard analysis must address human factors.[411] Contra Costa County, California, goes beyond this PSM requirement; refineries within its jurisdiction must abide by the County Safety Ordinance, which has provisions that each refinery develop and implement a human factors program for its process hazard analysis, operating and maintenance

405 Countries requiring use of the guidelines by force of regulation include Australia, Cuba, Denmark, Faeroe Islands, Germany, Ireland, the Netherlands, New Zealand, Norway, and the United Kingdom. Angola, Canada, Brazil, India, Malaysia, Oman, Qatar, Senegal, South Africa, and Trinidad & Tobago recognize the guidelines as best practice. See http://www.iadc.org/iadc-hse-case-guidelines/.

406 IADC, HSE Case Guidelines for MODU, Issue 3.4, November 2011, section 2.0.4 Demonstrating Assurance of HSE Management Objectives.

407 IADC, HSE Case Guidelines for MODU, Issue 3.4, November 2011, section 4.7 Risk Treatment.

408 IADC, HSE Case Guidelines for MODU, Issue 3.4, November 2011, section 4.7 Risk Treatment.

409 IADC, HSE Case Guidelines for MODU, Issue 3.4, November 2011, section 4.7 Risk Treatment.

410 IADC, HSE Case Guidelines for MODU, Issue 3.4, November 2011, section 6.3 Periodic Monitoring.

411 OSHA, Process Safety Management of Highly Hazardous Chemicals, 1910.119(e)(3)(vi).

procedures, and incident investigation management systems.[412] The Ordinance also stipulates that the human factors program include staffing and shiftwork considerations, as well as the management of organizational changes that affect staffing, and employee training on human factors principles and the human factors program itself.[413]

The State of California OSH proposed *Process Safety Regulation for Petroleum Refineries,* 5189.1, goes even further, requiring the written human factors program to examine issues including but not limited to workload, staffing, shiftwork arrangements, procedural clarity, and job task conditions as they influence human performance.[414] The proposed regulation also would require a human factors analysis of process controls (such as automated functions), as part of the larger process hazard analysis, for any major design changes to a process, and all incident investigations and organizational changes.[415]

Both the Contra Costa County Ordinance and the proposed State of California process safety regulation include requirements for employee and employee representative participation in developing the human factors program,[416] and that the regulated party document this program within its "safety plan."[417]

API Publication 770, *A Manager's Guide to Reducing Human Errors: Improving Human Performance in the Process Industries,*[418] provides guidance for onshore petrochemical processes on the topic of human factors engineering, a subset of larger human factors field, as well as on one specific human factors assessment method, human reliability assessment. The guidance illustrates the inherent and critical role of the human in successful completion of a hazardous operation throughout the lifecycle of operation (e.g., research and design, construction, installation, operation and maintenance), as well as throughout the various organizational levels within an organization (e.g., actions of the unit operator all the way to decisions by the corporate office).[419] This guidance has not been extended to offshore.

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[412] County Ordinance Chapter 450-8, Risk Management, 450-8.016(b)(1)(a, b, d, and e), Stationary source safety requirements, Human factors program, http://cchealth.org/hazmat/iso/ (accessed January 22, 2016).

[413] County Ordinance Chapter 450-8, Risk Management, 450-8.016(b)(1)(c and f) and 450-8.016(b)(3), Stationary source safety requirements, Human factors program, http://cchealth.org/hazmat/iso/ (accessed January 22, 2016).

[414] State of California, Division of Occupational Safety and Health, *Proposed GISO §5189.1, Process Safety Management for Petroleum Refineries,* Version 4.5, May 26, 2015, §5189.1(s)(2), p.26-27.

[415] State of California, Division of Occupational Safety and Health, *Proposed GISO §5189.1, Process Safety Management for Petroleum Refineries,* Version 4.5, May 26, 2015, §5189.1(s)(3) & (t), p.26-27.

[416] County Ordinance Chapter 450-8, Risk Management, 450-8.016(b)(2), Stationary source safety requirements, Human factors program, http://cchealth.org/hazmat/iso/ (accessed January 22, 2016).

[417] County Ordinance Chapter 450-8, Risk Management, 450-8.016(b)(4), Stationary source safety requirements, Human factors program, http://cchealth.org/hazmat/iso/ (accessed January 22, 2016) and State of California, Division of Occupational Safety and Health, *Proposed GISO §5189.1, Process Safety Management for Petroleum Refineries,* Version 4.5, May 26, 2015, §5189.1(s)(7), p.27 and §5189.1(q), p.24. The 'safety plan' is submitted by the regulated party to the regulator as a record of asserted compliance with the provisions of the regulation and description of the manner of that compliance. County Ordinance Chapter 450-8, Risk Management, 450-8.016, http://cchealth.org/hazmat/iso/ (accessed January 22, 2016).

[418] API Publication 770, A Manager's Guide to Reducing Human Errors: Improving Human Performance in the Process Industries, March 2001.

[419] See table 1 on page 2 of the referenced document for a useful example.

1.11 **Conclusion**

When a company does not complete a hazard assessment that accounts for well-specific conditions for safety critical procedures, does not identify vulnerability to human error in a structured and effective way, and does not identify appropriate controls to mitigate risk, it is relying on the workers' varied knowledge and experience to effectively perform drilling tasks. In other words, the operational barrier for activities such as displacement of a well and completion of a negative test is one hundred percent error-free performance by the workers. Thus, a question emerges from Macondo: If the workers' knowledge and experience do not match the particular details of a negative test and the human decisions regarding the test are in error, what barriers are left to ensure a safe outcome?

If the critical layer of protection is the crew, then assessment of their capabilities and interactions with each other, the equipment, and the work environment must be comprehensive, and it must acknowledge human nature, variability, capabilities and limitations. Performance expectations and standards need to be realistic and appropriate in light of this fact.

Macondo provides numerous examples of not addressing human factors considerations in planning and executing temporary abandonment, factors that contributed to the well operations crew's decisions and actions on the day of the incident. The multiple human factors issues explored in this chapter illustrate the need for incorporating human factors in process safety management for offshore oil and gas exploration and development activities. The full consequences of Macondo suggest a strong need for companies and regulators to assess how to strengthen the complex interactions among the human, technological, and organizational elements of a system. Yet, from the major reports published on the Macondo incident,[420] only NAE recommended incorporating human factors in safety management,[421] as part of two very broad recommendations aimed at improving offshore drilling safety and fostering an effective safety culture. Ultimately, the NAE recommendations make the same suggestions of the current SEMS Rule, to "consider" human factors principles for improving human performance and reliability, yet neither advocates for mandated action to ensure incorporation of human factors into MAE safety management. "Consider" is not enough, and as Volume 4 addresses more explicitly, it can lead to a check-the-box

[420] National Academy of Engineering and National Research Council of the National Academies. *Macondo Well – Deepwater Horizon Blowout: Lessons for Improving Offshore Drilling Safety;* The National Academies Press: Washington, D.C., 2011; BP. *Deepwater Horizon Accident Investigation Report;* September 8, 2010; Transocean. *Macondo Well Incident: Transocean Investigation Report Volumes I and II;* June, 2011; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; Transportation Research Board of the National Academies. *Evaluating the Effectiveness of Offshore Safety and Environmental Management Systems;* Special Report 309; National Academy of Sciences: Washington DC, 2012.

[421] NAE made the following recommendations: Industry should greatly expand R&D efforts focused on improving the overall safety of offshore drilling in the areas of design, testing, modeling, risk assessment, safety culture, and systems integration. Such efforts should encompass well design, drilling and marine equipment, human factors, and management systems. These endeavors should be conducted to benefit the efforts of industry and government to instill a culture of safety; and (2) Industry, BSEE, and other regulators should foster an effective safety culture through consistent training, adherence to principles of human factors, system safety, and continued measurement through leading indicators.

activity.[422] Consequently, a more rigorous incorporation of human factors and safety strategies for managing human performance into US safety management requirements and practices is necessary for preventing major accidents.

[422] Volume 4, Chapters 2 and 3.

2.0 Organizational Learning from Incident Investigations

Chapter 2.0

This chapter explores incident investigations from a variety of perspectives, including the operator/drilling contractor interface, different geographical regions of an international organization, and a regulatory regime that does not explicitly require root cause investigations to address safety management systems. It also highlights numerous challenges that inhibit effective communication of lessons learned across the international offshore industry.

In the months and years leading up to the Macondo blowout, multiple well control incidents occurred on Transocean rigs active around the world under various operators.[423] Several of these events call attention to aspects of offshore incident investigations that are addressed in this chapter, including the operator/drilling contractor interface and challenges to disseminating lessons learned in a global company and across an industry. The quality of the responsive risk reduction corrective actions implemented as a result of lessons learned will be affected by the nature of information gathered on the incident. Thus, this chapter concludes with a look at the US regulatory requirements for incident investigation during Macondo and currently for opportunities to overcome the challenges.

Investigations provide companies with an opportunity to formally review, report, track, and learn from undesirable events.[424] An effective incident investigation program identifies hazards and system causal deficiencies and takes corrective actions to reduce risk before further similar accidents occur.[425] By reviewing previous Transocean incidents that involved various operators, the CSB reiterates that not only a company, but in fact the industry, "suffers from repeated failures and incidents because less formal feedback mechanisms are not sufficient to identify effective recommendations."[426]

2.1 Joint Incident Investigations and Challenges to Disseminating Lessons Learned Between Companies

Work-as-imagined and work-as-done discrepancies, described in Section 1.8, are not unique to the Macondo incident or BP and Transocean.[427] For example, on February 20, 2009, Transocean experienced

[423] Internal Company Document, Transocean. *Transocean Annual Report - 2010 Well Control Events & Statistics 2005 to 2010*, TRN-MDL-01858257, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-036071.pdf (accessed October 7, 2015).

[424] Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007; pp 552, 556.

[425] American National Standards Institute/American Industrial Hygiene Association (ANSI/AIHA) Z10-2012, *Occupational Health and Safety Managment Systems*, 2012, p 25.

[426] Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007, p 556.

[427] In almost every investigation conducted by the CSB, the agency has found significant disparities between company policies and actual practice at the worksite. The reasons for the disparity are often multi-faceted.

a well control event that resulted in the riser unloading aboard the M.G. Hulme, Jr. while drilling for t Eni[428] off the coast of West Africa. The crew did not detect a kick until gas passed above the BOP when gas and drilling mud released onto the rig. The investigation concluded that the gas zone was reached earlier than predicted and the crew did not detect an influx that occurred when pumps had been shut down to investigate a problem.[429] Phrases found in Transocean's investigation report are indicators of inadequate bridging between work-as-imagined versus work-as-done (Table 2-1).

Table 2-1. Excerpts from the M.G. Hulme, Jr well control incident report that reflect WAI versus WAD conflicts.[430]

Excerpts from the Transocean M. G. Hulme, Jr. investigation report†	**CSB observations**
"the well program made no mention …" "the use of the […]† system is a significant change from conventional drilling …" "Did not challenge [the operator] on the quality of the pre-spud meeting or the adequacy of the well planning material." "the TSTP did not adequately quantify the hazards, nor did it discuss the preventative or mitigating controls" "due to the use of the E-CD† equipment the Driller did not understand that he could …" "Did not recognize the importance of…" "Assigned driller with limited […] experience" "the driller was in a new position …"	• Lack of, or minimal, detail provided by the operator in written work plans places a heavy reliance on the skills, knowledge, and experience of the drilling contractor which may not be sufficient for the task. • More than a set of instructions, procedures are tools for competent, motivated individuals to plan, coordinate, verify, and assure performance will achieve the intended results.

† Eni Circulation Device (E-CD), "permits the continuous circulation of mud in the well, which maintains a constant down hole pressure over the entire drilling process…," http://www.eni.com/en_IT/innovation-technology/technological-focus/safe-drilling/safe-drilling.shtml.

[428] http://www.eni.com/en_IT/home.html (accessed October 7, 2015).

[429] Internal Company Document, Transocean. *EAU Incident Investigation Report - M.G. Hulme, Jr. Well Control Incident - Riser Unloading*, OER-MGH-09-005, March 26, 2009, TRN-INV-01143039, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05650.pdf (accessed October 7, 2015).

[430] Internal Company Document, Transocean. *EAU Incident Investigation Report - M.G. Hulme, Jr. Well Control Incident - Riser Unloading*, OER-MGH-09-005, March 26, 2009, TRN-INV-01143039, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05650.pdf (accessed October 7, 2015).

The need to identify lessons from incidents like the Macondo blowout or the M. G. Hulme, Jr. well control event transcends individual companies because the operators and drilling contractors have different roles, expertise, and safety management systems that influence the design and operational risk of drilling a well. As a result, efforts to minimize the gap between WAI and WAD would be most effective if operators and drilling contractors alike work together to investigate incidents and identify corrective opportunities.

2.2 Challenges to Disseminating Lessons Globally

Four months before the Macondo incident, on December 23, 2009, a Transocean-owned rig, Sedco 711, experienced a significant well control event in the North Sea.[431] Delayed detection of a well kick resulted in gas and drilling mud from the riser unloading onto the rig with some being lost to the sea. Unlike the situation at the Macondo well, the flammable material that reached the rig did not ignite, and the BOP was able to seal the well and limit the release to what had already traveled above the BOP before it was closed.

The Sedco 711 incident occurred when a mechanical barrier that successfully passed a positive inflow test subsequently failed while the well was being underbalanced.[432] The crew did not detect the kick, in part, because the mud returns were being routed to reserve pits, which prevented the crew from monitoring the returns on the active pit system.[433,434] Other data were not interpreted as indicators of loss of well control based on the crew's faith in the successful well barrier test. Transocean identified three immediate technical and operational causes, including failure of the tested downhole barrier, failure to monitor and identify the influx, and failure to close in the well prior to the influx reaching the BOP.[435] Shell, the well

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431 Internal Company Document, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, TRN-MDL-02840795, http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip, Exhibit 5749, (accessed October 7, 2015); Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 13, 2011 pp 22-26, http://www.mdl2179trialdocs.com/releases/release201302281700004/Cameron_David-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, Transocean. *711 Well Control Incident Power Point*, TRN-MDL-00870381, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-01760.pdf (accessed October 7, 2015).; Internal Company Document, Shell. Incident Investigation Report Bardolino Well Control Incident, Report: EP201002315140, January 26, 2010, p 4, TRN-INV-01823569.

432 Internal Company Document, Transocean. *711 Well Control Incident Power Point*, p 4, TRN-MDL-00870381, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-01760.pdf (accessed October, 7 2015, October).

433 Internal Company Document, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, TRN-MDL-02840795, http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip, Exhibit 5749, (accessed October 7, 2015).

434 An important kick indicator is an increase in fluids coming from the well compared to the volume of fluids pumped into the well. As described by the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (Commission). *Chief Counsel's Report: The Gulf Oil Disaster*, February 17, 2011, p 165, "The active pit system refers to a computer setting that allows the driller (and others) to select several pits and aggregate their volumes into one "active pit volume" reading. Even though there are several different pits involved, the rig's computer system displays them as a single pit for volume monitoring purposes."

435 Internal Company Document, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, TRN-MDL-02840796, see Exhibit 5749.

operator, reported both onshore and offshore personnel believed that once the crew successfully performed the inflow test, the barrier would not fail, which "led to a blinkered approach" by the crew regarding the true well conditions.[436] The report states, "This belief is highlighted by the fact that there were clear indications of the operation not going to plan, but the thoughts were tailored in looking for surface reasons for the anomalies."[437] Ultimately, the crew rationalized the well control indicators to support the conclusion that the well barrier was intact.

A Transocean operations advisory noted a lack of clear well control procedures and a weak risk assessment for planning and executing the well plan.[438] As at Macondo, procedures were missing critical process parameters, "The well planning did not highlight that the well would be under balance during the […] operation. There were no hydrostatic step up/down charts to show the expected pressures in the well at the different stages of the well clean up, and specifically when the well went under balance."[439] As a result of the Sedco 711 event, Transocean and Shell, separately identified corrective actions. Shell's proposed actions focused on written tools that Section 1.8 previously noted were important for closing the WAI and WAD gap:

- Inclusion of loss of well barrier risks on TSTPs (see Section 1.8.3 for TSTP discussion);[440]
- Increased communication of Standing Instructions to the Driller (SID) with clear roles, accountability, and responsibilities listed (see Section 1.8.2 for SID discussion);[441]
- Development and use of written work instructions for well control operations that include guidance information on overbalance and underbalance operations and on conducting inflow tests, and that document the risk assessment and mitigation actions.[442]

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http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip (accessed October 7, 2015).

[436] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, p 12, TRN-INV-01823569.

[437] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, p 12, TRN-INV-01823569.

[438] Internal Company Document, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, TRN-MDL-02840796, see Exhibit 5749 http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip (accessed October 7, 2015).

[439] Internal Company Document, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, TRN-MDL-02840797, see Exhibit 5749 http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip, (accessed October 7, 2015).

[440] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, pp 41, TRN-INV-01823569.

[441] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, pp 20, TRN-INV-01823569.

[442] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, pp 4, 14, TRN-INV-01823569.

- Revisions to the Well Control Handbook pertaining to conducting fluid displacements under controlled conditions and calculating hydrostatic pressure;[443]
- Review of the Transocean (contractor) and Shell (operator) bridging document to clarify accountabilities and standardize the well control process into defined phases that identify when decision-making requires management or technical onshore support (see Section 4.4.5 for Macondo bridging documents discussion);[444] and
- Corrective actions for Schlumberger (third-party contractor) related to including relevant parties in hazard assessment activities[445] and to incorporating a lateral learning process for capturing lessons learned from operational incidents (to Schlumberger)[446] and risk assessment changes and management (to Shell).[447]

As part of its investigation, Transocean noted two "missed opportunities" related to the mudlogger. One was that the mudlogger reported an increase in well fluids, but the driller did not act upon it, attributing the increase instead to reasons other than loss of well integrity. A second was that the mudlogger did not inform the client supervisor, toolpusher, or the driller again when the flow of well fluids continued to rise.[448] These lines of communication match what is presented in Figure 1-12. Despite observing that the well kick indicator was reported by the mudlogger and that increased communication might have helped, neither Transocean's nor Shell's corrective actions addressed communication skills or gaps. Instead, their corrective actions focused more generally on increasing awareness among crew members by reviewing the incident, reiterating the need for early kick detection, and ensuring well programs noted when underbalanced conditions were to exist in a well. Third-party mudlogger services like those provided by Schlumberger during this project are contracted by the operator, indicating that the operator is likely best positioned to cause bridging between the drilling contractor and other third-party contractors. Beyond the mudlogger missed opportunities, Transocean was also concerned with updating its well control manual as a result of Shell's recommendation.[449]

Four months later, Transocean's Well Operations Manager in the Gulf of Mexico sent an email to colleagues in the North Sea, stating, "I'm still on the fence as to whether an advisory [on Sedco 711] is

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[443] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, pp 15, TRN-INV-01823569.

[444] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, pp 16, TRN-INV-01823569.

[445] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, pp 15, TRN-INV-01823569.

[446] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, 15, TRN-INV-01823569.

[447] Internal Company Document, Shell. *Incident Investigation Report Bardolino Well Control Incident*, Report: EP201002315140, January 26, 2010, pp 17, TRN-INV-01823569.

[448] Internal Company Documents, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, TRN-MDL-02840796, see Exhibit 5749 http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip, (accessed October 7, 2015).

[449] Email from Aberdeen Operations Manager, Transocean, to Well Operations Manager, Transocean, Subject: potential advisory from 711 event, March 31, 2010, TRN-INV-03407526.

required or not."[450] He was concerned that the well control manual sufficiently addressed underbalanced well conditions. The response he received from his North Sea counterparts was, "Expectation from Shell is an update in the [well control] manual—hence request for advisory until update issued. If not done then we will require to issue an [North Sea] advisory but I know Shell will ask what the Shell rigs are doing elsewhere in the world…"[451] Subsequently, an advisory for the Gulf of Mexico was developed that suggested additional text be included in the well control manual, including the statement, "Do not be complacent because the reservoir has been isolated and inflow tested. Remain focused on well control and maintain good well control procedures."

The DWH crew never received the US advisory describing the text changes that would be made to the well control manual.[452] Post-incident, Transocean's General Manager of North America who was responsible for forwarding the information to the GoM rigs stated that the email containing the advisory came in while he was on vacation and that he never saw it.[453] Another person covered the general manager's duties while he was on vacation, but upon review of both email accounts, neither person forwarded the advisory to employees working in the Gulf of Mexico. The advisory was posted on Transocean's internal electronic document system at the same time it was sent to the General Manager,[454] but unless employees subscribed for notifications of newly added documents, they would not have be made aware of its submission.[455]

Without auditable follow-up actions, and a person responsible for tracking them, such an unintended oversight is more likely to occur. Databases require users to initiate searches, and emails can languish in

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[450] Email from Aberdeen Operations Manager, Transocean, to Well Operations Manager, Transocean, Subject: potential advisory from 711 event, March 31, 2010, TRN-INV-03407526.

[451] Email from Aberdeen Operations Manager, Transocean, to Well Operations Manager, Transocean, Subject: potential advisory from 711 event, March 31, 2010, TRN-INV-03407526.

[452] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 28, 2011; see Johnson Designations Vol 1, pp 91-93, http://www.mdl2179trialdocs.com/releases/release201302281700004/Johnson_Paul-Depo_Bundle.zip (accessed October 7, 2015).; Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, October 27, 2011; see Braniff Designations Vol 1, p 27, http://www.mdl2179trialdocs.com/releases/release201302281700004/Braniff_Barry-Depo_Bundle.zip (accessed October 7, 2015).; Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 24, 2011; see Canducci Designations Vol 2, pp 141-142, http://www.mdl2179trialdocs.com/releases/release201302281700004/Canducci_Gerald-Depo_Bundle.zip (accessed October 7, 2015).

[453] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, July 27, 2011; see Sannan Designations Vol 1, p 75, http://www.mdl2179trialdocs.com/releases/release201302281700004/Sannan_Stuart-Depo_Bundle.zip (accessed October 7, 2015).

[454] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, July 27, 2011; see Sannan Designations Vol 1, p 81, http://www.mdl2179trialdocs.com/releases/release201302281700004/Sannan_Stuart-Depo_Bundle.zip (accessed October 7, 2015).

[455] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 25, 2011; see Rose Designations Vol 1, p 113, http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 7, 2015).

an inbox. Consequently, industry needs to consider how to most effectively communicate the various database resources (including those with email notifications) and how to absorb lessons into the organization's safety management systems. Inundating people with too much information leads to their overlooking critical information for immediate action. Changing this mindset will require industry and regulators to distinguish such critical information from learnings that could be reviewed on a less frequent basis.

The Well Operations Group Advisory developed for the Gulf of Mexico was also markedly different from the North Sea Operations Advisory concerning Sedco 711.[456,457] Where the GoM advisory described the event simply as a "well control event," the North Sea included a description of the consequences such as 11 days of lost time, cost of approximately 5.2 million Euros (~6.5 million US dollars), and significant loss to Transocean's reputation. While the US advisory only addressed the well control manual text changes, the North Sea advisory provided details concerning:

- misplaced faith in a tested barrier;
- secondary activities that obscure the ability to monitor the pit levels;
- rationalizing rig data;
- no clear procedures in underbalanced conditions;
- weak risk assessments;

Despite the suggestion of several inherent human performance issues, the advisory corrective actions focused on reminding the drill crew of the importance of kick detection and their responsibilities, as well as the need to provide written warnings in the daily instructions when a single mechanical barrier is in effect.[458] Missing was an attempt to understand the psychological and cognitive reasons the crew placed faith in the barrier or rationalized the data. (For example, perhaps control board design or inadequate instrumentation contributed to their situational awareness of the well. This would be unknown unless examined as part of the investigation.) Also absent were identified steps the company might take to provide procedural clarity, conduct more useful risk assessments, or ensure secondary activities do not eclipse safety critical activities in future projects. Furthermore, the mudlogger communication issues mentioned earlier were not addressed.[459] Both the North Sea advisory and the more limited US version do not address these important underlying factors in order to resolve the human factors issues revealed in the investigation.

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[456] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 28, 2011; see Johnson Designations Vol 1, pp 104-106, http://www.mdl2179trialdocs.com/releases/release201302281700004/Johnson_Paul-Depo_Bundle.zip (accessed October 7, 2015).

[457] Internal Company Documents, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, and *Well Operations Group* Advisory, HQS-OPS-ADV-09, April 5, 2010, TRN-MDL-02840793 and TRN-MDL-02840795, see Exhibit 5749 http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip, (accessed October 7, 2015).

[458] Internal Company Documents, Transocean. *Operations Advisory*, NRS-OPS-ADV-008, April 14, 2010, and *Well Operations Group* Advisory, HQS-OPS-ADV-09, April 5, 2010, TRN-MDL-02840793 and TRN-MDL-02840795, see Exhibit 5749 http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip, (accessed October 7, 2015).

[459] See Section 1.7.1.1.

Large corporations like Transocean often consist of a series of business units which act as freestanding commercial organizations. So, while Transocean's North Sea and Gulf of Mexico business units work from the same corporate policies, implementation of those polices is determined separately by the independent business unit leaders. This can be described as centralized direction with decentralized implementation. As the Sedco 711 incident exemplifies, this approach can lead to different results among business units in the same company. The CSB and others previously noted the role a decentralized organizational structure can play in a major accident,[460] leading to systemic and cultural differences across business units rather than a consistent approach to managing major accident risk.

2.3 Expanding Beyond Immediate Causes and Implementing Change

The broadest learning impact can be achieved when investigations extend beyond the immediate technical causes of an incident. Addressing deficient safety management systems and inadequate organizational practices can result in findings that go beyond the immediate chain events that preceded any one incident. As examples in this chapter show, while the immediate causes of a well control incident might vary, the safety management systems and organizational findings can be similar. Ultimately, BSEE has the opportunity to mandate such a focus and then facilitate the dissemination of lessons across the operator/drilling contractor boundary and geographical regions.

There is the danger of concentrating on the exact mechanism of the previous incident rather than identifying broad lessons. Regulatory requirements may exacerbate this narrow focus for investigating major accidents and near-misses. In the US, the SEMS Rule excludes drilling contractors and require only operators to complete incident investigations. Additionally, the SEMS Rule requires that the investigations identify contributing factors but do not explicitly require investigations to extend beyond the immediate causes to deficient safety management systems on the rig and inadequate organizational practices by either the operator or the drilling contractor.[461] In Europe, a recently adopted directive strives "to facilitate the exchange of information and to prevent future accidents of a similar nature," but then focuses on information of "technical interest" when describing information to be reported on near-misses.[462]

The global nature of drilling and the overlap that occurs when drilling contractors like Transocean work for multiple operators presents the opportunity for expediting industrywide learning with each well control event. Similarly, international operators could expose each other to learnings as a part of their

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[460] CSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005*, Report No. 2005-04-I-TX, March 2007.; Hopkins, A. *Disastrous Decisions;* CCH Australia: Australia, 2012; pp 97 - 110.; The Baker Panel. *The Report of the BP US Refineries Independent Safety Review Panel;* January, 2007; pp 94. http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf (accessed October 7, 2015).; UK Health and Safety Executive and Scottish Environment Protection Agency. *Major Incident Investigation Report BP Grangemouth Scotland;* August 18, 2003; p 62.

[461] 30 C.F.R. § 250.1919 (2015).

[462] Directive 2012/18/EU of the European Parliament and the Council of 4 July 2012 on the Control of Major-Accident Hazards Involving Dangerous Substances, Amending and Subsequently Repealing Council Directive 96/82/EC.

joint ventures. Well incident databases from before[463] and after[464] the Macondo incident collect safety incident information that can be analyzed and shared across the industry to increase lessons learned. While industry develops and maintains these incident databases, regulators can also influence incident reporting and the sharing and implementing of lessons learned.

[CALL-OUT BOX START]

Additional Roadblocks to Organizational Learning

Beyond the challenges discussed in this chapter, there are additional roadblocks that cannot be ignored.

Legal challenges to sharing information from internal investigations threaten maximum learning. At the Expert Forum on the Use of Performance-Based Regulatory Models in the US Oil and Gas Industry, Offshore and Onshore,[a] *a staff consultant from the Center for Chemical Process Safety commented, "too often when it's post-incident, lawyers get involved and it's very, very difficult to share information."*[b] *The speaker also described how companies fear that lessons learned will result in a punitive response from the regulator, so they start to protect documents under attorney-client privilege. He commented, "So, the more punitive the lawyers become concerned, the more closely they hold information. And really we need to go the other direction."*[c]

The timeliness of information is also of concern. The legalities surrounding incidents can affect when, if ever, information concerning an incident is released. For example, some technical findings related to the Macondo blowout were released within a year of the incident,[d] *but information that provided insight to the organizational and operational issues (including human performance) was not released until almost three years later when the US District Court for the Eastern District of Louisiana posted documents and depositions online that had been submitted as part of the criminal hearings.*

These two critical challenges must be overcome to further advance learning.

[a] Expert Forum on the Use of Performance-Based Regulatory Models in, 77 Fed. Reg. 50172 (August 20, 2012) https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=23267 (accessed October 7, 2015).

[b] Stakeholder meeting transcript for the Expert Forum on the Use of Performance-Based Regulatory Models in the U.S. Oil and Gas Industry, Offshore and Onshore, OSHA-2012-0033-0022, September 21, 2012, p 17.

[c] Stakeholder Meeting Transcript for the Expert Forum on the Use of Performance-Based Regulatory Models in the U.S. Oil and Gas Industry, Offshore and Onshore, OSHA-2012-0033-0022, September 21, 2012, p 36.

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[463] For example, Step Change in Safety supported Safety Alert Database and Information Exchange (SADIE) (now known as the Incident Alerts Database) https://www.stepchangeinsafety.net/safety-conversations/intro; (accessed October 7, 2015), SINTEF Offshore Blowout Database http://www.sintef.no/en/projects/sintef-offshore-blowout-database/ (accessed October 7, 2015), and the Norwegian Oil and Gas' Drilling Managers Forum initiative, Sharing to be Better, https://www.norskoljeoggass.no/en/Activities/HSE-and-operation/Sharing-to-be-better/.

[464] For example, in the UK the Oil & Gas Producers Wells Expert Group started a well control incident database http://www.iogp.org/Newsroom/News/PostId/71/well-control-incidents-database-submissions-a-benefit-to-industry (accessed October 7, 2015); in the US the Center for Offshore Safety initiated a Learning from Incidents program http://www.centerforoffshoresafety.org/COS%202013%20Annual%20Performance%20Report.pdf (accessed October 7, 2015).

[d] Bureau of Ocean Energy Management Regulation and Enforcement (BOEMRE). *Forensic Examination of Deepwater Horizon Blowout Preventer;* Report No. EP030842; March 11, 2011.

[CALL-OUT BOX END]

2.4 Effectiveness of post-Macondo SEMS Requirements for Incident Investigation

At the time of the Macondo blowout, BSEE's predecessor MMS published investigations of selected serious incidents,[465] but US offshore regulations did not require companies to investigate their own incidents. With BSEE's promulgation of the SEMS Rule, operators now must develop investigation procedures for "all incidents with serious safety or environmental consequences."[466] For situations that have the "potential" for serious consequences, facility management or the regulator may determine that an investigation is necessary. Factors that contributed to the incident and recommended changes must be addressed, and a corrective action program must be established where the conclusions are distributed to "similar facilities and appropriate personnel within their organization."[467] The requirements do not explicitly stipulate that safety management systems, the interface between the operator and contractors, or lessons learned from either international incidents or other companies be addressed. A March 8, 2010, well kick at Macondo exemplifies how an investigation lacking in these characteristics can result in missed opportunities to prevent similar consequences.

While drilling the Macondo well at a depth of approximately 13,250 feet, a well kick occurred.[468] The crew noted an increasing gain in pit volume,[469] prompting them to shut in the well for evaluation. Rig data indicates the well flowed undetected for approximately 30 minutes and resulted in a gain of 35 barrels before the situation was brought under control.[470] The larger the ingress, the greater the potential hazard,

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[465] See BSEE's Panel Investigation Reports at http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Panel-Investigation-Reports/Panel-Investigation-Reports/ (accessed October 7, 2015).

[466] 30 C.F.R. § 250.1919 (2014).

[467] 30 C.F.R. § 250.1919(b)(3).

[468] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, May 11, 2011; See Sepulvado Designations Vol 1, pp 29-32, http://www.mdl2179trialdocs.com/releases/release201304041200022/Sepulvado_Murry-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, Transocean. IADC Daily Drilling Report, Deepwater Horizon, Report No. 37 (March 8, 2010), http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00657.pdf (accessed October 7, 2015).

[469] See footnote 434 for definition.

[470] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, May 11, 2011; See Sepulvado Designations Vol 1, pp 29-32, http://www.mdl2179trialdocs.com/releases/release201304041200022/Sepulvado_Murry-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, Transocean. IADC Daily Drilling Report, Deepwater Horizon, Report No. 37 (March 8, 2010).; Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 20, 2011; see Burgess Designations pp 31 - 38, http://www.mdl2179trialdocs.com/releases/release201302281700004/Burgess_Mark-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, BP. *File Note: Information regarding kick taken on Deepwater Horizon on March 8th 2010*, Exhibit 676, BP-HZN-BLY00096442,

and Transocean documented that the majority of well kicks are detected in under 20 barrels, and noted that “failure to limit a kick to less than 20 barrels is less than ideal.”[471] Thus, the March 8 and previously described Sedco 711 and M.G. Hulme, Jr., incidents proved to be crucial missed opportunities for Transocean to examine crew kick response time, share the subsequent lessons learned, and incorporate changes in their safety management systems to support improvements. Ultimately, while Sedco 711 and M.G. Hulme identified systemic deficiencies, none appeared in the official investigation of the March 8 incident by either company, nor were corrective actions taken to remedy such failures.

BP requires well control incidents be reported in its official corporate incident reporting system, Tr@ction.[472] However, no Tr@ction report was created for the March 8 event.[473] The Wells Team Leader for the DWH “did not know that reporting this type of an incident was a requirement.”[474] BP did, however, conduct a technical examination of the kick, which looked at the variables such as the geological conditions of the well and pore pressure detection analytics.[475] BP’s Tiger Team[476] shared

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http://www.mdl2179trialdocs.com/releases/release201302281700004/Lee_Philip-Depo_Bundle.zip (accessed October 7, 2015).

[471] In 2009, Transocean recorded that 84% of kicks were detected in under 20 barrels, and 14% of kicks ranged from 20 to 60 barrels. Internal Company Document, Transocean. *Well Control Events & Statistics 2005 to 2009*, pp 6, TRN-INV-00760054, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05649.pdf (accessed June 24, 2015).

[472] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, Section 15.2.12, BP-HZN-BLY00034504, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[473] Internal Company Document, BP. *BP Incident Investigation Team - Notes of Interview with John Guide*, July 1, 2010, BP-HZN-BLY00124228, see Exhibit 0153 http://www.mdl2179trialdocs.com/releases/release201302281700004/Paine_Kate-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, BP. *BP Incident Investigation Team - Notes of Interview with Mark Hafle*, July 8, 2010, BP-HZN-BLY00144214, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-04447.pdf (accessed October 7, 2015).

[474] Internal Company Document, BP. *BP Incident Investigation Team - Notes of Interview with John Guide*, July 1, 2010, BP-HZN-BLY00124228, see Exhibit 0153 http://www.mdl2179trialdocs.com/releases/release201302281700004/Paine_Kate-Depo_Bundle.zip (accessed October 7, 2015).

[475] Internal Company Document, BP. *Macondo LL*, March 18, 2010, Powerpoint presentation prepared by the BP Macondo well onshore engineering team, BP-HZN-2179MDL00340813, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-000051.pdf (accessed October 7, 2015).; Internal Company Document, BP. *File Note: Information regarding kick taken on Deepwater Horizon on March 8th 2010*, BP-HZN-BLY00306271, see Exhibit 7321 http://www.mdl2179trialdocs.com/releases/release201302281700004/Cowie_James-Depo_Bundle.zip (accessed October 7, 2015).

[476] The Tiger Team is a group of experts (e.g., in shallow hazard assessment, pore pressure prediction, operations geology, etc.) that provides onshore sub-surface support for the planning and execution of deepwater exploration wells.

additional lessons learned through emails among the team.[477] Mainly, the lessons were technical, but one concerned better lines of communication among BP rig personnel and the "Houston office." It was noted that the mudlogger and wellsite pore pressure/fracture gradient[478] personnel should openly communicate with the wellsite geologist, who should then communicate with the BP well site leader.[479] However, this document did not address the potential human factors related to the well operations crew's kick response capabilities, nor how to improve that response through more effective technologies, barrier management, and safety system performance.

At the time of the incident, Transocean required a Well Control Event Report whenever the rig experienced a well kick.[480] The Well Control Event Report recorded the conditions in the well at the time of the kick (e.g., mud weight, shut in drillpipe pressure, size of influx), and it required a root cause analysis of the event. In response to the March 8 kick, Transocean created an operation event report for the March 8 kick, attributing the event to "drill[ing] into abnormal pressure," but provided minimal information about the event and identified no corrective actions.[481] In emails with the BP Wells Team Leader, the Transocean Rig Manager identified the need to improve hazard recognition among the crew.[482] However, neither BP nor Transocean connected similarities of the March 8 kick with previous Transocean incidents, nor reviewed previously identified safety management system or communication deficiencies that might also have occurred at the Macondo well.

Ultimately, the March 8 incident was not investigated for its safety implications. It is worth reemphasizing that BP did not identify the delayed response on March 8 as a safety concern in its formal investigation of the incident, but it did acknowledge it post-Macondo.[483]

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[477] Email from Tiger Team Members, BP, Subject: RE: Lesson learned - Plan forward: Macondo, March 18, 2010, BP-HZN-2179MDL00015694, http://www.mdl2179trialdocs.com/releases/release201304041200022/TREX-00214.pdf (accessed October 7, 2015).

[478] See Volume 1, Section 2.1 for description of pore pressure and fracture gradient.

[479] Email from Tiger Team Members, BP, Subject: RE: Lesson learned - Plan forward: Macondo, March 18, 2010, BP-HZN-2179MDL00015697, http://www.mdl2179trialdocs.com/releases/release201304041200022/TREX-00214.pdf (accessed October 7, 2015).

[480] Internal Company Document, Transocean. *Well Control Handbook*, Revision 01, HQS-OPS-HB-01, March 31, 2009, Well Control Procedures and Responsibilities and Appendix, BP-HZN-2179MDL0033078 AND BP-HZN-2179MDL00331106, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-00596.pdf (accessed October 7, 2015).

[481] Internal Company Document, Transocean. *Well Control Event Report*, OER-DWH-10-023, March 8, 2010, TRN-MDL-00287183, see Exhibit 0688 http://www.mdl2179trialdocs.com/releases/release201302281700004/Johnson_Paul-Depo_Bundle.zip (accessed October 7, 2015).

[482] Email from Macondo Rig Manager, Transocean, to Wells Team Leader, BP, Subject: Hazard Recognition, 18 March, 2010, BP-HZN-2179MDL00289217, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-000684.pdf (accessed October 7, 2015).

[483] In the aftermath of Macondo, the response time of the crew to the March 8 kick was criticized. The BP Wells Team Leader indicated that the well operations crew's response to the kick as "very poor," and that the Transocean Rig Manager believed the crew "had screwed up;" Internal Company Document, BP. *BP Incident Investigation Team - Notes of Interview with John Guide*, July 1, 2010, BP-HZN-BLY00124228, see Exhibit

While current US offshore regulations require companies to address contributing factors in incident investigations, the regulations do not explicitly require investigations to extend beyond the immediate causes to deficient safety management systems and inadequate organizational practices. The Macondo blowout and other incidents discussed in this chapter point toward a need for an investigation to cover the operator/ contractors interactions, but the SEMS Rule excludes contractor compliance.[484] And while the SEMS Rule requires that "The factors (human or other) that contributed to the initiation of the incident and its escalation/control" be addressed in incident investigations [250.1919(a)(2)], it does not provide guidance on human and organizational analyses and joint operator/drilling contractor investigations.

Companies may comply only minimally with regulations that require the conduct of an activity (in this case, investigation of an incident) but do not explicitly stipulate the outcome to be achieved (i.e., major accident prevention through demonstrated risk reduction).[485] This reality exists even when internal company policies stipulate more stringent practices (Section 4.1). The SEMS Rule does not require that corrective actions from investigation findings demonstrably reduce risk to an identified goal. Volume 2 of the CSB's Macondo investigation report highlights pitfalls of not requiring companies to mitigate risk to targeted risk levels.[486] In summary, the potential exists for a company to satisfy regulatory requirements even though they may not adequately or effectively reduce the hazards of major accidents. The SEMS Rule requirements need to move beyond an activity-based focus, require in-depth assessment of organizational contributions, and encourage sharing of lessons learned across the offshore global community within and between companies.

2.5 Conclusion

Several of the issues raised in Chapter 1 concerning system and organizational deficiencies were not unique to the work conducted at the Macondo well—latent kick detection was not a Deepwater Horizon crew problem, but a challenge that Transocean faced internationally several times before. International investigation reports reviewed in this chapter identified improvements in tools that help minimize the gap between WAI and WAD, as well as those to help raise a crew's hazard awareness, but they were not implemented in the Gulf of Mexico.

Offshore regulations provide the minimal safety expectations a company must meet. Accordingly, if US regulations do not establish goals for incident investigations that require not just immediate technical findings, but also lessons from international incidents, then companies have the opportunity to limit what they do in response to incidents and near-misses. The M G. Hulme Jr., Sedco 711, and Deepwater Horizon March 8 well control event and April 20 blowout all indicate that incidents and near-misses need to be viewed beyond an individual rig level and within the larger context of a safety performance indicators program (addressed in detail in the next chapter). But, an indicators program can be only as

0153 http://www.mdl2179trialdocs.com/releases/release201302281700004/Paine_Kate-Depo_Bundle.zip (accessed October 7, 2015).

[484] See Volume 4, Section 3.2 for details.

[485] See Volume 4, Section 2.5 for details.

[486] Volume 2, Section 6.1.1.1

good as the data upon which it is based, and it will be ineffective if the findings resulting from an investigation or indicator program are not actually acted upon to continually improve safety.

3.0 Safety Performance Indicators

Chapter 3.0 Overview

This chapter begins with a more detailed description of efforts to advance understanding of effective safety performance indicators and a review of why indicators reflected in company policies, practices, audits, rewards, and reports become the foundational elements of a company's approach to risk management. The chapter then illustrates that BP and Transocean inadequately collected and used process safety indicator data. Finally, a review of the guidance available to industry calls for further improvements in developing, collecting, and using safety performance indicators.

Companies involved in offshore drilling and production—and even trade associations and regulators—can develop and use organizational and managerial measures, also called indicators, to monitor safety performance, compare or benchmark that safety performance, and set goals for continual improvement.

In the oil and gas industry, safety performance can be separated into two categories: personal safety (also called occupational safety) and process safety, which addresses efforts to reduce the potential for a major accident event.[487] The distinction is important because the indicators to monitor and the approaches to manage the two categories are different. For example, good personal safety is indicated by low individual worker injury rates which, for some tasks, could be achieved by simply using appropriate personal protective gear. In contrast, an offshore process safety indicator might be a well operations crew's well kick response time which, as Chapter 0 indicates, could require a variety of approaches to improve including safety critical task analysis and better communication between the operator and contractors.

History has repeatedly proven that good personal safety statistics have, in fact, often preceded major accident events, yet industry and regulators still rely on personal safety metrics to indicate good process safety performance. After the Macondo blowout when, then-CEO, Tony Hayward commented on BP's safety record:

> Before this tragic incident, our safety record was improving, with the key metrics such as recordable injury frequency (RIF),[488] days away from work case frequency (DAFWC)[489] and on-site fatalities all on a downward trend. This accident has been a terrible exception to that trend and we must learn the lessons from it.[490]

Unfortunately, good personal safety indicators can produce a false sense of security concerning process safety performance. RIF and DAFWC trends are the wrong ones to monitor the robustness of safety critical barriers and safety management systems intended to prevent and mitigate major accident events.

[487] A process safety incident is the unexpected releases of toxic, reactive, or flammable liquids and gases in processes involving highly hazardous chemicals—*Process Safety Management*, OSHA 3132, 2000 (reprinted).

[488] Recordable injuries as those that result in death, days away from work, restricted work or transfer to another job, medical treatment beyond first aid, or loss of consciousness, § 1904.7

[489] An industry benchmark defined as injuries that result in an employee being away from work for at least one calendar day after the injury.

[490] Email from BP's Employee Communications, to BP Employees, Subject: Gulf of Mexico update from Tony Hayward, July 9, 2010, BP-HZN-2179MDL01617349, see Exhibit 6059, http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed October 7, 2015).

This chapter begins by distinguishing personal and process safety indicators, providing several demonstrable examples when good personal safety statistics did not equate to good process safety, and then delves into BP's and Transocean's indicator programs. At the time of the Macondo incident, both BP and Transocean measured and rewarded personal safety metrics, many of which require reporting to the regulator; correspondingly, both companies achieved low personal worker injury rates. Conversely, process safety did not receive the same attention from either company.

The chapter then describes advances in safety performance indicators since Macondo. After describing the general characteristics of effective process safety indicators, the chapter presents a selection of process safety indicators from various industry viewpoints. As the timescale of various indicators is diverse, this chapter discusses slow-moving metrics and real-time metrics that can be used to improve daily operational activities. Finally, the CSB proposes several indicators that could have made a positive impact on risk management at the Macondo well.

Both industry and the regulator must collect and assess valuable industrywide process safety indicators across the offshore community. Because companies may use various approaches to reduce risk and manage their major accident hazards, they also need to develop their process safety indicators for their specific barriers and actively monitor that data to maximize the benefits of their indicator programs. Industrywide good practice guidance on such indicators is relatively general at this time, so companies, regulators, and industry trade associations have an opportunity to propel it toward more detailed and practical proposed indicators.

3.1 Process Safety Performance Indicators for High-hazard Work Environments

Personal safety incidents can have serious consequences for individual workers, and are statistically far more common than major process safety incidents. As such, companies and regulators have taken steps to minimize them with some success. Yet process safety expert and chemical engineer Trevor Kletz (1922-2013) noted that relying on good personal safety performance results, such as recordable injury rates, as a barometer for process safety can introduce "a feeling of complacency, a feeling that safety was well managed."[491] Numerous findings from major chemical and petrochemical accidents in the United States, including several the CSB investigated, demonstrate that personal safety statistics are not good indicators for the health of barriers and safety management systems intended to prevent major accidents:

- In 1989, a Phillips chemical plant experienced a catastrophic series of explosions and fires that killed 23 workers, yet the company operated for several million work hours without a lost time incident.[492] Post-incident findings indicated that no hazard analysis was utilized at the plant to identify process hazards, a permit to work system was not enforced at the plant, and personnel

[491] Kletz, T. *An Engineer's View of Human Error,* 3rd ed.; Institution of Chemical Engineers: Warwickshire, UK, 2001.

[492] A Lost Time Incident (LTI) is an injury that makes so a worker is unable to perform his or her regular duties, needs to take time off for recovery, or has to be assigned modified job activities.

and critical control equipment were not separated from process units in accordance with accepted good engineering principles.[493]

- In 2004, the BP Texas City refinery was lauded by the BP Group CEO for the refinery's "best year ever" in terms of safety performance due to low recordable injury statistics—despite the documented failure to correct major process safety and management system deficiencies identified that same year in audits, mechanical integrity reviews and incident investigations. The following year, OSHA injury data noted the refinery was off to such a good start that its 2005 safety performance record "may be the best ever," a characterization which was turned on its head when a March 2005 refinery explosion killed 15 workers and injured 180 others.[494]
- In 2007, the Valero McKee Refinery in Sunray, Texas suffered a process safety incident that seriously burned 4 workers and forced an unexpected plant shutdown, despite low OSHA recordable injury rates and a fine personal safety record. Post incident findings noted a lack of management of change reviews before the incident,[495] a process hazard analysis that did not effectively identify hazards posed by fire exposure to neighboring equipment, and lack of engineering controls to stop the flow of high pressure flammable material.[496]
- In 2008, the Bayer CropScience facility in Institute, West Virginia, suffered a serious process safety incident that killed 2 workers and injured 8 others, among other documented process safety incidents, despite low OSHA recordable injury rates.[497] Post-incident findings indicated that a pre-startup safety review was not applied and personnel had been inadequately trained to operate new equipment involved in the accident.
- In 2010, CITGO's Corpus Christi refinery received national industry recognition[498] for safety performance in 2010 based on the refinery's low recordable injury rates in the previous year as reported to OSHA, notwithstanding that in 2009 the company suffered a major fire and release of dangerous hydrofluoric acid in its alkylation unit.[499]

[493] US Department of Labor Occupational Safety and Health Aministration. *The Phillips 66 Company Houston Chemical Complex Explosion and Fire*; 1990.

[494] USCSB, 2007. Refinery Explosion and Fire, Texas City, TX, March 23, 2005, Report No. 2005-04-I-TX, March 2007, pp 168 and 175, http://www.csb.gov/assets/1/19/csbfinalreportbp.pdf (accessed October 7, 2015).

[495] Management of Change is a systematic method for reviewing the safety implications of modifications to process technology, facilities, equipment, chemicals, organizations, policies, and standard operating practices and procedures.

[496] USCSB, 2008. *LPG Fire Valero - McKee, Sunray, TX, Feburary 16, 2007*, Report No. 2007-05-I-TX, July 2008, http://www.csb.gov/assets/1/19/CSBFinalReportValeroSunray.pdf (accessed October 7, 2015).

[497] USCSB, 2011. *Pesticide Chemical Runaway Reaction and Pressure Vessel Explosion, Bayer Crop Science, Institute, West Virginia, August 28, 2008,* Report No. 2008-08-I-WV, January 2011, http://www.csb.gov/assets/1/19/Bayer_Report_Final.pdf (accessed October 7, 2015).

[498] This CITGO site received the National Petrochemical and Refiner's Association (now called the American Fuel & Petrochemical Manufacturers, or AFPM) annual award for the previous year's safety performance. Through the latter portion of the last decade, NPRA/AFPM relied exclusively on records maintained for employee injuries, illnesses, or death as recorded on the required OSHA 300 Form, though according to AFPM's website, current award qualification criteria is now based on both the "OSHA 300A Summary and API 754 Process Safety Collection." See www.afpm.org/Safety-Programs/ (accessed October 7, 2015).

[499] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; pp 13 – 14, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

- In 2010, the Tesoro Refinery in Anacortes, Washington, only a few weeks after winning the same national safety award as CITGO, suffered a devastating explosion and fire that took seven workers' lives when a nearly 40-year-old heat exchanger catastrophically failed during a maintenance operation to switch a process stream between two parallel banks of exchangers.[500] Post-incident findings indicated that safeguards were not evaluated, hazardous leaks at the refinery were normalized, process hazard analyses repeatedly failed to control the hazards presented by the leaks, and Tesoro did not monitor the actual operating conditions of the equipment that failed.
- At the time of the Macondo incident, a visiting team of executives focused on personal safety issues, touring the Deepwater Horizon rig to help celebrate the rig's excellent total recordable injury rate and to share lessons learned from a personal injury incident on another rig.[501]

Risk management approaches and measures to monitor for and manage the process safety hazards noted above are different than those for personal safety. Table 3-1 highlights some of significant differences.

[CALL-OUT BOX START]

"Industry has a long history of measuring safety performance based on lost time accident (LTA) rates … Safety is taken very seriously by most organizations and senior management takes an active interest in reducing LTA rates, providing leadership and resources aimed at improving performance … Unfortunately, LTAs do not show senior managers how well the low frequency/high consequence accidents are being managed. Incidents involving the failure of process safety can be devastating with the potential for multiple fatalities, offsite impacts and large scale environmental damage. Managers often fall into the trap of believing that a low and reducing LTA rate means that corporate safety is under control. History shows us that this is often not the case."

Christopher J. Beale, *Process Safety Performance Indicators – Experience Gained from Designing and Implementing a System of PSPIs for Different Chemical Manufacturing Operations*, ICheme Loss Prevention Bulletin 212 (April 2010), p 23.

[CALL-OUT BOX END]

[500] USCSB, 2014. *Catashtrophic Rupture of Heat Exchanger*, *Anacortes, WA*, *April 2, 2010,* Report No. 2010-08-I-WA, May 2014, http://www.csb.gov/assets/1/7/Tesoro_Anacortes_2014-May-01.pdf (accessed October 7, 2015).

[501] CSB interviews.

Table 3-1. Distinctions between Process and Personal Safety[502, 503, 504]

	Process Safety	**Personal Safety**
Examples of Safety indicators	Hydrocarbon releases, inspection frequency, number of well kicks, well kick response time, PSM/SEMS audit action item closure	Recordable injury rate, days away from work frequency, number of behavior observations
Scope	Complex technical and organizational systems and/or operations and barriers	Individuals, individual behaviors/actions
Risk	Incidents with catastrophic potential (low frequency, high consequence)	Slips, trips, falls, dropped objects, etc. (high frequency, low consequence in terms of number injured)
Consequences of a single event	Release of dangerous materials or energy (e.g., fires, explosions) with the potential for multiple fatalities, major destruction of property/equipment, and environmental damage, all of which could extend beyond the confines of the workplace, as well as commercial and reputational damage	Most often results in individual workplace injury/fatality and/or minor facility/equipment damage.

Yet, many companies, as well as industry groups, and even the Occupational Safety and Health Administration (OSHA)[505] and the Mineral Management Service (MMS, now BSEE), as onshore and offshore safety regulators, respectively, have tended to rely on personal safety performance indicators as the preeminent measures of a company's overall status of "safety."[506] This leaves a critical gap in process safety performance monitoring that needs to be filled to prevent the next Macondo.

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502 Holmstrom, D. *US Performance Indicators to Drive Improvement: CSB Overview*, CSB Safety Performance Indicator Public Hearing, Houston, TX, July 23, 2012, slide 4. http://www.csb.gov/UserFiles/file/Holmstrom%20%28CSB%29%20PowerPoint.pdf (accessed October 7, 2015).

503 The Baker Panel. *The Report of the BP US Refineries Independent Safety Review Panel;* January, 2007; p 21. http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf (accessed October 7, 2015).

504 Hopkins, A. *Thinking About Process Safety Indicators;* Working Paper 53; National Research Centre for OSH Regulation: May, 2007, p 3.

505 While OSHA injury and illness collected data do not focus on process safety, it can reflect critical occupational health and safety indicators that extend beyond "personal" safety matters. For example, the data may establish patterns of illness or injury that affect worker populations.

506 See Volume 4, Section 4.2 for discussion on MMS/BSEE's use of indicators. An industry example includes the International Association of Drilling Contractors (IADC) which tracks work-related recordable injuries as part of its Incident Statistics Program (ISP) that recognizes companies for their "outstanding safety performance," http://www.iadc.org/isp/ (accessed October 7, 2015).

3.2 BP's Selection and Use of Performance Indicators

Through a review of key corporate documents, corporate-wide communications, and programs, this section shows that BP primarily used lagging, infrequent, and personal safety performance indicators as a means of assessing, measuring, and managing process safety.

3.2.1 BP Corporate Policies Reflect a Focus on Production, Personal Safety, and Lagging Indicators

BP's overall approach to using performance indicators in the Gulf of Mexico at the time of the Macondo incident is described in the *BP Gulf of Mexico Drilling and Completions Operating Plan and Local OMS Manual*.[507] In the document, BP committed that its management system was part of a continual improvement process that would establish clear plans and controls to achieve and maintain goals. This process was to be monitored by establishing key performance indicators to track progress using different safety, environmental, and regulatory metrics, which became for GoM business unit leaders the content of a report, commonly referred to as the Maroon Book (see Table 3-4).[508,509]

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[507] Internal Company Document, BP, *GoM Drilling and Completions; GoM D&C Operating Plan/Local OMS Manual*, 2200-T2-DM-MA-0001, November 1, 2009, pp 19, BP-HZN-MBI00193448, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-06065.pdf (accessed October 7, 2015).

[508] BP operations are divided into business units like the Gulf of Mexico Drilling & Completions or the Gulf of Mexico Exploration & Appraisal units. Individual business unit leaders oversee operations and performance of the units.

[509] Hearing before the Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 10, 2013, Morning Session pp 8109 – 8110, http://www.mdl2179trialdocs.com/releases/release201304101200025/2013-04-10_BP_Trial_Day_25_AM-Final.pdf (accessed October 7, 2015).; Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 17, 2011, see Dupree Designations Vol 2 pp 176, http://www.mdl2179trialdocs.com/releases/release201302281700004/Dupree_James-Depo_Bundle.zip (accessed October 7, 2015); Internal Company Document, BP. *Gulf of Mexico SPU Operating Plan (OMS Handbook)*, December 3, 2008, BP-HZN-2179MDL00333175, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-002908.pdf (accessed October 7, 2015).

Table 3-2. Indicator data collected for the Gulf of Mexico as reported in BP's Maroon Book for 2009.[510]

Gulf of Mexico (GoM)	BP's Classification/Description	Reported Number for 2009
Major Incidents and HIPOs		
Major Incident Announcements (MIAs)	Lagging	0
High Potential Incidents (HIPOs)	Lagging	11 total (only 1 process safety related)
MIA & HIPO Lessons Learned Reports Issued	Leading	9
Health and Safety		
Workforce Fatalities	Lagging, mature industry standard metric	0
Days Away from Work Case Frequency (DAFWCF) †	Lagging, mature industry standard metric	0 BP/0.1 Contractors
Recordable Injury Frequency (RIF)	Lagging, mature industry standard metric	0.9 BP/0.54 Contractor
Recordable Occupational Illness Frequency	Lagging, aim is improved reporting	0.09 BP/0 Contractor
Operations Integrity		
Process Safety Incident Index*	Lagging metric	21 BP/ Contractor not reported
Fires & Explosions	Lagging, industry standard	-
Loss of Primary Containment (LOPC)	Lagging, emerging industry standard	26 BP/ 2 Contractor
Flammable Gas Releases	Lagging, based on LOPC	11 BP/ 0 Contractor
Number of Oil Spills	Lagging, mature industry standard metric	8 BP/1 Contractor
Volume of Oil Spills	Lagging, mature industry standard metric	All spills less than 100 barrels
Overdue Plant Inspections & Tests	Leading	No reported numbers
Major Accident Risk (MAR) Assessments Completed	Leading	No reported numbers
MAR Action Closures	Leading	No reported numbers
Compliance, Audit and Action Closure		
Safety & Operations (S&O) Audit Delinquent Actions	Number overdue	0
Number of Approved Changes	Change to content/Due Date/Responsibility for S&O Audit Action	0
Incident Investigation - Action Closure	Actions from HIPO & MIA Investigations	100%

†An industry benchmark defined as injuries that result in an employee being away from work for at least one calendar day after the injury (see definition in API 754). API 754 classifies DAWFC as process safety events only if they are the result of an actual loss of containment due to weaknesses in barriers. BP did not distinguish between personal and process safety DAWFC in its metrics.

*The Process Safety Index considers four outcomes: (1) hazard severity of LOPC, (2) severity of fires and explosions, (3) injuries sustained, and (4) environmental impact.

510 Internal Company Document, BP. *GoM Maroon Book*, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-045257.xls (accessed June 16, 2015).

As BP indicated, no reported data for the leading indicators was listed in Table 3-2, and the rest of the indicators were lagging, many of them typical metrics used across industry and collected by the regulator.[511] Notably missing from Table 3-2 are process safety indicators to address safety management systems, safety critical barriers, or even well kicks, several of which BP-contracted Transocean rigs experienced.[512] Nor is there any indication of threats (e.g., weather, ship traffic, or active work permits) that could provide feedback to original risk assessment assumptions.[513] As evident in Table 3-2, contractor data is incorporated into the Maroon Book statistics.

BP also published an Orange Book quarterly that was shared with senior BP executives and the Board, [514] and included metrics used to generate the Maroon Book, but it addressed the entire international upstream segment.[515,516] Although BP executives and management could have used the Orange Book data for action planning or other more strategic initiatives related to process safety or major accident prevention (MAP), the indicators did not provide insight for BP's safety management systems, safety critical barriers, or threats. Furthermore, lacking from the Orange Book were stated goals, objectives, or other desired outcomes (e.g., reduction targets), set forth as expectations against which to compare, measure, and improve actual safety performance. BP did not state in advance how it would use the data to drive continual improvement, and it did not discuss variance in the level of safety attained versus the level of safety expected.

3.2.2 Individual Performance Plans Lacked Process Safety Metrics

Performance indicators can be used to drive individual performance safety goals when management uses them to steer the organization toward specific safety goals. In this way, the workforce can be influenced to approach "safety" as the company defines it. A review of performance contracts for BP employees connected to the Macondo well at various levels and job positions (Figure 3-1) indicates that personal

[511] Oil and Gas and Sulphur Operations in the Outer Continental Shelf - Incident Reporting Requirements, 71 Fed. Reg. 19,640 (April 17, 2006).

[512] Internal Company Document, Transocean. *Annual Report - 2009 Well Control Events & Statistics 2005 to 2009*, pp 7, TRN-INV-00760087, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05649.pdf (accessed May 22, 2015).

[513] Section 3.4 provides more examples of potential indicators.

[514] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, Feburary 28, 2013 pp 1156-1157, http://www.mdl2179trialdocs.com/releases/release201302281700004/2013-02-28_Barbier_Day_04_PM-Final.pdf and June 29, 201, see Mogford Designation Vol 2,1 p 49, http://www.mdl2179trialdocs.com/releases/release201302281700004/Mogford_John-Depo_Bundle.zip (accessed October 7, 2015).

[515] BP's upstream segment encompasses exploration, development and production activities.

[516] Internal Company Document, BP.

safety metrics such as Total Recordable Incident Rate (TRIR)[517] and DAFWC trends were included in individual performance goals, but several indicators tracked in the Maroon and Orange Books were not.[518] Instead, many of the indicators listed on BP performance plans were compliance-based metrics that lacked continual performance process safety goals (e.g., adherence to regulations, completed training, adherence to BP policies). During CSB interviews, BP drilling and well completion managers and engineers alike stated that BP's safety focus in audits, reviews, and safety score cards primarily addressed personal safety, which was also reported to be the sole focus in relevant team meetings and company reports, and during benchmarking activities.

[517] TRIR = (the number of medical treatment cases other than first aid + the number of restricted Work/Transfer Cases + the number of Lost Time Incidents + the number of fatalities) multiplied by 200,000 then divided by the Total Hours Worked. See IADC definitions at http://www.iadc.org/wp-content/uploads/2014/01/2015-ISP-Reporting-Guidelines.pdf (accessed October 7, 2015).

[518] BP provided numerous Annual Individual Performance Assessments to the CSB. Two examples that have been made public for the Macondo Well Site Leader and a Gulf of Mexico Engineering Manager are, Exhibit 3555 found at http://www.mdl2179trialdocs.com/releases/release201304041200022/Kaluza_Robert-Depo_Bundle.zip and Exhibit 0755 found at http://www.mdl2179trialdocs.com/releases/release201302281700004/Sprague_John-Depo_Bundle.zip (accessed October 7, 2015).

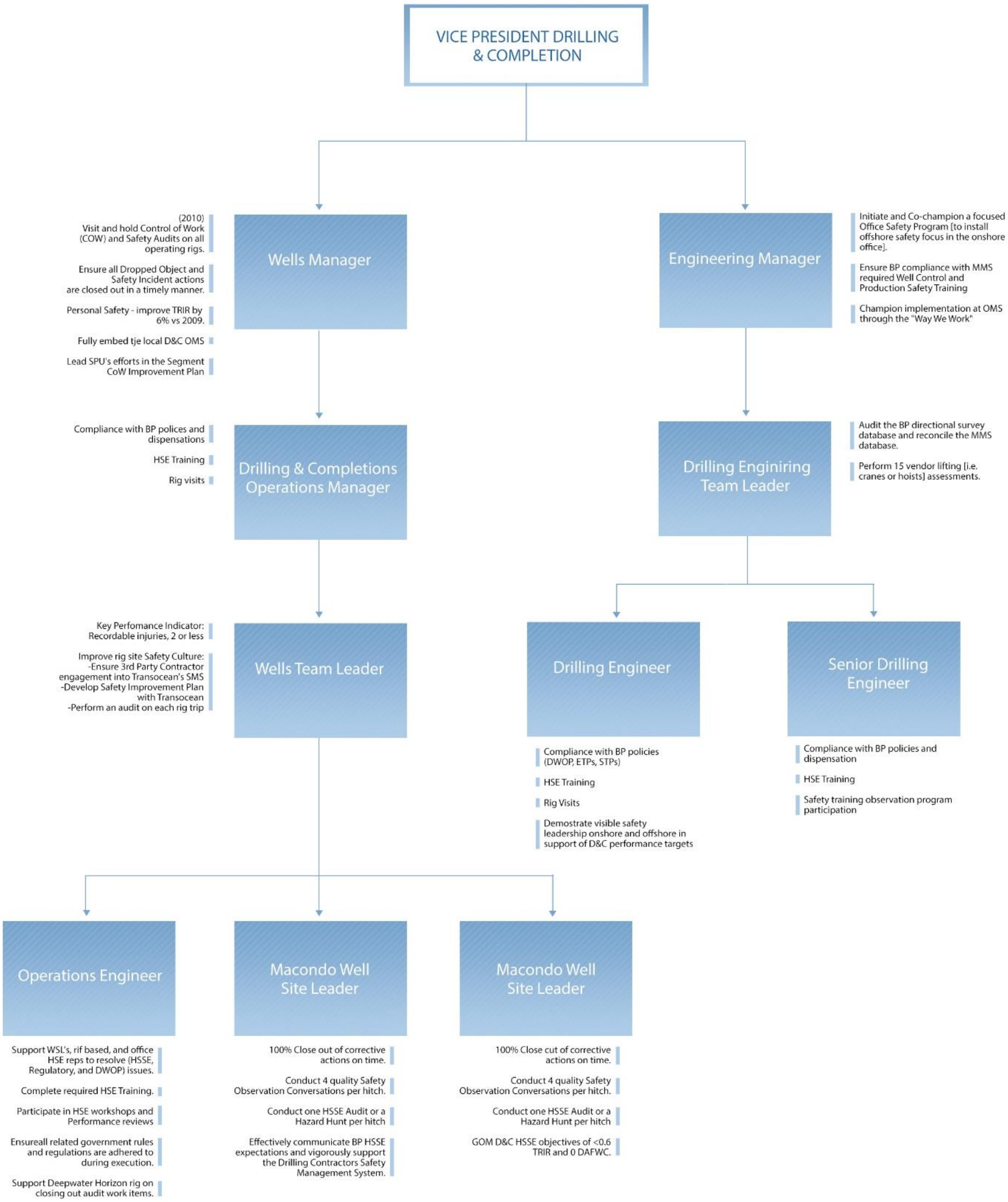

Figure 3-1. Safety performance goals for BP employees that were a part of the Deepwater Horizon's organizational structure.

Without an explicit focus on process safety, employee performance expectations can be overshadowed by intense cost performance expectations. For example, a former BP vice president of drilling and completion indicated an "incredible pressure with respect to cost reduction in 2008 and 2009," while at the same time production targets in his own individual performance contract were "significantly" raised.[519] The net result was that in pursuit of his duties, this vice president "slashed hundreds of millions of costs and increased production" from BP's offshore drilling operations.[520] BP's vice president of drilling and completions at the time of the Macondo incident also noted that his own individual performance contract had a number of cost containment goals, particularly in 2008 and 2009, due in part to a then-recent drop in oil prices.[521] These goals were informed by benchmarking information from industry sources relating to metrics of drilling progress, primarily in terms of cost and time,[522] along with "a lot of emphasis on cost," driven by specific targets for cost reduction during the calendar year before Macondo, all of which shaved approximately 10 percent off the 2009 operating budget.[523] However, this came without an accompanying set of goals for process safety in his performance contract.[524]

Even when there are safety indicators, such as those for personal safety, the former vice president of drilling and completion indicated to the CSB that he made conscious efforts to ensure leaders "were not putting pressure on the [well site leaders] and confusing the value of safety with priorities on cost or time." He observed, "it was a bit of a new thing for [leaders/well site leaders] to talk about how to have safety and performance in the same conversation."[525] Production focus is not unique to companies operating in the Gulf of Mexico. A 2012/2013 multinational audit in the North Sea observed that benchmarking key performance indicators (KPIs) often focused on drilling progress and efficiency with little to no mention of well control. The auditors noted:

> There is the potential for such performance orientated KPIs to conflict with safety performance, as it was common practice to have penalties in place for underperformance (e.g., in relation to the downtime rate of drilling progress) but how this was being managed from a human factors perspective was not clear. In other words, there was a lack of attention as to how penalties for underperformance could influence the performance of the driller in relation to safety-related decision-making and behaviour at the front-line.[526]

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[519] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 1, 2011, see Lacy Deposition, pp 792-804, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-25002.pdf (accessed October 7, 2015).

[520] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 1, 2011, see Lacy Deposition, p 804, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-25002.pdf (accessed October 7, 2015).

[521] While this individual discussed his performance plan with the CSB during an interview, BP did not provide the actual performance plan to the CSB.

[522] CSB interview.

[523] CSB interview.

[524] CSB interview.

[525] CSB interview.

[526] North Sea Offshore Authorities Forum (NSOAF). *Multi-National Audit Human and Organisational Factors in Well Control 2012-2013*, pp 13. http://www.hse.gov.uk/offshore/nsoaf.pdf (accessed May 2016, 2015).

3.3 Transocean's Selection and Use of Performance Indicators

Transocean identified two "key tools" for safety management in both its contract with BP and in its Health and Safety Policies and Procedures Manual: (1) a risk assessment policy, which asked the workforce to identify hazards immediately before conducting a task, and (2) a safety observation program to identify positive and negative actions by the crew. [527] These two programs, the THINK Planning Process (described in Section 1.8.3) and the START Observation and Monitoring Process, and the data derived from them ultimately resulted in a direct company focus on personal/occupational safety and individual behavioral-based safety improvements and inattention to control major accident hazards. [528]

The aims of programs such as THINK and START are to reinforce safe behavior and correct unsafe acts or conditions.[529] These programs rely upon the employees to observe and recognize unsafe situations or activities. Thus, the types of safety issues likely to be documented are those that are readily observable, such as breaches to occupational safety rules and policies (e.g., missing personal protective equipment, poor housekeeping). However, process safety hazards and the active and passive safeguards meant to control, reduce, or mitigate them are not always readily observable. Thus, the THINK and START programs emphasized worker focus on personal safety observations and easily identifiable deviations from safety rules and company practices.[530]

Transocean required all personnel to monitor work practices and workplace conditions. All Transocean rig personnel were required to participate by each submitting a START observation card daily where they

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[527] Internal Company Document, BP. *Amendment No. 38 to Drilling Contract No. 980249*, September 28, 2009, BP-HZN-CEC041519, see Exhibit 1488, http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Preface, BP-HZN-2179MDL00132055, see Exhibit 4942, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[528] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Safety Policies, Procedures and Documentation, BP-HZN-2179MDL00132454, see Exhibit 4942, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, Transocean. *Asset Managment Handbook*, Issue 01, Revision 00, HQS-OPS-HB-06, April 22, 2008, Physical Asset Management Implementation, TRN-INV-00160105, This document established key performance indicators (KPIs) "to evaluate performance against an agreed benchmark" in specified areas in order to "achieve compliance or realize performance improvement." The first two categories of KPI's focused on protecting assets, as well as improving performance. The third category focused on HSE matters, with a heavy emphasis on personal safety and related lagging indicators (some of which were termed leading indicators), and none of which were focused on process safety or major hazards.

[529] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Preface, see Exhibit 4942, BP-HZN-2179MDL00132055, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[530] In CSB interviews, one Transocean crew member from the Deepwater Horizon conveyed that another crew member wrote a START observation on him when he entered a particular location on the rig without wearing safety glasses. Crew members also provided positive examples of "good" START observations, such as being properly tied off or having all the correct safety gear for a job.

describe observed positive or negative work practices.[531] Such reporting requirements are susceptible to underreporting due to the perceived negative potential consequences of candid self-reporting. This was true on the Deepwater Horizon, where some individuals reported hesitation about writing START observations.[532] Crewmembers stated they did this out of a fear of discipline or reprisal for being observed breaking a safety rule and that completing the START cards according to the "one a day" rule resulted in unnecessary observations, which in turn diluted the efficacy of actual worker concerns.[533] Crewmembers also reported that discussions in rig safety meetings focused on the quantity of cards, not the quality of the content.[534] Ultimately, management undermined the value of START card observations as indicators for risk management success by not addressing crew concerns and actively working to change the crew's perceptions.

At the time of the Macondo incident, Transocean also identified key leading and lagging health, safety, environmental, and operational performance indicators (KPIs), which it used to set goals and targets for itself:[535]

- Leading
    - Potential Severity Rate
    - START Observations

[531] In interviews, Transocean crew members conveyed to the CSB that they were given 15 minutes on each shift to fill out a START observation card; this requirement was also reflected in some of the publicly available interview notes, e.g., Internal Company Document, Transocean. *Interviewing Form*, June 24, 2010, pp 5, TRN-INV-00000300, see Exhibit 3339 http://www.mdl2179trialdocs.com/releases/release201304041200022/Bertone_Stephen-Depo_Bundle.zip (accessed October 7, 2015).

[532] As Transocean workers conveyed in CSB interviews, "I've seen guys get fired for someone [writing] a bad START card about them, … I've seen the people get fired for it;" "they wrote [a START card] on me and turned it in, and I was called into the office the next day and chewed up one side and down the other," and "people [tried] not to rat people out so to speak, you know like you wanted to be helpful, […] whereas some of the higher-ups in the office, they kind of wanted to weed out problems …"

[533] Internal Company Document, Transocean. *Lloyd's Register Safety Management Systems and Safety Culture/Climate Reviews: Deepwater Horizon*, March 16, 2010, Closing Meeting, slide 5, TRN-INV-00016752, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-04261.pdf (accessed October 7, 2015).; Internal Company Document, Transocean. *Safety Management and Safety Culture/Climate: North America Division Summary Report*, July 2, 2010, TRN-HCEC-00090580, see Exhibit 0929 http://www.mdl2179trialdocs.com/releases/release201304041200022/Bertone_Stephen-Depo_Bundle.zip (accessed October 7, 2015).

[534] Internal Company Document, Transocean. *Safety Management and Safety Culture/Climate: North America Division Summary Report*, July 2, 2010, TRN-HCEC-00090663, see Exhibit 0929 http://www.mdl2179trialdocs.com/releases/release201304041200022/Bertone_Stephen-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, Transocean. *Lloyd's Register Safety Management Systems and Safety Culture/Climate Reviews: Deepwater Horizon*, March 16, 2010, Closing Meeting, slide 5, TRN-INV-00016752, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-04261.pdf (accessed October 7, 2015).

[535] Internal Company Document, Transocean. *Performance Monitoring Audit and Assessment Procedures*, Issue 03, Revision 00, HQS-CMS-PR-02, December 31, 2008, Performance Monitoring Audit and Assessment Plan, TRN-MDL-00039491, see Exhibit 0927 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 7, 2015).

  - HSE Training Compliance
- Lagging
  - Actual Severity Rate
  - TRIR
  - Serious Injury Case (SIC) [536]
  - Safety statistics (for categories of incidents, such as dropped objects[537])

For safety, the potential and actual severity rates listed are based upon a classification system for personal injuries (e.g., first aid, restricted work, extended time off of work, etc.). There were also severity rate classification systems for environmental and operational indicators based on releases (e.g., to the rig, atmosphere, or overboard and the extent of cleanup efforts) and loss of revenue or cost to repair.[538] Transocean's health, safety, and environmental 2009 goals and targets appear in Table 3-3.[539]

Table 3-3. Corporate Quality, Health, Safety and Environment (QHSE) Strategy and Target Goals Status as reported by Transocean[540]

Safety Target	Goal	Year to Date (October 2009)
Fatalities	0	4
TRIR	$\leq$ 0.82	0.85
SIC Rate	$\leq$ 0.29	0.39

[536] As defined by Transocean, "any injury resulting from a work-related incident that prevents the injured person from continuing on his next shift," Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Annex, Definitions, pp TRN-HCEC-00005205, the publicly available version of the Transocean Health and Safety Policeis and Procedures Manaul does not include the annex of defitions, so a version provided to the CSB that does is beign cited here.

[537] Dropped objects are a concern on rigs because they can result not only in injury, but also death if the mass and/or height from which the object is dropped is sufficient. In the oil and gas industry, dropped objects are among the top 10 causes of fatality and serious injury. See information provided by DROPS, an industrywide initiative focused on preventing dropped objects, http://www.dropsonline.org/assets/DROPS%20Intro.pdf (accessed December 20, 2015).

[538] Internal Company Document, Transocean. *Field Operations Policies & Procedures Manuel*, Issue 01, Revision 00, HQS-POP-PP-01, August 8, 2009, Performance Management: Rig and Well Operation Management, TRN-CSB-00016311.

[539] This was completed under the auspices of the QHSE Steering Committee which met at least twice a year to review and set HSE goals and performance. Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, QHSE Steering Committees, see Exhibit 4942, BP-HZN-2179MDL00132097, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[540] Internal Company Document, Transocean. *QHSE Steering Committee Meeting Minutes*, October 19, 2009, TRN-MDL-00039081, see Exhibit 0934 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 7, 2015).

Potential Severity Rate	≤ 30.00	45.31
Number of High Potential Dropped Objects	≤ 129	137
Environmental Target	**Goal**	**Year to Date (October 2009)**
Loss of Containment Major Reports	≤ 25	18

3.3.1 Transocean Recognized Need for Process Safety Performance Indicators

Transocean senior leadership voiced dissatisfaction with the company's development and use of leading indicators. In response to an email string between BP and Transocean senior leadership approximately eight months before the Macondo blowout, Transocean President Steven Newman forwarded his observations about Transocean's use of leading indicators to several senior Transocean managers:

> I am not convinced at all that we have the right leading indicators. The leading indicators we report today are all just different incident metrics—they have nothing to do with actually preventing accidents. What if we asked our OIMs to report the number of tasks that proceeded without a think plan discussion? Their first response would obviously be zero—which would then be the start of an interesting conversation (how do you KNOW that?). This is by no means a scientifically measured leading indicator, but the nature of the discussion would get the OIMs thinking about the culture on the decks—and the only way they could really meaningfully answer the questions would be to get out on the decks.[541]

Newman's comment echoes earlier sentiments expressed in this chapter, that "incident metrics" do not address the barriers and safety management systems meant to prevent or mitigate process safety events. His comment also recognizes the need to triangulate indicators information to meaningfully manage risk. For example, ensuring the rig crew completes a THINK plan discussion does not guarantee effective risk management. To fully assess whether THINK plans are driving an understanding of hazards and control measures connected to the task at hand, periodic walkthroughs to engage with the workforce directly or reviews of THINK plans might be necessary to determine exactly how the plans are used. This is particularly important, as THINK plans have been associated with numerous serious incidents and near-misses (see Section 3.5.2.2).

One opportunity for such a review occurred when Transocean completed its Performance Monitoring Audit and Assessment (PMAA) of the Deepwater Horizon.[542] The PMAA audit was intended to "evaluate

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[541] Email from President, Transocean, Subject: FW: Prellmlnary thoughts and supplementary lnfo, September 25, 2009, TRN-MDL-03999532, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-26032.pdf (accessed October 7, 2015).

[542] Internal Company Document, Transocean. *Performance Monitoring Audit and Assessment Procedures*, Issue 03, Revision 00, HQS-CMS-PR-02, December 31, 2008, PMAA Policy and Procedure, TRN-MDL-00039467, see Exhibit 0927 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-

performance of people in achieving the expectations and requirements described in the Company Management System."[543] Transocean's expectations were to analyze at a minimum of every 30 months each component of the company, from the facilities, installations, and offices, up through business units, sectors, divisions, and the corporate level.[544] However, during the Deepwater Horizon's last PMAA, THINK plans that addressed safety critical tasks were not assessed beyond an indication that they should mention the company's management system more.[545] As indicated previously (Section 1.8.4), several Deepwater Horizon TSTPs were vague and lacked well-specific hazards.

Transocean PMAA procedures indicate that key performance indicators should be evaluated so that the PMAA team can determine if performance improvement is occurring.[546] The health and safety indicators noted during the Deepwater Horizon PMAA were TRIR and SIC,[547] reflecting corporate focus and reinforcing the Transocean president's concerns that the indicators being tracked were "just different incident metrics."

3.3.2 Transocean Bonus Awards Insufficiently Focused on Performance Relating to Process Safety and MAP

In a 2009 Transocean "asset reliability" project, Lloyd's Register found that individual performance contracts were underutilized and represented an "opportunity for improvement," and that KPIs were

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Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, Transocean. *Company Management System*, Issue 04, Revision 05, HQS-CMS-GOV, November 30, 2009, Corporate Policies and Procedures, Level 1, TRN-MDL-00032866, see Exhibit 0925 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 7, 2015).

[543] Internal Company Document, Transocean. *Performance Monitoring Audit and Assessment Procedures*, Issue 03, Revision 00, HQS-CMS-PR-02, December 31, 2008, PMAA Policy and Procedure, TRN-MDL-00039467, see Exhibit 0927 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 7, 2015).

[544] Internal Company Document, Transocean. *Performance Monitoring Audit and Assessment Procedures*, Issue 03, Revision 00, HQS-CMS-PR-02, December 31, 2008, PMAA Policy and Procedure, TRN-MDL-00039468 - TRN-MDL-00039476, see Exhibit 0927 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 7, 2015).

[545] Internal Company Document, Transocean. *Management Summary of Corrective and Improvement Opportunities: Deepwater Horizon*, July 2, 2009, Performance Monitoring, Audit and Assessment Management Principles, TRN-MDL-01007259, see Exhibit 5766 http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip (accessed October 7, 2015).

[546] Internal Company Document, Transocean. *Performance Monitoring Audit and Assessment Procedures*, Issue 03, Revision 00, HQS-CMS-PR-02, December 31, 2008, PMAA Policy and Procedure, TRN-MDL-90 see Exhibit 0927 http://www.mdl2179trialdocs.com/releases/release201302281700004/Rose_Adrian-Depo_Bundle.zip (accessed October 7, 2015).;

[547] Internal Company Document, Transocean. *Management Summary of Corrective and Improvement Opportunities: Deepwater Horizon*, July 2, 2009, Performance Monitoring, Audit and Assessment Management Principles, TRN-MDL-010072579, see Exhibit 5766 http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip (accessed October 7, 2015).

"limited" as they focused on items like "downtime, overdue maintenance and money spent."[548] Transocean's approach to safety through the calculation and payment of performance bonuses at the time of the Macondo incident reinforced Lloyd's findings.[549] Transocean calculated upper management bonuses on three safety metrics: TRIR, the total potential severity rate (TPSR),[550] and high potential dropped objects (HPDO).[551] In Transocean's 2009 annual report to shareholders, safety performance was defined by a formula that relates to bonus calculations. Safety performance related to only 20 percent of any total bonus payment, while financial performance related to 70 percent, and "new builds" accounted for the final 10 percent.

The variables used in Transocean's bonus calculation formula do not distinguish between occupation/personal safety injuries and process safety injuries. Additionally, there is no mention of process safety, major hazards, or catastrophic risks. This type of bonus calculation formula did not provide for balanced safety goal-setting, nor did it lend itself to developing or implementing adequate process safety performance indicators which could boost a company's ability to prevent catastrophic accidents. Furthermore, Transocean's 70 percent weighting toward financial goals broke down into three sub-elements: cash flow value add (relative to budget), overhead costs, and lost revenues. These economic measures are arguably valid business measures, yet process safety measures are necessary to indicate how those economic optimizations may affect the company's ability to effectively manage the process safety risks.

[CALL-OUT BOX START]

Process Safety Metrics Necessary to Counter Unintended Safety Consequences of Small Steps to Optimization

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548 Internal Company Document, Transocean. *Asset Reliability Project/Phase I: Discovery & Defintion*, May 2009, pp 57, TRN-MDL-01134224, see Exhibit 5638 http://www.mdl2179trialdocs.com/releases/release201304041200022/Hart_Derek-Depo_Bundle.zip (accessed October 7, 2015).

549 Transocean. *Annual Report;* 2009; Performance Award and Cash Bonus Plan, pp 35. The bonus plan is described as "a goal-driven plan that gives participants, including named executive officers, the opportunity to earn annual cash bonuses based on performance measured against predetermined performance goals." *Id*. at 34. The annual report explains that the bonus plan and the performance goals connected to it are set by the Board, through the Executive Compensation Committee, not the Health Safety and Environment Committee, in accordance with the company's "safety vision" for "an incident-free workplace—all the time, everywhere," stating: "The Committee sets our safety performance targets at high levels each year in an effort to motivate our employees to continually improve our safety performance towards this ultimate goal." *Id*. at 35.

550 As defined by Transocean, "TPSR is a proprietary safety measure that we use to monitor the total potential severity of incidents and comprises 35% of this metric. Each incident is reviewed and assigned a number based on the impact that such incident could have had on our employees and contractors, and the total is then combined to determine the TPSR;" Transocean. *Annual Report;* 2009.

551 As defined by Transocean, "HPDO is a dropped object that has a potential of causing a serious injury (an injury in which the employee is out of work for six months or more) or a fatality. HPDO is calculated by multiplying the mass of the object by the height dropped and then applying an industry standard formula to determine potential severity. HPDO comprises 30% of this measure. The occurrence of a fatality can override the safety performance measure;" Transocean. *Annual Report;* 2009.

"Drift into failure is marked by… small steps … Constant organizational and operational adaptation around goal conflicts, competitive pressure and resource scarcity produces small, step-wise normalizations. Each next step is only a small deviation from the previously accepted norm, and [meanwhile] continued operational success is relied upon as a guarantee of future safety."

Dekker, S. Drift into Failure: From Hunting Broken Components to Understanding Complex Systems; Ashgate Publishing: Burlington, VT, 2011, p 179.

[CALL-OUT BOX END]

Without process safety indicators, the company may be rewarding organizational performance that weakens or masks its ability to effectively manage and control its major hazards. In fact, Transocean's bonus calculation was configured to reward its top-level corporate executives with significant financial bonuses for the company's "best year in safety" in 2010 despite the 11 fatalities onboard the Deepwater Horizon.[552] These bonus calculations and awards raise questions about the validity of Transocean's chosen safety performance indicators and metrics, and what the company was measuring and rewarding. This public expression of Transocean's bonuses was the cause of widespread backlash by media, government, and the public, prompting an apology from Transocean's CEO and the donation of the executives' safety bonuses to the families of the 11 workers killed during the incident.[553]

3.4 Advancing the Development and Use of Process Safety Performance Indicators

This section focuses on recent efforts to further develop and effectively manage safety performance indicators to prevent major accidents.

3.4.1 CSB Efforts to Advance Understanding and Use of Process Safety Performance Indicators

On July 23-24, 2012, the US Chemical Safety and Hazard Investigation Board conducted a two-day public hearing in Houston, Texas focused on safety performance indicators.[554] The CSB's hearing brought together international regulators, workforce representatives, and industry groups, along with representatives of other high-hazard industries, where process safety indicators are monitored, with an eye

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552 Internal Company Document, Transocean. *Proxy Statement Pursuant to Section 14(a) of the Securities Exchange Act of 1934; Definitive Proxy Statment*, April 1, 2011, pp P-35, P-45. As stated in the document, "Based on the foregoing safety performance measures, the actual TRIR was 0.74 and the TPSR was 35.4 for 2010. These outcomes together resulted in a calculated payout percentage of 115% for the safety performance measure for 2010. However, due to the fatalities that occurred in 2010, the Committee exercised its discretionary authority to modify the TRIR payout component to zero, which resulted in a modified payout percentage of 67.4% for the safety performance measure."

553 McMahon, J. Transocean Execs Keep Most of Their Bonuses. *Forbes*, April 6, 2011.

554 CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; http://www.csb.gov/events/csb-public-hearing-safety-performance-indicators/ (accessed October 7, 2015). (including the agenda, the verbatim transcript of the proceedings, working papers submitted, and PowerPoint presentations and other materials from the proceedings are all available and included as part of the CSB's record pertaining to the Macondo investigation).

toward exploring how companies and the regulator could expand and improve the use of safety performance indicators to manage risks and drive continual safety improvements.

The hearing underscored a growing recognition within the oil and gas industry that actively monitoring leading process safety indicators is critical for high-hazard safety management. The event outlined the challenges faced by industry and regulators in using safety performance indicators. It also illuminated the development and implementation of process safety indicators in offshore oil-producing jurisdictions outside the US and other high-hazard industries within the US. One speaker at the hearing noted that no "silver bullet" set of indicators ensures catastrophic accidents will never happen,[555] but the hearing concluded that indicators effective in reducing the risk of a major accident event share several characteristics:

- Indicators should measure the health of the company's safety management system (SMS) and the specific barriers in place to prevent or mitigate major accident hazards.[556]
- The amount of indicator data should suit the intended use, with enough data collected to facilitate long-term studies as well as intracompany or industrywide comparisons.[557]
- Indicators should be statistically robust so that trends can be monitored not only for large changes or safety upsets (e.g., fire or explosion), but also smaller safety changes that may be a leading indicator for an underlying, latent problem, such as when a process upset triggers the functioning of a safety control and prevents a release of hazardous material, a fire, or explosion.[558]
- "An indicator is an indicator of something, not the phenomena itself;" therefore, other tools such as cultural surveys, sociological studies, and accident investigations, can be the most effective method to triangulate actual risk areas.[559]
- Indicators should be "intuitive in the sense what is measured is considered intuitively by the workforce to be important for the prevention of major accidents."[560]As major accidents are rare, a company, or even the personnel assigned to a particular facility or work crew, may have never

[555] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Ian Whewell, *Performance Indicators in Major Hazard Industries– An Offshore Regulator's Perspective*, pp 135, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[556] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Gunhild Eie, *Performance Indicators for Major Accident Prevention*, p 183, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[557] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Joe Stough, *Overview of Leading Indicator and Usage*, p 187, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[558] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Manuel Gomez and Kara Kane, *Using Performance Indicators to Drive Improvement: CSB Overview* and *Summary of CSB Evaluation of ANSI/API Recommended Practice 754*, pp 18, 25, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[559] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Oyvid Lauridsen, *Trends in Risk Level Norwegian Petroleum Activity (RNNP)*, pp 147-148, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[560] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Oyvid Lauridsen, *Trends in Risk Level Norwegian Petroleum Activity (RNNP)*, p 180, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

experienced a major accident. Therefore, it may be difficult for employees and managers to understand the importance of accurately reporting specified indicator data without intuitively linking it to the major hazard risks. Moreover, having indicators that closely reflect actual hazard mechanisms may also "contribute to maintaining the awareness about the risk mechanisms."[561]

- The selected indicators should be actionable in terms of the necessary actions to improve some specific aspect of safety performance. To this end, once managers observe an undesirable trend, they "[should be able to] turn around and do something about it."[562]
- Avoiding too many indicators is important. Some organizations solve this problem by "rolling-up" multiple indicators into combined indicators with more information available when desired.[563]
- Contractors should be required to provide data for company indicator programs, as they most often perform the bulk of the front-line work in deepwater drilling operations, including safety critical work capable of preventing major accidents, and they are often uniquely positioned to capture—and rely on—important safety data that can prevent accidents.[564]

Finally, for an indicators program to be effective and ensure continual risk reduction of major accident events, upper management must be involved and act on the data. As one speaker cautioned at the CSB's indicator hearing,

> "unless at board and senior management level there is a recognition and an understanding of the significance of the data and the data drives decision-making, then its collection becomes an ineffectual exercise and leads to cynicism. [Oil and gas industry leaders] should be able to demonstrate that they understand the role of major hazard risk controls and the significance of key performance indicators. In addition, to achieve a convincing safety culture at all levels in the organization, industry leaders must acknowledge their responsibility for the effective management of major accident hazard risks. There must also be a recognition that the culture of the organization is important in ensuring that Board-level data is accurate and reflects reality, again, not what the Board or senior management would like reality to be."[565]

[561] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Oyvid Lauridsen, *Trends in Risk Level Norwegian Petroleum Activity (RNNP)*, p 180, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[562] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Joe Stough, *Overview of Leading Indicator and Usage*, p 187, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[563] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Martin Sedgwick & Angela Wands, *The Implementation of Effective Key Performance Indicators to Manage Hazard Risks*, pp 86.; testimony of Gunhild Eie, *Performance Indicators for Major Accident Prevention*, pp 183 - 185, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[564] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Martin Sedgwick & Angela Wands, *The Implementation of Effective Key Performance Indicators to Manage Hazard Risks*, pp 92, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

[565] CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012; testimony of Ian Whewell, *Performance Indicators in Major Hazard Industries– An Offshore Regulator's Perspective*, pp 136, http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).

3.4.2 Selection of Effective Performance Indicators[566]

ANSI/API RP 754, *Process Safety Performance Indicators for the Refining and Petrochemical Industries*,[567] was created in response to findings and recommendations that came out of the CSB's investigation of the BP Texas City onshore disaster. Specifically, the CSB found that BP—and the oil and chemical industries in general—did not have effective programs for developing and using process safety performance indicators. As such, the CSB recommended to API and the United Steelworkers that the two jointly develop a voluntary consensus standard for creating leading and lagging process safety indicators in the refining and petrochemical industries.[568] Leading indicators are those that record performance before an incident occurs, such as monitoring open action items identified in an audit, while lagging indicators record the consequences of an unwanted event, such as a hydrocarbon release. The recommendation aimed to develop a standard that would provide guidance on how to develop key process safety indicators, to drive measurable facility, company-level, and industrywide improvement, and to make publicly available individual company and industrywide performance data after collection.

API 754 served as a significant and positive step forward in establishing safety performance indicators, and was part of the development of the international recommended practice, *Process Safety - Recommended Practice on Key Performance Indicators Report No. 456* (IOGP 456),[569] generated by International Association of Oil & Gas Producers (IOGP). Both API 754 and IOGP 456 identify process safety indicators by four tiers:[570]

- Tier 1: A Loss of Primary Containment (LOPC) that results in the release of material with the greatest consequence, such as a fatality or large fire or explosion;
- Tier 2: An LOPC, but of lesser consequences than a tier 1 incident (e.g., no casualties, property damage less than 2,000$, on a release of process chemical less than pre-defined reportable quantities). These events also play a "leading" role in preventing more serious events if the company uses them as a learning opportunity to improve its process safety performance;

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[566] The only U.S. guidance document specifically pertaining to offshore safety indicators is API RP 75, *Recommended Practice for Development of a Safety and Environmental Management Program [SEMP] for Offshore Operations and Facilities*. However, API RP 75 focuses on personal safety metrics such as "recordable injuries/illnesses," "DART injuries/illnesses," and the like, as well as infrequent, lagging safety performance indicators of infrequent incidents such as the "blow-out incident rate," "fire/explosion incident rate," and the "number of [oil] spills" suffered by a driller, among others. API Recommended Practice 75, 3rd ed. (2004, reaffirmed 2008), *Recommended Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities*, Appendix E, pp 37 - 41.

[567] API Recommended Practice 754, 1st ed., Process Safety Performance Indicators for the Refining and Petrochemical Industries, April 2010.

[568] USCSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005,* Report No. 2005-04-I-TX, March 2007, pp 25 – 26, 144 – 146, 149, 154 – 155, 159, 163, 165, http://www.csb.gov/assets/1/19/CSBFinalReportBP.pdf (accessed October 7, 2015).

[569] IOGP, *Process Safety - Recommended Practice on Key Performance Indicators, Report No. 456*, November 2011.

[570] API Recommended Practice, 754, 1st ed., Process Safety Performance Indicators for the Refining and Petrochemical Industries, April 2010; International Association of Oil & Gas Producers Recommended Practice, Process Safety - Recommended Practice on Key Performance Indicators, Report No. 456, November 2011.

- Tier 3: A challenge to a safety system, which results when exceeding defined process limits and a safety system is initiated to bring the system back to an accepted safe state (e.g., the activation of a shutdown system or a pressure relief device);
- Tier 4: Performance of barriers and management system components, such as management of change (MOC) compliance, inspections, or timely training schedules.

Tiers 1 and 2 tend to be more lagging and infrequent, and they are more generally applicable throughout an industry, while 3 and 4 indicators tend to be more leading, frequent, and company specific. As both the API and IOGP guidelines indicate, monitoring process safety and barrier performance can be complex, requiring a combination of indicators, so the tiers help differentiate the frequency, severity, and timing (leading or lagging) of a monitored event or process.

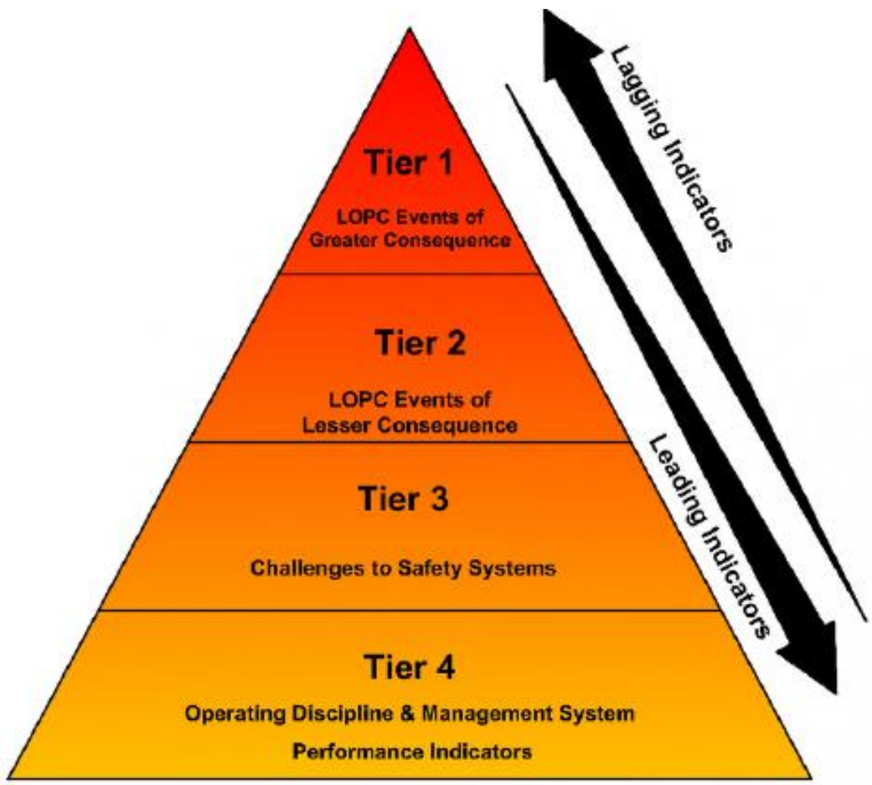

Figure 3-2. Process Safety Indicator Pyramid as identified by the American Petroleum Institute and the International Association of Oil & Gas Producers.[571]

[571] API Recommended Practice, 754, 1st ed., *Process Safety Performance Indicators for the Refining and Petrochemical Industries*, April 2010, pp 8; International Association of Oil & Gas Producers Recommended Practice, *Process Safety - Recommended Practice on Key Performance Indicators, Report No. 456*, November 2011, Section 2.2.

At least two professional groups, the Oil and Gas UK's Well Lifecycle Practices Forum (WLCPF)[572] and the Center for Offshore Safety (COS),[573] have been advancing initial efforts by API and IOGP by more clearly defining or tracking indicators for offshore drilling and well operations.[574] For instance, COS expands the API RP 754 Tier 1 and 2 definitions, which COS refers to as Safety Performance Indicators (SPI) (Table 3-4), and publicly reports indicator data from its members:[575]

Table 3-4. COS definitions of SPI 1 and SPI 2 process safety events.[576]

	SPI Number	
	1	**2**
SPI Definition	A. Fatality (one or more)	A. Tier 2 (API RP 754) process safety event
	B. Five of more injuries in a single event	B. Collision resulting in property or equipment damage ≥ $25,000
	C. Tier 1 (API RP 754) process safety event	C. Crane or personal/material handling operations incident
	D. Loss of well control	D. Loss of station keeping resulting in a drive off or drift off
	E. ≥$1 million direct cost from damage to or loss of facility, vessel and/or equipment	E. Life boat, life raft, rescue boat event
	F. Oil spill ≥ 10,000 gallons (238 barrels)	

[572] The Well Lifecycle Practices Forum is a group of over 45 well operators and management companies established by Oil and Gas UK in 2010, which provides a forum for discussion and industry guideline development. See http://www.oilandgasuk.co.uk/knowledgecentre/Well_Life_Cycle_Practices.cfm for more information (accessed October 7, 2015).

[573] COS is an industry-sponsored group created in 2011 to focus exclusively on deepwater drilling in the Gulf of Mexico (Http://www.centerforoffshoresafety.org/, accessed October 7, 2015).

[574] Oil and Gas UK Well Lifcycle Practices Forum. Guide to Drilling Process Safety Performance Measurement, Draft Form, Version 2.

[575] One major part of the COS mission, as stated on its webpage, is "compiling and analyzing key industry safety performance metrics." The COS convened a committee aimed at developing an indicators program for use offshore. COS published its first indicators report in 2015 for the 2013 reporting yes; *Annual Performance Report for 2013 Reporting Year;* April, 2015; http://www.centerforoffshoresafety.org/COS%202013%20Annual%20Performance%20Report.pdf (accessed October 7, 2015). COS published a second report for the 2014 reporting year: *Annual Performance Report for 2014 Reporting Year;* September 21, 2015; http://www.centerforoffshoresafety.org/2015_COS_2nd%20APR_FINAL.pdf (accessed December 7, 2015).

[576] Center for Offshore Safety. *Annual Performance Report for 2013 Reporting Year;* April, 2015, Appendix 3; http://www.centerforoffshoresafety.org/COS%202013%20Annual%20Performance%20Report.pdf (accessed October 7, 2015).

The WLCPF decided that Tier 1 and 2 indicators (blowouts or high potential blowouts where an incident almost occurred) were well defined, but decided that Tier 3 and 4 indicators need more clarification, so it was considering classifying Tier 3 indicators in four categories:[577,578]

1. Engineering Design and Execution of the Well
    a. Double Barrier principle compromised with or without an influx
    b. Dispensations from technical standards granted
    c. Deviations from well design parameters during operations
    d. Company defined exceedences of safe operational envelopes related to the well design
2. Safety-critical Equipment on the Drilling Unit
    a. Operation with Rig Audit "Critical Items" outstanding
    b. Partial or complete failure of safety-critical well monitoring system
    c. Partial or complete failure of safety-critical rig equipment or systems in operation or during testing
    d. Operation of safety-critical systems outside their performance limitations
3. Control of Work
    a. Noncompliance with or uncontrolled deviations from safety-critical standard operating procedures
    b. Noncompliance with or uncontrolled changes to detailed operations plans
4. Personnel Competency
    a. Presence of incompetent or unqualified personnel at the work site
    b. Personnel inappropriately qualified for the task at hand

The WLCPF also grappled with identifying effective Tier 4 indicators and recognized them as more difficult because testing organizational or human barriers is not as straightforward as is testing physical barriers. Since the health of organizational and human barriers is closely linked to an individual company's safety management systems, the WLCPF is not suggesting specific Tier 4 indicators (like it does with Tier 3), but rather areas that a company can use to focus its own company-specific activities in defining its own parameters. These areas include six foci that may provide information on the health of the organization:[579]

1. HSE (or other) Audit Action Tracker – Receive reports on overdue items and number of close-outs. Include critical items from rig audits and outcomes from formal audits of HSE activities from global reviews, a local business unit, or team-based periodical reviews.
2. Well Control Equipment, Personnel, Barrier Integrity Log – Monitor status of well control equipment certification, people qualifications, barrier integrity, and pressure tests.
3. MOC & Program Changes –Review the register of changes, dispensations, or changes to identify common themes potentially requiring further action or review.
4. Well Examination Report – Review on a quarterly basis summary statistics from the well examination process. Some organizations may do this as an annual formality. This report, if

[577] Oil and Gas UK Well Lifcycle Practices Forum. Guide to Drilling Process Safety Performance Measurement, Draft Form, Version 2, p 9.

[578] The WLCPF notes that in some cases, these indicators could be normalized against man hours worked, but that others would be best normalized on a rig-months or per-well basis.

[579] Oil and Gas UK Well Lifcycle Practices Forum. Guide to Drilling Process Safety Performance Measurement, Draft Form, Version 2, p 12.

submitted quarterly and reviewed by leadership, might provide valuable information concerning the health of the well examination process.

5. Competency Assurance – Track activities and outcomes associated with a competency management program of company staff and contractors.
6. Log of Minor Events – Review minor events, such as alarm systems switched off and related to barrier integrity, but which do not represent a threat to the primary barriers.

The WLCPF draft guidance document suggests that the data collected on the 6 focus areas can be incorporated into a metric dashboard[580] that summarizes safety status of an organization. The trends evident on the dashboard could then be used to identify areas for attention or interventions to reestablish safe operations determined by previously established targets, as part of a risk-based approach to maximize efforts for managing risk.[581] Not all barriers necessarily provide metrics that can be assessed on the same time scales, and identifying slow moving and "real-time" barrier metrics will maximize indicator efforts to manage risks.[582]

About ten years before API 754 and IOGP 456 were developed, Statoil defined a framework that identified four types of indicators, some of which correlate to the four-tier classification system created by API, but Statoil more specifically addressed the timescale of these indicators.[583] Statoil not only distinguished lagging and leading metrics, but also between slow moving and real-time metrics. The timescale distinction summarized in Table 3-5 is useful in describing CSB indicator findings in connection with the Macondo incident described in the next section.

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[580] Some companies create visual displays for the status of various process safety indicators. For instance, green could indicate a healthy barrier while yellow and rid could indicate barriers in need of attention. For example, see Sedgwick, M. *Process Safety Key Performance Indicators*, CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 24, 2012; http://www.csb.gov/UserFiles/file/Sedgwick%20%28Scottish%20Power%29%20PowerPoint%20-%20printed.pdf (accessed October 7, 2015).

[581] Pitblado, R. *Real-Time Safety Metric and Risk-Based Operations*, 11th International Symposium Loss Prevention, 2004; pp 5.

[582] Kortner, H.; Sorum, M.; Brandstorp, J. M. *Framework For Life-Cycle Assessment of Technical Safety Conditions at Statoil Operated Plants*, ESReDA Seminar on Lifetime Management, Erlangen, Germany, November 5-6, 2001. Cited in Pitblado, R. *Real-Time Safety Metric and Risk-Based Operations*, 11th International Symposium Loss Prevention, 2004; pp 5.

[583] Kortner, H.; Sorum, M.; Brandstorp, J. M. *Framework For Life-Cycle Assessment of Technical Safety Conditions at Statoil Operated Plants*, ESReDA Seminar on Lifetime Management, Erlangen, Germany, November 5-6, 2001.

Table 3-5. Four indicators as defined by Statoil in 2001.[584]

Indicator Type as per Statoil	CSB Correlation with Tier Indicator System Developed by API	Description[585]
Lagging measures	Tiers 1 and 2	Statistical accumulations of actual incidents or near-miss events for a facility. Typically these are slow moving and make sense only over longer time periods (e.g., annual averages).
Leading measures	Tier 4	Measures of PSM management system elements that support environmental, health, and safety (EHS), such as management of change systems, training systems, etc. These are mainly assessed by 2-3 year audits. They are slow moving measures not well suited for day-to-day operational management.
Barrier/Real-Time measures	Tier 3 and 4 (as defined by the WLCPF)	Measures of the status of EHS barriers from fully functional to seriously degraded or non-functioning. Suitable candidate for real-time measure.
Threat measures	No Correlation	Measures of the degree of threat to the facility. These are typically EHS challenges at a rate higher than anticipated in the risk assessment that underlies the safeguarding system. These can be determined by monitoring / predicting weather, nearby ship traffic, work permit activity, contractors on board, etc. This is also a suitable candidate for real-time measure.

3.5 Process Safety Metrics Gleaned from the Macondo Blowout

Operators and contractors look to industry-specific trade associations for good practice guidance and recommendations for all manner of operational concerns, including performance indicators. However, as efforts by the WLCPF group indicate, industry guidance pertaining to safety performance indicators could be further improved to provide practicable indicator suggestions. Benefiting from a perspective admittedly enlightened by hindsight, this section explores potential lead indicators that the Macondo well operations crew and onshore management could have used to manage risk.

[584] Kortner, H.; Sorum, M.; Brandstorp, J. M. *Framework For Life-Cycle Assessment of Technical Safety Conditions at Statoil Operated Plants*, ESReDA Seminar on Lifetime Management, Erlangen, Germany, November 5-6, 2001.

[585]These descriptions come from Pitblado, R. *Real-Time Safety Metric and Risk-Based Operations*, 11th International Symposium Loss Prevention, 2004, p 5.

3.5.1 Real-time Indicators for Safety Critical Elements

Volume 2 identified barriers as safety critical elements (SCEs), tasks, or pieces of equipment that lead to a disproportionate level of protection against major accident events (MAE), and conversely whose failure can lead to an immense increase in risk for a MAE.[586] In Volume 2, these safety critical elements appear on a bowtie diagram which illustrates how a major accident might evolve through the failure of a series of technical, organizational, and operations barriers. (Figure 3-3 is another bowtie example depicting various barriers.)

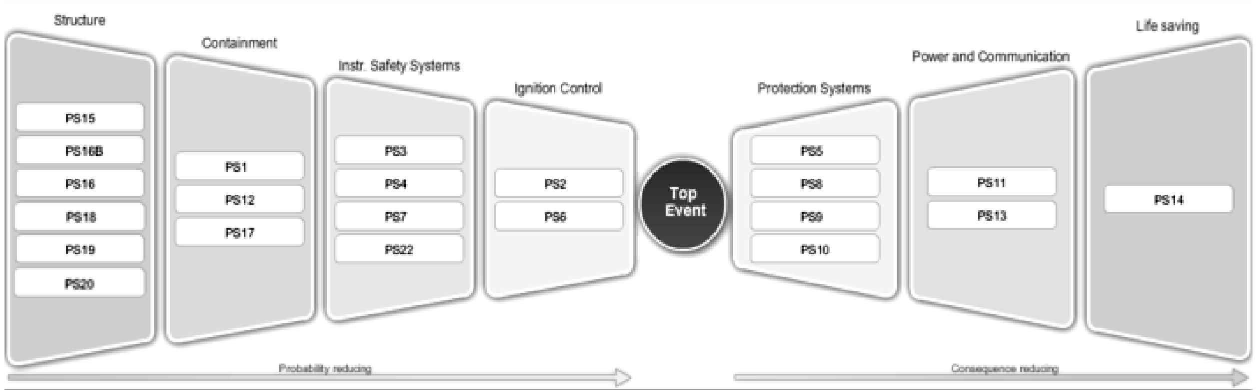

Figure 3-3. A Bowtie diagram model used by Statoil to track the health of specific barriers that are preventive or mitigative for major accident risks.[587]

As proposed in Volume 2, safeguarding an SCE's effectiveness throughout its lifetime should begin by clearly identifying and distinguishing it from noncritical equipment and tasks.[588] Standards should be developed to define the required performance of an SCE to reduce the risk of an MAE. Written assurance and verification activities should then define the needed activities to maintain SCE. Through this monitoring, improvements to performance gaps should be initiated to reestablish targets.

These SCE activities are candidates for indicators that can be used to influence daily operations in real time as they coincide with WLCPF recommendations to develop Tier 3 indicators for safety critical equipment on the unit. For example, trends and analysis on SCE maintenance backlogs and SCE verification activity failures could provide information on the robustness of the safety critical elements. The Macondo incident demonstrated several instances when the emergency functions of the BOP intended to prevent and mitigate an MAE were not tested or properly maintained:

1. Transocean and BP conducted routine inspections and weekly function testing of operational BOP components necessary for daily drilling operations, but these were insufficient to identify latent failures of the emergency systems (Volume 2, Chapter 5.0);

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[586] Volume 2, Section 4.2.3.1, p 58.

[587] Eie, G. *Performance Indicators for Major Accident Prevention*, CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 24, 2012, slide 5. http://www.csb.gov/UserFiles/file/Eie%20(Statoil)%20PowerPoint.pdf (accessed October 7, 2015).

[588] Volume 2, Chapter 5 presents the lifecycle in more detail.

2. For an extended time during the drilling process, the Deepwater Horizon BOP blind shear ram could not have reliably sheared the drillpipe used at Macondo during an emergency situation[589] (Volume 2, Section 5.2.1); and
3. A miswired solenoid valve in the yellow pod and the deficient wiring in the blue pod needed to function the Deepwater Horizon BOP in an emergency system could not have passed the manufacturer's factory acceptance testing procedures (Volume 2, Sections 5.3.1 and 5.3.2).

These findings highlight the importance of clearly identifying safety critical functions and performance expectations during an emergency scenario of equipment that might also serve an operational function.[590] Once identified, the appropriate assurance activities needed to test the safety critical functions must be defined, executed, and monitored as appropriate for deviations from the performance metrics.

3.5.1.1 Well Kicks

A kick is an indicator that the primary well barrier failed and secondary well control actions by the crew are needed. After a kick, if the crew does not recognize the need to activate the BOP or is delayed in activating it—as was the case with Macondo—then a gas-in-riser event or even a blowout can occur.[591]

Transocean compiled a Well Control Events & Statistics report covering the years 2005 to 2009.[592] In the report, Transocean reviewed data from various well types (e.g., development or exploration) during various phases of the drilling operations (e.g., abandonment or active drilling) to explore well control trends and compare previous years to 2009. Transocean noted 121 well control events in 2009 that spanned 32 different operators from various geographical locations. Of those 121 well events, 71 were categorized as kicks. In the report, Transocean identifies several potential indicators:[593]

- Kick volume – indicator of rig and crew performance in shutting in the well;
- Kick intensity – indicator of operator's accuracy in predicting pore pressure; and
- Riser unloading events,[594] which the Transocean report identified as the biggest concern.

A well kick falls under the Tier 3 definition provided in Section 3.4.2 because it represents a challenge to a safety system—the human actions to detect and activate the BOP and the original threat analysis to predict anticipated pore pressures. Although Tier 3 indicators are generally company-specific, this not the

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[589] In manual mode, the Deepwater Horizon crew developed a multi-step work-around where the crew would fist close the Casing Shear Ram, move drillpipe stub clear, and then close the Blind Shear Ram to seal the well. The rig's AMF/deadman automatic emergency system also relied upon the blind shear ram and was similarly impaired, but had no workaround as it could not close the casing shear ram before the blind shear ram.

[590] For another example, see the diverter discussion in Section 1.2.1.

[591] See Chapter 2.0, which describes incidents when late kick detection occurred, but the BOP was able to seal the well.

[592] Internal Company Document, Transocean. *Well Control Events & Statistics 2005 to 2009*, TRN-INV-00760054, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05649.pdf (accessed June 24, 2015).

[593] Internal Company Document, Transocean. *Well Control Events & Statistics 2005 to 2009*, TRN-INV-00760059, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05649.pdf (accessed June 24, 2015).

[594] Riser loading events occur when riser fluids (e.g., drilling mud, sea water, or hydrocarbons from the well) are released onto the drilling rig. They can occur only on floating rigs using a subsea BOP.

case for well kicks. The Transocean data demonstrates that well kicks are not an isolated problem which only BP or the Gulf of Mexico region face, but rather kicks happen under the supervision of many operators all around the world. Well kick data can be used as a safety benchmark for the offshore industry both intracompany and industrywide. For example, international analyses of offshore blowout and well release frequencies have been completed, like one by Lloyd's Register that analyzed a SINTEF well release and blowout database[595] for three international geographical regions.[596]

3.5.2 Slow Moving Indicators for SMS Elements

3.5.2.1 Emerging MOCs Themes

The WLCPF suggested monitoring MOC programs to identify common themes. Safety management program performance metrics are categorized as slow moving indicators in 3.4.2, implying that larger timeframes (i.e., a year or longer) are needed to assess safety trends. The CSB also observes that monitoring one SMS element will likely lead to learnings for other safety management systems. Both of these facts were evident for the Deepwater Horizon.

3.5.2.1.1 MOC Indicators - Transocean

The CSB examined Transocean-identified DWH MOCs completed during the seven years prior to the Macondo incident for changes to the blowout preventer (BOP). Transocean corporate policies mandate that all changes to safety critical systems, such as a BOP,[597] should trigger a formal MOC and risk assessment.[598] Table 3-6 lists 10 MOCs for the BOP from 2003 to 2009. A preliminary theme emerging from the table[599] is that the BOP was not consistently identified as safety critical in the MOCs. Instead, only four MOCs identified it as such, and further, only four of the MOCs indicated that a risk assessment was required to complete the change.

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595 See https://www.sintef.no/en/projects/sintef-offshore-blowout-database/ (accessed December 7, 2015).

596 Lloyd's Register. *Blowout and Well Release Frequencies based on SINTEF Offshore Blowout Database 2009 (Draft A);* 80.005.003/2010/R3; Lloyd's Register: March 17, 2010; pp BP-HZN-BLY00104032. See Exhibit 4156, http://www.mdl2179trialdocs.com/releases/release201302281700004/Baxter_John-Depo_Bundle.zip (accessed May 28, 2015).

597 Transocean identified the BOP as safety critical in its Major Accident Hazard Risk Assessment; Internal Company Document, Transocean. *Major Accident Hazard Risk Assessment Deepwater Horizon*, Revision 01, August 29, 2004, TRN-MDL-01184581, http://www.mdl2179trialdocs.com/releases/release201303141200012/TREX-02188.pdf (accessed October 7, 2015).

598 Internal Company Document, Transocean. *Field Operations Policies & Procedures Manuel*, Issue 01, Revision 00, HQS-POP-PP-01, August 8, 2009, Management of Change, TRN-CSB-0002251-0002260.

599 Internal Company Document, Transocean. *Managment of Change 2004 2005 2006 2009 Deepwater Horizon,* TRN-INV-00758181; Internal Company Document, Transocean. *Change Proposal SS-024*, April 12, 2009, BP-HZN-BLY00395154.

Table 3-6. Summary of MOCs documented by Transocean for the Deepwater Horizon BOP.

ID #	Date	Subject	BOP identified as Safety Critical?	Indication of a Required Risk Assessment?	Description[†]
1	12/29/2003	Upper Annular (UA) Failure	**No**	**No**	Hydraulic leak on the UA, so electronically locked. Will rely on lower annular.
2	1/5/2004	BOP MOC for Horizon	**No**	**No**	Changes to the control and mechanical systems. Required modifications to installation drawings and operating procedures, vendor involvement, and engineering approval.
3	8/28/2004	LMRP failsafe panel removal	**No**	**No**	Removed unnecessary BOP components; required modification of installation drawings, acceptance testing, and engineering approval.
4	11/21/2004	BOP Test Rams	**No**	*Yes*	Converted the lowest pipe ram into a test ram.
5	2/6/2006	Auto Shear Circuit Not Working	*Yes*	*Yes*	Autoshear circuit leaked, so disabled.
6	3/9/2006	18-3/4" Annular stripper packer	**No**	**No**	Installed a different UA to allow for stripping of 6 5/8" drillpipe which changed operating procedures.
7	1/11/2006	BOP Operation	**No**	**No***	Yellow pod malfunctioning, so remainder of well drilled with the blue pod selected which changed operating procedures.
8	3/5/2007	Software Modification	*Yes*	**No**	Software modification to address erroneous faults, required vendor involvement and acceptance testing upon completion.
9	10/29/2008	Auto Shear Circuit Not Working	*Yes*	*Yes*	Autoshear circuit leaked, so disabled.
10	4/12/2009	Auto Shear Circuit Not Working	*Yes*	*Yes*	Autoshear circuit leaked, so disabled.

[†] Definitions for technical terms used in this column appear in Volume 2 of the CSB's Macondo investigation report.

*Six days after the facility manager signed this MOC (and original date of MOC), the technical manager noted, "Moot as BOP is on the deck at this point; however, a) This would normally require a risk analysis and b) steps must be taken to communicate this change to those who follow (placards on control panels, for example)."

A review of the Deepwater Horizon MOCs for the autoshear emergency function points to another potential theme: the MOC process might have devolved into a check-the-box activity. Three MOCs from 2006, 2008, and 2009 addressed leaks in the autoshear system[600] (MOC # 5, 9, and 10 from Table 3-6). Each of the autoshear MOCs indicated a risk assessment was required to address disabling the system, and the later MOCs from 2008 and 2009 noted the previous situation(s) when the same issue arose.[601] The risk of operating without an autoshear for a finite period might be acceptable compared to (a) operating with a leak or (b) bringing the BOP to the surface for repair. But that risk management choice, the real-time well conditions, or the duration of operating without the autoshear are not indicated on any of the approved MOCs.

A final theme emerges that the MOC process was documenting changes, but other safety management systems were not being updated to reflect the controls needed to mitigate the risks introduced by the changes. MOC #4 in Table 3-6 concerns the conversion of a pipe ram to a test ram.[602] Pipe rams like those installed on the Deepwater Horizon BOP are designed to hold pressure from one direction and normally are installed to hold pressure coming up from the well, such as would be expected during a well kick. To save time and money during required subsea pressure tests of the BOP stack, BP requested that the lowest pipe ram in the Deepwater Horizon's BOP be installed upside down to hold pressure from above.[603] A consequence of this change is the loss of a pipe ram for well control, leaving only two, so less redundancy. Despite the indication on the MOC that a risk assessment was needed, the CSB could not identify any Transocean-authored risk assessments concerning the test ram. For Transocean, the new hazards introduced by the conversion of the pipe ram to a test ram included new operational procedures and practices that would be required by the crew and third-party contractors.

Hazards introduced by the new test rams procedures and practices were highlighted in a February 2010 Transocean investigation report that documented an incident when the Deepwater Horizon well

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[600] The autoshear system is a safety critical element designed to close the BOP's blind shear rams and seal the well in the event the lower marine riser package (LMRP) is inadvertently disconnected from the wellhead. The disconnect could result from, for example, either an accidental push of the LMRP unlatch button on one of the rig-based BOP control panels or from a malfunction within the BOP control system. See Section 2.1, Volume 2 for more details.

[601] Internal Company Document, Transocean, *Change Proposal SS-15: Auto Shear Circuit Not Working*, February 6, 2006, TRN-INV-01262584, see Exhibit 4312, http://www.mdl2179trialdocs.com/releases/release201304041200022/Odenwald_Jay-Depo_Bundle.zip; *Change Proposal SS-23: Auto Shear Circuit Not Working*, October 29, 2008, TRN-INV-01595873.; *Change Proposal SS-23: Auto Shear Circuit Not Working*, October 29, 2008, TRN-INV-01595873.; *Change Proposal SS-24: Auto Shear Circuit Fluid Leak*, April 12, 2009, BP-HZN-2179MDL00359935, see Exhibit 4610, http://www.mdl2179trialdocs.com/releases/release201304041200022/Odenwald_Jay-Depo_Bundle.zip;

[602] Internal Company Document, Transocean. *Change Proposal SS-10: BOP Test Rams*, November 21, 2004, TRN-INV-01262577, see Exhibit 4309 http://www.mdl2179trialdocs.com/releases/release201304041200022/Odenwald_Jay-Depo_Bundle.zip (accessed October 7, 2015).

[603] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, August 17, 2011, see Keeton Designations Vol 1 pp 43, http://www.mdl2179trialdocs.com/releases/release201302281700004/Keeton_Jonathan-Depo_Bundle.zip (accessed October 7, 2015).

operations crew failed to close the test rams before beginning subsea pressure test procedures.[604] Transocean's investigation report noted that the Task Specific THINK Procedure for the subsea test did not explicitly require closing the test rams[605] and that on two occasions, closing the test rams had been a step added to the procedure, but that not all test sheets were updated to include this critical step.

3.5.2.1.2 Dispensation/MOC Indicators - BP

Internal company standards contain the boundaries, requirements, and practices that management agrees upon, essentially describing the risk an organization formally accepts for a process. For drilling and well operations, BP's company standards appear in the Drilling and Well Operations Practice (DWOP) and related Engineering Technical Practices[606] (ETPs). At the time of the Macondo blowout, BP stated that "deviations from the Drilling and Well Operations Practice and ETPs shall only be considered in exceptional circumstances."[607] During the planning of the Macondo well, BP processed six MOCs for dispensations from the DWOP and seven more after drilling began. Actively monitoring the number of dispensations or MOCs for a well or a rig provides indications of possible safety issues to manage for MAE potential.

First, several Macondo well MOCs completed by BP noted that the company standards in the DWOP and ETP were not appropriate for deepwater wells,[608] implying that similar MOCs would be required for BP to drill other deepwater wells. An increase in dispensations from company standards may indicate that they need updating or expansion. The potential danger is clear. Relying on outdated company standards increases improvisation because the standards do not accurately represent the work conditions, and it perpetuates a lack of organizational controls for managing risk to acceptable levels commensurate with the company's goals. One potential solution might be to develop an ETP that specifically addresses deepwater drilling.

Second, no one metric can define when an organization's focus on the risk of a major accident event begins to drift, and will likely require a triangulated approach that includes reviewing the content of dispensations and MOCs. For example, some of the BP MOCs completed for Macondo describe conditions that could lead to burst casing, but then state, "This scenario has a very low probability of occurring."[609] Low probability still means some probability, a point highlighted in another Macondo

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[604] Internal Company Document, Transocean. *Deepwater Horizon BOP Test Rams*, Feburary 9, 2010, TRN-MDL-00481481, see Exhibit 1441, http://www.mdl2179trialdocs.com/releases/release201302281700004/Burgess_Mark-Depo_Bundle.zip (accessed October 7, 2015).

[605] Transocean indicated that no one involved in the task actually reviewed the TSTP.

[606] BP's used Engineering Technical Practices (ETPs), Site Technical Practice (STPs), and Group Practices to define minimum engineering and operations corporate standards.

[607] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, pp A-4, BP-HZN-BLY00034504, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[608] For example: Internal Company Document, BP. DCMOC-09-0048: Kick tolerance less than 25 bbls with a 1.0 ppg kick intensity, July 10, 2009.; Internal Company Document, BP. DCMOC-09-0049: Design Pore Pressure (DPP) requirements, July 10, 2009.

[609] See text from MOCs for 22" and 16" casing burst designs, Internal Company Document, BP. *Dispensation from Drilling and Well Opeartions Policy*, BP-HZN-2179MDL00252262, BP-HZN-2179MDL0025226, see Exhibit

MOC where the requester stated, "This would certainly be a worst-case scenario; however, I have seen it happen so know it can occur."[610] Minimizing the probability of a worst-case scenario could lead those responsible for risk management to prematurely stop looking for controls to prevent or mitigate the unwanted consequences.

[CALL-OUT BOX START]

Indicators Developed by BP Post-Macondo

BP itself came to recognize potential safety performance indicators in the aftermath of Macondo. BP's internal investigation team recognized an opportunity to initiate revisions to its safety performance indicator program. As a result, the team recommended the following improvements to the company:

> *4.1 Establish D&C leading and lagging indicators for well integrity, well control and rig safety control equipment, to include but not be limited to:*
>
> - *Dispensations from DWOP.*
> - *Loss of containment (e.g., activation of BOP in response to a well control incident).*
> - *Overdue scheduled critical maintenance on BOP systems.*
>
> *4.2 Require drilling contractors to implement an auditable integrity monitoring system to continuously assess and improve the integrity performance of well control equipment against a set of established leading and lagging indicators.*[†]

[†] *BP. Deepwater Horizon Accident Investigation Report; September 8, 2010; pp 184.*

[CALL-OUT BOX END]

3.5.2.2 Cross Reference Indicators Between the Operator/Drilling Contractor

An independent 2009 Deepwater Horizon rig audit requested by BP[611] observed:

> The TSTP which provides the core risk assessment procedure is only used if one is available for the job. It was evident that the extensive TSTP library was not being fully utilised. That said the written THINK plans reviewed were generally of an acceptable quality and personnel were seen to be actively involved during the THINK Planning process.

The acceptable quality noted in the audit conflicts with observations made in this report on the Deepwater Horizon TSTPs as well as TSTPs associated with serious near-misses Transocean had recently experienced:

6092 http://www.mdl2179trialdocs.com/releases/release201302281700004/Thierens_Henry-Depo_Bundle.zip (accessed October 15, 2015).

[610] See text from MOC for 9-7/8" production casing collapse design; Internal Company Document, BP. *Dispensation from Drilling and Well Opeartions Policy*, BP-HZN-2179MDL00252277, see Exhibit 6092 http://www.mdl2179trialdocs.com/releases/release201302281700004/Thierens_Henry-Depo_Bundle.zip (accessed October 15, 2015).

[611] Internal Company Document, BP. *Deepwater Horizon Follow Up Rig Audit, Marine Assurance Audit and Out of Service Period September 2009*, September 2009, p 5, BP-HZN-I IT -0008875, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-000275.pdf (accessed October 7, 2015).

- As a result of Transocean's Sedco 711 incident, Shell recommended that TSTPs include loss of well barrier risks and well control implications.[612]
- In connection with the M.G. Hulme incident, Transocean's investigation report noted that the TSTP was not approved and did not adequately identify the hazards and cover risk mitigation and preventive controls.[613]
- At Macondo, the TSTP for the negative test was general, lacking process parameters or other criteria to assist the crew in recognizing when the well began drifting outside safe conditions.[614]

Hindsight can be a powerful tool in examining the quality of risk assessment tools. Cross referencing findings in routine audits, either internal or client-requested, with those from incidents and near-misses, regardless of where they occurred, could provide a new perspective on what should be considered acceptable.

Improvements in the selection and use of process safety performance indicators are necessary to effectively reduce the risks of a major accident event offshore. BP, Transocean, and industry more broadly had access to data that provided insights into the performance of safety critical barriers and safety management systems before the April 20 blowout. Yet the focus from both companies—in audits, performance contracts, and award measures— was on personal safety without an equal and sufficient emphasis on major accident risks.

3.6 Regulatory Requirements for Indicators Reporting

At the time of the Macondo incident, MMS required operators to report primarily lagging and infrequently occurring events, such as losses of well control, fires, explosions, collisions, and incidents that damaged or disabled safety systems or equipment.[615, 616] MMS also voluntarily collected from its lessees and operators information on the number of recordable injuries/illnesses of company and contract employees, DART[617] injuries/illnesses of company and contract employees, notices of EPA noncompliance, and oil spills greater than one barrel annually, as well as the total volume for those reported spills.[618] Appendix E of API 75, which was merely a voluntary recommended practice at the

[612] See Section 2.2.

[613] Internal Company Document, Transocean. *EAU Incident Investigation Report - M.G. Hulme, Jr. Well Control Incident - Riser Unloading*, OER-MGH-09-005, March 26, 2009, pp 12, TRN-INV-01143039, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05650.pdf (accessed October 7, 2015); see also Section 2.1.

[614] See Section 1.8.3.

[615] More detail is available in Volume 4, Section 4.3.

[616] Oil and Gas and Sulphur Operations in the Outer Continental Shelf - Incident Reporting Requirements, 71 Fed. Reg. 19,640 (April 17, 2006).

[617] DART stands for Days Away from work, Restricted duty, and Transfer situations; US DOI MMS Performance Measures Data, MMS-131, http://www.ocsbbs.com/ntls/ntl2005-n02-formmms-131.pdf, (accessed October 7, 2015).

[618] US DOI MMS Notice to Lessees and Operators of Federal Oil and Gas Leases on the Outer Continental Shelf: Performance Measures for OCS Operators and Form MMS-131, NTL2005-N02, https://ocsbbs.com/ntls/ntl05-n02.asp, and US DOI MMS Performance Measures Data, MMS-131, http://www.ocsbbs.com/ntls/ntl2005-n02-formmms-131.pdf, (accessed October 7, 2015).

time of Macondo, recommended the collection of those same safety performance metrics, as well as fire, explosion, and blow-out incident rates, and Incidents of Noncompliance issued by MMS.[619] Since these data reporting recommendations were voluntary, the regulator did not have access to a full range of data possible to assess industry performance, identify negative safety trends, or set targets for industry improvement. Post-Macondo, the potential for the US regulator to use safety performance indicator data to further advance safety offshore is recognized, with the regulator's voluntary request becoming mandatory in February 2011 and the introduction of an anonymous near-miss reporting program, SafeOCS, in 2015.[620] Volume 4 describes approaches BSEE might take to promote offshore safety improvements using indicator data it collects.[621]

3.7 Conclusion

The imperative to prevent another offshore catastrophe supports efforts by industry to actively monitor safety performance indicators that capture barrier and safety management system health. This chapter highlights some of the more advanced work on the issue to suggest ways companies can effectively collect and use safety data to manage major accident hazards. Volume 4 of the CSB Macondo Investigation Report, describes in detail how the regulator can play an influential role in developing and using safety performance indicators.

[619] API Recommended Practice, 75, 3rd (2004, reaffirmed 2008) ed., Recommended Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities, Appendix E, pp 37-41.

[620] https://near-miss.bts.gov/ (accessed January 15, 2015).

[621] Section 4.3.

4.0 Ineffective Risk Management Approaches at Macondo and the Challenges of the Multi-Employer Offshore Work Environment

Chapter 4.0 Overview

This chapter examines various BP and Transocean policies for managing major accident risks during drilling operations. The chapter demonstrates how despite contracted rigs represent a majority of BP's blowout risks and Transocean's rigorous corporate management risk policies, neither company sufficiently managed major hazard risks at the Macondo well.

Major process safety incidents such as the 1988 UK Piper Alpha (offshore production facility)[622] and the 1989 Phillips 66 Chemical Complex (petrochemical production facility)[623] explosions were shaped by factors related to contractor management and ensuring safe operations in a multi-employer environment. At Piper Alpha, causal factors included deficiencies in contractor training and communication related to safety critical procedures as well as emergency response.[624] For the 1989 Phillips 66 incident, findings addressed dispersed responsibility for employee safety where one or more contractors were engaged in potentially hazardous activities at the worksite.[625] In its Phillips 66 investigation report, OSHA compared the owner/contractor problem to threats that can arise from dividing safety responsibility at construction sites where procedures were not in place.[626] Similar lessons presented themselves at Macondo, but with nuances specific to the offshore drilling industry.

As detailed in Section 1.8, while BP designed the Macondo well, Transocean supplied most of the workforce and drilling equipment. Before drilling began, BP agreed to use Transocean's Safety Management System (SMS) on the Deepwater Horizon.[627] For the workforce under the drilling

[622] On July 6, 1988, an explosion occurred aboard the Piper Alpha oil production platform 120 miles off the coast of Scotland in the North Sea. A series of explosions and fire killed 167 workers and almost completed destroyed the platform. This incident became the deadliest accident in the history of the offshore industry.

[623] On October 23, 1989, an explosion occurred at the Phillips 66 Company's Houston Chemical Complex where high-density polyethylene plastic for milk bottles and other containers was produced, killing 23 workers and injuring 130 others. This was one of the worst industrial workplace accidents in the United States.

[624] Department of Energy. The Public Inquiry into the Piper Alpha Disaster; Presented to Parliament by the Secretary of State for Energy by Command of her Majesty; November, 1990; noted in several locations, including examples on pp 194, 213, 293, and 356.

[625] U.S. Department of Labor Occupational Safety and Health Administration, The Phillips 66 Company Houston Chemical Complex Explosion and Fire: Implementation for Safety and Health in the Petrochemical Industry, April 1990, p vii.

[626] OSHA noted, "Following the L'Ambiance Plaza apartment complex collapse in Bridgeport, Connecticut, in April 1987, in which 28 workers were killed, OSHA held the primary contractor responsible for not meeting the safety and health requirements at the site. It was the agency's position that the primary contractor, in its role of supervisor of the entire project, could have prevented those violations regardless of whether part of the work was subcontracted." U.S. Department of Labor Occupational Safety and Health Administration, *The Phillips 66 Company Houston Chemical Complex Explosion and Fire: Implementation for Safety and Health in the Petrochemical Industry*, April 1990, p 63.

[627] Internal Company Document, BP. *Transocean Drilling Contract for the Deepwater Horizon, 1998*, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-004271.pdf (accessed May 27, 2015).; Hearing before the Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 29, 2011, see Mogford Designations Vol 2 pp 22-25,

contractor, consistently working within one safety management system should improve front-line activities as the drilling rig moves from one well to another or as crew members work on wells managed by different operators. However, as Section 1.8 indicates, the interface of the safety management systems between the operator and the contractors, particularly the drilling contractor, can play an important role in bridging the natural gap between work-as-imagined in the drilling program and work-as-done by the well operations crew. To do so effectively, the interface must encompass fundamental hazard identification and both companies' process safety risk management practices.

At Macondo, BP and Transocean did not clarify hazard identification and risk management roles and responsibilities for safety critical activities contained within the temporary abandonment program. Consequently, while both companies had more rigourous corporate policies for risk management, neither assumed effective responsibility for ensuring their implementation at Macondo. This chapter addresses the corporate policies that establish the basis for BP and Transocean's risk managment expectations.

4.1 BP and Transocean Risk Reduction Goal: ALARP

Companies need an effective, and realistic, risk reduction goal because they cannot eliminate every risk completely—absolute safety is not possible. The question then becomes, when are efforts to reduce the level of residual risk sufficient? This challenge led to reducing risk to a level as low as is reasonably practicable, or ALARP, an important concept to explore in risk reduction practices employed during the Macondo drilling project since both BP and Transocean had policies to apply ALARP principles.[628]

No prescribed methodology defines the type or number of barriers needed to demonstrate ALARP.[629] The determination relies on informed judgments supported by a robust hazard analysis process that weighs the strengths and weaknesses of a range of potential barriers. Generally, proof that ALARP levels have been achieved is accepted when companies can show they adhere to generally recognized codes, standards, and

http://www.mdl2179trialdocs.com/releases/release201302281700004/Mogford_John-Depo_Bundle.zip (accessed October 7, 2015); Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 21, 2011, see Baxter Designations Vol 1 pp 26-27, http://www.mdl2179trialdocs.com/releases/release201302281700004/Baxter_John-Depo_Bundle.zip (accessed October 7, 2015).

[628] BP's OMS Exploration and Production Drilling and Well Operations Practice (DWOP) states, "all risks shall be managed to a level which is as low as reasonably practical" or ALARP, Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, "This document contains the practices that have been agreed by BP management as current and relevant for drilling and well operations.", pp A-8, BP-HZN-BLY00034518, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015). Transocean policies require employees to manage risks to ALARP, which Transocean defines as "… requiring personnel to consider the various additional risk reduction measures (additional controls) and determine if the effort and cost of those measures justify the additional amount of risk reduction obtained" Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Section 4 (Safety Policies, Procedures and Documentation), pp BP-HZN-2179MDL00132218, see Exhibit 4942, BP-HZN-2179MDL00132055, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[629] Executive, H. a. ALARP "at a glance", http://www.hse.gov.uk/risk/theory/alarpglance.htm (accessed October 7, 2015), 2015.; NOPSEMA. *Guidance Note: ALARP;* N-04300-GN0166 Revision 6; June, 2015; pp 5-7. http://www.nopsema.gov.au/assets/Guidance-notes/N-04300-GN0166-ALARP.pdf (accessed October 7, 2015).

relevant good practices.[630] ALARP is also defined as "efforts to reduce risk [that are] continued until the incremental sacrifice (in terms of cost, time, effort,or other expenditure of resources) is grossly disproportionate to the incremental risk reduction achieved."[631] In practice, these efforts by the company are twofold. First, they are the initial identificaton and implementation of physical, operational/human, and organizational safety barriers to reduce the risk of a major accident as determined by a hazard analysis. Second, they are adherence to safety managment systems intended to ensure strong barriers throughout the lifetime of an operation. The success of these systems hinges on the risk management approach and corporate oversight of that approach to create a strong and supportive culture. Collaboration of this magnitude means actively monitoring for, and then addressing, barrier performance gaps appropriately. Thus, while an initial effort to address risk levels is necessary, the efforts should be continual and in response to various factors such as new technology developments, updated industry standards, or lessons learned from an incident.

ALARP is not required by the SEMS Rule. Despite its lack of presence, several widely recognized standards and guidelines recommend using ALARP. Specific to drilling, ALARP is recommended by the IADC, a trade association of which Transocean is a member.[632] While this chapter details ALARP provisions stipulated in both BP and Transocean corporate policies to demonstrate inadequacies in their risk management approaches, Volume 4 expands the ALARP conversation and addresses the important role of the regulator in overseeing and verifying adequate risk reduction measures by industry in an ALARP environment.

4.2 Contractor Safety Management Guidance Calls for Clear Definition of Roles and Responsibilities

The International Association of Drilling Contractors (IADC), the Center for Chemical Process Safety (CCPS),[633] and API guidance identify that keys to managing major process risk between a contracting

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[630] The Center for Chemical Process Safety (CCPS) identifies ALARP as an appropriate risk reduction approach in their hazard identification and risk analysis guidance; Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007; see generally Chapter 9, Hazard Identification and Risk Analysis, pp 209-244.

CCPS is a not-for-profit industry alliance within the chemical engineering professional society - the American Institute of Chemical Engineers (AIChE) "that identifies and addresses process safety needs within the chemical, pharmaceutical, and petroleum industries, http://www.aiche.org/ccps/about (accessed February 28, 2015). CCPS's mission is to "eliminate process safety incidents in all industries" but much of CCPS safety guidance has historically focused on onshore process safety issues, http://www.aiche.org/ccps/about/mission-vision (accessed February 28, 2015). Member companies include major oil companies such as BP, Chevron, ConocoPhillips, ExxonMobil, Total and Shell that manage process safety both on and offshore.

[631] Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007; pp xxxvii.

[632] With the exception of the US, regulators of the leading oil and gas producing countries of the world have recognized or adopted these guidelines. IADC Safety Case Guidelines web page detailing the 21 countries where the guidelines have been adopted or are pending adoption, http://www.iadc.org/iadc-hse-case-guidelines/ ; International Association of Drilling Contractors *Health, Safety and Environment Case Guidelines for Mobile Offshore Drilling Units*, January 2015, Issue 3.6, Part 4, pp 22-23.

[633] Guidelines for managing risk have been produced by various authors including the CCPS and IADC. While the CCPS guidelines were not expressively written for offshore operations, they have recently been effectively

company and a contractor are clear definition and communication of safety critical roles and responsibilities.[634] IADC recommends that a drilling contractor identify in writing hazardous operations and barriers that likely fall under its responsibility, including running drillpipe into and out of a well, well testing, and displacing a well.[635] The objective of such an activity is to incorporate input from relevant stakeholders (like an operator) on the uncertainties and assumptions made when identifying risk reduction measures, and then communicating the information to the workforce.[636] The IADC also identifies that a bridging document between the operator and contractor should describe "individual and collective stakeholder responsibilities during the various operational phases,"[637] which include HSE management responsibilities and authorities[638] as well as HSE critical activities and verification of effectiveness.[639]

CCPS emphasizes that owners/operators need to "establish expectations, roles and responsibilities for safety program implementation and performance."[640] CCPS states that one key principle for owners/operators in contractor management is to "maintain high standards of safety performance during the conduct of the contracted services," and it further asserts that the contracting company must implement a contractor management program to ensure safe operations.[641] Maintaining a dependable process safety practice and ensuring consistent implementation require "compliance with specific company, facility or regulatory requirements. Responsibility for each associated work activity should be identified and designated, as appropriate to the company or contractor."[642] CCPS also states that most companies require that contractor safety standards and practices be comparable to the owner/operator's.

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implemented in drilling and well operations (Chajai, H.; Smith, C. *Defining and Improving Process Safety for Drilling and Well Services Operations*, IADC/SPE Drilling Conference and Exhibition, Fort Worth, TX, March 4 - 6, 2014) As such, they complement the IADC guidelines for assessing policies and practices relevant to the Macondo incident.

[634] Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007; p 365.

[635] International Association of Drilling Contractors *Health, Safety and Environment Case Guidelines for Mobile Offshore Drilling Units*, January 2015, Part 4, Section 4.8, p 36.

[636] International Association of Drilling Contractors *Health, Safety and Environment Case Guidelines for Mobile Offshore Drilling Units*, January 2015, Part 4, Section 4.8.1, p 37.

[637] International Association of Drilling Contractors *Health, Safety and Environment Case Guidelines for Mobile Offshore Drilling Units*, January 2015, Part 2, Section 2.2.1, p 4.

[638] International Association of Drilling Contractors *Health, Safety and Environment Case Guidelines for Mobile Offshore Drilling Units*, January 2015, Part 2, Section 2.2.3.4, pp 8.

[639] International Association of Drilling Contractors *Health, Safety and Environment Case Guidelines for Mobile Offshore Drilling Units*, January 2015, Part 6, Section 6.4, pp. 6-7.

[640] Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007, p 367.

[641] Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007, p 368.

[642] Center For Chemical Process Safety. *Guidelines for Risk Based Process Safety;* John Wiley & Sons: Hoboken, NJ, 2007, p 370.

API Recommended Practice 76,[643] *Contractor Safety Management for Oil and Gas Drilling and Production Operations*, establishes owner/operator responsibilities for contractor safety performance, including drilling contractors, and advises that the "operator should identify the safety requirements and communicate them to the contractor." [644] Where contractors have specialized expertise and knowledge of expected hazards, it is important that a determination be made "as to which individual or company will have the primary responsibility for implementing additional safety requirements applicable to their specialty."[645]

4.3 Transocean did not apply its More Rigorous Corporate Risk Management Policies to the Deepwater Horizon and Macondo Well

This section shows that Transocean offered minimal internal guidance and unclear expectations of the risk management tools its personnel should use for an offshore operation or facility, and the more rigorous ones were not applied at the Macondo well. Transocean claims not to have used the ore rigorous ones because US regulations did not require them.[646]

Transocean's rig crews manage risk with the THINK planning process (Section 1.8.3), a hierarchical approach with levels of risk assessment that depended on factors such as the complexity and potential safety impact of the task.[647] As the complexity and severity of the potential risk increases, responsibility should shift from the rig crew to further up the organizational hierarchy, and the company should use more rigorous risk management approaches, including HAZOP/HAZID, Major Accident Hazard Risk Assessment (MAHRA; sometimes referred to as MHRA or Major Hazard Risk Assessment), and the Health Safety and Environmental (or safety) case and operations integrity case (OIC) (see Figure 4-1 and Table 4-1).

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[643] API RP 76 has been cited as a potentially helpful document in "developing guidelines for contractor selection" in API Recommended Practice 75 that was made mandatory in offshore regulations post-Macondo. See Volume 4, Section 2.1 for more discussion.

[644] Note that API 76 has not been updated since 2007 or revised in the aftermath of the Macondo incident. API Recommended Practice 76, 2nd ed., *Contractor Safety Management for Oil and Gas Drilling and Production Operations*, November 2007 (, reaffirmed January 2013), p 1.

[645] It should be noted that the language used in API RP 76 revolves around permissive "should" and not "shall" requirements. Also, API 76 has not been updated since 2007 or revised in the aftermath of the Macondo incident; API Recommended Practice 76, 2nd ed., *Contractor Safety Management for Oil and Gas Drilling and Production Operations*, November 2007 (reaffirmed January 2013), p 1.

[646] See text in Section 4.3.1.1; Internal Company Document, Transocean. *Investigations - Hazard Studies*, July 29, 2010, p TRN-INV-03403088.

[647] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Risk Management Think Planning Process, see Exhibit 4942, BP-HZN-2179MDL00132218 - 20, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

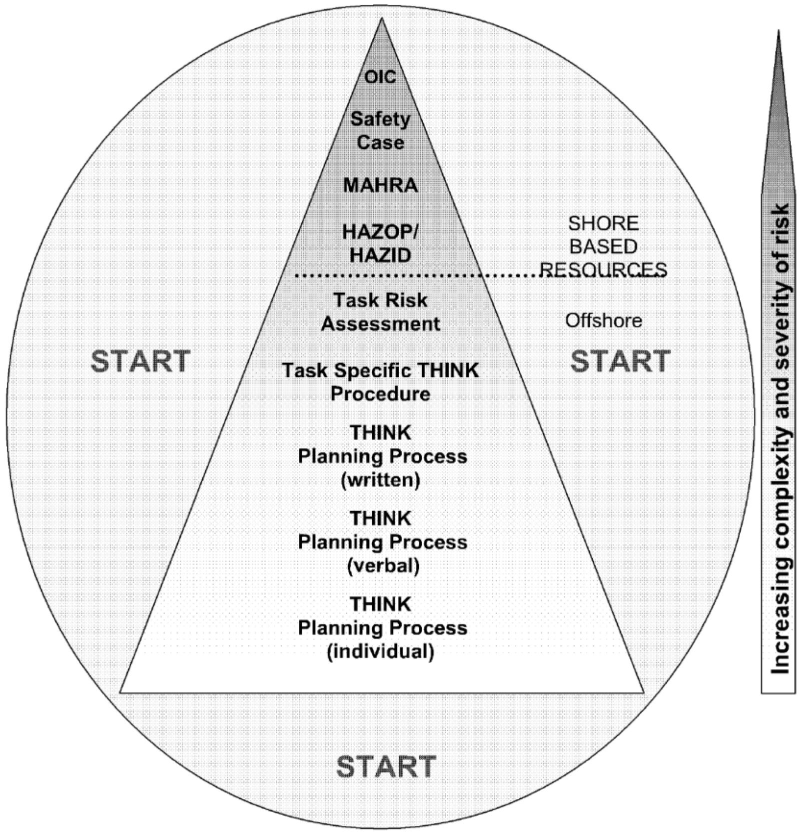

Figure 4-1.[648] Transocean's Levels of Risk Management. The higher level risk management approaches were applied to activities with greater complexity and severity of risk.

[648] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Risk Management Think Planning Process, see Exhibit 4942, BP-HZN-2179MDL00132220, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

Table 4-1. Shore-based risk management tools as identified and described in Transocean's *Health and Safety Policies and Procedures Manual-Level*.

Risk Management Tool	Transocean Description[649]
Hazard Identification (HAZID)/ Hazard and operability (HAZOP)	A HAZID study is the structured, systematic risk assessment of an activity in order to identify the hazards associated with it. A HAZOP study is used to identify health, safety, and environmental hazards and operability issues for equipment or systems to reduce risks to ALARP. HAZOPs are primarily used during a design stage.
Major Hazard Risk Assessment (MAHRA)	Demonstrates that the company has identified the major hazards of an installation, qualitatively assessed the risk associated with those hazards, and identified the preventive and mitigating controls necessary to reduce the risk to ALARP.
Safety Case	A summary of the installation, installation management, and company safety management system, showing the company has identified and evaluated all major hazards that may affect the installation and has appropriate means for controlling risks of those hazards.
Operation Integrity Case (OIC)	Assures that the company has identified major and other workplace hazards, assessed the risks associated with these hazards, and possesses the necessary controls to reduce the risk to as low as reasonably practicable. A person is assigned to each identified control. The OIC process is based on the Company Management System.

These tools, requiring varying levels of analysis and organizational responsibility, should assist in identifying and managing needed safeguards. For the Macondo well, scant evidence exists that Transocean used any of these risk management tools to adequately assess hazards and implement effective controls to manage loss-of-well control risks.

4.3.1 Transocean Lacks Implementation Guidance for its Risk Management Tools

The Transocean Health and Safety Manual (HSE Manual) in effect at the time of the incident provided little guidance on the selection of risk management tools and their requirements. For the higher level risk tools, Transocean merely states that every vessel in the fleet must have a current version of the MHRA, Safety Case, or OIC. [650] Of these three tools, Transocean does not describe which tool is required under given conditions except to say that countries such as the UK use the Safety Case to demonstrate that risks

[649] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Safety Policies, Procedures and Documentation, see Exhibit 4942, BP-HZN-2179MDL00132229, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[650] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Safety Policies, Procedures and Documentation, BP-HZN-2179MDL00132229, see Exhibit 4942, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

are ALARP.[651] While the Transocean HSE Manual indicates that these three tools should be used where the severity and complexity of risk "increases" (Figure 4-1), it provides no direction about their benefits for major accident prevention under different risk conditions. In April 2010, Transocean commissioned Lloyd's Register to review its safety management systems.[652] Lloyd's Register reported that Transocean's offshore workforce was confused about the risk management hierarchy and that the workers viewed the tools as poorly described and lacking guidance on "when and how [the tools] should be applied." The report found that while Transocean's risk management procedure required quantifying hazards and reducing risks to ALARP, the management system lacked a procedure to do so.

The various levels of Transocean's risk management hierarchy were all intended to demonstrate that risks were reduced to ALARP.[653] However, Transocean did not use the good practice test for ALARP for the Deepwater Horizon rig or the Macondo well project, which requires that the incremental sacrifice (in terms of cost, time, etc.) be grossly disproportionate to the incremental risk reduction achieved. Rather Transocean stated that ALARP "requires personnel to consider the various risk reduction measures (additional controls) and determine if the effort and cost of those measures justify the additional amount of risk reduction obtained."[654] By eliminating the gross disproportionality test, Transocean expressly allowed risk reduction to carry less weight and cost factors to play a greater role in the ALARP determination.

BP notes that traditional risk assessments are not appropriate for managing the risk of low probability, high consequence major accident events, requiring instead a different strategy that does not lead to excluding them from further risk reduction efforts (see Section 4.4.1).

4.3.1.1 Transocean Identified Risk Mitigation Tool Weaknesses Post Incident

Despite the high severity of known risks in exploring high pressure/high temperature wells in deep water, like Macondo, the only Transocean higher level risk management activity completed was a generic Major Hazard Risk Assessment (MHRA) for the Deepwater Horizon rig.[655] While Transocean's HSE Manual

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[651] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Safety Policies, Procedures and Documentation, BP-HZN-2179MDL00132229, see Exhibit 4942, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[652] Internal Company Document, Transocean. *An Independent Review of CMS and SMS, Client: Transocean*, April 9, pp 11, 2010,TRN-INV-02825041.

[653] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Demonstrating Risks are ALARP, see Exhibit 4942, BP-HZN-2179MDL00132229, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[654] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Demonstrating Risks are ALARP, see Exhibit 4942, BP-HZN-2179MDL00132229, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[655] Internal Company Document, Transocean. *Major Accident Hazard Risk Assessment Deepwater Horizon*, Revision 01, August 29, 2004, TRN-MDL-01184581, http://www.mdl2179trialdocs.com/releases/release201303141200012/TREX-02188.pdf (accessed October 7, 2015).

required a review and update of the MHRA,[656] the Horizon MHRA had not been revised since 2004, nearly six years before the Macondo incident. The purpose of the MHRA was to "demonstrate that adequate controls were in place so that HSE risks on the Deepwater Horizon can be considered both tolerable and ALARP." The MHRA examined a number of hazards using a generic risk matrix that defined the categories of severity and likelihood.[657] Ultimately, this led to a designation that a well blowout was a "medium risk" for the Deepwater Horizon and required review, but Transocean did not issue recommendations for the well blowout hazard under its scheme.[658] (See also Volume 2, Section 5.1.1.) Despite the critical role of manual activation of the BOP in ensuring the BOP can act as a physical barrier against a well kick or blowout,[659] Transocean has no record that it identified, evaluated, and implemented the necessary corresponding human and process controls.

Post-incident, Transocean technical personnel concluded that the MHRA approach was less effective than what other countries require and observed an absence of a Macondo bowtie[660] analysis to address safety barriers.[661] A Transocean outside risk consultant agreed, noting that the use of MHRA is "not as good as the bowties," in part as they are not "user friendly" and do not address barrier effectiveness or circumstances that could compromise barriers.[662] The Transocean DWH Investigation team identified that regulatory requirements to undertake more in-depth analysis of major hazard events influenced the level

[656] Internal Company Document, Transocean. *Health and Safety Policies and Procedures Manual*, Issue 03, Revision 07, HQS-HSE-PP-01, December 15, 2009, Risk Management Think Planning Process, see Exhibit 4942, BP-HZN-2179MDL00132229, http://www.mdl2179trialdocs.com/releases/release201302281700004/Farr_Daniel-Depo_Bundle.zip (accessed October 7, 2015).

[657] The likelihood categories were based on the subjective determination of the personnel involved. For a medium likelihood, an event such as a blowout would have had to occur on the Horizon. Low likelihood was assigned if the staff knew the event occurred in industry. The report has no justification for using the categories or the significant gap between "known to have occurred in the industry" and "occurs on this rig." Based on this subjective approach, the MHRA concluded that while the consequences of a well blowout were judged to be "extremely severe" based on the fact that no blowout had occurred on the Deepwater Horizon, the likelihood of occurrence was low.

[658] Internal Company Document, Transocean. *Major Accident Hazard Risk Assessment Deepwater Horizon*, Revision 01, August 29, 2004, TRN-MDL-01184597 and TRN-MDL-01184589 - 91, http://www.mdl2179trialdocs.com/releases/release201303141200012/TREX-02188.pdf (accessed October 7, 2015).

[659] Volume 2, Section 2.2.

[660] Bowtie diagrams are introduced in Volume 2, Section 4.2.1. A bowtie diagram (also referred to simply as a bowtie) is a visual tool that depicts the relationships between hazards, barriers, and the major accident events the barriers are intended to prevent.

[661] Internal Company Document, Transocean. *Investigations - Hazard Studies*, July 29, 2010, TRN-INV-03403088.

[662] Email from Operations Manager, Marex, to Deepwater Horizon Investigation Team, Transcoean, Subject: FW: Champion's - Major Hazard Risk Assessment or Safety Case, May 13, 2010, TRN-INV-02872965. The email specifically states "barrier effectiveness, escalation." 'Escalation' factors are commonly used to describe barrier threats, see Lewis, S.; Smith, K. *Lessons Learned From Real World Application of hte Bow-tie Method*, American Institute of Chemical Engineers 2010 Spring Meeting 6th Global Congress of Process Safety, San Antonio, TX, March, 2010.

of analysis actually conducted by the company.[663] The comments from the Transocean investigation team portray the use of MHRA as a minimum compliance approach—Transocean will use the more effective approach only if the regulatory regime requires it. This minimal compliance approach undermines Transocean's claim of reducing major accident risk to ALARP. If the same company recommends and uses a more effective risk management approach for the same activity, then the less rigorous approach clearly is not ALARP.

4.4 Post-Texas City Refinery Disaster, BP Developed but Macondo did not Benefit from the Robust Corporate Risk Management System

The 2007 Baker Panel and CSB reports[664] issued in the wake of the 2005 BP Texas City refinery accident led to a renewed global emphasis on process safety performance for many high-hazard industries and regulators beyond the oil refining sector. Two major lessons with broad implications from both reports were (1) the necessity to focus on process safety separate and distinct from personal safety and (2) the influential power of corporate leadership and organizational culture in driving continual process safety improvement.[665]

The Baker Panel report recommended that BP implement "an integrated and comprehensive process safety management system that systematically and continuously identifies, reduces, and manages process safety risk."[666] BP agreed to adopt the Baker Report recommendations, establishing a Board reporting process to track progress to implementation. BP also responded to findings and recommendations from the CSB and Baker Panel by developing an overhaul of its corporate safety management system approach to its entire global operations. It termed this approach the BP Operating Management System Framework or OMS, which in 2008 replaced the business-wide HSE management system Getting Health, Safety, and Environment Right (GHSER).[667] The BP Group Chief Executive Tony Hayward asserted "the operating management system (OMS) is fundamental to delivering safe and reliable operating activities in BP."[668]

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[663] Internal Company Document, Transocean. *Investigations - Hazard Studies*, July 29, 2010, p TRN-INV-03403088.

[664] The Baker Panel. *The Report of the BP US Refineries Independent Safety Review Panel;* January, 2007; http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf (accessed October 7, 2015).; USCSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005,* Report No. 2005-04-I-TX, http://www.csb.gov/assets/1/19/CSBFinalReportBP.pdf (accessed October 7, 2015), March 2007.

[665] Hopkins, A. Failure to Learn - the BP Texas City Reginery Disaster; CCH Australia Limited: 2009; pp 63-64.

[666] The Baker Panel. *The Report of the BP US Refineries Independent Safety Review Panel;* January, 2007; p xvi. http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf (accessed October 7, 2015).

[667] Internal Company Document, BP. *The BP Operating Management System Framework, Part 1, An Overview of OMS*, Version 2, November 3, 2008, BP-HZN-2179MDL00333196, see Exhibit 2352 http://www.mdl2179trialdocs.com/releases/release201302281700004/Lynch_Richard-Depo_Bundle.zip (accessed October 7, 2015).

[668] Internal Company Document, BP. *The BP Operating Management System Framework, Part 1, An Overview of OMS*, Version 2, November 3, 2008, pp 2, BP-HZN-2179MDL00333198, see Exhibit 2352 http://www.mdl2179trialdocs.com/releases/release201302281700004/Lynch_Richard-Depo_Bundle.zip (accessed October 7, 2015).

The CSB Texas City report noted that GHSER, the OMS predecessor, listed "expectations" encompassing both personal safety and some limited process safety elements, but the reporting requirements to corporate leaders focused on personal safety, which weakened BP's ability to prevent the Texas City incident.[669] In contrast, OMS addresses both process and personal safety in its risk approach and included a larger collection of process safety-related policies and engineering and technical practices that represented, as a whole, a more structured and rigorous approach to major accident prevention. BP explicitly approved these policies for implementation "across the BP Group"[670] and intended to apply them to onshore and offshore operations, including drilling and completions.[671]

Under OMS, BP required the systematic identification of process safety hazards, risk assessment, and risk reduction measures at the plant, process, and people levels.[672] OMS's risk approach required an annually updated risk register that identified specific safety and environmental risk reduction measures.[673] Implementing OMS was intended to include at least an annual gap assessment of the entity's operations based on the OMS guidance and related standards at all levels of the organization.[674] The standards included Group Engineering Technical Practices, which defined minimum engineering and operations process safety corporate standards for reducing risks, including Integrity Management,[675] a Hazard and

669 USCSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005,* Report No. 2005-04-I-TX, pp 149, http://www.csb.gov/assets/1/19/CSBFinalReportBP.pdf (accessed October 7, 2015), March 2007.

670 BP Group management is the global corporate management responsible for business operations, including exploration and production (E&P).

671 Internal Company Document, BP. *Gulf of Mexico SPU Operating Plan (OMS Handbook)*, December 3, 2008, BP-HZN-2179MDL00333155, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-002908.pdf (accessed October 7, 2015).

672 Internal Company Document, BP. *Gulf of Mexico SPU Operating Plan (OMS Handbook)*, December 3, 2008, BP-HZN-2179MDL00333155, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-002908.pdf (accessed October 7, 2015).

673 Internal Company Document, BP. *The BP Operating Management System Framework, Part 2, Elements of Operating including Group Essentials*, Issue 2, November 3, 2008, see Exhibit 2352, BP-HZN-2179MDL00333245, http://www.mdl2179trialdocs.com/releases/release201302281700004/Lynch_Richard-Depo_Bundle.zip (accessed October 7, 2015).

674 Internal Company Document, BP. *The BP Operating Management System Framework, Part 2, Elements of Operating including Group Essentials*, Issue 2, November 3, 2008, see Exhibit 2352, BP-HZN-2179MDL00333245, http://www.mdl2179trialdocs.com/releases/release201302281700004/Lynch_Richard-Depo_Bundle.zip (accessed October 7, 2015).

675 "This practice provides requirements for designing, constructing, operating and maintaining […] floating structures throught their lifecycle. The intent is to prevent loss of containment, structural failure or unintended release of stored energy;" Internal Company Document, BP.

Operability Study,[676] Inherently Safer Design,[677] and Layers of Protection Analysis (LOPA).[678] As the CSB shows in recently published investigation reports, policies like these have the potential of more robustly reducing process safety risk.[679] Other risk management practices that BP required included BP's Major Accident Risk Process[680] and the Drilling and Well Operations Practice (DWOP).[681] Both are detailed in this section.

4.4.1 OMS Roll-out Lags Macondo Well Planning and Drilling—Related Safety Practices were not Effectively Applied at the Macondo Well

BP pledged to implement OMS as a response to the Texas City recommendations across all operations. As indicated on the timeline in Figure 4-2 BP first announced OMS in 2006, with piloting of the new system beginning in 2007 and large company rollout in 2008.[682] In 2008, BP CEO Tony Hayward stated at an annual general meeting for shareholders, "Our intense focus on process safety continues. We are making good progress in addressing the recommendations of the Baker Panel and have begun to implement a new Operating Management System across all of BP's operations."[683] By 2009, BP

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[676] Internal Company Document, BP. *GP 48-02Hazard and Operability (HAZOP) Study*, June 12, 2008, BP-HZN-CSB00181666.

[677] Internal Company Document, BP. *GP 48-04 Inherently Safer Design (ISD)*, June 5, 2008, BP-HZN-CSB00181764, "Inherently safer design (ISD) is a way of thinking differently from traditional hazard management. Instead of identifying hazards and adding layers of protection to prevent and minimise hazards, inherently safer design first challenges whether the hazard can be eliminated completely or reduced in severity."

[678] Internal Company Document, BP. *GP 48-03 Layers of Protection Analysis (LOPA)*, June 5, 2008, "This GP describes the method used to evaluate the effectiveness of independent protection layer(s) in reducing the likelihood or severity of an undesirable event." BP-HZN-CSB00181723.

[679] USCSB, 2013. *Final Investigation Report: Chevron Richmond Refinery Pipe Rupture and Fire*, *Richmond*, *CA*, *August 6*, *2012*, Report No. 2012-03-I-CA, http://www.csb.gov/assets/1/19/Chevron_Interim_Report_Final_2013-04-17.pdf (accessed October 7, 2015), April 2013.; USCSB, 2014. *Catashtrophic Rupture of Heat Exchanger*, *Anacortes*, *WA*, *April 2*, *2010*, Report No. 2010-08-I-WA, http://www.csb.gov/assets/1/7/Tesoro_Anacortes_2014-May-01.pdf (accessed October 7, 2015), May 2014.

[680] Internal Company Document, BP. *BP Group Engineering Technical Practices, Major Accident Risk (MAR) Process, GP 48-50*, June 5, 2008, BP-HZN-2179MDL00407937, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed May 22, 2015).

[681] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, "This document contains the practices that have been agreed by BP management as current and relevant for drilling and well operations." BP-HZN-BLY00034504, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[682] See BP Sustainability Reviews from 2006 – 2008 at http://www.bp.com/en/global/corporate/sustainability/about-our-reporting/Sustainability-report/sustainability-report-archive.html (accessed March 3, 2016).

[683] Hayward, T. *Tony Hayward's speech at the 2008 Annual Genearl Meeting*, Docklands, London, April 17, 2008; see Exhibit 6015, http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed 7 2015, October).

announced rollout was 80% complete businesswide, and specifically in the Gulf of Mexico by December 2009.[684]

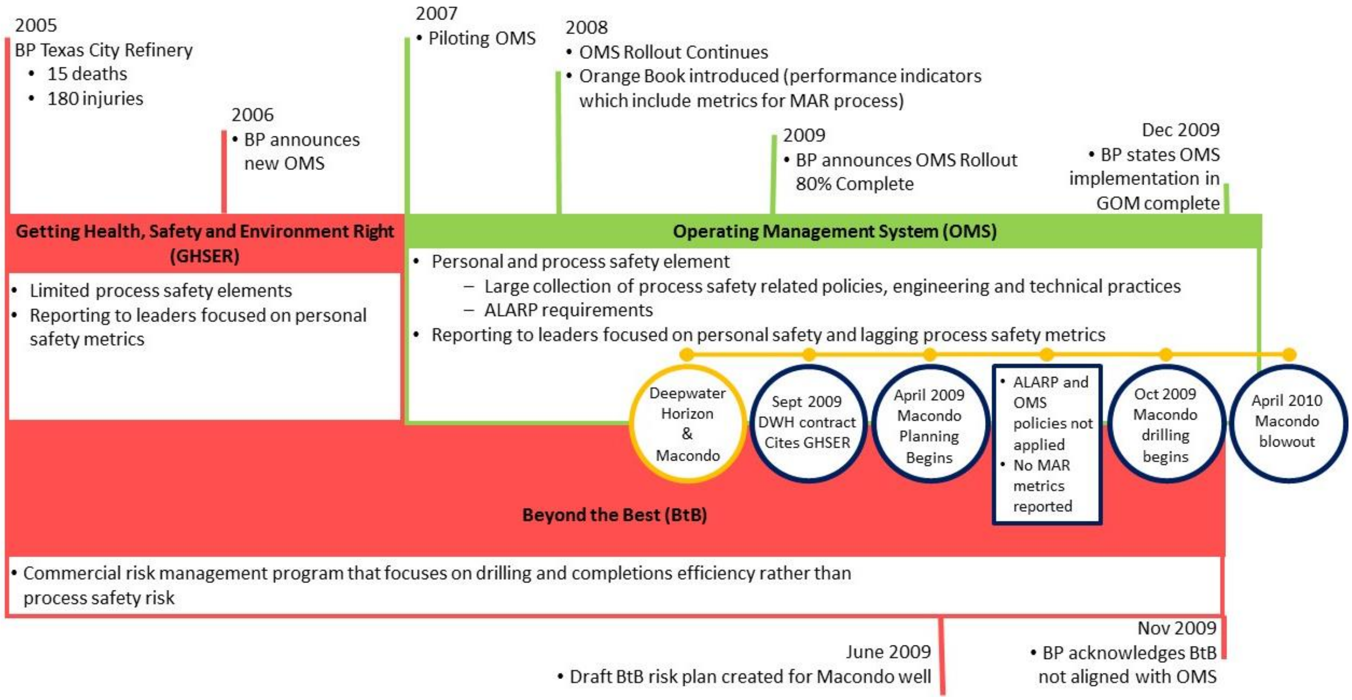

Figure 4-2. OMS Rollout at BP, 2006-2009

BP's guidance indicates that the OMS requirements would be applicable to contractor-owned rigs,[685] but the "delivery of HSSE [health, safety, security and environment] would be accomplished through the

[684] See BP Sustainability Reviews from 2008 – 2010 at http://www.bp.com/en/global/corporate/sustainability/about-our-reporting/Sustainability-report/sustainability-report-archive.html (accessed March 3, 2016).

[685] For example, BP's *Gulf of Mexico SPU, Drilling and Completions OMS Implementation Terms of Reference* states that "OMS is not an option; it is a requirement … OMS applies to all operations and premises, controlled or owned by BP and sites operated or controlled on BP's behalf … For GoM D&C this document serves to define the activities planned for 2009 to ensure clarity around how OMS will apply to both BP-owned and contractor-operated and contractor-owned and operated rigs and further how the organization is currently conforming to OMS expectations." Internal company document, BP, *Gulf of Mexico SPU Drilling and Completions OMS Implementation Terms of Reference*, February 13, 2009, BP-HZN-2179MDL00369586, see Exhibit 0784 http://www.mdl2179trialdocs.com/releases/release201302281700004/Grounds_Cheryl-Depo_Bundle.zip (accessed October 7, 2015).

drilling contractor's Safety Management System (SMS)."[686,687] Even though BP did not require Transocean to directly apply OMS in lieu of its own management system, OMS expressly applied to BP's drilling projects with contracted rigs in the GoM in two key ways:

1. OMS applied to BP's well drilling planning and execution activities, "performed under the control or supervision of BP, or on behalf of BP"; and[688]
2. BP's Drilling and Well Operations Practice (DWOP) requires a well control bridging document; thus, BP's GoM Drilling and Completion (D&C) procedures required that the parties execute a bridging document to align BP and the drilling contractors' safety management system.[689]

Consequently, while contractors do not have to adopt OMS verbatim, its associated technical practices do apply to contracted wells like Macondo. Unfortunately, as indicated in Figure 4-2, OMS requirements were just starting for D&C during the initial Macondo planning stages and when the well was first drilled.[690] The CSB found no evidence that BP retroactively initiated OMS elements at Macondo that could have impacted risk management at the well. The following sub-sections describe those OMS examples.

4.4.2 Macondo Risk Analysis Lacked BP ALARP Requirements

Before Macondo, BP did not apply the Baker and CSB process safety lessons learned that led it to adopt OMS. Rather, it employed the pre-Texas City "Beyond the Best (BtB) Common Process" for contracted rigs.[691] BtB was a commercial risk management approach for D&C projects that "focused on improving

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[686] Hearing before the Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 29, 2011, see Mogford Designations Vol 2 pp 22 - 25, http://www.mdl2179trialdocs.com/releases/release201302281700004/Mogford_John-Depo_Bundle.zip (accessed October 7, 2015); Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, June 21, 2011, see Baxter Designations Vol 1 pp 26 - 27, http://www.mdl2179trialdocs.com/releases/release201302281700004/Baxter_John-Depo_Bundle.zip (accessed October 7, 2015).

[687] Internal Company Document, BP. *Gulf of Mexico SPU Drillign and Completions The Way We Work*, 2200-T2-PM-RP-000001, May 12, 2009, pp 24, BP-HZN-2179MDL00394896, http://www.mdl2179trialdocs.com/releases/release201302281700004/Lacy_Kevin-Depo_Bundle.zip (accessed October 7, 2015).

[688] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, Section 1.3, pp A-4, BP-HZN-BLY00034514, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[689] Internal Company Document, BP. *Gulf of Mexico SPU Drillign and Completions The Way We Work*, 2200-T2-PM-RP-000001, May 12, 2009, pp 24, BP-HZN-2179MDL00394896, http://www.mdl2179trialdocs.com/releases/release201302281700004/Lacy_Kevin-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, Section 15.2.17, pp B-10, BP-HZN-BLY00034545, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[690] Additionally, as communicated in a CSB interview, "we [D&C] had just started this year [2010] with [OMS]. And we were in the process of rolling it out to the organization."

[691] Beyond the Best was developed in 2001 and was described as having "passed the test of time," Internal Company Document, BP. *Exploration and Production, Drilling and Completions, Beyond the Best Common Process*, June

drilling and completions efficiency."[692] BtB had a typical project management stage-gate approach that defined risk not in terms of process safety, but as "uncertain future events" which could have "an impact on the delivery of well objectives."[693] The outputs of the process were to be recorded in a risk register where impact types could be categorized under safety and environment, but other commercial impact types were listed as well, such as cost and schedule.[694]

The November 2009 version of the GoM Drilling and Completions Local OMS Manual recognized that the BtB risk management approach needed to align with OMS.[695] While BtB listed commercial impacts, BP's Group Defined Practice (GDP) for *Assessment, Prioritization and Management of Risk*, GDP 3.1 – 0001, issued in 2008, focused specifically on "Health, Safety, Security and Environmental (HSSE) and operating risks in projects."[696] The Group practice emphasized the implementation of risk reduction action plans with deliverables and timelines for completion. It recommended the hierarchy of controls to assess the effectiveness of risk reduction measures and referenced BP's Layers of Protection Analysis practice as a tool.[697] Post-incident, the former D&C Vice President and a senior process safety engineer

2008, pp 2, BP-HZN-2179MDL00333309, http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed October 7, 2015).; Internal Company Document, BP. *GoM Drilling and Completions; GoM D&C Operating Plan/Local OMS Manual*, 2200-T2-DM-MA-0001, November 1, 2009, p 22, BP-HZN-MBI00193469, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-06065.pdf (accessed October 7, 2015).

692 Internal Company Document, BP. *Exploration and Production, Drilling and Completions, Beyond the Best Common Process*, June 2008, pp 7, BP-HZN-2179MDL00333314, http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed October 7, 2015).

693 Internal Company Document, BP. *Exploration and Production, Drilling and Completions, Beyond the Best Common Process*, June 2008, p 54, BP-HZN-2179MDL00333361, http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed October 7, 2015).

694 Internal Company Document, BP. *Risk Register and Action Tracking Sheet for E&P Projects (Macondo)*, Risk Rating Matrix: Type of Impact, pp 12, see Exhibit 4189 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

695 Internal Company Document, BP. *GoM Drilling and Completions; GoM D&C Operating Plan/Local OMS Manual*, 2200-T2-DM-MA-0001, November 1, 2009, p 22, BP-HZN-MBI00193469, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-06065.pdf (accessed October 7, 2015).

696 Internal Company Document, BP. *GDP 3.1-0001 Assessment, Prioritization and Management of Risk*, October 14, 2009, pp 6, 16-17, BP-HZN-2179MDL00998896, see Exhibit 8013 http://www.mdl2179trialdocs.com/releases/release201302281700004/Yilmaz_Barbara-Depo_Bundle.zip (accessed October 7, 2015).

697 Internal Company Document, BP. *GDP 3.1-0001 Assessment, Prioritization and Management of Risk*, October 14, 2009, pp 11-12, BP-HZN-2179MDL00998896, see Exhibit 8013 http://www.mdl2179trialdocs.com/releases/release201302281700004/Yilmaz_Barbara-Depo_Bundle.zip (accessed October 7, 2015).

acknowledged the BtB approach did not meet the requirements of examining the HSSE impacts in Group Defined Practice 3.1 and that the BtB risk register provided "limited direction."[698]

BP D&C was moving to the consistent use of a tool that examined HSSE risk, but the required transition to the new BP Risk Assurance Tool (BP RAT), occurred for GoM D&C after developing the Macondo well risk register. Thus the BtB tool was used.[699] Also the risk management practices for the GoM Strategic Performance Unit (SPU)[700] were not scheduled to align with GDP 3.1-0001 until June 2010, after the Macondo accident.[701]

When BP developed the Macondo risk register, its GoM D&C draft Risk Management Plan noted that using the BtB risk tool was a fragmented approach lacking consistency.[702] The draft plan found significant issues with D&C's use of BtB, including lack of a single point of accountability, no clear roles and responsibilities, and little understanding of what OMS entails and how it impacts the risk management process.[703] The draft plan also noted that aggregating risks was difficult, a finding that would affect efforts to identify companywide process safety indicators (see Chapter 3.0).[704] Similar to the lack of

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698 Hearing before the Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, May 4, 2011 pp 109-112, http://www.mdl2179trialdocs.com/releases/release201302281700004/Grounds_Cheryl-Depo_Bundle.zip (accessed October 7, 2015).; Hearing before the Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 17, 2013 pp 9305-9307, http://www.mdl2179trialdocs.com/releases/release201303141200012/O'Bryan_Patrick-Depo_Bundle.zip (accessed October 7, 2015).

699 Hearing before the Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, April 17, 2013 p 9306, http://www.mdl2179trialdocs.com/releases/release201303141200012/O'Bryan_Patrick-Depo_Bundle.zip (accessed October 7, 2015).

700 BP divided its operating segments such as exploration and production into regional Strategic Performance Units or SPUs. The drilling of the Macondo well was conduct in BP's Gulf of Mexico.

701 Internal Company Document, BP. *Gulf of Mexico SPU, Operating Plan (OMS Handbook)*, Revision 1, 2000-T2-OP-PL-0001, March 1, 2010, p 13, BP-HZN-2179MDL01160046, see Exhibit 3893 http://www.mdl2179trialdocs.com/releases/release201302281700004/Armstrong_Ellis-Depo_Bundle.zip (accessed October 7, 2015).

702 The draft plan was based on interviews with D&C team leads and personnel responsible for managing risk;. Internal Company Document, BP. *Gulf of Mexico SPU; GoM D&C; Risk Management Plan; Assessment, Recommendations and Implementation Plan*, Revision B, 2200-T2-PM-RP-000000, January 1, 2010, p 6, BP-HZN-2179MDL01793825, see Exhibit 4165 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

703 Internal Company Document, BP. *Gulf of Mexico SPU; GoM D&C; Risk Management Plan; Assessment, Recommendations and Implementation Plan*, Revision B, 2200-T2-PM-RP-000000, January 1, 2010, pp 6-9, BP-HZN-2179MDL01793825-28, see Exhibit 4165 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

704 Internal Company Document, BP. *Gulf of Mexico SPU; GoM D&C; Risk Management Plan; Assessment, Recommendations and Implementation Plan*, Revision B, 2200-T2-PM-RP-000000, January 1, 2010, p 7, BP-HZN-2179MDL01793826, see Exhibit 4165 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

HSSE impacts listed in the Macondo risk register, the draft plan found in many cases that "major hazard and accident risks are not included in register and subsequently not addressed as expected."[705] Despite these findings, the Macondo risk register completed later that month was not reviewed or revised to address HSSE risk consistent with GDP 3.1-0001.

The outputs of the risk register for the Macondo well were used to create a risk rating matrix. BP determined in the Macondo risk matrix that the impact of an uncontrolled well control event—just considering cost—would be "medium,"[706] judged to be $1-3 million based upon the team's subjective evaluation that comparable events were within their direct experience.[707] However, the case was not a well control event involving a kick and blowout, but rather a lost wellbore due to an unspecified problem within the well, presumably due to stuck pipe or lost circulation; in fact, both did occur earlier in the Macondo well.[708] The risk register also listed PP/FG (pore pressure/fracture gradient) uncertainty as a risk, implying a possible kick,[709] but one that would be controllable and therefore a "medium" risk for cost.

BP used an ALARP tool in the risk matrix to determine the need for risk reduction. For the moderate category, risk reduction was required only "where cost beneficial."[710] On that basis, BP accepted the well control risk for the Macondo project and proposed no additional actions. BP's approach minimized the risk of an uncontrolled kick or blowout. Ultimately, there was no evaluation of barriers and their effectiveness to prevent or mitigate such events. Despite BP's ALARP requirements, no documentation shows that BP performed any analysis that well control safeguards were effective and that safety risk was driven to as low as reasonably practicable.

[705] Internal Company Document, BP. *Gulf of Mexico SPU; GoM D&C; Risk Management Plan; Assessment, Recommendations and Implementation Plan*, Revision B, 2200-T2-PM-RP-000000, January 1, 2010, p 7, BP-HZN-2179MDL01793826, see Exhibit 4165 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[706] Internal Company Document, BP. *Gulf of Mexico SPU; GoM D&C; Risk Management Plan; Assessment, Recommendations and Implementation Plan*, Revision B, 2200-T2-PM-RP-000000, January 1, 2010, p 7, BP-HZN-2179MDL01793826, see Exhibit 4165 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[707] Internal Company Document, BP. *Gulf of Mexico SPU; GoM D&C; Risk Management Plan; Assessment, Recommendations and Implementation Plan*, Revision B, 2200-T2-PM-RP-000000, January 1, 2010, p 7, BP-HZN-2179MDL01793826, see Exhibit 4165 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[708] National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. *Chief Counsel's Report: The Gulf Oil Disaster;* Feburary 17, 2011; p 59.

[709] See Volume 1, Section 2.1 for discussion of pore pressure/fracture gradient.

[710] Internal Company Document, BP. *Gulf of Mexico SPU; GoM D&C; Risk Management Plan; Assessment, Recommendations and Implementation Plan*, Revision B, 2200-T2-PM-RP-000000, January 1, 2010, p 7, BP-HZN-2179MDL01793826, see Exhibit 4165 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

BP had not yet applied its own OMS framework to its deepwater operations in the geologically difficult Gulf of Mexico, a clear example of failure to implement ALARP even to the risk level of its own safety standards.

4.4.3 BP's Major Accident Risk (MAR) Process was not Implemented

BP determined that traditional strategies for managing risk did not adequately address high consequence-low frequency events, so it developed the MAR Process. Acknowledging resources to reduce risk are finite, the MAR process requires the company to prioritize efforts to continually drive down risk of accidents.[711] The method for an MAR study starts by identifying and quantifying the likelihood of potential major accident events and their consequences.[712] The MAR Process allows for risk assessment across a group of multiple facilities.[713] For offshore operations, this includes risk scenarios like riser unloading events and blowouts.[714] The goal of the MAR study is to evaluate preventive and mitigative controls, and show that MAR is "on a steady decline."[715] Ultimately, the leader of each BP Operation, such as D&C, is accountable for ensuring a MAR study is completed, reviewed, and the results communicated to the appropriate level.[716]

The MAR Process applied to contractors and required that an MAR study be conducted with the cooperation of the contractor.[717] In January 2010, BP identified loss of well control, specifically blowouts,

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[711] Internal Company Document, BP. *BP Group Engineering Technical Practices, Major Accident Risk (MAR) Process, GP 48-50*, June 5, 2008, pp 9-10, BP-HZN-2179MDL00407945-46, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed May 22, 2015).

[712] Internal Company Document, BP. *BP Group Engineering Technical Practices, Major Accident Risk (MAR) Process, GP 48-50*, June 5, 2008, p 13, BP-HZN-2179MDL004074949, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed May 22, 2015).

[713] Internal Company Document, BP. *BP Group Engineering Technical Practices, Major Accident Risk (MAR) Process, GP 48-50*, June 5, 2008, p 17, BP-HZN-2179MDL004074953, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed May 22, 2015).

[714] Internal Company Document, BP. *BP Group Engineering Technical Practices, Major Accident Risk (MAR) Process, GP 48-50*, June 5, 2008, p 24, BP-HZN-2179MDL00407960, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed May 22, 2015).

[715] Internal Company Document, BP. *BP Group Engineering Technical Practices, Major Accident Risk (MAR) Process, GP 48-50*, June 5, 2008, p 55, BP-HZN-2179MDL00407991, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed May 22, 2015).

[716] Internal Company Document, BP. *BP Group Engineering Technical Practices, Major Accident Risk (MAR) Process, GP 48-50*, June 5, 2008, p 12, BP-HZN-2179MDL00407948, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed May 22, 2015).

[717] Internal Company Document, BP. *BP Group Engineering Technical Practices, Major Accident Risk (MAR) Process, GP 48-50*, June 5, 2008, p 9, BP-HZN-2179MDL00407945, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed May 22, 2015). The practice states, "If BP relies on a contractor to perform work that would be subject to GRP STD 01 if

as one of the two highest MAR risks for D&C in the GoM and BP.[718] While BP included Transocean's Deepwater Horizon in the "high risk" category as part of its MAR review,[719] BP did not apply the MAR process or perform an MAR study with the Deepwater Horizon or other contracted rigs.[720] This inaction disregarded the fact that contracted rigs represented the greater percentage of BP's well blowout risk (see Call-out Box). As a result, BP used the MAR approach to identify actions plans that included developing barrier effectiveness tools and identifying controls and recovery measures to prevent and respond to loss of well control events; however, these action plans only applied to BP-owned drilling rigs.

If BP had worked with Transocean to develop an MAR study, it could have examined a Transocean 2009 report that expressed riser unloading events as "the biggest concern" when identifying areas for improvement.[721] Transocean experienced six such events in the previous year.[722] Transocean's report recommended preventing the riser unloading events by "treating every positive indicator as a kick, [and] shutting in the well quickly."[723] BP and Transocean could have used that analysis to improve well control planning, training, and response practices and continually reduce risk of a Macondo-type event.

[CALL-OUT BOX START]

Contracted Rigs Represented Major Portion of BP's Drilling Operation Loss of Well Control and Blowout Risk

In March 2010, BP described itself as the largest oil and gas operator in the Gulf of Mexico, possessing approximately 30% of the total deepwater GoM production.[a] *This included 8 platforms, which were BP assets, and 22 other producing fields for which BP held some financial interest. In early 2010, BP stated that in the Gulf of Mexico Thunder Horse was the only BP-owned drilling rig and that the remaining rigs*

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performed by BP employees … BP shall, after an appropriate risk assessment, endeavor to conduct a MAR study with the cooperation of the contractor/third party." The drilling and completions work would be subject to GRP STD 01 and OMS if performed by BP personnel so the MAR process should apply to contracted drilling rigs.

[718] Internal Company Document, BP. *BP Gulf of Mexico SPU Annual Engineering Plan, Rev 0*, January 15, 2010, p 27, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-02910_NATIVE.pdf (accessed May 22, 2015).

[719] Internal Company Document, BP. *BP Gulf of Mexico SPU Annual Engineering Plan, Rev 0*, January 15, 2010, p 27, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-02910_NATIVE.pdf (accessed May 22, 2015).

[720] Testimony given in the U. S. Districk Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, July 21, 2011 pp 20-21, see Jassal Designations (BP GoM SPU D&C Integrity Engineer and risk management specialist), http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed May 22, 2015).

[721] Internal Company Document, Transocean. *Annual Report - 2009 Well Control Events & Statistics 2005 to 2009*, pp 7, TRN-INV-00760060, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05649.pdf (accessed May 22, 2015).

[722] Internal Company Document, Transocean. *Annual Report - 2009 Well Control Events & Statistics 2005 to 2009*, pp 7, TRN-INV-00760060, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05649.pdf (accessed May 22, 2015).

[723] Internal Company Document, Transocean. *Annual Report - 2009 Well Control Events & Statistics 2005 to 2009*, pp 7, TRN-INV-00760060, http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-05649.pdf (accessed May 22, 2015).

were contracted mobile offshore drilling units (MODUs) operated by Transocean.[b] *Worldwide, BP was the most significant client for Transocean based on operating revenue in 2008*[c] *and Transocean managed three-fourths of the global MODU drilling operations for BP.*[d]

The BP GoM Drilling and Completion SPU maintained responsibility for two major accidents risks: loss of well control and loss of drilling riser.[e] *BP recognized that "[b]oth risks represent major exposure to GoM SPU with a severity level of D and above." Severity levels were measured in terms of health, safety and environment. A Level D event was at the low end of the impact scale representing a "very major health/safety incident" with the potential for 3 or more fatalities. Level A was the most severe representing an event "comparable to the most catastrophic health/safety incidents ever seen in industry" with the potential for 100 or more fatalities. Because both risks involved activities conducted by drilling contractors, Transocean's GoM well drilling and completion activities represented a major percentage of BP's risk in these areas.*

[a] Internal Company Document, BP. *Gulf of Mexico SPU, Operating Plan (OMS Handbook)*, Revision 1, 2000-T2-OP-PL-0001, March 1, 2010, BP-HZN-2179MDL01160037, see Exhibit 3893 http://www.mdl2179trialdocs.com/releases/release201302281700004/Armstrong_Ellis-Depo_Bundle.zip (accessed October 7, 2015).

[b] Internal Company Document, BP. *BP Gulf of Mexico SPU, Annual Engineering Plan 2009*, Revision 0, 2010-T2-PM-PR-2009, January 15, 2010, BP-HZN-2179MDL02206804 to BP-HZN-2179MDL02206805, see Exhibit 4170 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[c] Internal Company Document, BP.

[d] Internal Company Document, BP, *Memo from BP's GoM Vice President of Drilling and Completion: Transocean Improvement Plan*, January 23, 2008, BP-HZN-CEC055713, see Exhibit 7205 http://www.mdl2179trialdocs.com/releases/release201302281700004/Baxter_John-Depo_Bundle.zip (accessed October 7, 2015).

[e] Internal Company Document, BP, *Drilling & Completions Recommended Practice*, 2200-T2-RM-DC-000000, January 20, 2010, BP-HZN-2179MDL00332282, see Exhibit 1975 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[CALL-OUT BOX END]

4.4.4 Absent Reporting Requirements

BP's October 2008 E&P OMS Drilling and Well Operations Practice (DWOP) applied to well drilling and completions, requiring the DWOP to "form part of the contractual relationship between BP and the service providers."[724] The DWOP required that the contractor's safety management system "incorporate

[724] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, pp A-4, A-7, BP-HZN-BLY00034504, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

or be supplemented to address the requirements of the OMS framework."[725] The purpose of DWOP was to support BP's goal of "no accidents, no harm to people and no damage to the environment."[726] Since BP considered the DWOP critical for conformance with its OMS framework, all staff and contractors had to be knowledgeable in the DWOP.[727] However, the 2008 DWOP training was not initially rolled out to BP's own GoM Well Site Leaders until April 14-15, 2010, just a week prior to the well blowout.[728]

While BP applied the DWOP to the Macondo well, in part by MOCs where BP personnel sought deviations from the DWOP, the company did not implement key substantive provisions of the DWOP related to Macondo causal factors. DWOP well control practices require completion of a well control incident report in BP's Tr@ction electronic incident reporting system.[729] The BP OMS framework requires incident investigation reports to identify system-level causes and to establish safety improvement action items with specific due dates tracked to completion.[730] However, BP did not issue in Tr@ction an investigation report related to the March 8, 2010 well control incident (described in Section 2.3). Similar to the Macondo blowout, that incident also involved a delayed response to a well kick.[731] Post-incident, a BP Macondo Well Site Leader indicated that the "incident was not recorded in Tr@ction, as this was not the normal process in the Deepwater GoM." He further indicated he "did not know that reporting this type of an incident was a requirement of DWOP."[732]

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[725] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, p A-7, BP-HZN-BLY00034504, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[726] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, p A-1, BP-HZN-BLY00034504, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[727] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, p A-1, A-4, BP-HZN-BLY00034504, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[728] Internal Company Document, BP. *BP Incident Investigation Team - Note of Interview with John Guide*, July 1, 2010, p 7, BP-HZN-BLY00124223, see Exhibit 0153 http://www.mdl2179trialdocs.com/releases/release201304041200022/Sepulvado_Murry-Depo_Bundle.zip (accessed October 7, 2015).

[729] Internal Company Document, BP. *GP 10-00 Drilling and Well Operations Practice*, Issue 1, October 2008, Section 15.2.12, p B-10, BP-HZN-BLY00034545, http://www.mdl2179trialdocs.com/releases/release201304110900026/TREX-06121.pdf (accessed May 26, 2015).

[730] Internal Company Document, BP. *The BP Operating Management System Framework, Part 2, Elements of Operating including Group Essentials*, Issue 2, November 3, 2008, Section 4.4, Incident Management, p 32, BP-HZN-2179MDL00333255, http://www.mdl2179trialdocs.com/releases/release201303071500008/TREX-45002.pdf (accessed October 7, 2015).

[731] BP Wells Team Leader for the Deepwater Horizon in his interview with the BP investigation team acknowledged that BP did not initiate a formal investigation of the March 8 incident that included a significant delay in well kick response for 35-40 minutes. Internal Company Document, BP. *BP Incident Investigation Team - Note of Interview with John Guide*, July 1, 2010, p 12, BP-HZN-BLY00124228, see Exhibit 0153 http://www.mdl2179trialdocs.com/releases/release201304041200022/Sepulvado_Murry-Depo_Bundle.zip (accessed October 7, 2015).

[732] Internal Company Document, BP. *BP Incident Investigation Team - Note of Interview with John Guide*, July 1, 2010, p 12, BP-HZN-BLY00124228, see Exhibit 0153

4.4.5 BP did not implement OMS-required Application to Contracted Rigs through Contracts and Bridging Documents

BP's Group OMS emphasized that OMS was "relevant to all projects as well as facilities, sites and operations" and included provisions on its application to contractors.[733] BP identified that OMS:

> shall as needed, include and apply contract provisions such that the work is carried out in a way that supports and is consistent with BP's application of OMS to BP's Operating activities. Where such contract provisions are not included in an existing contract, BP shall endeavor to amend the contract as needed, immediately or on renewal.

BP, however, did not amend its Deepwater Horizon contract with Transocean to ensure every drilling activity "supports and is consistent with" OMS. BP did not implement OMS provisions when it amended health and safety requirements in Deepwater Horizon contract on September 28, 2009.[734] In fact, the 2009 Amendment 38 included new safety management provisions introducing the outdated GHSER safety program.[735] Elsewhere, BP developed HSSE contract provisions for offshore drilling units that included OMS requirements;[736] however, it did not apply these provisions to the Deepwater Horizon contract. The 2009 amendment had no references to OMS, the DWOP, or other BP post-Texas City engineering technical practices. The contract did contain some process safety requirements described as "minimum conditions" attached as an Exhibit D, including the use of ALARP, the hierarchy of controls, risk assessment tools such as HAZID and HAZOP, and Major Accident Hazard Identification and Assessment. However, the listed requirements were not scheduled to apply until the renewal date of September 18, 2010, about five months after the Macondo incident.[737]

BP and Transocean each had their own safety management systems, but they agreed that Transocean's safety management systems would govern well drilling operations on the DWH, as supplemented by BP

http://www.mdl2179trialdocs.com/releases/release201304041200022/Sepulvado_Murry-Depo_Bundle.zip (accessed October 7, 2015).

[733] Internal Company Document, BP. *The BP Operating Management System Framework, Part 4, OMS Governance and Implementation*, Issue 2, November 3, 2008, Section 4, Applicability and Deviation Requirements, pp 7, BP-HZN-2179MDL00333144, see Exhibit 2352 http://www.mdl2179trialdocs.com/releases/release201302281700004/Lynch_Richard-Depo_Bundle.zip (accessed October 7, 2015).

[734] Internal Company Document, BP. *Amendment No. 38 to Drilling Contract No. 980249*, September 28, 2009, see Exhibit 1488, BP-HZN-CEC041519, http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed October 7, 2015).

[735] Internal Company Document, BP. *Amendment No. 38 to Drilling Contract No. 980249*, September 28, 2009, see Exhibit 1488, BP-HZN-CEC0 041493 and BP-HZN-CEC0 041513 , http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed October 7, 2015).

[736] Internal Company Document, BP.

[737] Internal Company Document, BP. *Amendment No. 38 to Drilling Contract No. 980249*, September 28, 2009, see Exhibit 1488, BP-HZN-CEC041519, http://www.mdl2179trialdocs.com/releases/release201302281700004/Hayward_Anthony-Depo_Bundle.zip (accessed October 7, 2015).

through a bridging document.[738] Transocean's Quality, Health, Safety, and Environment manager for North America asserted that a bridging document should provide "primacy" for operators and drillers in determining which aspects of each companies' safety management systems would govern.[739] He stated, "[B]oth Transocean and BP have safety management systems. And we can't run both systems onboard one vessel. So in general terms, one would have to be selected over another. And there are times when one group's management system supersedes that of another and that would be clarified if it were the agreed wish of both parties use one management system . . . day-to-day. But [if] there is an issue or two that the other system was desired to be used, you could express those wishes in a bridging document."[740]

For Macondo, the two companies created a five-page bridging document signed by senior managers from each organization. It sought to address gaps between BP's and Transocean's safety management systems. Ultimately, the resulting bridging document was only envisioned for personal safety issues without mention of process safety items, such as the TSTPs or SIDs (discussed in Section 1.8) or other measures aimed at major accident prevention.[741] For example, the heart of the bridging document, the HSE Management Systems Table, referenced only six issues, five of which focused on personal safety:

- Fall Protection
- Personal Protective Equipment
- Travel
- General Safe Work Practices
- Incident Reporting
- Dive Operations

[738] Internal Company Document, BP/Transocean. *Drilling Contract RBS-8D Semisubmersible Drilling Unit, Contract No. 980249*, December 9, 1998, Section 3.0: Compatibility of HSE Management Systems, BP-HZN-MB100021887-8, http://www.mdl2179trialdocs.com/releases/release201305171200030/TREX-004271.pdf (accessed October 7, 2015).

[739] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 24, 2011 pp 177-178, http://www.mdl2179trialdocs.com/releases/release201302281700004/Canducci_Gerald-Depo_Bundle.zip (accessed October 7, 2015).

[740] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, March 24, 2011 p 178, http://www.mdl2179trialdocs.com/releases/release201302281700004/Canducci_Gerald-Depo_Bundle.zip (accessed October 7, 2015).

[741] BP's GoM SPU *Drilling and Completions The Way We Work* well project management guidance states that the GoM SPU "Safe Practices Manual" (SPM) would be bridged to the contractor's safety management systems. BP described the SPM as containing "BP-approved standards for personal safety, MOC and industrial hygiene," but the pre-Texas City manual first issued in 2002 contained little mention of process safety and no reference to the OMS framework. Internal Company Document, BP. *Gulf of Mexico SPU Drillign and Completions The Way We Work*, 2200-T2-PM-RP-000001, May 12, 2009, p 27, BP-HZN-2179MDL00394922, see Exhibit 0760 http://www.mdl2179trialdocs.com/releases/release201302281700004/Lacy_Kevin-Depo_Bundle.zip (accessed October 7, 2015).

The fifth issue, incident reporting, can cover both personal and process safety issues, but its utility depends largely upon what the receiver of that information does with the incident report (e.g., whether the information reported was used for learning and continual improvement or simply tallied and reported).

Nothing in the bridging document distinguished process safety or MAP.[742]

The bridging document notes some minimal process safety-type concepts in a section "Additional BP Requirements." For example, the General Safety Work Practices had an additional requirement to conduct an MOC for any worker asked to work in excess of 28 continuous days within a 42-day period. Another addition, under Incident Reporting, required "All Serious Incidents (HIPO, DAFWC, Medical Treatment and Restricted Work) will be investigated and led by Transocean and supported by BP to identify root cause and corrective actions within 30 day time frame set forth in BP reporting guidelines." But other than the HIPO category, these serious incidents typically capture personal safety events. All other additional BP requirements more plainly focused on personal safety (e.g., secondary fall protection requirements, respiratory protection program requirements, life vests, etc.).

API Bulletin 97, Well Interface Control Document Guidelines, *(1st ed., November 2013) seeks to help address deficiencies in the bridging process between leaseholders and drilling contractors. Included in the Bulletin are recommendations about what type of information should be shared between the leaseholder and the drilling contractor regarding well construction and rig-specific operating guidelines. The Bulletin intends to align the leaseholder's safety and environmental management system (SEMS) with the drilling contractor's safe work practices. Covered in this guidance is a recommended full informational exchange, along with other opportunities for alignment between the parties—a step forward compared to what occurred during the bridging process between BP and Transocean prior to drilling Macondo. However, API 97 is a Bulletin and not a recommended practice, and the language used in the Bulletin is permissive with the pervasive use of "should" denoting that its recommendations are at the discretion of the company.*

American Petroleum Institute (API) Bulletin 97, Well Construction Interface Document Guidelines, First Edition, (November 2013), p. iii.

The bridging document also included a commitment to form an "HSE Steering Team" of representatives from both companies, with specific reference to the positions required for participation. They would meet quarterly to resolve "gaps across the different business units in the GoM operating area" to "review and implement new programs" and to delete or change existing programs.[743] However, the bridging document

[742] Even Section 4.0 of the bridging document itself, entitled "Revision Log," confirms that the four documented updates to the bridging document focused on personal safety, with attention paid to items such as fall protection, scaffolding, electrical safety and hazardous materials, or rudimentary administrative matters such as a change in document custodian. Internal Company Document, BP/Transocean. *BP Gulf of Mexico Transocean Offshore Deepwater Drilling Inc. North America HSE Management System Bridging Document*, September 8, 2008, see Exhibit 0948, pp 5, BP-HZN-BLY00076264, http://www.mdl2179trialdocs.com/releases/release201302281700004/Canducci_Gerald-Depo_Bundle.zip (accessed October 7, 2015).

[743] Internal Company Document, BP/Transocean. *BP Gulf of Mexico Transocean Offshore Deepwater Drilling Inc. North America HSE Management System Bridging Document*, September 8, 2008, see Exhibit 0948, pp 3, BP-

sets no dates for forming the HSE Steering Team and establishes no goals or objectives for reviewing safety surrounding well operations or making adjustments to anything as part of a continual improvement process.

In the months leading to the Macondo blowout, BP became aware of bridging document problems. In February 2010, BP commissioned a work team to investigate the effectiveness of bridging documents used at contractor rigs.[744] That team determined that most bridging documents were outdated or poorly understood and noted that many contractors' supervisors had a poor understanding of their own safety management systems.[745]

[CALL-OUT BOX START]

The Macondo blowout prompted numerous international responses, including a multinational audit in the North Sea in 2012/2013 to assess the incorporation of organizational factors into operator and drilling contractor safety management systems.[a] A major conclusion from the audit was the lack of role clarity in bridging documents intended to identify and address potential gaps between the operator and drilling contractor's safety management systems. The audit team found:

- *The quality and content of the companies' bridging documents varied;*
- *Individuals directly affected by the bridging documents insufficiently verified their content; and*
- *Client auditing of the drilling contractor's safety management system was either nonexistent or focused upon equipment.*

The multinational audit focused on systems and standards, such as those found in well control manuals, and the audit's findings are similar to ones presented in this report.

[a] North Sea Offshore Authorities Forum (NSOAF). *Multi-National Audit Human and Organisational Factors in Well Control 2012-2013;* http://www.hse.gov.uk/offshore/nsoaf.pdf (accessed May 2016, 2015). Eleven audits of jack-up and semi-submersible rigs were completed in Netherlands, Denmark, Germany, Norway, and the UK during 2012/2013.

[CALL-OUT BOX END]

4.5 BP Did Not Pursue Its 2008 Initiative to Engage GoM D&C Contractors in Risk and Barrier Management

In May 2008, BP's GoM Drilling and Completions (D&C) Leadership Group met with a new D&C Vice President to emphasize the importance of process safety and contractor engagement in preventing major

HZN-BLY00076262, http://www.mdl2179trialdocs.com/releases/release201302281700004/Canducci_Gerald-Depo_Bundle.zip (accessed October 7, 2015).

[744] Hearing before the U.S. District Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, July 27, 2011 pp 75, see Yilmaz Designations Vol 2 http://www.mdl2179trialdocs.com/releases/release201302281700004/Yilmaz_Barbara-Depo_Bundle.zip (accessed October 7, 2015).

[745] Internal Company Document, BP. *Improving Control of Work within Drilling & Completions*, Feburary 2010, slide 6, BP-HZN-MBI00109889, see Exhibit 0951 http://www.mdl2179trialdocs.com/releases/release201302281700004/Yilmaz_Barbara-Depo_Bundle.zip (accessed October 7, 2015).

accidents such as well blowouts. The intent of the meeting was to emphasize that deepwater drilling has special challenges that include reliance on manual crew intervention to prevent a major accident and contractor engagement for risk management.[746]

A BP presentation at the meeting, *Major Accident and Risk Management,* was prompted by findings and major themes expressed in the Baker Panel Report and recent major BP incidents, including:[747]

1. the importance of process safety culture that continually reduces risk;
2. defined expectations and accountability; and
3. the effective use of leading and lagging indicators.

The presentation identified that the scope of BP's risk management policy included major drilling projects where BP was the operator. The objectives included assessing and reducing risk through prevention and control measures using the Major Accident Risk Process with defined key management and engineering accountabilities.[748] Tools included risk registers and process safety ETPs such as HAZOP and LOPA. Key to the presentation was the use of bowtie diagrams with identified independent barriers and controls and the maintenance of safety critical systems. The presentation identified top GoM Strategic Performance Unit (SPU) and D&C risks as safety, environmental, or reputational, with a focus on BP assets.

In response to the question about who is responsible for managing the risk, the leadership presentation answered, "Ultimately it is the BP Wells Team."[749] Another important question addressed was "How do we engage contractors to manage risk?"

The implication was that nearly two years before Macondo, the "Major Accident and Risk Management" presentation provided a structured, robust proposal for strengthening the engagement with contractors to manage risk. The presentation proposed reviewing with contractors existing bowties to identify additional hazards, causes, and barriers. It recommended updating bowties, MAR registers, and risk mitigation plans with contractors as well as agreeing on the use of tools such as the BP risk register and the HAZID

[746] Internal Company Document, BP. *GOM-D&C Major Hazard and Risk Management Leadership Action*, 2008, Slide 3, see Exhibit 2952 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[747] Internal Company Document, BP. *GOM-D&C Major Hazard and Risk Management Leadership Action*, 2008, Slide 6, see Exhibit 2952 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[748] Internal Company Document, BP. *GOM-D&C Major Hazard and Risk Management Leadership Action*, 2008, Slide 23, see Exhibit 2952 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).; BP's Major Accident Risk Process, GP 48-50, was an ETP approved for implementation across the BP Group; Internal Company Document, BP. *GP 48-50 Major Accident Risk (MAR) Process*, June 5, 2008, BP-HZN-2179MDL00407937, http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-01734.pdf (accessed October 7, 2015).

[749] Internal Company Document, BP. *GOM-D&C Major Hazard and Risk Management Leadership Action*, 2008, Slide 19, see Exhibit 2952 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

analysis.[750] The presentation emphasized the need to agree on risk management roles and responsibilities. Two types of barriers were identified: those BP directly and indirectly controlled under a contract and those the contractor controlled. The presentation noted the importance of potentially modifying existing agreements with contractors to assure conformance with the safety requirements. The path forward with contractor engagement was to "review risks and determine if there are any additional risks, barriers, mitigations … update register and bowties accordingly."[751] A responsibility matrix was presented for risk tasks, deliverables, and the role of the BP Wells Team and contractor (see Figure 4-3). The process intended to identify which barriers and controls BP and the contractor would manage and to demonstrate how they managed them.

The promise of the more robust approach presented at the Leadership Action presentation was not fulfilled. In the same month as the D&C Leadership Group presentation, BP personnel proposed a work plan for future risk assessment activities, use of risk tools, and contractor engagement,[752] but little evidence exists that BP pursued the path forward for contractor engagement presented to BP's D&C Leadership Team.[753,754] In fact, the use of bowties in the BP organization itself was not officially rolled out until January 2010,[755] and no document shows that either BP or Transocean used bowties or allocated barrier responsibility for risk management or communication at the Macondo well.

[750] Internal Company Document, BP. *GOM-D&C Major Hazard and Risk Management Leadership Action*, 2008, Slide 52, see Exhibit 2952 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[751] Internal Company Document, BP. *GOM-D&C Major Hazard and Risk Management Leadership Action*, 2008, Slide 57, see Exhibit 2952 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[752] Email from Engineering Manager, BP, to Drilling Engineering Team Leader, BP, Subject: IM Bowties - Let's try and simplify, May 22, 2008, BP-HZN-2179MDL01002350, see Exhibit 4187 http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed October 7, 2015).

[753] Hearing before the U. S. Districk Court for hte Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, July 21, 2011 pp 77-79, see Jassal Designations (BP GoM SPU D&C Integrity Engineer and Risk Management Specialist) http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed May 22, 2015).

[754] Hearing before the U. S. Districk Court for hte Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, July 21, 2011 pp 78-79, see Jassal Designations (BP GoM SPU D&C Integrity Engineer and Risk Management Specialist) http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed May 22, 2015).

[755] Hearing before the U. S. Districk Court for the Eastern District of Louisiana under the Multi-District Litigation docket MDL No. 2179, July 21, 2011 p 79, see Jassal Designations (BP GoM SPU D&C Integrity Engineer and Risk Management Specialist) http://www.mdl2179trialdocs.com/releases/release201302281700004/Jassal_Kalwant-Depo_Bundle.zip (accessed May 22, 2015).

D&C Teams and Contractor Engagement

bp

Responsibility Matrix

Task	Wells Team	Contractor	IM Team Lead	Deliverable
Internal Review				
Step1 – IM Overview	P		R	Agreed set of requirements and action plan
Step 2 – Review MAR Etc	R		F	ID (a) gaps and agree on MAR, Causes, and Consequences (b) Define how BP will manage barriers and controls
Step 3 – BP managed Barriers/Controls	R		F	
Step 4 – Update Register & Bowties	R		F	Updated risk register and Bowties for MAR
Session With All Contractors (Mini HAZID)				
Step 5 – IM Overview	R	P	F	Agreed set of requirements and action plan
Step 6 – Review MAR, Etc	R	P	F	ID gaps and agree on MAR, Causes and consequences
Step 7 – Review/ID Controls & Gaps	P	R	F/P	ID (a) gaps & agree on Causes, consequences barriers and controls (b) Define how contractor will manage barriers and controls
Step 8 – Contractor managed barriers	P	R	F	
Step 9 – Update Registers & Bowties	R		F	Updated risk register and Bowties for MAR
Step 10 – Action Plan for Roll-out	P	R	F	Formulate plan covering procedure, equipment
Step 11 – Demonstrate barriers	P	R	F	Demonstrate how Barriers and controls are being managed

R = Responsible; P = Participate: F = Facilitate

Integrity Management
Reducing Risk in GoM

Figure 4-3. May 2008 BP D&C Teams and Contractor Engagement from the Major Hazard and Risk Management Presentation to the D&C Leadership group. The presentation, two years before the Macondo incident, envisioned a detailed allocation of risk and barrier management responsibilities between BP and the contractor. BP did not implement the responsibility matrix approach.

4.6 Conclusion

Both this chapter and Section 1.8 demonstrate that BP and Transocean detailed daily operational tools and overarching corporate policies regarding how to handle major accident risk in a number of key areas during drilling operations. Also, internal BP and Transocean policies required risks to be reduced to an ALARP level. Unfortunately, these policies did not translate to practices at Macondo despite the bridging process intended to clarify safety roles and responsibilities while identifying potential gaps in the operative safety management systems. Instead, personal safety considerations predominated over process safety and major accident prevention, and the bridging document failed to look ahead in a meaningful way toward major accident prevention.

A fundamental question emerges: How in the United States can BP, Transocean, or any company operating in the areas subject to BSEE jurisdiction be required to implement effective risk management practices? Volume 4 addresses this question in depth, but the basic answer is to enact regulatory requirements for more robust risk management approaches, including demonstrated risk reduction to ALARP and explicit safety accountability by all parties creating the risk.

In the US, both the leaseholder/operator and the drilling contractor have well control responsibilities under offshore regulations.[756] But before the Macondo incident, the leaseholder/operator was held as the primary entity responsible for the safe conduct of offshore exploration and production in the US GoM. There was little, if any, history of citations against offshore contractors despite their legal responsibility for well control actions.[757]

As Volume 4 details, post-Macondo, contractors such as Transocean and Halliburton were cited for a number of safety violations, and BSEE, the offshore regulator, asserted that drilling contractors and other well service providers can be cited for future safety violations.[758] However, the key federal offshore safety regulations—the Safety and Environmental Management Systems (SEMS) Rule[759] issued in the wake of the Macondo incident—does not directly apply to contractors, does not have a requirement for demonstrated risk reduction to an ALARP level (or similar), and does not clarify major hazard roles and responsibilities of the operators and drilling contractors when it comes to design and operational risk.

[756] This was true at the time of Macondo and present day, 30 C.F.R. § 250.400, 401.

[757] BSEE. Inspection and Enforcement: Incidents of Noncompliance, http://www.bsee.gov/Inspection-and-Enforcement/Enforcement-Programs/Incidents-of-Non-Compliance/ (accessed October 7, 2015).

[758] Notification of Incident(s) of Noncompliance, with respect to offshore operations in the Gulf of Mexico, off the coast of Louisiana. 00071 IBLA 2013-137 (District Supervisor, District Office, Bureau of Safety and Environmental Enforcement September 25, 2015).

[759] 30 C.F.R. § 250 Subpart S (2011).

5.0 Corporate Governance, the Influence of Shareholders and Public Disclosure of Process Safety Information

Chapter 5.0 Overview

This chapter examines the corporate governance approaches by both BP and Transocean to demonstrate both companies' efforts to manage personal safety and commercial risk without an equivalent focus on the effective management of barriers and safety management systems for preventing major accident events. This chapter explores the influence of shareholders in managing process safety and advances in corporate governance in other international offshore regions.

The importance of a corporation's board of directors cannot be overstated, especially when the corporation is involved in a high-hazard industry such as offshore drilling. The BP and Transocean boards of directors demonstrated varying levels of effectiveness in efforts aimed at helping their respective companies avoid a catastrophic event like the Macondo blowout. Despite efforts to manage process safety and major accident risk, the two companies' boards adopted governance approaches that emphasized personal safety and commercial risk without assuring process safety and major accident prevention. In part, these approaches are illustrated through a study of shareholder communications, required US Securities and Exchange Commission (SEC) [760] reporting, and other public information released by both companies. Some elements of this analysis are further explored in other chapters of Volume 3, including Chapter 2 (Organizational Learning), Chapter 3 (Indicators), Chapter 4 (Risk Management), and Chapter 6 (Safety Culture). This chapter primarily explores publicly available records and compares BP and Transocean's corporate governance approaches with best practices in other international jurisdictions with active offshore drilling, illustrating broader offshore sector issues concerning corporate governance and securities disclosures that merit further discussion and improvements.

As Macondo made clear, major accident events (MAEs) can interfere with drilling operations and production, damage reputation, and cause significant financial distress for a company with predictable, negative outcomes.[761] Consequently, corporate boards of directors must act vigilantly in preventing MAEs from their position as the highest echelon of leadership within the company. It is in shareholders' best interests to understand the relevant information needed to assess the companies in which they invest, and to benchmark the process safety performance of such companies. In doing so, shareholders would be positioned to better understand and question companies' business decisions. They can both directly and indirectly help to ensure or improve process safety and major accident prevention efforts of companies engaged in offshore drilling and production. Thus, enhanced reporting not only benefits shareholders, but all stakeholders, including workers, the public, and the environment.

[760] The SEC is a Federal agency whose mission is "to protect investors, maintain fair, orderly, and efficient markets, and facilitate capital formation." http://www.sec.gov/about/whatwedo.shtml (accessed October 7, 2015).

[761] For example, reduction or elimination of dividend payments, inability to expand or otherwise initiate new profit-making activities, necessity of selling productive assets to raise cash for risk contingencies and potential liabilities, decrease in share price.

This idea is especially important for a company like BP, which suffered several significant process safety incidents in a ten-year period including Grangemouth (2000), BP Texas City (2005), BP Prudhoe Bay (2006), and Macondo (2010). This string of MAEs in such a short time and across different business segments within the company's worldwide operations raises a question as to whether the BP board of directors is sufficiently engaged in process safety matters, and even whether there is a corporate "failure to learn."[762] This is especially true in the BP Texas City incident, investigated independently by the CSB, and by the company itself through the BP US Refineries Independent Safety Review, the Baker Panel, an independent panel which examined BP's US refineries and the company's safety culture. Both reports recommended that the BP board deepen its commitment to adopt process safety policies, take preventive actions, and monitor indicators.[763] Despite BP board governance improvements since BP Texas City, serious problems remain that leave the company vulnerable to a Macondo-type of event.

For its own part, Transocean's board exhibited some of the same flawed approaches as BP, but exhibited less of a willingness to engage in self-reflection and the desire to make significant improvements concerning responsibility for the incident.

This chapter also explains that SEC reporting requirements for companies like BP and Transocean impede shareholder efforts to examine process safety matters related to major accident prevention which could impact the investment worthiness of companies working offshore. Inconsistent or even sometimes obscure information emerges from such companies, if at all, in a sometimes cumbersome or more generalized narrative style that avoids more straightforward inclusion of a full slate of health and safety metrics and other critical process data (e.g., leading and lagging process safety performance indicators) across the spectrum of corporate operations and related risk activities. To be clear, both BP and Transocean appeared to satisfy SEC requirements in their disclosures in shareholder communications, and in required reporting with the Commission. Therefore, this chapter more generally explores the information shareholders need to monitor the process safety performance of companies with MAE potential. BP and Transocean are referenced as salient examples to show the weakness of the US regulatory reporting scheme relating to the disclosure of material MAE risks offshore.

Lastly, this chapter describes the relationship between the regulator and the board of directors both in the US and other international regulatory drilling regimes. Various offshore oil and gas regulatory regimes adopted proactive approaches using audits, investigations, published guidance, and training to influence industry at the board level, whereas BSEE's mechanisms for change today are still primarily focused on the facility/site level through permit approvals, dispensations, inspections, compliance audits, accident investigations, and citations stemming from enforcement activities. As a result, BSEE now has an

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762 Hopkins A. Failure to Learn – The BP Texas City Refinery Disaster; CCH Australia Limited: 2009. See also Reed S. & Fitzgerald A. In Too Deep; John Wiley & Sons: 2011, p. 156 ("The lessons learned at Texas City and Prudhoe Bay apparently had not reached the Gulf of Mexico.")

763 The Baker Panel. *The Report of the BP US Refineries Independent Safety Review Panel;* January, 2007; pp xvi. http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf (accessed October 7, 2015); USCSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005,* Report No. 2005-04-I-TX, Recommendations 2005-4I-TX-R11 to 2005-4I-TX-R13, http://www.csb.gov/assets/1/19/CSBFinalReportBP.pdf (accessed October 7, 2015), March 2007.

opportunity to work with industry more proactively to strengthen the role of boards of directors and to improve corporate governance for publicly traded companies at work in US waters.

5.1 Boards of Directors and Shareholders

5.1.1 What is Corporate Governance?

Corporate governance is broadly defined as "the system by which companies are directed and controlled," or "the whole set of legal, cultural, and institutional arrangements that determine what publicly traded corporations can do, who controls them, how that control is exercised, and how the risks and returns from the activities they undertake are allocated."[764] Shareholders typically vote for individuals to serve on a corporation's board of directors and expect them to serve as the highest echelon of an overall system of managerial activities as well as a means of checks and balances. Rooted in a series of fiduciary duties,[765] once directors are in place, a board must act to protect the best interests of the company as a whole, ensuring its overall success.

Historically, corporate boards have taken a hands-off approach to oversight. Chancellor of the Delaware Court of Chancery and judicial scholar on corporate governance William Allen explained:

> The conventional perception is that boards should select senior management, create incentive compensation schemes and then step back and watch the organization prosper. In addition, board members should be available to act as advisors to the CEO when called upon and they should be prepared to act during a crisis: an emergency succession problem, threatened insolvency or a management buy-out proposal, for example.[766]

Allen went on to challenge this view as inadequate, calling for boards of directors to play a more active role in ensuring the health of an organization:

> This view of the responsibilities of membership on the board of directors of a public company is, in my opinion, badly deficient. It ignores a most basic responsibility: the duty to monitor the

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[764] Clarke, D. C. Nothing But Wind? The Past and Future of Comparative Corporate Governance; *Am. J. Comp. L.* 2011**,** *75*, p 59., *citing* The Committee on the Financial Aspects of Corporate Governance . *The Financial Aspects of Corporate Governance;* "the Cadbury Report," 1992; http://www.icaew.com/~/media/corporate/files/library/subjects/corporate%20governance/financial%20aspects%20of%20corporate%20governance.ashx (accessed October 7, 2015). See generally: The Financial Reporting Council. *The UK Approach to Corporate Governance;* October, 2010; https://www.frc.org.uk/Our-Work/Publications/Corporate-Governance/The-UK-Approach-to-Corporate-Governance.aspx (accessed October 7, 2015).

[765] "A fiduciary duty is a legal duty to act solely in another party's interests. Parties owing this duty are called fiduciaries. The individuals to whom they owe a duty are called principals … A fiduciary duty is the strictest duty of care recognized by the US legal system. Examples of fiduciary relationships include those between a lawyer and her client, a guardian and her ward, *and a director and her shareholders*." (emphasis added) Legal Information Institute, Cornell University Law School, http://www.law.cornell.edu/wex/fiduciary_duty (accessed October 7, 2015).

[766] Martin Lipton & Jay W. Lorsch, *A Modest Proposal for Improved Corporate Governance*, The Business Lawyer, Vol. 48 (November 1992) pp. 61-62, citing Chancellor William T. Allen, *Redefining the Role of Outside Directors in an Age of Global Competition*, presented at Ray Garrett, Jr., Corporate and Securities Law Institute, Northwestern University, Chicago (April 1992).

> performance of senior management in an informed way. Outside directors should function as active monitors of corporate management, not just in crisis, but continually. They should have an active role in the formulation of the long-term strategic, financial, and organizational goals of the corporation and should approve plans to achieve those goals. They should as well engage in the periodic review of short and long term performance according to plan and be prepared to press for correction when in their judgment there is need.[767]

The "informed way" implies that if a company goal is to avoid major accident events, boards must be equipped with adequate and timely information to question and hold management accountable, or even to assert a course of correction when such challenge is needed. To perform this role, however, at least some number of board members must have adequate levels of relevant education, training, and professional experience to allow them to assess the sufficiency of the information they receive and to challenge executive management, if necessary. This especially applies to independent directors.[768] In this role, boards as a whole, by committees or through individual directors playing specialized leadership roles, can help to shape corporate activity at the highest level (e.g., policies, communications, strategic goals and objectives, mergers and acquisitions, indicators, compensation and incentive pay programs). These decisions help to shape the corporation's overall culture and the degree to which that culture is focused on safety and major accident prevention. (See Chapter 6.)

5.1.2 The Role of Shareholders and their Influence on Corporate Governance

When shareholders become dissatisfied with corporate performance or governance, they can lobby for change either through direct dialogue with the board of directors, for instance, by speaking during open corporate meetings or filing formal shareholder proposals for shareholder vote.[769] These activities, referred to as "shareholder activism," can result in significant change, such as redirecting a company's business strategy (e.g., financial restructuring, spin-offs, acquisitions, increasing dividends) or affecting the organization's behavior as a corporate citizen (e.g., proposals concerning labor practices, political spending, lobbying, social issues, environmental issues).[770] Activists are typically single minority

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[767] Martin Lipton & Jay W. Lorsch, *A Modest Proposal for Improved Corporate Governance*, The Business Lawyer, Vol. 48 (November 1992) pp. 61-62, citing Chancellor William T. Allen, *Redefining the Role of Outside Directors In an Age of Global Competition,* presented at Ray Garrett, Jr., Corporate and Securities Law Institute, Northwestern University, Chicago (April 1992).

[768] In defining an independent (also called a non-executive) director, the NYSE notes: "no director qualifies as 'independent' unless the board of directors affirmatively determines that the director has 'no material relationship' with the listed company, either directly or as a partner, shareholder or officer of an organization that has a relationship with the company," while the NASDAQ requires that an independent director "must not be an officer or employee of the company or its subsidiaries or any other individual having a relationship that, in the opinion of the company's board of directors, would interfere with the exercise of independent judgment in carrying out the responsibilities of a director." See generally Larkin, G. *Just What is an Independent Director Anyway?* The Conference Board, September 10, 2010, available at http://tcbblogs.org/governance/2010/09/10/just-what-is-an-independent-director-anyway/.

[769] Cossin, D.; Caballero, J. *Shareholder Activism Background Literature Review;* IMD Global Board Center: July, 2013, pp 5-6.

[770] PwC. Shareholder Activisim: Who, What , When and How?; March, 2015, p 2-4.

investors with large block holdings in a company, or institutional investors with majority holdings,[771] such as mutual, pension, or hedge funds. Labor unions and nonprofit organizations also engage in shareholder activism.[772] Activism occurs because a public company is, after all, owned by its shareholders. Regardless of the size of holdings, shareholders are always free to sell their shares, and non-shareholders can refrain from purchasing shares. Such decisions to sell or to refrain from buying can effectively weaken companies that investors deem to be poor investment choices, decisions which can be prompted through informed decision-making relating to a company's poor process safety practices or other insufficient efforts aimed at major accident prevention, among other issues. Thus, whether through activism or marketplace decisions to buy or sell, shareholders have demonstrated that they have influence.

Scholars acknowledge this reality, and note that a number of such "social controls" can

> indirectly influence industrial safety performance, such as laws and norms for corporate governance that cause companies to inform shareholders and potential investors about corporate activities so they can make informed decisions about financial risks. If the activities are hazardous, these sources of financial support may need to be convinced that their financial risks are held to acceptable levels by evidence of effective safety management, which thereby makes it necessary for companies to develop and implement codes of conduct and safety management practices that adhere to industrial standards and comply with government regulations.
>
> Similarly, corporate governance principles also establish management accountability to these financial stakeholders, and cause companies to take the pragmatic step of securing insurance coverage for losses and liabilities which could arise from accidents and other mishaps. This induces companies to maintain their safety performance at a level sufficient to convince insurers to provide sufficient coverage at affordable rates. Thus, "corporate governance is not only a legal concept but is also embedded in organizational theory." It creates a linkage between financial risk and risks to health, safety, property and the environment and can be an important promoter of safety management.[773]

Numerous high profile organizations, including Yahoo, Staples-Office Depot, Target, and eBay have recently been affected by shareholder activist efforts.[774] Currently, a number of active shareholder resolutions face several major US corporations that focus on issues such as climate change, energy, water scarcity, and sustainability reporting.[775]

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[771] Cossin, D.; Caballero, J. Shareholder Activism Background Literature Review; IMD Global Board Center: July, 2013, p 5.; PwC. Shareholder Activisim: Who, What , When and How? March, 2015, pp 2-4.

[772] Cossin, D.; Caballero, J. *Shareholder Activism Background Literature Review;* IMD Global Board Center: July, 2013, p 5.

[773] Lindoe, P; Baram, M; Renn, O, *Risk Governance of Offshore Oil and Gas Operations*, Cambridge University Press, 2014; pp. 36-37; citing OECD (2012) *Corporate Governance for Process Safety*. OECD: Paris; CERES; Swiss Re (2011) *Operational Hazards in the Oil and Gas Industry*. Zurich; and De Groot, C (2009), *Corporate Governance as a Limited Legal Concept*. Wolters Kluwer Law & Business: Amsterdam, p. 128.

[774] Jay, M. Dow-DuPont-Activist Investors story. *AP*, December 14, 2015, http://finance.yahoo.com/news/agitators-behind-dow-dupont-yahoo-214607644.html (accessed December 16, 2015).

[775] "Ceres tracks shareholder resolutions filed by our investor network participants on sustainability-related issues that companies are facing, focusing on climate change, energy, water scarcity, and sustainability reporting. These resolutions are part of broader investor efforts encouraging companies to address the full range of environmental, social and governance issues. The resolutions are filed by some of the nation's largest public pension funds, foundations, and religious, labor and socially responsible investors. Many of the investors are members of Ceres'

Recent examples of successful shareholder activism involve two chemical manufacturers (DuPont Co. and Dow Chemical Co.), and even BP itself. Dow and DuPont recently announced a merger of the two companies to create one new company worth more than $120 billion, after which, the company will split into three separate companies.[776] The companies' chief executives worked with activist investors, including the Trian Fund Management LP (Trian), to plan and execute the deal.[777] As observed by Chris Davis, a lawyer who advises activists, "Seven months ago, DuPont had beaten Trian in a proxy fight, a victory some thought could mark a pushback on activism's rise. Now, Trian looks vindicated. America's corporate landscape is being permanently reshaped under the influence of two of its pre-eminent activists."[778]

In the case of BP, CCLA Investment Management formally led an effort to form a coalition of investor groups called "Aiming for A." Their proposal, Strategic Resilience for 2035 and Beyond, sought to influence BP, as well as Dutch oil and gas major Royal Dutch Shell, to adopt a strategic approach to the challenges posed by climate change and the desire to lower carbon emissions. The coalition put forward this resolution "to address our interest in the longer term success of the Company, given the recognised risks and opportunities associated with climate change."[779] The shareholders requested annual reporting about "ongoing operational emissions management … low-carbon energy research and development (R&D) and investment strategies; relevant strategic key performance indicators (KPIs) and executive incentives; and public policy positions relating to climate change." BP's board of directors supported the resolution, and after 98% in-favor vote, the resolution passed. One member group of the coalition, the Church of England, recently noted on its website that the positive reception offered by both BP and Shell in an area like this is "completely unprecedented,"[780] while a spokesperson for another member of the coalition, the Chair of the Local Authority Pension Fund Forum said: "This development from BP is a clear example of the effectiveness of shareholder engagement backed by investor commitment … taking

Investor Network on Climate Risk (INCR)," http://www.ceres.org/investor-network/resolutions (accessed December 17, 2015).

[776] Benoit, D. Dow, DuPont Deal Cements Activists' Rise. *The Wall Streen Journal*, December 11, 2015, http://www.wsj.com/articles/dow-dupont-deal-cements-activists-rise-1449882586 (accessed December 16, 2015).

[777] Benoit, D. Dow, DuPont Deal Cements Activists' Rise. *The Wall Streen Journal*, December 11, 2015, http://www.wsj.com/articles/dow-dupont-deal-cements-activists-rise-1449882586 (accessed December 16, 2015).

[778] Benoit, D. Dow, DuPont Deal Cements Activists' Rise. *The Wall Streen Journal*, December 11, 2015, http://www.wsj.com/articles/dow-dupont-deal-cements-activists-rise-1449882586 (accessed December 16, 2015).

[779] Ceres. Investor Network > Sharehodler Resolutions > BP Report Annually on Carbon Asset Risk Mitigation , http://www.ceres.org/investor-network/resolutions/bp-report-annually-on-carbon-asset-risk-mitigation (accessed December 17, 2015).

[780] BP Board Advises Shareholders to Support Resolution on Climate Change at 2015 AGM, https://www.churchofengland.org/media-centre/news/2015/02/bp-board-advises-shareholders-to-support-resolution-on-climate-change-at-2015-agm.aspx (accessed March 2, 2016).

an active approach to long-term risk, sustainability and carbon management issues has benefits both for our beneficiaries and for our underlying investments."[781]

These examples demonstrate the potential shareholder influence on a board of directors.

5.1.3 Corporate Governance Risk Management and Sustainability

Informed oversight activities by a board of directors includes questioning management about significant risks challenging the company and its ongoing viability in worst-case scenarios. These concerns involve a concept of "corporate sustainability." At its core, sustainability means that the corporation will remain viable and profitable for its shareholders while providing jobs for employees and products or services needed within the broader economy, but it is also inclusive of other factors reflective of a progressive society**.** For example, the "Dow Jones Sustainability Indexes (DJSI) defines corporate sustainability as 'a business approach that creates long-term shareholder value by embracing opportunities and managing risks deriving from economic, environmental and social developments.'"[782]

Thus, sustainability can involve an assessment of how environmental stewardship and social policies affect long-term viability of the corporation as it aligns social and environmental demands with the need for profitability, products, and services, and the ability to provide healthy and safe jobs for employees.

At the macro level, risk assessment and management types of activity by boards of directors is termed enterprise risk management (ERM), the process by which a firm determines the major risks it faces and the risk management strategies it deploys to face those risks (e.g., acceptance, mitigation, transfer, elimination).[783] ERM is undeniably a critical board function.

[CALL-OUT BOX START]

According to the Committee of Sponsoring Organizations,[784] the four broad categories of ERM focus are strategy, operations, reporting, and compliance. They include eight specific activities:

1. *Internal Environment – This activity encompasses the tone of an organization and sets the basis for how an entity's people view and address risk, including risk management philosophy and risk appetite, integrity and ethical values, and the environment in which they operate.*

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[781] BP Board Advises Shareholders to Support Resolution on Climate Change at 2015 AGM, https://www.churchofengland.org/media-centre/news/2015/02/bp-board-advises-shareholders-to-support-resolution-on-climate-change-at-2015-agm.aspx (accessed March 2, 2016).

[782] Center for Resilience, Ohio State University, available at http://www.resilience.osu.edu/CFR-site/resilienceandsustainability.htm (accessed on March 8, 2016).

[783] According to the leading ERM framework, designed by the Committee of Sponsoring Organizations of the Treadway Commission (COSO), ERM "is a process, effected by an entity's Board of Directors, management and other personnel, applied in strategy settings and across the enterprise, designed to identify potential events that may affect the entity, and manage those risks to be within its risk appetite, to provide reasonable assurance regarding the achievement of the entity objectives." Committee of Sponsoring Organizations. *Enterprise Risk Management – Integrated Framework, Executive Summary;* September, 2004, p 2.

[784] COSO describes its mission on its website. "The Committee of Sponsoring Organizations' (COSO) mission is to provide thought leadership through the development of comprehensive frameworks and guidance on enterprise risk management, internal control and fraud deterrence designed to improve organizational performance and governance and to reduce the extent of fraud in organizations." http://www.coso.org/aboutus.htm (accessed October 7, 2015).

2. *Objective Setting – Objectives must exist before management can identify potential events affecting their achievement. Enterprise risk management ensures management has in place a process to set objectives and that the chosen objectives support and align with the entity's mission and are consistent with risk appetite.*
3. *Event Identification – The entity must identify internal and external events affecting achievement of its objectives, distinguishing between risks and opportunities. Opportunities are channeled back to management's strategy or objective-setting processes.*
4. *Risk Assessment – The entity analyzes risks, considering likelihood and impact as a basis for determining how to manage them, and they assess risks inherently and residually.*
5. *Risk Response – Management selects risk responses—avoiding, accepting, reducing, or sharing risk—developing a set of actions to align risks with the entity's risk tolerances and risk appetite.*
6. *Control Activities – Management establishes and implements policies and procedures to help ensure the effective risk response.*
7. *Information and Communication – The entity identifies, captures, and communicates relevant information in a form and timeframe that enable people to carry out their responsibilities. Effective communication also occurs in a broader sense, flowing down, across, and up the entity.*
8. *Monitoring – Ongoing management activities and separate evaluations monitor of the entire enterprise's risk management and makes modifications as necessary.*

[CALL-OUT BOX END]

The Committee of Sponsoring Organizations (COSO) asserts that boards of directors should:

> discuss with senior management the state of the entity's enterprise risk management and provide oversight as needed. The board should ensure it is apprised of the most significant risks, along with actions management is taking and how it is ensuring effective enterprise risk management. The board should consider seeking input from internal auditors, external auditors, and others.[785]

A growing trend among US boards of directors is a greater readiness to engage whenever and wherever appropriate to ensure management is effectively leading and managing the many areas of a corporation's business activities.[786] The rationale for that development has been long in the making, but is straightforward: "By acting early and effectively, directors may prevent small problems from growing into a major crisis."[787] In terms of ERM responsibilities, the role of boards "has become increasingly challenging as expectations for board engagement are at all-time highs."[788] COSO recently opined about corporate failures during the last financial crisis, but the statements have broader applicability across the gamut of corporate risk:

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785 Committee of Sponsoring Organizations. Enterprise Risk Management—Integrated Framework, Executive Summary; September, 2004; pp 6-7.

786 Bussey, J. Governance Grows Up: Governance Grows Up in American Baord Rooms. *The Wall Street Journal*, October 12, 2010, pp 1, 5.

787 Lipton, M.; Lorsch, J. W. A Modest Proposal for Improved Corporate Governance; *The Business Lawyer* **1992,** *48*, pp 62.

788 Committee of Sponsoring Organizations. Effective Enterprise Risk Oversight: The Role of the Board of Directors; 2009; pp 1.

> The benefit of hindsight has shown us that boards have a difficult task in overseeing the management of increasingly complex and interconnected risks that have the potential to devastate organizations overnight. At the same time, boards and other market participants are receiving increased scrutiny regarding their role … Boards are being asked—and many are asking themselves—could they have done a better job in overseeing the management of their organization's risk exposures.[789]

So whether through managing a CEO and executive management team, audit and oversight, or establishing corporate goals and objectives or other high-level policies (such as compensation systems and bonus structures), the role of a company's board of directors is multifaceted and ongoing. It is not enough to set certain goals and objectives or to delegate such activities to the CEO and the senior management team. Instead, the board must at least monitor the company's performance with an eye toward policies they have implemented, to ensure they take appropriate actions and achieve anticipated results. Perhaps for this reason, Bob Dudley, shortly after taking over as CEO at BP, instigated a review of BP's compensation practices, especially incentive pay, out of potential concern that the company was incentivizing behaviors contrary to corporate safety goals. Dudley said: "BP is reviewing its compensation practices so that they are aligned with BP's corporate safety goals. While safety has long been a component of the company's performance incentives plan, going forward, all compensation structures are being reviewed to ensure that safety-first behavior is appropriately and permanently incentivized across all of BP's businesses."[790] Mr. Dudley further explained he took this step "to be absolutely clear that safety, compliance and operational risk management is BP's number one priority."[791]

The rationale for board engagement in risk management and corporate sustainability in the offshore drilling sector takes on even more urgency, especially with the benefit of hindsight of a disaster like Macondo. As examples in this chapter indicate, economic, legal, and reputational damages of the magnitude caused by such catastrophic accidents threaten both a company's short-term performance and long-term viability.[792] In effect, a board of directors' oversight and strategic leadership are vital for process safety and issues concerning major accident events. To be clear, micromanagement is not suggested or appropriate; rather, an engaged board willing and able to meet its oversight responsibility is the key. Boards of directors must be knowledgeable about the major accident risks in a company's operations, and they must insist on access to relevant information to play an active role in overseeing management of those risks and to ensure those risks are communicated appropriately to shareholders and regulators.

[789] Committee of Sponsoring Organizations. Effective Enterprise Risk Oversight: The Role of the Board of Directors; 2009; pp 1.

[790] BP's COMMITMENT TO SAFETY, p. 1.

[791] BP's COMMITMENT TO SAFETY, p. 3.

[792] Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012; pp 7-8. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

5.1.4 The Business Case for Effective Process Safety Oversight

The Organization for Economic Cooperation and Development (OECD) is an intergovernmental organization with representatives from 34 industrialized countries in North and South America, (including the US), Europe, and the Asia and Pacific region, as well as from within the European Commission. OECD meets as a body to coordinate and harmonize policies, discuss issues of mutual concern, and collaborate to respond to international problems.

In June 2012, through its "Environment, Health and Safety Chemical Accidents Program," OECD published the guidance *Corporate Governance for Process Safety: Guidance for Senior Leaders in High Hazard Industries*. OECD instructs "Good process safety management needs the active involvement of senior leaders, and it is important that they are visible within their organisation, because of the influence they have on the overall safety and organisational culture."[793] The document outlines a business case in favor of effective process safety management. Noting significant international incidents such as Bhopal,[794] BP Texas City, and Buncefield,[795] OECD asserts that a growing tide of corporate social responsibility is emerging around the globe, and that regulators, shareholders of companies in high-hazard industries, and citizens alike are all expecting more of business leaders in the modern business environment.[796] Businesses can suffer if they do not meet those expectations. Corporate leaders are expected to manage the risks posed by their businesses alongside other critical factors within their businesses, with severe consequences for failure to do so.[797]

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[793] Organisation for Economic Co-operation and Development (OECD). *Corporate Governance for Process Safety: OECD Guidance for Senior Leaders in High Hazard Industries;* June, 2012; pp 9. http://www.oecd.org/chemicalsafety/chemical-accidents/corporate%20governance%20for%20process%20safety-colour%20cover.pdf (accessed October 7, 2015). Note, some existing guidance is unclear whether a term like "senior leadership" includes the board of directors (including independent directors), or is limited to the executive leadership team, or others further down the management chain. Many best practices in this area apply equally well to all levels of leadership, and some are more particularized; however, it is clear that as one considers the corporate hierarchy, the higher the level of leadership, the more appropriate it becomes to apply a higher scope of duties.

[794] On December 3, 1984, a methyl isocyanate (MIC) release at the Union Carbide insecticide plant in Bhopal, India resulted in an estimated 3,800 people that died within days, and tens of thousands that were injured. Eventually, the release killed tens of thousands of people. See http://www.csb.gov/on-30th-anniversary-of-fatal-chemical-release-that-killed-thousands-in-bhopal-india-csb-safety-message-warns-it-could-happen-again-/?pg=4 (accessed June 17, 2015).

[795] On December 11, 2005 a large vapor cloud explosion and multiple tank fires occurred after the overfilling of a tank when unnoticed. The explosion injured 43 people, damaged 22 additional tanks at the site, and $1.5 billion damage in a commercial and residential property; Johnson, D. The Potential for Vapour Cloud Explosions: Lessons from Buncefield; *Journal of Loss Prevention in teh Process Industries* **2010,** *23,* pp 921-927.

[796] Organisation for Economic Co-operation and Development (OECD). *Corporate Governance for Process Safety: OECD Guidance for Senior Leaders in High Hazard Industries;* June, 2012; pp 8-9. http://www.oecd.org/chemicalsafety/chemical-accidents/corporate%20governance%20for%20process%20safety-colour%20cover.pdf (accessed October 7, 2015).

[797] BP Plc., CEO Bob Dudley recently likened the Macondo blowout to a near-death experience, "Sometimes it takes a near death experience to radically change a company;" US Gulf oil spill nearly ruined BP, says chief Bob Dudley. *BBC News*, January 2, 2016, http://www.bbc.com/news/uk-35210450 (accessed January 15, 2016).

Similar to the work of COSO, OECD reminds that major accidents are just like other significant business risks, especially when considering the integrated nature of many high-hazard businesses.[798] OECD explains that good corporate governance in process safety is not just about avoiding potential negative effects. Key commercial benefits of good process safety management include (1) less downtime and higher plant/facility availability, (2) easier-to-forecast maintenance budgets, (3) longer lifespans for plants/facilities and equipment, (4) improved efficiency and flexibility in operations, (5) enhanced employee, stakeholder-regulator relationships, and (6) improved access to capital and insurance at more attractive rates or premiums.[799] Stated differently, good process safety equates to good business.

[CALL-OUT BOX START]

In the UK, international utility giant Scottish Power demonstrates that a commitment to safety can be part of a strategy toward increased and sustainable profits and total shareholder value—key goals of any high performing corporate board of directors. Judith Hackitt, Chair of the UK HSE, recently cited Scottish Power as an example of a company whose board has "led the way" in demonstrating commitment to safety and reliability from the top to the bottom of the organization, and throughout the process delivered real benefits in terms of both safety and profitability.[a] With a formal governance model that involves monthly meetings on reviewing process safety dashboard information from the facility level up to the board itself, the company started to "establish ownership and accountability for process safety management" and to foster a corporate culture intentionally designed "to ensure people are always thinking about what could go wrong and never complacent."[b]

[a] Hackitt, J. *Why Corporate Governance and Why Now?*, Conference on Corporate Governance for Process Safety, Paris, France, June 14-15, 2012; http://www.hse.gov.uk/aboutus/speeches/transcripts/hackitt140612.htm (accessed October 7, 2015).

[b] CSB. CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012, p 86 http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015); Sedgwick, M.; Wands, A. *The Implementation of Effective Key Performance Indicators to Manage Major Hazard Risks*, CSB Sfaety Performance Indicator Public Hearing, Houston, TX, July 23, 2012. slide 4. http://www.csb.gov/UserFiles/file/Sedgwick%20%28Scottish%20Power%29%20PowerPoint%20-%20printed.pdf (accessed October 7, 2015).

[CALL-OUT BOX END]

[798] Organisation for Economic Co-operation and Development (OECD). *Corporate Governance for Process Safety: OECD Guidance for Senior Leaders in High Hazard Industries;* June, 2012, pp 8-9. http://www.oecd.org/chemicalsafety/chemical-accidents/corporate%20governance%20for%20process%20safety-colour%20cover.pdf (accessed October 7, 2015).

[799] Organisation for Economic Co-operation and Development (OECD). *Corporate Governance for Process Safety: OECD Guidance for Senior Leaders in High Hazard Industries;* June, 2012, pp 9-10. http://www.oecd.org/chemicalsafety/chemical-accidents/corporate%20governance%20for%20process%20safety-colour%20cover.pdf (accessed October 7, 2015).

5.1.5 The Need for Better Reporting Illustrated by Consequences Stemming from the Macondo Blowout

The messages to shareholders in annual reports illustrate what a board of directors and senior management team consider necessary to demonstrate the investment value of the company. These reports include a domestic company's 10-K report,[800] a foreign issuer's 20-F report,[801] and any company reports produced for the benefit of shareholders and the public, such as BP's sustainability reports, or annual board performance reports. US reporting regulatory requirements apply to foreign companies, such as BP (United Kingdom) or Transocean (Switzerland), whose stock trades in US markets as American Depositary Shares or American Depositary Receipts.[802]

BP and Transocean are required to communicate relevant information to shareholders about major hazard risks, especially where information about risks are determined to be material. Failure to do so could lead to liability under Section 10(b) of the Securities Exchange Act of 1934.[803] Failure to disclose material information could also lead to potential civil liability arising from shareholder litigation.[804] The theory in

[800] 10-K reports are comprehensive annual financial reports required by the SEC, the requirements for which are detailed in the Securities and Exchange Act of 1934. http://www.investopedia.com/terms/1/10-k.asp (accessed October 7, 2015).

[801] 20-F reports are comprehensive annual financial reports required by the SEC from "foreign private issuers" who issue equity shares available in US markets, the requirements for which are detailed in the Securities Exchange Act of 1934. *See* http://www.investopedia.com/terms/s/sec-form-20-f.asp (accessed October 7, 2015).

[802] BP Shares trade as American Depositary Shares rather than American Depositary Receipts, which are similar instruments. See http://www.bp.com/en/global/corporate/investors/shareholder-information/managing-your-shares---ads-holders.html. Transocean shares trade as American Depositary Receipts. http://deepwater.com/investor-relations.html. See generally http://www.investopedia.com/ask/answers/06/adrvsads.asp (all sites accessed October 7, 2015).

[803] Codified at 15 U.S.C. § 78j(b); see also 17 C.F.R. § 240.10b-5, "Employment of Manipulative and Deceptive Practices," which states, in part: "It shall be unlawful for any person, directly or indirectly, by the use of any means or instrumentality of interstate commerce, . . . (b) To make any untrue statement of a material fact *or to omit to state a material fact necessary in order to make the statements made, in the light of the circumstances under which they were made, not misleading* . . ." (Emphasis added.)

[804] Although factual allegations in a complaint cannot be presumed as true, and can only be accepted as fact after litigation on the merits, shareholder litigation pending against both BP and Transocean asserts safety disclosure failures relative to the Macondo blowout. See *Alameda County Retirement Association v. BP* which asserts, inter alia, that shareholder-plaintiffs lost millions of dollars on their BP investments as a result of false and misleading statements made by the defendants regarding the extent of BP's commitment to a "safety first" approach to oil drilling and a "profits first" corporate culture. See Consolidated Complaint, ¶ 2, Case No.: 12-CV-01256, 12-CV-01261, 12-CV01614. Similarly, a suit against Transocean by shareholder-plaintiffs Thomas Yuen and Sumni Ahn accused Transocean of misrepresenting a string of failures involving blowout preventers. This class action suit alleged that false claims by management caused the price of Transocean stock to rise artificially due to a lack of understanding of actual risks, and then to plunge when the truth was later revealed. See Complaint – Class Action, ¶¶ 1, 6 Case No: 2:10-CV-01467-JCZ-SS. The common underpinning of these suits is the fact that the risk of a subsea blowout was well understood by industry, making such information inherently "material," defined as "of such a nature that knowledge of the item would affect a person's decision-making process." *Black's Law Dictionary*, 7th ed. (1999); see also *TSC Industries v. Northway*, 426 U.S. 438, 449 (1976) (must be a substantial likelihood that the reasonable investor would view the disclosure of an omitted fact as having significantly altered the "total mix" of available information in a manner that shareholders would consider relevant to the buying and selling of stocks).

this type of litigation is that insufficient disclosure prevents shareholders from understanding the risk they are taking by purchasing shares at what essentially is an artificially high share price, because the risk associated with the companies' activities could not adequately be factored into the market's assessment of share prices.

In a relevant example, following Macondo, BP shares fell in value by over 48% between April 20, 2010 and June 25, 2010.[805] The slide in share value was compounded by BP's need to set aside money for anticipated litigation costs related to the accident, in both criminal and civil contexts. These funds were to be generated by suspending regular shareholder dividend payments as well as the sale of potentially lucrative oil fields to competitors at a time of rising oil prices.[806] Other costs continue to mount, including a negotiated $18.7 billion dollar settlement the company reached with the US government,[807] along with ongoing environmental remediation costs and marketing costs related to rebuilding BP's image with the American public. The possibility remains of more adverse judgments stemming from other pending legal actions.[808] BP's 2014 annual report noted that potential costs related to the Macondo blowout still could not be fully estimated, and "they have had and could continue to have a material adverse impact on the group's business, competitive position, financial performance, cash flows, prospects, liquidity, shareholder returns and/or implementation of its strategic agenda, particularly in the US."[809] Transocean had a similar statement in its own annual report that indicated "the Macondo well incident could result in increased expenses and decreased revenues, which could ultimately have a material adverse effect on us … we are currently unable to estimate the full impact the Macondo well incident will have on us."[810]

Issues of required disclosures in the case of BP and Transocean must, however, be kept in proper context. For its part, based on annual reports filed in 2011 for the 2010 performance year, BP was recognized by public interest group Ceres as having provided shareholders with "good" disclosures relating to deepwater

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[805] *Alameda County Retirement Association v. BP*, Consolidated Complaint, ¶¶ 399-402, Case No.: 12-CV-01256, 12-CV-01261, 12-CV01614.

[806] BP. *Annual Report and Form 20-F 2011*, p 103 http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-and-form-20f-2011.pdf (accessed December 17, 2015); See also, http://dealbook.nytimes.com/2012/09/10/bp-said-to-be-in-talks-to-sell-gulf-of-mexico-assets-for-6-billion/?_r=0 (sales in the Gulf of Mexico and sales pending in Russia); http://articles.latimes.com/2010/jul/12/nation/la-na-0712-oil-spill-bp-20100712 (Alaska).

[807] http://www.bloomberg.com/news/articles/2015-07-02/bp-said-to-settle-2010-gulf-oil-spill-claims-with-u-s-states. This settlement was approved by the judge presiding over the case on April 5, 2016; see http://www.cnbc.com/2016/04/05/us-judge-approves-bp-settlement-for-2010-gulf-of-mexico-oil-spill.html?__source=facebook%7Cbusiness%7Clink%7C040416%7C5AM%7Cjudge-approves-bp-settlement.

[808] For example, on December 11, 2015 Acciones Colectivas de Sinaloa filed a class action lawsuit against BP seeking compensation for environmental damage sustained in Mexico as a consequence of the 2010 oil spill; Rodriguez, J. C. Mexico Files Class Action Lawsuit Against BP plc (ADR) over Deepwater Horizon Spill. *Law360*, December 11, 2015, http://www.law360.com/articles/737080/bp-hit-with-class-action-in-mexico-over-deepwater-horizon (accessed January 15, 2015).

[809] BP *Annual Report and Form 20-F 2014*, p 228. http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-and-form-20f-2014.pdf (accessed December 17, 2015).

[810] Transocean. *Annual Report*, 2014, pp AR15-AR16.

drilling risks in four of five categories among the world's ten largest publicly-owned oil and gas companies.[811]

As this chapter explains, more could have been disclosed but disclosure was not required, in light of controlling SEC regulation or other accompanying guidance. Moreover, as Ceres found even in a post-Macondo world, none of the world's ten largest publicly traded oil and gas companies produced "excellent" disclosures with respect to climate change and deepwater drilling risks; yet, these companies continue to make extensive capital investments in extracting oil and gas and expanding deepwater exploration and production efforts. In doing so, they are "posing significant risks to investors and stakeholders."[812] To that end, Ceres called on investors to push for better quality disclosure from oil and gas companies, and for securities regulators to "keep close tabs" on the quality of corporate disclosures of those companies working offshore in the extractive industry with specific regard to deepwater drilling risks, while "prodding companies that continue to fall short."[813]

Ceres' recognition of companies with better reporting is further tempered by the fact that "even the best reporting provided narrative discussions of deepwater drilling policies and actions, without providing investors sufficient metrics to evaluate the success of new policies designed to reduce the risks of accidents."[814]

5.2 BP and Transocean: Corporate Governance and Communication of Process Safety and Major Accident Prevention Information

BP and Transocean boards of directors met requirements for disclosing material information about safety, but neither board effectively communicated process safety performance in the form of leading indicator data and lagging metrics of sufficient scope and frequency, which could have provided greater depth concerning the safety of drilling operations. As this section describes, shareholder communications and other public information about board activities and corporate risk demonstrate missed opportunities by

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[811] For its 2010 annual report, Ceres recognized BP for "Good Disclosures" with respect to Safety & Environmental Statistics, Drilling Risk Management, Safety R&D, and Corporate Governance on Drilling, while it recognized BP for "Fair Disclosures" relating to Spill Response. Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012; pp 1-3. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[812] Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012; pp i, 1, 4-5. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[813] Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012; pp i. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[814] Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012; p 2. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

BP's and Transocean's boards to communicate additional information from the highest level to focus their companies' efforts on safety in a manner that could help to minimize the potential for a catastrophic event like the one on April 20, 2010. The rationale underpinning this critique is straightforward. In business, "your measurement system will determine what your staff will pay attention to."[815] On the executive level, "Leaders create cultures by what they systematically pay attention to."[816] In effect, a successful corporate safety program aimed largely at personal safety provides little insight into how well the company is controlling, mitigating, and managing major hazards and catastrophic risk, especially in the area of process safety risk. As described in Section 3.1, it could even lull observers from all levels of a company—and even shareholders—into a false sense of security over major hazards.

5.2.1 A Case Study of Board Involvement Demonstrated in Shareholder Communications

BP and Transocean both publicly reported health and safety information about risk and the sustainability of operations to shareholders in annual reports for many years. An analysis of BP board communications before and after the BP Texas City disaster in 2005, and of BP and Transocean communications before and after the Macondo disaster, illustrate an evolving focus and approach to process safety and major accident prevention communications from BP's board of directors' perspective, and a somewhat more static and traditional approach taken by Transocean.

5.2.1.1 BP Shareholder Communications Before and After BP Texas City

Following the BP Texas City disaster, the Baker Panel found a "substantial gulf" between the information management reported to the BP board of directors and the reality in the field, where company personnel were generating process safety information and making operational decisions which had major accident risk implications for the company. Specifically:

> BP's Board of Directors has been monitoring process safety performance of BP's operations based on information that BP's corporate management presented to it. A substantial gulf appears to have existed, however, between the actual performance of BP's process safety management systems and the company's perception of that performance. Although BP's executive and refining line management was responsible for ensuring the implementation of an integrated, comprehensive, and effective process safety management system, BP's Board has not ensured, as a best practice, that management did so. In reviewing the conduct of the Board, the Panel is guided by its chartered purpose to examine and recommend any needed improvements. In the Panel's judgment, this purpose does not call for an examination of legal compliance, but calls for excellence. It is in this context and

[815] Eves, D.; Gummer, J. *Questioning Performance: Essential Guide to Health, Safety and the Environment ;* IOSH Services Ltd: Wigston, United Kingdom, 2011, p 103 (as attributed to Peter Drucker). HSE also commissioned research into the types of KPIs a company could select, which investment institutions would likely regard as significant, with obvious implications for a company's access to capital, and simultaneously an easy way for directors to drive safety and profit. See *id.* at p 106.

[816] Schein, E. H. *Organizational Culture and Leadership,* 4th ed.; Jossey-Bass: San Francisco, CA, 2010., as cited in Ellis, G. Process Safety Begins in the Board Room. *Chemical Processing*, March 21, 2013, http://www.chemicalprocessing.com/articles/2013/process-safety-begins-in-the-board-room/?show=all (accessed October 7, 2015).

> in the context of best practices that the Panel believes that BP's Board can and should do more to improve its oversight of process safety at BP's five US refineries.[817]

Consider that following the Texas City disaster, BP was assessed $50 million in penalties for felony safety violations leading to the event. BP's sustainability report in 2005, issued after Texas City, communicated the message that the company was learning from its mistakes and working toward safer performance.[818] In particular, the report commented in detail on BP's response to the Texas City disaster with its own investigations, a "fundamental" review of its safety systems and processes, and a whole host of new measures and investments to "maintain the safety of our people and the integrity of our plant."[819]

In fact, little changed in BP's management of Texas City. When OSHA re-inspected the facility 2009, OSHA found "439 instances of 'willful' violations, most or all of which were designated with gravity of 10 on a scale of 1 to 10."[820] OSHA issued notices of violations in response to several significant remaining safety concerns.[821, 822] By August 12, 2010, BP still had not addressed these issues fully. For its failure to act, BP negotiated yet another agreement with OSHA to pay a $50.6 million penalty for ongoing failure-to-abate violations—the largest penalty ever paid in the history of OSHA enforcement.[823] Shareholders, for their part, received little in the way of specifics, despite a narrative-style summary of the ongoing issues and their resolution.

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[817] The Baker Panel. *The Report of the BP US Refineries Independent Safety Review Panel;* January, 2007, pp XV. http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf (accessed October 7, 2015).

[818] BP. *Making energy more-Sustainability Report 2005;* pp 3-4. http://www.bp.com/content/dam/bp/pdf/sustainability/group-reports/bp_sustainability_report_2.pdf (accessed October 7, 2015).

[819] United States Department of Labor. Fact Sheet on BP 2009 Monitoring Inspection, https://www.osha.gov/dep/bp/Fact_Sheet-BP_2009_Monitoring_Inspection.html (accessed December 15, 2015).; Sanford, L. Lessons on Corporate "Sustainability" Disclosure from Deepwater Horizon; *New Solutions* 2011**,** *21,* p 202.

[820] OSHA. Inspection: 311962674 - Bp Products North America, Inc., https://www.osha.gov/pls/imis/establishment.inspection_detail?id=311962674&id=310266085#311962674; US Department of Labors OSHA issues record-breaking fines to BP, https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=16674 (accessed October 7, 2015).

[821] "Our information indicates that for some identified hazards, BP has not specified or allocated the specific layers of protection needed and for other identified hazards where BP has specified the layers of protection it will use to control the hazards, the specified instrument controls have not been installed or are not operational." From Sanford, L. Lessons on Corporate "Sustainability" Disclosure from Deepwater Horizon; *New Solutions* 2011**,** *21,* p 202.

[822] OSHA warned in September 2009 that its audit identified "systemic deviations from the industry standards" and further noted that "areas of concern included a failure, four years after the blast, to complete a determination of which alarm functions in each unit were critical to process safety." From Sanford, L. Lessons on Corporate "Sustainability" Disclosure from Deepwater Horizon; *New Solutions* 2011**,** *21,* p 202.

[823] Sanford, L. Lessons on Corporate "Sustainability" Disclosure from Deepwater Horizon; *New Solutions* 2011**,** *21,* p 199. To be clear, these violations were not the same issues that led to the Texas City disaster, but instead were violations occurring afterward due to the failure of BP to implement needed fixes.

BP's 2009 annual report, issued before Macondo, carried another important message to shareholders. Opening with a letter from Carl-Henric Svanberg, the Chairman of the BP's board, the company made it clear that it remained ready and able to take on the risks presented by its operations. He noted:

> Risk remains a key issue for every business, but at BP it is fundamental to what we do. We operate at the frontiers of the energy industry, in an environment where attitude to risk is key. The countries we work in, the technical and physical challenges we take on and the investments we make – these all demand a sharp focus on how we manage risk. We must never shrink from taking on difficult challenges, but the board will strive to set high expectations of how risk is managed and remain vigilant on oversight.[824]

CEO Tony Hayward's own letter in the 2009 annual report paralleled the Chairman:

> Our priorities have remained absolutely consistent—safety, people and performance—and you can see the results of this focus with improvements on all three fronts. This year we have increased emphasis on operational efficiency, with a particular focus on compliance and continuous improvement. Achieving safe, reliable and compliant operations is our number one priority and the foundation stone for good business. This year we achieved a reported recordable injury frequency of 0.34, an improvement of 20% over 2008. In Refining and Marketing reported major incidents have been reduced by 90% since 2005. All our operated refineries and petrochemicals plants now operate on the BP operating management system (OMS), which governs how BP's operations, sites, projects and facilities are managed. In Exploration and Production 47 of our 54 sites completed the transition to OMS by the end of 2009, and I expect all BP operations to be on OMS by the end of 2010.This represents good progress and we must remain absolutely vigilant.[825]

Together, these letters communicated the company's willingness to operate at the "frontiers" of the energy sector, essentially willing to take on bigger risks for bigger rewards. Macondo represented just this kind of risk/reward, referred to as the "well from hell,"[826] and presenting BP and Transocean numerous operational challenges, while promising a significant payoff of potential hydrocarbon reserves. The letters also sought to communicate a sense of safety to investors, presenting not only the board's perspective on safety in general, but even some specific safety results deemed important from the perspective of the CEO. The remainder of the report, however, provided little in the way of process safety, major hazards, and process safety indicators—perhaps because no express regulatory requirement existed for the reporting of such information, and because BP's industry peers do not report the same type of information.

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[824] BP 2009 Annual Report, letter from Carl-Henric Svanberg, Chairman of the Board, p 3.

[825] BP 2009 Annual Report, letter from Tony Hayward, Group CEO, p 6.

[826] See http://www.nytimes.com/2014/09/05/business/bp-negligent-in-2010-oil-spill-us-judge-rules.html?_r=0 (referencing exploration and production challenges "in the deep waters of the Gulf of Mexico, where high pressures and temperatures in the wells test the most modern drilling technologies.") See also in re: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico on April 20, 2010, Findings of Fact and Conclusions of Law, Judge Barbier, ¶56 ("Drilling the Macondo well did not go smoothly. Some called it the "well from hell."); and exhibit TREX-22924, "Macondo Was the Well from Hell," (timeline showing challenges in drilling Macondo), available at http://www.mdl2179trialdocs.com/releases/release201304041200022/D-3126.pdf.

5.2.1.2 BP Shareholder Communications Before and After Macondo

In its 2009 annual shareholder report, four years after BP Texas City but one year before Macondo, BP included only three indicators which the company described as having to do with safety: Recordable Injury Frequency (RIF), oil spills, and greenhouse gas emissions. As noted in Chapter 3 and as Hayward touts in his letter, BP achieved strong results with respect to personal safety as measured by RIF. The BP workforce (employees and contractors) achieved a RIF of "0.34, significantly below 2008 and 2007 levels of 0.43 and 0.48, respectively." Oil spills, which were defined as spills of one barrel or more, also showed a reduction from the two prior years, down from 340 in 2007, 335 in 2008, and 234 in 2007. In contrast, greenhouse gas emissions were up in 2009 from levels as reported in 2007 and 2008, which the company attributed to "increases in operational activity" in various regards. This is the type of data upon which shareholders could assess BP's performance in personal safety issues impacting the company's workforce. These two limited lagging indicators on oil spills and greenhouse gas emissions illustrate environmental concerns and give some indication of process safety management results.

At the same time, however, safety data also illustrates the area of potential improvement open to BP, notwithstanding the current absence of a regulatory requirement for more. The company provided no leading process safety indicators that could have given shareholders or the regulator insight into specifics about process safety issues or major accident prevention.[827] While BP discussed both personal and process safety concepts and issues throughout the report, the absence of meaningful indicator data weakens the effectiveness of the communication. It gave no KPI or metrics-driven discussions relating to success in process safety management issues, especially for offshore drilling and production.

In another example, similar to the phrasing noted in Hayward's letter and the "90% reduction in major incidents," the Exploration and Production section noted, "We also achieved improvements in the number of process safety-related incidents and a significant reduction in the number of spills."[828] These statistics are not particularly illuminating to shareholders, even from a lagging indicators perspective. Although on its face a 90% reduction in major incidents is a positive development, a reader cannot know the number of major incidents that actually occurred, how near-misses were handled in terms of data collection, or whether these incidents had a common causation. Also absent were the operational goals for this area, leaving a shareholder uncertain as to whether BP met its objectives in this area. Missing as well is any attempt to benchmark the number of major incidents against industry standards.

In contrast, in the Refining and Marketing section of the report, BP provides some financial indicators about specific industry benchmarks.[829] In terms of safety, Refining and Marketing again repeated the 90% reduction of "reported major accidents" as well as the previously noted reduction of oil spills and RIF and

[827] BP. *Annual Report and Accounts;* 2009; p 15. http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-accounts-2009.pdf (accessed October 15, 2015).

[828] BP. *Annual Report and Accounts;* 2009; p 12. http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-accounts-2009.pdf (accessed October 15, 2015).

[829] Such benchmarks include refining margin and refining availability percentage. See BP. *Annual Report and Accounts;* 2009; p 18. http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-accounts-2009.pdf (accessed October 15, 2015).

the absence of workplace fatalities for the year.[830] Some improvement in the area of reporting would be helpful because BP appeared to be tracking matters like reported major accidents internally, so bringing that type of data into its annual reports would cost little, but could add much by way of transparency.

In deeper consideration of BP's indicators chosen for report, oil spills and greenhouse emissions are lagging indicators, providing shareholders and the regulator with little more than notice of events that already occurred, rather than including any specific mention of near-misses or the myriad of more sophisticated leading process safety indicators that are frequently tracked and trended offshore which, if disclosed, could have provided readers with far better insights into major process safety issues. Such indicators could have included, for example, data pertaining to challenges to barriers, problems with barriers discovered during inspections, overdue inspections and audits, well kick frequency, response time to well kicks, and the like.

Ceres also cited the improvement in BP's 2010 report over its previous edition in its study on the disclosures made by companies engaged offshore, as well as the limitations in that reporting, noting, "BP's and several other companies deepwater drilling disclosure improved significantly after Macondo. As explained above, however, even the best narrative-style reporting relative to offshore operations, without the addition of indicators, KPIs, or metrics, cannot provide the basis to understand and evaluate the impact of policies and procedures designed to reduce the risk of accidents."[831] This finding by Ceres corroborates the CSB's findings, which is that although BP described issues concerning process safety risk in narrative form, it provided little about significant process safety performance indicators before or immediately after Macondo.

In a positive development, post-Macondo, BP's communication from its board to its shareholders evolved through more transparent and complete reporting related to major hazards. Only briefly in its 2010 annual report, and then more fully its 2011-2014 reports,[832] BP's communications with shareholders began to provide even more information relating to the company's safety performance. For example, the 2011 report emphasized work on a wide swath of corporate activity aimed at improving safety, including coverage of numerous and significant critical safety issues. The report highlighted categories of key accomplishments, such as safety and operational risk, upstream restructuring, operational review, values and behaviors, individual performance and reward, contractor management, technology, and joint ventures not operated by BP.[833] The core of the report, the "Business Review—BP in More Depth" section, included detailed subsections on topics such as risk factors, safety and operational risks, and

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[830] BP. Annual Report and Accounts; 2009, p 21. http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-accounts-2009.pdf (accessed October 15, 2015).

[831] Coburn, J., Salmon, R., Grossman, D. Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk; CERES: August, 2012, p 2. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[832] BP. Annual reporting archive, http://www.bp.com/en/global/corporate/investors/results-and-reporting/annual-report/annual-reporting-archive.html (accessed December 17, 2015), 2015.

[833] BP. *Annual Report and Form 20-F 2010;* p, 36. http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-and-form-20f-2010.pdf (accessed October 2015, 2015).

environmental and social responsibility.[834] It also included a special section detailing ongoing issues in the Gulf of Mexico cleanup efforts.[835] Most of this type of information would benefit the entire sector in publicly traded companies' annual reports.

5.2.1.3 Transocean Shareholder Communications Before and After Macondo

The year before Macondo, in the Chairman's and CEO's joint letter to shareholders accompanying Transocean's 2009 annual report and proxy statement, the company related a corporate message focused on personal safety: "Unfortunately, despite our continued focus on safety and operational excellence and our best-ever total recordable incident rate of 0.77 incidents per 200,000 hours worked, four of our employees suffered fatal accidents while working on our rigs in 2009."[836] Transocean related no other safety performance indicators or other metrics-driven safety data in this public disclosure, with no specific reference to process safety or major accident prevention.

In Transocean's 2009 annual report to shareholders, Transocean defined safety performance through a formula that related to bonus calculations used to reward individual executives and employees. However, safety performance translated to only 20 percent of any total bonus payment, while financial performance related to 70 percent, and "new builds" accounted for the final 10 percent. Thus, per the public transmission of information in its annual report, Transocean intended to incentivize financial performance and new building activity versus safety in an 80/20 split. Moreover, for the 20 percent allocation to safety performance, the report indicated that a total score on this component is computed by reference to three variables: (1) Total Recordable Injury Rate, (2) Total Potential Severity Rate, and (3) High Potential Dropped Objects, with the total score used to calculate employee bonus payments.[837]

The variables used in Transocean's bonus calculation formula were mainly personal safety statistics relating to the higher frequency—and typically lower consequence—events that most often result in a single person injury, but could potentially include a fatality.[838] However, there was no mention of process safety, major hazards or issues of catastrophic accidents, which represent the potential for numerous serious injuries/fatalities, as well as large scale damage to property or the environment. By choosing these

[834] BP. *Annual Report and Form 20-F 2010;* p, 59-72. http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-and-form-20f-2010.pdf (accessed October 2015, 2015).

[835] BP. *Annual Report and Form 20-F 2010;* p, 76-79. http://www.bp.com/content/dam/bp/pdf/investors/bp-annual-report-and-form-20f-2010.pdf (accessed October 2015, 2015).

[836] Transocean. *Annual Report,* 2009, 2009 Letter to the Shareholders, p 1.

[837] Transocean. *Annual Report,* 2009. The three variables comprised 35%, 35%, and 30 % of the measure respectively. TRIR is described in Section 0. TPSR is a proprietary measure used to monitor the total potential severity of incidents, and High Potential Dropped Objects are dropped objects that could cause serious injury resulting in an employee being out of work for six or more months.

[838] Transocean. *Annual Report;* 2009, "Performance Award and Cash Bonus Plan," p 35. The bonus plan is described as "a goal-driven plan that gives participants, including named executive officers, the opportunity to earn annual cash bonuses based on performance measured against predetermined performance goals." *Id.*, p 34. The annual report explains that the bonus plan and the performance goals connected to it are set by the Board, through the Executive Compensation Committee—not the Health Safety and Environment Committee—in accordance with the company's "safety vision" for "an incident-free workplace—all the time, everywhere," stating: "The Committee sets our safety performance targets at high levels each year in an effort to motivate our employees to continually improve our safety performance towards this ultimate goal." *Id.*, p 35.

measures, the Transocean board of directors did not provide for appropriate process safety goal-setting. Instead, Transocean's 70 percent weighting toward financial goals broke down into three sub-elements: (1) cash flow value add relative to budget, (2) overhead costs, and (3) lost revenues,[839] each of which provides incentives to push drilling along faster, without an accompanying set of factors or overarching philosophical approach to help employees meet company goals safely.

Transocean's 2010 annual report is largely the same, with the exception of the company's acknowledgment of the Macondo disaster and a promise to produce a publicly available investigation report as well as a "risk assessment" for shareholders regarding the risks to the company presented by Macondo in terms of business interruption, lawsuits, and the like.[840] Conversely, BP initiated its own investigation, publicly releasing a report on September 8, 2010.[841] Notably, no accounting from Transocean's Health, Safety and Environment Committee[842] appeared in the report, despite the inclusion of reports by other standing committees of the board of directors, including the Audit and Executive Compensation committees on unrelated matters. In addition, notwithstanding the sinking of the Deepwater Horizon, the deaths of 11 workers, and a massive oil spill, Transocean also disclosed bonuses for the company's "best ever" year in safety.[843]

Transocean's 2011 report appeared similar in content to the 2010 version, although it mentions Transocean's overall findings and conclusions of its investigation of the Macondo well blowout.[844] However, the annual report's summary of the investigation focuses only on the safety shortcomings of BP in its role as operator and the party that was legally responsible as the leaseholder, from Transocean's perspective. There is no mention of Transocean internal safety lapses or other deficiencies and no lessons learned for improving the safety of its offshore drilling operations. The 2011 report also lacks any discussion of process safety management issues, major hazards, or catastrophic risk beyond mentioning the formation of a risk management subcommittee that would help the Transocean audit committee to analyze risk for the company in varied settings. In any event, such support would prove fruitless with no

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[839] Transocean. *Annual Report;* 2009, pp 34-35.

[840] Transocean. *Annual Report;* 2009, pp 34-35.

[841] *Deepwater Horizon* Accident Investigation Report, (known informally as the "Bly Report"), dated September 8, 2010, available at http://www.bp.com/content/dam/bp/pdf/sustainability/issue-reports/Deepwater_Horizon_Accident_Investigation_Report.pdf.

[842] Transocean. *Annual Report*, 2010, pp 27. Despite the Macondo disaster and the loss of the Deepwater Horizon and eleven employees, the HSE Committee met only once in 2010. In contrast, the Corporate Governance Committee met 4 times, the Finance/Benefits Committee met 4 times, the Executive Compensation Committee met 5 times, and the Audit Committee met 17 times. *Id*., p 28.

[843] Transocean. *Annual Report*, 2010, p 44. This public expression of Transocean's bonuses was the cause of widespread backlash by media, government and the public alike, prompting an apology from Transocean's CEO. *See, e.g.*, McMahon, J. Transocean Executives Get Bonuses for "Best Year in Safety" Despite Gulf Oil Disaster. *Forbes*, April 4, 2011."Notwithstanding the tragic loss of life in the Gulf of Mexico, we achieved an exemplary statistical safety record as measured by our total recordable incident rate and total potential severity rate. As measured by these standards, we recorded the best year in safety performance in our Company's history, which is a reflection on our commitment to achieving an incident free environment, all the time, everywhere."

[844] Transocean. *Annual Report*, 2010, p 5.

apparent application of process safety principles or adequate consideration of MAP and related operational risk. The substance surrounding the work of that subcommittee, however, was not explained.

In a positive development, Transocean recently updated its most current compensation scheme. Its 2014 annual report includes process safety considerations as part of the overall individual calculations for employees. Now, 30 percent of compensation relates to safety, and the measurement is based on “process safety events” that the company is treating as indicators with potential for a major accident event in their fleet’s operations.[845] According to the report, Transocean is using standard industry definitions to describe the “process safety events,” but limited to incidents involving fire, explosion, release of a hazardous substance with serious injury or fatality, major structural damage, serious injuries/fatalities, and uncontrolled release of hazardous fluids.

5.3 Historical BP Corporate Governance Issues

During its investigation of the 2005 explosion at the BP Texas City refinery, the CSB found that BP exhibited ineffective corporate leadership and oversight of refinery operations, which cascaded from the company’s board of directors through successive layers of corporate management, creating a safety culture vulnerable to catastrophe.[846]

The CSB’s report in that case made specific reference to the existing Turnbull Guidance adopted by the UK’s Financial Reporting Council. It also referenced guidance in the UK Health and Safety Executive’s report on the BP Grangemouth refinery and provided references to other HSE directives to make clear the existing health and safety responsibilities that a corporate board of directors must meet in major accident prevention.[847] In detail, the CSB report stated:

> Directors should, at least annually, review systems of control including risk management, financial, operational, and compliance controls that are the key to the fulfillment of the company’s business objectives. The HSE has prepared guidance for directors in order to help them ensure that the health and safety risks arising from their organizations’ activities are properly managed. Directors should be fully aware of their corporate responsibilities in relation to the control of major accident hazards.[848]

The CSB’s report noted that at the time of the BP Texas City incident, no independent member of the board of directors had a background in refinery operations and process safety management. Thus, no then-serving member had the professional background necessary to discern whether the board as a whole had received all necessary information, and whether the information received from management reflected

[845] Transocean. *2014 Extraordinary General Meeting Definitive Proxy Statement;* Schedule 14A; March 23, 2015; pp P-28. http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9NTUxMDI5fENoaWxkSUQ9MjQ1NDY1fFR5cGU9MQ==&t=1 (accessed October 7, 2014).

[846] USCSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005,* Report No. 2005-04-I-TX, pp 187-191. http://www.csb.gov/assets/1/19/CSBFinalReportBP.pdf (accessed October 7, 2015), March 2007.

[847] USCSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005,* Report No. 2005-04-I-TX, pp 189-190. http://www.csb.gov/assets/1/19/CSBFinalReportBP.pdf (accessed October 7, 2015), March 2007.

[848] USCSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005,* Report No. 2005-04-I-TX, pp 190. http://www.csb.gov/assets/1/19/CSBFinalReportBP.pdf (accessed October 7, 2015), March 2007.

appropriate consideration of the process safety impacts on corporate decisions. As a result, the CSB recommended that BP "Appoint an additional non-executive member of the Board of Directors with specific professional expertise and experience in refinery operations and process safety. Appoint this person to be a member of the Board Ethics and Environmental Assurance Committee."[849] At the time of the Macondo blowout, BP had still not met the express terms of this recommendation, and no independent member of the board of directors on April 20, 2010 had a background in refinery operations and process safety.[850] Similarly, no then-serving independent board member of the company's Safety, Ethics and Environment Assurance Committee (SEEAC) committee had a professional background in offshore drilling relevant to the major accident risks undertaken at a well like Macondo.

Of course, these are difficult issues, but a legitimate question can be posed as to whether the presence of an independent board member with a background in process safety and refining operations could have helped to inform the board of emerging safety issues at BP Texas City, and whether an independent board member with process safety and offshore drilling and production experience could have provided more effective board oversight for major accident risk management at Macondo. One example relates to the Orange Book, discussed earlier. BP established the Orange Book after hiring Duane Wilson, the board's retained process safety expert. Chapter 3 noted the limitations of the Orange Book process safety indicators. This data is provided to the SEEAC in the form of quarterly reports. The SEEAC, and even the Board as a whole, would be in a disadvantageous position with this limited safety information without a fellow board member with the experience and knowledge to parse through the information, identify any limitations, and ask insightful process safety questions of its corporate personnel. SEEAC members lacking an educational and professional experience in process safety within the refining or drilling sector could find themselves wholly reliant on an employee of the company to identify for them potential gaps in the information. Refining and drilling are two critical areas that represent the most significant business risks facing the company. Thus, adequate representation of those sectors in conjunction with process safety are critical for informed board decision-making. Despite several other actions intended to improve board function, BP's board remained less effective in oversight and risk mitigation than it might otherwise have been. Governance experts agree that oversight and risk management are among a board's chief obligations, and any actions to improve board function in these areas should be encouraged.

This challenge is not unique to BP. The safety committee of Pike River Coal Company was chaired by the company's CEO, an executive board member with an extensive background in iron mining; however, he lacked experience in coal mining, which posed unique hazards, and the company proved unable to steer clear of disaster in that case. (See callout box.)

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[849] USCSB, 2007. *Refinery Explosion and Fire, Texas City, TX, March 23, 2005*, Report No. 2005-04-I-TX, pp 190. http://www.csb.gov/assets/1/19/CSBFinalReportBP.pdf (accessed October 7, 2015), March 2007.

[850] Instead, the company chose to take a number of alternative actions in light of the CSB recommendation, along with the Baker Panel's recommendations. For example, the company (1) hired an outside expert to advise the board on process safety matters for a fixed term of five years; (2) created the Group Operational Risk Committee (GORC) at the highest level within the company to help understand and manage risk; (3) created the Orange Book in an attempt to communicate both leading and lagging indicators directly to the Board of Directors in general and the SEEAC in particular; and (4) reinvigorated the SEEAC through an expansion of the committee's role and authority with respect to assessing health and safety risk of all types.

In addition, board members without industry-specific knowledge may assess inadequate information without realizing its profound impact on process safety and the company's sustainability. They may not readily detect critical correlations between seemingly tangential issues and process safety and major accident prevention. This shortcoming makes it difficult for boards to decide wisely on policy or strategy. For example, Chapter 3 discusses BP management employee's individual performance contracts, which focused primarily on operational success measures such as drilling speed and well completions, and safety was rewarded in a lower percentage than other measures of operational success. Even where safety was mentioned, it related primarily to personal safety indicators, such as Recordable Injury Frequency and Days Away from Work Case Frequency. Without understanding the implications of this model, board members were not positioned to foresee potential shortcomings, and could not challenge this construct. Board decisions on setting corporate goals and objectives cascade through the organization through a traditional management-by-objective methodology.[851] Thus, board decisions based on incomplete information could guide a company's actions towards less safe operations in a push for target completions.[852] In sum, board involvement and oversight of process safety management and major accident prevention can serve to sharpen a company's focus on safety. Various tools, described in Section 5.5, aim to improve levels of operational safety while boosting overall corporate performance.[853]

[EXTENDED CALL-OUT BOX START]

Corporate Governance "Underlying Cause" of Pike River Coal Mine Disaster –International Lessons for the Offshore Industry

Accident investigations from the entire spectrum of all high-hazard industries present opportunities for lessons learned that cross industry-specific boundaries. For example, accidents in coal mining, nuclear energy production, chemical manufacturing, oil refining, natural gas production, and even air travel all create learning opportunities for those who wish to avoid similar events. Many lessons from a variety of industrial accidents can be used to improve the safety of offshore drilling. For example, following the Pike River Coal Mine disaster in New Zealand that killed 31 people, the Royal Commission, which investigated the disaster, issued a 400-plus page report along with a series of associated safety

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[851] *See, e.g.,* Drucker, P. *The Practice of Management;* Harper & Row: New York, 1954 (establishing "management by objective" as the management theory most capable of driving execution in business through the balancing of competing corporate needs with goal-setting). However, critics of "management by objective," including business scholars such as W. Edwards Deming, actually argued against management by objective, stating that a lack of understanding of contextual environment and other interrelated systems commonly results in the misapplication of objectives by managers and companies, and that setting production targets encourages resources to be allocated to meet those potentially arbitrary production targets through whatever means necessary, which can result in poor quality or other negative consequences. Deming, E. *Out of the Crisis*.

[852] In re: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico on April 20, 2010, Report of Expert Witness Patrick Hudson, PhD., pp. 23-29 (describing BP's decision to continue a strategy rooted in "loss avoidance" and a culture that "continued to encourage excessive risk taking in pursuit of commercial targets.")

[853] Martin Sedgwick & Angela Wands, *The Implementation of Effective Key Performance Indicators to Manage Major Hazard Risks*, testimony presented by Martin Sedgwick Head of Engineering ScottishPower/Iberdrola Group on July 23, 2012 at the CSB's public meeting, "CSB Public Meeting: Safety Performance Indicators," transcript pp. 85-86, http://www.csb.gov/about/publichearing.aspx. See also Martin Sedgwick & Angela Wands, *The Implementation of Effective Key Performance Indicators to Manage Major Hazard Risks*, pp. 2-3, 8, Figures 10-12 (2012), presented by Martin Sedgwick Head on July 23, 2012.

recommendations.[a] Three of those recommendations focused on good corporate governance—something found to be lacking at the board level in that particular case and which the Royal Commission identified as an underlying cause of the disaster.

The key failing of the Pike board of directors centered around the company's rush to begin producing coal before it was ready to do so safely, particularly because this company was new, and this was its only coal mine. The board tried to make the mine productive as quickly as possible to staunch the flow of heavy borrowing for funding initial mine operations. The Royal Commission concluded that Pike had "not completed the safety systems and infrastructure needed to safely produce coal."

The Royal Commission found that the Pike board provided ineffective oversight in risk management, internal reporting, and legal compliance, and that the board over-relied on management to bring to its attention significant safety issues; meanwhile, the board lacked efficient mechanisms to ensure management was meeting critical health and safety requirements. For example, the board did not know about the results of an insurance risk survey, which disclosed several significant safety risks, including the risk of methane gas explosion—the cause of the fateful disaster that claimed so many lives. Content to rely on management's assurances about safety, including statements about methane gas being "more a nuisance and daily operational consideration than a significant problem or barrier to operations," the board was not well positioned to hold management accountable or to act correctively. Instead the board remained "distracted by the financial and production pressures that confronted the company." In addition to the tragedy of 31 miners killed in the blast, the company itself was believed to have been reduced instantly to "worthless" when it closed the mine and stopped production indefinitely. The court placed the company in receivership.[b] Eventually, the mine was sold, but its new owner has not yet conceived of a way to reopen the mine safely, whether for commercial mining, or just to recover the remaining 29 bodies of the 31 employees killed who remain entombed inside.

At the time of the incident, Pike's board had six members, but none of them were found to have any underground coal mining experience. The Chairman of the board had experience in metalliferous mining, but no professional experience with coal mining. In fact, shortly before the incident, the board realized there was a knowledge gap and undertook a search to find new board members to replace retiring board members who had underground coal mining experience. This is not unlike BP's SEEAC committee's lack of experience in offshore drilling, and BP's resistance to the CSB's 2007 BP Texas City recommendation that BP add an independent board member with professional training and experience in refinery operations and process safety management in light of the findings of that accident.

The Royal Commission also found that the Pike board worked in a dysfunctional manner. It had three committees, one which focused on Health, Safety and Environment (HSE) consisting of two individuals: the Chairman and one board member who had professional training as a mechanical engineer. The HSE committee was tasked specifically with ensuring that "Pike provided a safe workplace, monitoring compliance with environmental consents, permits and agreements, and reviewing projects," but it was not specifically asked to look at major hazards or to provide oversight on issues of catastrophic risk, notwithstanding Pike's operations in underground coal mining, a high-hazard industry with well-known and significant potential for disaster. At the time of the explosion, the HSE subcommittee had not met for 13 months despite being chartered to meet at least once every six months, and no HSE committee meetings were scheduled for 2011.

The HSE committee also had little knowledge of major legal compliance problems derived over the course of eight site visits by a leading mine safety consultant, and was only vaguely aware of a number of serious incidents in the months leading up to the fateful explosion. The committee also lacked an appreciation of the dangers associated with certain conditions at the mine, such as not having remote gas monitoring systems observable in the control room and inadequate ventilation systems combined with documented incidents where levels of methane gas reached its lower explosive limit within the mine.

In light of these failings by the Pike board, the Royal Commission made the following recommendations:

- *Recommendation 5: The statutory responsibilities of directors for health and safety in the workplace should be reviewed to better reflect their governance responsibilities.*
- *Recommendation 6: The health and safety regulator should issue an approved code of practice to guide directors on how good governance practices can be used to manage health and safety risks.*
- *Recommendation 7: Directors should rigorously review and monitor their organization's compliance with health and safety law and best practice.*

The Royal Commission's findings pertaining to the Pike River Coal board of director's failures being an underlying cause of the disaster, and the recommendations intended to prevent recurrence of similar circumstances in the future, apply equally well to the formulation of corporate governance policy, guidance, and best practices in the offshore drilling environment in the Gulf of Mexico in the post-Macondo world.

[a] Royal Commission on the Pike River Coal Mine Tragedy*;* Wellington, New Zealand, October, 2012; Volume 1: pp 12, 13, 18, Volume 2: 46, 50, 5-55. http://pikeriver.royalcommission.govt.nz/vwluResources/Final-Report-Volume-One/$file/ReportVol1-whole.pdf and http://pikeriver.royalcommission.govt.nz/vwluResources/Final-Report-Vol2-Part1-only/$file/Report-Vol2-Part1-only.pdf (accessed October 7, 2015).

[b] Behrmann, E. Pike River Coal's Future 'Bleak' After Mine Blasts. *Bloomberg Business*, November 24, 2010, http://www.bloomberg.com/news/articles/2010-11-24/pike-river-coal-s-future-bleak-after-new-zealand-mine-blast (accessed October 7, 2015).; NZ Oil and Gas. Receivers appointed for PRCL. *Scoop Business Independent News*, December 13, 2010, http://www.scoop.co.nz/stories/BU1012/S00406/receivers-appointed-for-prcl.htm (accessed October 7, 2015).

[CALL-OUT BOX END]

5.4 US Financial Regulation Absent Regarding HSE Reporting

US securities laws and regulations contain numerous requirements for disclosure of material information to shareholders, whether the company issuing shares is a domestic or foreign company, so long as they issues shares in some form on US exchanges for trading. Most of these requirements are general, requiring interpretation of the company and its counsel as to whether a specific issue must be reported. Few specific data points relevant to a company's health, safety, and environment operations are specifically required for disclosure to shareholders of companies trading in the US under regulations promulgated by the SEC pursuant to the Securities and Exchange Act of 1933 or 1934, Sarbanes-Oxley, Dodd-Frank, or any other existing financial law or regulation.[854]

[854] Regulation S-K, Item 103, a securities regulation enforced by the US Securities and Exchange Commission, presents a small but under-enforced exception. Item 103 requires disclosure of certain environmentally related legal proceedings where anticipated penalties could result in monetary sanctions of over $100,000. However, as

The obligation of companies to disclose information in shareholder reports or other communications includes not only the specifics required by SEC disclosure forms, but also the often more relevant requirement to disclose any other information necessary to prevent the disclosed information from being misleading. Yet, a recent investigation by Ceres, an internationally recognized public interest firm comprising representatives from over 100 institutional investment firms and other private sector organizations, found that "companies making extensive capital investments related to [environmental] climate change and deepwater drilling are failing to adequately disclose their substantial material risks in those areas."[855] In fact, the Ceres study showed that "based on the annual financial filings submitted in the first quarter of 2011 by ten of the world's largest oil and gas companies, [the Ceres investigation] finds that none of them provided high quality reporting of their [environmentally-related] climate change and deepwater drilling risks and opportunities."[856] This is true despite the unique and numerous exposures to a variety of risk heightened by the "massive capital employed in the extractive industries and the importance of natural resource access and management to the national security and strategic objectives of the United States,"[857] along with broader worldwide markets.

Notwithstanding this exposure, "the SEC's guidance for disclosure in these areas does not yet require complete, and therefore completely accurate, assessment of companies' climate or deepwater drilling performance or risks."[858] This absence of a regulatory requirement limits the potential for increasing shareholder knowledge, and thus is an inherent limit on safety because shareholders are not equipped with the information needed to benchmark companies against one another, or to challenge decisions by corporate management or boards.

However, the SEC does require disclosure of trends, events, and other uncertainties in the management discussion and analysis (MD&A).[859] According to the SEC, one of most critical responsibilities includes

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one legal commentator observed, based on the US EPA's own findings as well as a study by the University of Arkansas, documented noncompliance in this area by US corporations is as high as 74%.

[855] Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012, p i. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[856] Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012, p i. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[857] Bugala, P. *Materiality of disclosure required by the Energy Security through Transparency Act;* Calvert Investments: 2010; http://www.calvert.com/NRC/literature/documents/10003.pdf (accessed October 7, 2015).

[858] Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012; pp i. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[859] 17 C.F.R. § 299.303. *See also* "Interpretation: Commission Guidance Regarding Management's Discussion and Analysis of Financial Condition and Results of Operations," Release Nos. 33-8350; 34-48960; FR-72 (December 29, 2003), p 1: "Information provided in the MD&A by companies are "intended to elicit more meaningful disclosure in MD&A in a number of areas, including the overall presentation and focus of MD&A with general emphasis on the discussion analysis of known trends, demands, commitments, events and uncertainties, and specific guidance on disclosures about liquidity, capital resources and critical accounting estimates."

"communicating with investors in a clear and straightforward manner," not just for technical disclosure requirements or a recitation of financial statements in narrative form, but to share information about the company as seen through the eyes at the top of the corporate hierarchy and that is "informative and transparent"[860] for the benefit of shareholders. One area for improvement by most Fortune 500 companies, the SEC's Division of Corporate Finance found, is "the focus and content of MD&A (including materiality, analysis, key performance measures and known material trends and uncertainties)."[861] In fact, the SEC emphasized that:

- companies should identify and discuss key performance indicators, including nonfinancial performance indicators, that their management uses to manage the business and that would be material to investors;
- companies must identify and disclose known trends, events, demands, commitments, and uncertainties that are reasonably likely to have a material effect on financial condition or operating performance; and
- companies should provide not only disclosure of information responsive to MD&A requirements, but also an analysis that is responsive to those requirements by explaining management's view of the implications and significance of that information[862]

These rules may have particular relevance to significant safety issues for offshore drilling, especially as shareholders appear to be pressing the SEC to articulate more clearly for companies the requirements concerning materiality about disclosures of enterprise risk issues. In response, the SEC is starting to seek greater disclosures from companies in these areas.[863]

Case in point: After Macondo, the SEC corresponded with both BP and Transocean about statements they made pertaining to safety, insurance coverage, oil spill containment, and the like.[864] Although helpful or

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[860] "Interpretation: Commission Guidance Regarding Management's Discussion and Analysis of Financial Condition and Results of Operations," Release Nos. 33-8350; 34-48960; FR-72, (December 29, 2003), pp 1-2.

[861] "Interpretation: Commission Guidance Regarding Management's Discussion and Analysis of Financial Condition and Results of Operations," Release Nos. 33-8350; 34-48960; FR-72 (December 29, 2003), p 2.

[862] "Interpretation: Commission Guidance Regarding Management's Discussion and Analysis of Financial Condition and Results of Operations," Release Nos. 33-8350; 34-48960; FR-72 (December 29, 2003), p 2.

[863] Heller, M. SEC Encouraging Firms to 'Tell Their Story' in MD&A. November 25, 2014, http://ww2.cfo.com/auditing/2014/11/sec-encouraging-firms-tell-story-mda/ (accessed October 7, 2015). In addition to recommending a balanced summary of key challenges, drivers and risks, the SEC has recently been encouraging companies to disclose known trends and uncertainties, quantify components of overall changes in financial statement line items, and enhance their explanation and analysis of the factors causing those changes.

[864] BP corresponded with the SEC at least 13 times between August 10, 2010 and September 29, 2013, on matters ranging from disclosures about safety to issues pertaining to the oil spill, containment, and remediation. For an examples, see letter of August 6, 2010 to H. Roger Schwall of the SEC Re: BP plc, Form 20F for Fiscal Year Ended December 31, 2009 (the "Form 20F"), filed March 5, 2010, File No. 00106262; and letter of September 19, 2013 to H. Roger Schwall of the SEC BP p.l.c. Form 20F for the Fiscal Year Ended December 31, 2012 filed March 6 2013 File No. 00106262. Similarly, Transocean engaged with the SEC in about the same fashion with respect to safety disclosures during a similar period. See letter OF September 23, 2014 to Peggy Kim of the SEC Re: Transocean Ltd. Revised Preliminary Proxy Statement on Schedule 14A, filed March 26, 2013, File No.053533; letter of September 23, 2014 to Karl Hiller of the SEC Re: Transocean Ltd. Form 10K for Fiscal Year ended December 31, 2013 filed February 27, 2014; and Response Letter of September 2, 2014 File No. 053533.

even necessary under some circumstances, this type of back-and-forth dialogue could be minimized or avoided by enhanced SEC reporting requirements concerning what the securities regulator considers to be material information for companies engaged in offshore drilling (e.g., leading and lagging safety performance indicators, other related metrics such as KPI's relating to health, safety and the environment, safety culture survey results, etc.), while helping shareholders and the investing public at large with enhanced information about the investment worthiness of companies engaged offshore, at least in terms of process safety and major accident prevention efforts.

That is why, rather than focusing on the individual companies involved in Macondo where compliance requirements appear to have been met, another option is a regulatory change at the SEC, requiring enhanced disclosure of drilling risks as a means of advancing the public policy interest of offshore drilling safety. This could be accomplished in the same manner that the Dodd-Frank Act now requires expanded disclosures about mine safety pursuant to Section 1503 of that legislation.[865] Such disclosures could track those required of mining, with the addition of various leading and lagging safety performance indicators relevant to offshore, as well as records of citations or other enforcement activities. All of these records could better inform shareholders while causing boards, senior executives, and legal counsel to highlight results in these areas in annual reports, all of which have the potential to boost process safety performance.

Along these lines, in December 2010, the California and Pennsylvania state treasurers, whose pension funds had been affected by investments in companies offshore at the time of Macondo, requested that the National Oil Spill Commission make a recommendation to the SEC to develop new guidance specifically focused on deepwater drilling disclosures, and subsequently asked the SEC to take steps to improve existing reporting in this area.[866] This request dovetails with a similar filing by the Social Investment Forum,[867] which requested that the SEC (1) require all issuers to report annually on a comprehensive set of sustainability indicators using the Global Reporting Initiative's reporting guidelines, and (2) issue new interpretive guidance that would clarify requirements relating to short- and long-term sustainability risks in the Management Discussion and Analysis section of the 10-K.[868] Such indicators could already be implicated under applicable SEC guidance, which requires disclosure of "key performance indicators

[865] See The Dodd-Frank Wall Street Reform and Consumer Protection Act, Pub. L. No. 111-203, 124 Stat. 1376 (2010).

[866] Coburn, J.; Salmon, R.; Grossman, D. *Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk;* CERES: August, 2012, p 7, http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[867] The Social Investment Forum (now called US SIF), or The Forum for Sustainable and Responsible Investment "is the US membership association for professionals, firms, institutions and organizations engaged in sustainable, responsible, and impact investing. US SIF and its members advance investment practices that consider environmental, social and corporate governance criteria to generate long-term competitive financial returns and positive societal impact." http://www.ussif.org/about.

[868] Letter from Lisa Woll, CEO of SIF to the Honorable Mary L. Schapiro, Chairman of the US Securities and Exchange Commission, July 21, 2009, p 2.

including non-financial performance indicators, that … management uses to manage the business, and that would be material to investors."[869]

Additional help for greater transparency with respect to health and safety issues may also come from another source as well: the Sustainability Accounting Standards Board (SASB), an independent nonprofit organization whose mission "is to develop and disseminate sustainability accounting standards that help public corporations disclose material, decision-useful information to investors."[870] Part of SASB's mission is to help define materiality of sustainability metrics for determining what information belongs in a company's SEC-required reports, across numerous industries and sectors. The SASB stated that its work involves "revealing the value of material information about companies' environmental stewardship, social policies and corporate governance," and that its mission is to develop and disseminate sustainability accounting standards that help public corporations disclose material, decision-useful information to investors. SASB describes its decisions regarding which criteria are material as evidence-based, meaning it established standards for what they were able to find evidence of financial materiality.

SASB created health, safety, and emergency management reporting standards for both onshore and offshore operations, though currently SASB standards recommend different metrics for the two. For onshore activities, SASB references API RP 754 Tier 3 challenges to safety systems indicator rates, as well as a discussion of measuring operations discipline and management system performance data through reporting of a Tier 4 indicator (see Section 3.4.2). As indicated in Chapter 3.0, Tier 3 and 4 indicators also can be developed for offshore operations. Adding these types of reporting requirements, as well as other potential indicators (e.g., specific metrics that relate to safety culture) could make SASB's recommendations more informative to shareholders, which in turn could drive major accident prevention.

5.5 The Offshore Regulator's Role – An International Perspective

In other countries with active offshore drilling, regulators are engaging corporate boards of directors on process safety by (1) conducting audits and investigations with a specific focus on factors that can inform management teams and boards of directors to drive major accident prevention, and (2) providing training and a number of good practice documents. These efforts can help corporate boards to take a more active oversight role in HSE matters and to ensure adequate protections against hazards and risks are in place for their companies.

Conversely, US regulators have not yet promulgated good practice guidance and training materials on corporate governance with specific reference to process safety, major hazards, or catastrophic risk in the offshore environment. BSEE can learn from these other jurisdictions, following up on its new safety culture policy guidance, by fashioning its own broader guidance on good practice in corporate

[869] Coburn, J.; Salmon, R.; Grossman, D. Sustainable Extraction? An Analysis of SEC Disclosure by Major Oil & Gas Companies on Climate Risk & Deepwater Drilling Risk; CERES: August, 2012; p 9, citing 2003 SEC MD&A Guidance at p. 3. http://www.ceres.org/resources/reports/sustainable-extraction-an-analysis-of-sec-disclosure-by-major-oil-gas-companies-on-climate-risk-and-deepwater-drilling-risk/view (accessed October 17, 2015).

[870] http://www.sasb.org/sasb/vision-mission/ (accessed October 7, 2015). SASB's vision is also instructive: "SASB envisions a world where a shared understanding of corporate sustainability performance allows companies and investors to make informed decisions that drive value and improve sustainability outcomes."

governance, and then by engaging boards of directors through training and other initiatives. BSEE is best positioned to work with other government agencies, industry, labor, environmental groups, and interested stakeholders on creating guidance for the offshore industry in the US.

5.5.1 Norway: Management Findings from Audits and Investigations

In Norway, the Petroleum Safety Authority (PSA) studied serious drilling, production, and refining incidents of all types, especially offshore. PSA's audits and investigations led to a number of important findings and suggested practices that advance major accident prevention and safety improvement offshore, some focusing on corporate governance. For example, PSA's work demonstrated that a management team's focus on safety—complemented by the involvement and oversight provided by its board of directors—makes a significant difference in a company's safety performance in major accident prevention. Specifically, "Experience confirms that management of major accident risk is part of a continuous interplay between actions that permeate all the activities and are integrated in the way the management runs the activities, also at the company [Board] level."[871]

Drawing from its history of offshore investigations, PSA initiated a study to review past incidents and surveys of 11 major offshore operators. PSA distilled important factors that can inform management teams and boards of directors to drive major accident prevention in their organizations, many of which echo the CSB's findings in Volume 3. They include:

1. Clarity in the distribution of responsibilities concerning prevention of major accidents, including among various levels of corporate leadership;
2. Knowledge of and attention to major accident risk inherent in the company's activities, including major accident risk associated with change processes;
3. Capacity and competency in the organization regarding handling the risk of major accidents;
4. Ability to learn from serious incidents; and
5. Ability to effectively self-evaluate the overall work needed to reduce the risks of major accidents.[872]

PSA also found other factors that could positively influence major accident prevention through effective board oversight. One key finding was understanding that "links between different processes and goals are under-estimated, including safety-related consequences of cost reductions, organisational changes and incentive schemes."[873] Boards of directors can make a priority of monitoring management of

[871] Petroleumstilsynet (Petroleum Safety Authority Norway). *Managing the Risk of Major Accidents in a Governance Perspective;* http://www.ptil.no/getfile.php/PDF/REB-TX-17303-tilsyn%20styring%20storulykkesrisiko%20samlerapport-eng%20%28endelig%20versjon%29.pdf (accessed October 7, 2015).

[872] Petroleumstilsynet (Petroleum Safety Authority Norway). *Managing the Risk of Major Accidents in a Governance Perspective*, pp 3-4. http://www.ptil.no/getfile.php/PDF/REB-TX-17303-tilsyn%20styring%20storulykkesrisiko%20samlerapport-eng%20%28endelig%20versjon%29.pdf (accessed October 7, 2015).

[873] Petroleumstilsynet (Petroleum Safety Authority Norway). *Managing the Risk of Major Accidents in a Governance Perspective*, p 7. http://www.ptil.no/getfile.php/PDF/REB-TX-17303-tilsyn%20styring%20storulykkesrisiko%20samlerapport-eng%20%28endelig%20versjon%29.pdf (accessed October 7, 2015).

organizational changes, in light of a board's fiduciary duties and the scope of information that should be available to boards for their high level oversight. Another pair of related findings focused on the commonalities of high-reliability organizations, including an organization's attention to "so called weak signals of hazardous conditions and their approach to uncertainty, complexity, redundancy and learning," including the use of activities such as resilience engineering, and an "emphasis on the connections between different processes … which together can affect the organization's ability to monitor, predict and interpret factors that are important for major accident risk."[874] Again, board oversight can guide a corporation's CEO and senior management team along appropriate pathways through varied means, seeking the right balance between competing factors (e.g., production pressures versus safety, etc.) in a suitable enterprise risk framework.

PSA repeatedly identified the need for clarity in managerial roles because different functions, tasks, disciplines, and operations each have their own particular role and importance in safety. PSA noted that phrases such as "responsibility rests with the line" are too ambiguous to ensure that line managers understand the risk they are accountable for, or that they have the information they need to handle that particular risk, and the means to handle relevant responsibilities. Based on PSA's work in this area, the CSB finds that individual directors working collectively would benefit from the same role clarification within the corporate framework so that they can play an appropriate role in their company for the risks they face. The obligation for safety rests with the board, which must ensure safety responsibilities are divided and managed appropriately throughout all managerial levels, and which the board must monitor and assess.

PSA also noted that in many of its investigations following major accidents, organizations had been "confronted with clear and repetitive symptoms of deterioration of safety-critical barriers," but the "information was not recognized as alarming and/or was not adequately handled." PSA found that much of this phenomena stemmed from two possible causes: (1) faulty assumptions (e.g., safe historical performance which appeared to provide reliable information about risk, so that a decline in the number of incidents by itself unreasonably became an indicator of the robustness of barriers that are preventing accidents), or (2) "systematic under-estimations" of the importance that a myriad of potential changes could have on corporate safety ranging from new investments, procurements, alliances, mergers, change processes, inadequate safety margins, or even an exaggerated confidence at the company level in the systems or barriers standing in the way of a major accident. Boards of directors are perfectly situated to monitor all of these issues though effective and ongoing oversight, in a management of change capacity, provided they are engaged, have all relevant information, and are positioned to test or, if needed, to challenge management's words and actions.

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The Norwegian oil company Statoil, an example of strong corporate governance, provided helpful testimony at the CSB's two-day safety performance indicators event in July 2012. According to Statoil's Vice President of HSE Competence Centre, the company's CEO recently noted that the two top threats to

[874] Petroleumstilsynet (Petroleum Safety Authority Norway). *Managing the Risk of Major Accidents in a Governance Perspective*, p 7. http://www.ptil.no/getfile.php/PDF/REB-TX-17303-tilsyn%20styring%20storulykkesrisiko%20samlerapport-eng%20%28endelig%20versjon%29.pdf (accessed October 7, 2015).

Statoil are major accidents and a loss of [corporate] integrity.[a] *Along those lines, three of Statoil's top four focus areas for HSE are Leadership and Compliance to our Governing [Governance] System, Improved Risk Management, and Simplification and Harmonization of Work Processes and Governing System.*[b] *Based on the testimony presented, these activities suggest healthy corporate governance, competent ERM, active efforts aimed at nurturing of a robust safety culture, and a sustainable company overall.*

[a] *Eie, G. Performance Indicators for Major Accident Prevention, CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 24, 2012, slide 2. http://www.csb.gov/UserFiles/file/Eie%20(Statoil)%20PowerPoint.pdf (accessed October 7, 2015).*

[b] *Ibid., pp slide 3; see also Statement of Statoil delivered by Guhild Holtet Eie at CSB Public Hearing: Safety Performance Indicators, Houston, TX, July 23-24, 2012, p 184. http://www.csb.gov/assets/1/19/CSB_20Public_20Hearing.pdf (accessed October 7, 2015).*

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5.5.2 United Kingdom: Guidance and Training

In the UK, seminal guidance jointly published by that country's Health and Safety Executive and the Institute of Directors & Health and Safety Executive offers three essential principles that corporate boards of directors must heed to drive effective corporate governance in health and safety:

1. Boards must take ownership of health and safety from the top down using a strong downward communication and management approach that demonstrates the board is leading the initiative in an active and visible manner, and that health and safety is integrated into the business from the highest level in terms of how management and safety decisions are made.
2. Boards must engage the workforce in promoting and achieving safe and healthy conditions, creating the means for effective upward communication with employees, while providing high-quality training aimed toward safe operations.
3. Boards must identify and manage key health and safety risks, seeking and following competent advice, and then monitoring, reporting, and reviewing safety performance. In a recommended good practice, at least yearly, HSE indicates that each board member should seek to understand and record all relevant data, including auditing results and conclusions from relevant reports, and ensure the information is communicated in the company's annual reports to investors and stakeholders.[875]

To implement this guidance, HSE lays out a multi-step series of elements in the form of desired "core actions," which include planning, delivering, monitoring, and reviewing a company's health and safety performance, with each step having a number of key components recommended to create full board engagement. HSE explains that these core actions are to be effected through a series of good practices which are practical, actionable steps that help to aim a board's actions toward an increasingly safer

[875] Insititute of Directors, Health and Safety Executive. *Leading Health and Safety at Work: Actions for directors, board members, business owners, and organisations of all sizes;* INDG417(rev1), June, 2013, p 1. http://www.hse.gov.uk/pubns/indg417.pdf (accessed October 7, 2015). Many of these same ideas have also been captured and expanded on separately in another helpful treatise produced by IOSH, the chartered body for health and safety professionals in the U: Eves, D.; Gummer, J. *Questioning Performance: Essential Guide to Health, Safety and the Environment ;* IOSH Services Ltd: Wigston, United Kingdom, 2011.

company. This and other guidance provides boards with an action-oriented checklist by which directors can methodically consider their corporation's performance in HSE matters, both good and bad, with an eye toward continual improvement.[876]

Combined, these factors can spark board discussion and engagement during oversight activities and management of executive performance, as well as the fuller scope of corporate activities more generally. By doing so, boards can be challenged to think through worst-case scenarios of instances when leadership may fall short in meeting responsibilities, or even where regulators may need to step in to address issues of compliance that management did not handle appropriately.

In 1999, the UK's FRC adopted guidance for risk management and internal controls, *Internal Control: Guidance for Directors on the Combined Code*,[877] commonly referred to as the Turnbull Guidance, advising on oversight responsibilities, decision-making activities, and communications expected of corporate boards of directors across the full spectrum of corporate activity. The Turnbull Guidance also helps directors understand their obligations under existing British law.[878]

In addition to detailing the many critical areas for board member involvement and direction, the Turnbull Guidance and requirements of its Combined Code enshrined in British law notes that board members may have to play an even more significant role in certain areas, depending on the nature of a corporation's business operations. This approach recognizes the need for "a degree of flexibility … boards must see good governance as a means to improve their performance, not just a compliance exercise. To be effective it [governance] needs to be implemented in a way that fits the culture and the organization of the company. This can vary enormously . . . depending on factors such as size, ownership, structure and complexity of activities."[879]

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[876] See generally Leading Health and Safety at Work: Actions for directors, board members, business owners, and organisations of all sizes; INDG417(rev1); June, 2013; http://www.hse.gov.uk/pubns/indg417.pdf (accessed October 7, 2015); see also Health and Safety Executive. Leadership for the Major Hazard Industries; INDG277(rev1); September, 2011; http://www.hse.gov.uk/pubns/indg277.pdf (accessed October 7, 2015)., a booklet produced for senior leadership to help them achieve "continuous improvement in health and safety;" Eves, D.; Gummer, J. Questioning Performance: Essential Guide to Health, Safety and the Environment ; IOSH Services Ltd: Wigston, United Kingdom, 2011, explaining that directors must communicate its attitude and expectations around health and safety, the articulated intention of going "beyond compliance" and the desire for a level of HSE performance that delivers cost savings in accident prevention and reduction in lost days, the board's position that HSE is a business risk to be managed, and the board's recognition that it needs to know how the company is managing HSE functions to uphold the company's reputation.

[877] The Institute of Chartered Accountants. *Internal Control Guidance for Directors on teh Combined Code;* The Institute of Chartered Accountants: London, England, September, 1999; http://www.ecgi.org/codes/documents/turnbul.pdf (accessed October 7, 2015).

[878] Accomplishment of HSE recommended "good practices" and compliance with the Turnbull Guidance is in accord with the "UK Corporate Governance Code," maintained and enforced by the UK's Financial Reporting Council, the UK analog to the United States' Securities and Exchange Commission. *See* The Financial Reporting Council. *The UK Approach to Corporate Governance;* October, 2010; https://www.frc.org.uk/Our-Work/Publications/Corporate-Governance/The-UK-Approach-to-Corporate-Governance.aspx (accessed October 7, 2015).

[879] The Financial Reporting Council. *The UK Approach to Corporate Governance;* October, 2010, p 6. https://www.frc.org.uk/Our-Work/Publications/Corporate-Governance/The-UK-Approach-to-Corporate-Governance.aspx (accessed October 7, 2015).

Additionally, the Turnbull Guidance cautions boards that assembling a list of risks for the board's attention and action is a "multidimensional" exercise.[880] The guidance pointedly asks directors, "Are the significant internal and external operational, financial, compliance and other risks identified and assessed on an ongoing basis? (Significant risks may, for example, include those related to market, credit, liquidity, technological, legal, health, safety and environmental, reputation, and business probity issues.)"[881] Turnbull makes clear that where such issues are present, it is incumbent upon the board members to play a larger role than might otherwise be expected of a board member at a company that does not face those same risks. The updated Turnbull Guidance (2005)[882] continues to instruct directors to drive health and safety from the top of the organization, thereby protecting their respective companies from all manner of harm, including catastrophic risk.

To facilitate existing UK corporate legislation's effectiveness, and to complement written guidance and training materials, the UK provides corporate boards of directors with other sources of best practices and training materials through partnerships with trade groups and professional associations. For example, at a 2012 conference on corporate governance, Judith Hackitt, Chair of the UK HSE spoke of the agency's "Process Safety Leadership Programme" aimed at board and senior executive level, along with its "Principles of Process Safety Leadership," that industry had "enthusiastically adopted." [883] This model is touted as a successful alternative to the more traditional approach of introducing tougher legislation in the face of challenges. Despite calls for more stringent regulation, a voluntary partnership between government and industry in the UK is being pursued, but as Ms. Hackitt warned, "If you believe, as I think you do, that a voluntary approach is preferable to regulation then demonstrate that you can deliver and don't take too long to do it."[884] Hackitt also commented on the fact that major hazards industries

[880] Belcher, A. Corporate Risk Managment and Legal Strategy. In *Legal Strategies: How Corporations Use Law to Improve Performance;* Masson, A., Shariff, M. J., Eds.; Springer-Verlag Berlin Heidelberg: New York, 2010; p 262. Citing Turnbull Guidance and its various focus areas envisioned for corporate boards of directors.

[881] The Institute of Chartered Accountants. *Internal Control Guidance for Directors on the Combined Code;* The Institute of Chartered Accountants: London, England, September, 1999; Appendix, p 13. http://www.ecgi.org/codes/documents/turnbul.pdf (accessed October 7, 2015).

[882] Financial Reporting Council. *Internal Control-Revised Guidance for Directors of the Combined Code;* The Financial Reporting Council: London, October, 2005; https://www.frc.org.uk/getattachment/5e4d12e4-a94f-4186-9d6f-19e17aeb5351/Turnbull-guidance-October-2005.aspx (accessed October 7, 2015). Based on the information gathered by this group, the FRC found that "respondents considered that substantial improvements in internal control instigated by application of the Turnbull guidance have been achieved without the need for detailed prescription as to how to implement the guidance," all through the use of a "principles-based approach [that] has required boards to think seriously about control issues and enabled them to apply the principles in a way that appropriately dealt with the circumstances of their business."

[883] Hackitt, J. (HSE Chair) *Why Corporate Governance and Why Now?*, Conference on Corporate Governance for Process Safety, Paris, France, June 14-15, 2012, http://www.hse.gov.uk/aboutus/speeches/transcripts/hackitt140612.htm (accessed October 7, 2015).

[884] Hackitt, J. (HSE Chair) *Why Corporate Governance and Why Now?* Conference on Corporate Governance for Process Safety, Paris, France, June 14-15, 2012, http://www.hse.gov.uk/aboutus/speeches/transcripts/hackitt140612.htm (accessed October 7, 2015).

within the UK are starting to deliver training to executives and board members on process safety management.[885]

The UK's tripartite Step Change for Safety also contributed with similar initiatives. Step Change for Safety hosted a number of informational trainings and discussions focused on good governance and safety leadership, which benefited leaders at all levels in industry, including boards and senior management.[886]

In parallel, the UK's Chemical Industries Association[887] also created guidance for boards of directors in effective process safety leadership within the UK's chemical industry. This guidance includes establishing:

- A board champion for process safety, ensuring discussion at all board meetings to review performance and set priorities;
- Communication of process safety policies, stressing the importance set by the board and the role of people at all levels in protecting against major hazards;
- Visibility of board-level management (e.g., visiting control rooms, making presentations on major hazard risks);
- Use of effective leading and lagging process safety performance indicators to allow board-level monitoring;
- Board-endorsed formalized process safety improvements plan for ensuring continuous improvement; and
- Outward-looking approaches taken by the company, and the board itself, including a cross-industry approach to learning and sharing the lessons from incidents.[888]

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Under the auspices of the Health and Safety Commission, the HSE published a series of case studies demonstrating the vital role of directors in ensuring that risks are properly managed in all types of companies and industries.[a] Of particular note is the case study on Amec, a UK company that serves the oil and gas, clean energy, environment and infrastructure, and mining markets.[b] According to HSE's case study, Amec's corporate governance includes:

[885] Hackitt, J. (HSE Chair) *Why Corporate Governance and Why Now?* Conference on Corporate Governance for Process Safety, Paris, France, June 14-15, 2012, http://www.hse.gov.uk/aboutus/speeches/transcripts/hackitt140612.htm (accessed October 7, 2015).

[886] https://www.stepchangeinsafety.net/about-step-change-safety/previousevents.

[887] The Chemical Industries Association includes primarily chemical and pharmaceutical companies, as well as some drilling services and petrochemical companies, http://www.cia.org.uk/AboutUs/AboutCIA.aspx (accessed October 7, 2015).

[888] Chemical Industries Association. *Best Practice Guide: Process Safety Leadership in the Chemicals Industry;* Chemical Industries Association: London, 2008, in Ellis, G. Process Safety Begins in the Board Room. *Chemical Processing*, March 21, 2013, http://www.chemicalprocessing.com/articles/2013/process-safety-begins-in-the-board-room/?show=all (accessed October 7, 2015).

- *One of the company's directors having the necessary experience in petrochemicals, oil and gas, and gas pipelines across the company's many business lines and in operations around the globe;*
- *A corporate approach to safety that is rooted in major accident avoidance;*
- *Board-level training initiatives including a variety of health and safety training courses germane to high-hazard industries, as well as the creation of company-specific programs such as Amec's SHAPE (Safety and Health in Amec Process & Energy) program with a specific emphasis on process safety;*
- *A deep commitment for the Director who leads safety oversight and other initiatives on behalf of the board, which includes:*
    - *monthly safety briefings at Board meetings,*
    - *real-time updates on safety incidents that are occurring,*
    - *his or her own personal performance contract with safety goals that are available for all the company to see on the company's intranet,*
    - *personal site visits at least once per month,*
    - *operational safety reviews for all businesses quarterly,*
    - *an annual review of each business that specifically covers HSE and sustainability,*
    - *sit-down discussions during all site visits with local management teams focused on safety,*
    - *a companywide safety, health, and environment conference every two years; and*
- *Consistent corporate policies, as well as:*
    - *procedures for hazard identification, risk assessment, and controls,*
    - *documented plans and objectives,*
    - *a clear management structure with established responsibilities,*
    - *competence assurance and training,*
    - *excellent communications and timely notifications,*
    - *established operating procedures, document control, performance indicators,*
    - *investigations and documentation of findings, and*
    - *an audit system, management reports and management reviews.*

[a] McMahon, A.; Shaw, J.; Cash, B.; Wright, M.; Antonelli, A. *Case studies that identify and exemplify Boards of Directors who provide leadership and direction on occupational health and safety;* Research Report 499; Greenstreet Berman Ltd: Reading, Berkshire pp 26-47. http://www.hse.gov.uk/research/rrpdf/rr499.pdf (accessed October 7, 2015); Health and Safety Executive. Case Studies-Successful Leadership, http://www.hse.gov.uk/leadership/casestudies.htm (accessed October 7, 2015).

[b] http://www.amecfw.com/aboutus/at-a-glance (accessed October 7, 2015).

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5.6 Conclusion

Board engagement in major accident risk management has the potential to make companies safer, assuming boards receive all relevant information needed to inform decision-making, and the board members are empowered to use the information for the benefit of the company. Good communication of those efforts could also then ensure that shareholders receive critical information to hold management, and even the board itself, accountable for a company's safety performance. Thus, a collateral benefit of improved corporate transparency creates an additional layer of safety oversight that comes from the informed self-interest of the corporations' shareholders. Good safety practices and oversight then become self-reinforcing from an additional perspective as the company's equity owners continually obtain information needed to monitor their boards and their companies' safety performance. Transparent reporting rounds out the system of checks and balances needed to maximize effective corporate governance, and thus sustainability.

With appropriate guidance and increased board engagement through interactions with the regulator, more effective board governance can be encouraged, which can translate into a more mature and robust corporate safety culture for companies, with the result being improved major accident prevention fostered by continuous and effective oversight. Additionally, future modifications to existing SEC regulation or other guidance could better guide the entire offshore industry toward greater transparency, helping to focus boards more specifically on process safety and major hazard risks, leading to shareholders empowered with sufficient information to help guide their own decision-making and potential advocacy efforts. Meanwhile, BSEE is well positioned to begin to engage with the US offshore industry, as the agency's international counterparts are doing, to promote major accident prevention through yet another established mechanism.

6.0 Culture for Safety: Focus and Response

Chapter 5.0 Overview

This chapter briefly explores the issue of culture, highlighting the challenges through a review of relatively recent safety culture surveys conducted by BP and Transocean. Measuring and influencing safety culture is a challenge that continues to deserve industry and regulator attention.

"A strong safety culture cannot eliminate all accidents, especially in technologically complex and dynamic industries such as deepwater drilling. There is always a risk that an accident will happen. Strong safety cultures can reduce the likelihood of accidents and the severity of accidents should they occur."[889] For this reason, the CSB addresses culture—as it relates to Macondo, and more broadly to major accident prevention—as part of the human and organizational analysis presented in this volume.

Throughout Volumes 2 and 3, the CSB Macondo report addresses technical, organizational and operational barrier failures that were intended to create multiple layers of defense so that no single barrier became an exclusive line of defense. James Reason describes how culture affects such a defense-in-depth[890] approach: "Because of their diversity and redundancies, the defenses-in-depth will be widely distributed throughout the system. As such, they are only collectively vulnerable to something that is equally widespread. The most likely candidate is safety culture. It can affect all elements in a system for good or ill."[891]

This evidence given in these CSB volumes reveals that the BP and Transocean organizational cultures did not promote process safety. Both companies exhibited organizational behaviors and practices depicting an overarching focus on personal safety without equal attention to managing the barriers and control systems for preventing major accident events. Furthermore, evidence suggests both companies had an organizational focus more akin to minimal compliance with US regulations. To various degrees, both companies exhibited the following organizational behaviors that were detrimental to process safety:

- Poor adherence to their own corporate major hazard management policies, which contained more stringent risk reduction responsibilities than regulations stipulated (Chapters 1.0 and 4.0);
- Inadequate consideration for human and organizational factors in work planning, risk assessment, and incident investigations (Chapters 1.0 and 2.0);
- Inadequate individual performance contracts and bonus structures with limited inclusion of process safety goals (Chapter 3.0);
- Inadequate development and usage of relevant process safety performance indicators (Chapter 3.0);
- Failed efforts aimed toward bridging major risks (Chapter 4.0); and
- Boards of Directors not sufficiently engaged in process safety (Chapter 5.0).

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[889] Expert report of Kathleen M. Sutcliffe, October 17, 2011, for the United States District Court for the Eastern District of Louisiana, MDL No. 2179, Section: J, re. Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010, p 92.

[890] Defense-in-depth is discussed in the CSB Macondo Investigation Report, Volume 2, Section 4.2, pp 51-52.

[891] Reason, J. *A Life in Error* 2013, p 81.

This chapter briefly defines culture as a concept that needs to be understood, along with some of the underlying complexities in interpreting and working with culture. To illustrate these challenges, the chapter describes a number of safety culture assessments conducted of BP and Transocean both preceding and post-incident. The chapter then discusses how culture can be influenced from the top of an organization and addresses efforts BSEE implemented to encourage a focus on a culture for safety offshore.

6.1 Assessing Culture and whether it Promotes Process Safety

Organizational culture refers to the characteristics of the environment, such as the values, rules and common understandings that influence employees' perceptions and attitudes. A culture for process safety refers to those environmental characteristics that influence employees' perceptions and attitudes *about the importance the organization places on process safety*.[892] Many aspects of an organization's culture are unstated, underlying, and often operate at a subconscious level. As such, efforts to assess and change culture are challenging.[893] Frequently depicted visually as an iceberg, only a small portion of culture is actually observable (Figure 6-1). Examples of these artifacts include the proclaimed values of the company, the messages it communicates to its management, workforce, and the public; the policies it establishes and the practices it implements; and the organizational behaviors it exhibits in its daily operation. But underneath the water's surface are the shared values and assumptions that might not be so readily apparent—the norms, attitudes, actual values, shared understandings, and basic assumptions that drive employee behavior and performance.[894] Change must occur throughout the entire iceberg for culture to be impacted.

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[892] Haber, Sonja, Culture for Safety, Human Performance Analysis, Corp., February 17, 2016. CSB Learning Seminar.

[893] Schein, Edgar H. 2004. *Organizational Culture and Leadership, 3rd ed.,* Jossey-Bass: San Francisco, CA, pp 25-37.

[894] Haber, Sonja, Culture for Safety, Human Performance Analysis, Corp., February 17, 2016. CSB Learning Seminar.

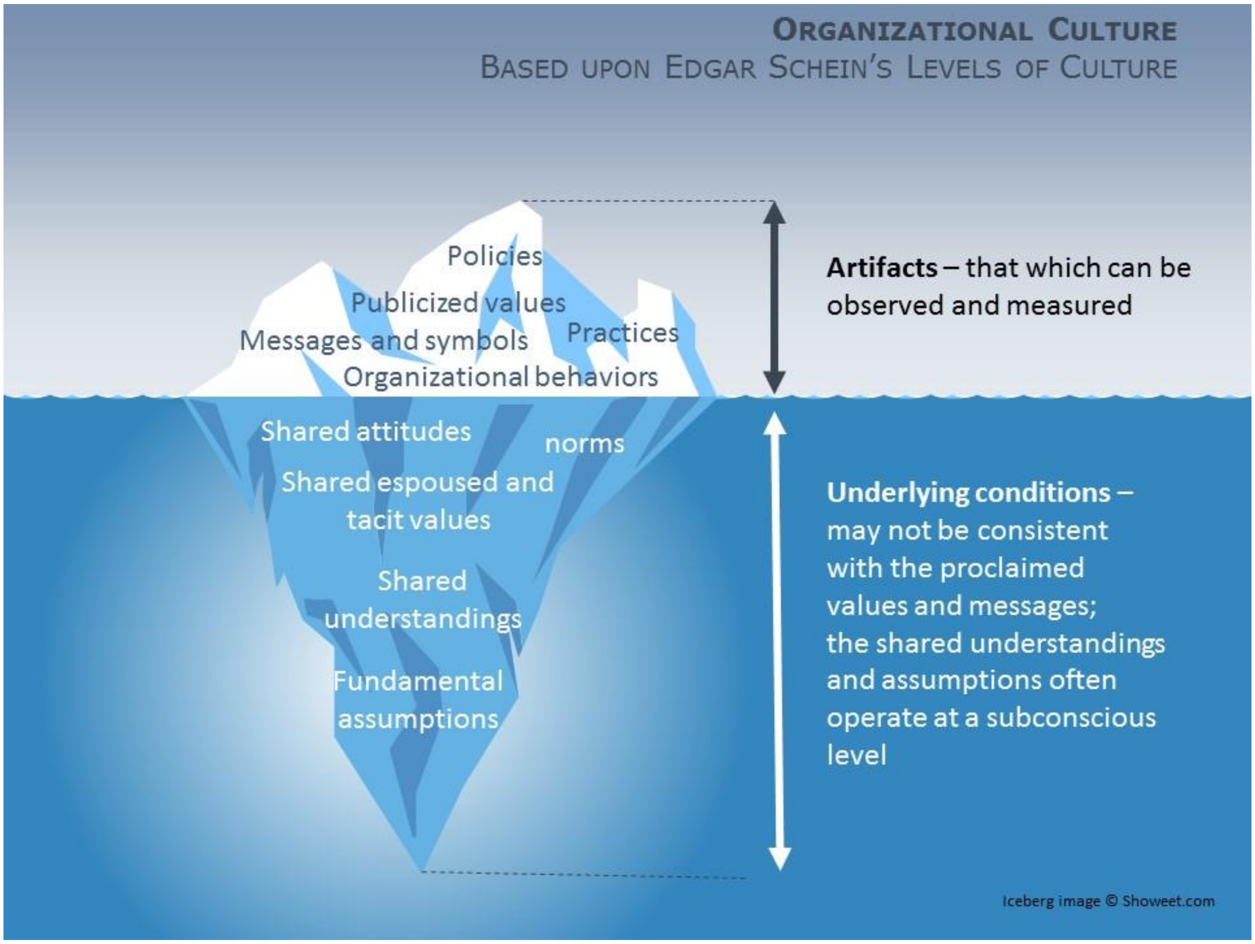

Figure 6-1. Visual representation of organizational culture, based on Edgar Shein's levels of culture[895]

The observable artifacts tell only one piece of the culture story, but they are the outcomes of the shared understandings and fundamental assumptions. They can provide clues of disparities between proclaimed cultural values and actual shared values. Therefore, culture is expressed not only in the stated goals, policies, procedures, and practices that a company formally adopts to enhance process safety, but also in the actual commitment by leaders, management, and the workforce to meet those corporate requirements. This commitment impacts "how the organization behaves when no one is watching" [896] and influences decisions by personnel at all levels of the organization.

Comparing what actually happens in the organization to the proclaimed values and stipulated corporate policies provides insights into the unstated values of the organization that influence daily worker actions and decisions. Incongruences between the proclaimed values and the actual practices give evidence that

[895] Schein, Edgar H. 2004. *Organizational Culture and Leadership, 3rd ed.*, Jossey-Bass: San Francisco, CA, pp 25-37.

[896] American Institute of Chemical Engineers (AICHE). Safety Culture: What is at Stake?; *Safety Science* 2015**,** *77,* pp 102-111.

what is being said is not necessarily indicative of the actual culture and the basic assumptions at the organization's core. The practice(s) reflect the actual values.[897] With this perspective, the CSB examines a number of culture assessments of BP and Transocean in the next section.

6.2 Culture Assessments of BP and Transocean

In the years leading up to the Macondo incident, both BP and Transocean commissioned reviews of their respective safety cultures. For BP, the review took the form of the Baker Panel commission, which was prompted by an urgent CSB recommendation in response to the 2005 BP Texas City explosion.[898] In that post-incident safety culture assessment, the Baker panel noted five fundamental observations concerning BP's safety with respect to its US refineries:

1. BP had not provided effective process safety leadership to establish a focus on process safety as a core value, rather emphasizing personal safety;
2. BP had not established a positive, trusting, and open environment with effective lines of communication;
3. BP had not always ensured it identified and provided resources, both financial and human, required for strong process safety performance;
4. BP did not effectively incorporate process safety consideration into management decisions; and
5. BP did not instill a common, unifying culture among its various refineries.

Arriving at these conclusions, the Baker panel employed a multifaceted approach that included (but was not limited to) a process safety culture survey of the BP refinery workforce and interviews with corporate-level management.

A culture/climate review of Transocean's North American Division (including the Deepwater Horizon) was commissioned by the company months before the Macondo incident, after the company experienced four separate fatality incidents.[899] The review determined that, in some respects, the company displayed evidence of a relatively strong culture for safety:[900]

> Overall, […] Deepwater Horizon was relatively strong in many of the core aspects of safety management. The strong team culture onboard Deepwater Horizon and the levels of mutual trust evident between crews means that the rig safety culture was deemed to be robust, largely fair, and inclusive, which was contributing to a 'just culture.'… The findings from the […] review indicated that the overwhelming majority of participants felt empowered with regard to safety on the rig. In particular, almost everyone felt they could raise safety concerns and these issues would

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[897] Wilkinson, P., 2016, Culture: Values and Practices – can you have one without the other? p 2, available at the csb.gov website; Hopkins, A., 2005. *Safety, Culture and Risk,* CCH Australia Ltd, pp 6-11

[898] The Baker Panel. *The Report of the BP US Refineries Independent Safety Review Panel;* January, 2007, p 94. http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf (accessed October 7, 2015).

[899] Internal Company Document, Transocean, *Transocean Launches Evaluation Safety and Processes and Culture*, October 21, 2009, TRN-MDL-04335708. http://www.mdl2179trialdocs.com/releases/release201303211200016/TREX-52646.pdf (accessed October 8, 2014).

[900] Internal Company Document, Transocean. *Safety Management and Safety Culture/Climate: North America Division Summary Report,* July 2, 2010, see Exhibit 0929, TRN-HCEC-00090579, http://www.mdl2179trialdocs.com/releases/release201304041200022/Bertone_Stephen-Depo_Bundle.zip (accessed October 7, 2015).

> be acted upon if this was within the immediate control of the rig. Supervisor support for legitimate safety concerns was praised on a number of occasions, and it was clear that issues were elevated (when appropriate) via line management structures. In short, individuals reported that they could confidently approach rig management with any safety concerns they may have, knowing that, if their concern is justified, they will receive full backing.

Yet a disparity between rig culture and the larger organization was also identified. The review followed the positive statements about culture by noting, “It must be stated at this point, however, that the workforce felt that this level of influence was restricted to issues that could be resolved directly on the rig, and that they had little influence at Divisional or Corporate levels.”[901] This finding alludes to the influential role of leadership from the highest levels on culture, particularly on important issues like communication, trust, and engagement throughout the organizational hierarchy. The review went on to describe several safety issues, including management and communication of change and the complexities and inconsistencies with implementation of the various risk management policies. Section 4.3 highlighted a number of specific disparities between corporate policy and worksite practice.

Post-Macondo, BP commissioned another safety culture assessment of its organization, which concluded that “BP succeeded in creating a well elaborated safety culture,”[902] citing evidence that the company regularly and continuously reflects on safety performance and the causes of incidents, makes efforts to learn from them in real time in both formal and informal ways, and encourages learning and continuous improvements in safety in the programs, policies and procedures it has implemented.[903] While this professional assessment of safety culture certainly identified strong points in the organization, in its attempt to examine how the safety culture is *enabled, enacted,* and *elaborated*,[904] it did not assess whether the company’s policies for risk management and operational success were followed at Macondo.

A culture that truly promotes safety extends beyond workers’ perceptions, espoused values, and documented policies. As described in Section 6.1, a culture for safety is characterized not only by goals, policies, and procedures, but by the company’s commitment to them and what it actually does. Chapters 1.0 and 4.0 describe many situations where the company did not initiate or uphold safety policies meant to manage major accident hazards. For example, Transocean’s planning and risk management processes

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901 Internal Company Document, Transocean. *Safety Management and Safety Culture/Climate: North America Division Summary Report*, July 2, 2010, see Exhibit 0929, TRN-HCEC-00090579, http://www.mdl2179trialdocs.com/releases/release201304041200022/Bertone_Stephen-Depo_Bundle.zip (accessed October 7, 2015).

902 Expert report of Kathleen M. Sutcliffe, October 17, 2011, for the United States District Court for the Eastern District of Louisiana, MDL No. 2179, Section: J, re. Oil Spill by the Oil Rig “Deepwater Horizon” in the Gulf of Mexico, on April 20, 2010, p 70.

903 Expert report of Kathleen M. Sutcliffe, October 17, 2011, for the United States District Court for the Eastern District of Louisiana, MDL No. 2179, Section: J, re. Oil Spill by the Oil Rig “Deepwater Horizon” in the Gulf of Mexico, on April 20, 2010, p 70.

904 The culture assessor defines these terms as the three elements of a strong safety culture: “(1) it is enables, meaning that the organization and its leaders emphasize safety and create a positive safety climate; (2) it is enacted, meaning that members of the organization put the organization’s safety policies and procedures into practice; and (3) it is elaborated, meaning that the organization rigorously reflects on its safety performance and seeks to improve its policies and procedures as a result.” Expert report of Kathleen M. Sutcliffe, October 17, 2011, for the United States District Court for the Eastern District of Louisiana, MDL No. 2179, Section: J, re. Oil Spill by the Oil Rig “Deepwater Horizon” in the Gulf of Mexico, on April 20, 2010, p 5.

at Macondo lacked implementation, yet the safety culture survey indicated a belief that "the THINK process was sound and contributed to safe working practices." The Deepwater Horizon crew also indicated they felt good about safety on the rig, but the metric the crew judged this performance on was the Lost Time Incident (LTI) personal safety metric. In fact, the crew indicated the LTI rate was a "key driver in raising awareness and promoting safe behaviors."[905] Akin to the LTA metric described in Section 3.1[906] LTI is an indication of good personal safety but conveys little about process safety performance.

Furthermore, it is commendable that BP can cite policies and efforts to investigate incidents,[907] but as Chapter 2.0 describes, the focus and type of investigation conducted will influence the lessons derived. If the focus is on technical matters, without exploration into the human and organizational factors, and without a systemic approach, as was the case, for example, with the March 8 kick, then the lessons derived will reflect that limitation. A culture that values process safety must examine such issues for future prevention. As another example, BP's Macondo investigation did not include an analysis of management and organizational factors that contributed to the incident,[908] thus choosing not to explore that avenue of potential learning that might have revealed systemic deficiencies. If an incident on the scale of Macondo does not evoke action to explore systemic causes, what does that convey about the underlying values of the organization? Sound process safety risk awareness and management is a focus throughout this report, and Transocean's positive pre-incident safety culture assessment findings suggest that sufficient information on the culture of the organization cannot be derived without effectively addressing all levels of culture, including identifying the underlying basic assumptions. Then the company must strive to support those values and basic assumptions in practice.[909]

6.3 Influencing a Culture for Process Safety from the Top

The manner in which culture change is accomplished is multifaceted and beyond the scope of this investigation; however, this discussion is mindful that "Companies have found that if safety and health values are not consistently and (constantly) shared at all levels of management and among *all* employees, any gains that result from declaring safety and health excellence a "priority" are likely to be short-lived."[910] "Shared" does not mean that all employees have the same level of influence on culture, or the

[905] Internal Company Document, Transocean. *Safety Management and Safety Culture/Climate: North America Division Summary Report*, July 2, 2010, see Exhibit 0929, TRN-HCEC-00090587, TRN-HCEC-00090598, http://www.mdl2179trialdocs.com/releases/release201304041200022/Bertone_Stephen-Depo_Bundle.zip (accessed October 7, 2015).

[906] In company documents, Transocean referred to this metric as the total recordable injury rate (TRIR), but the crew referred to the safety metric in terms of LTIs rather than the TRIR. See Section 0 for the introduction to TRIR.

[907] Expert report of Kathleen M. Sutcliffe, October 17, 2011, for the United States District Court for the Eastern District of Louisiana, MDL No. 2179, Section: J, re. Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010.

[908] BP, Deepwater Horizon Accident Investigation Report, September 8, 2010, p 12 and Appendix A.

[909] Wilkinson, P., 2016, Culture: Values and Practices – can you have one without the other? p 2, available at the CSB.gov website.

[910] Quoted in *The Report of the BP US Refineries Independent Safety Review Panel;* January, 2007, p 23, footnote 19. http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf (accessed October 7, 2015).

actual authority to get things done. Indeed, "implementing practices is a leadership responsibility and requires great care to avoid unintended consequences, as well as active monitoring[911] to verify they are applied as intended."[912] Thus, a company's most senior leadership, starting at the board of directors, plays the pivotal role in influencing a culture that robustly promotes process safety. Cases show that actual practices repeated by a group over time, when enforced and verified by an authoritative entity, can lead to a culture change.[913] Institutional actions offer deep insight into a corporate culture: "critical controls to prevent a major incident are just another way of describing important organisational practices."[914]

The relationship between major accident prevention and organizational culture has been recognized across the full spectrum of high-hazard industries, including offshore drilling, aviation safety, underground mining, and nuclear power. For more than 25 years, the US Nuclear Regulatory Commission has been refining its safety culture expectations for organizations performing or overseeing regulated nuclear activities.[915] It defines safety culture as the "core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment."[916]

In light of the DWH incident and repeated calls for promoting a culture for safety offshore, BSEE released its *Safety Culture Policy Statement*, announcing expectations "that individuals and organizations performing or overseeing activities regulated by BSEE establish and maintain a positive safety culture commensurate with the significance of their activities and the nature and complexity of their organizations and functions."[917]

[CALL-OUT BOX START]

BSEE's Safety Culture Policy Statement *lists the following characteristics that "typify a robust safety culture":*[918]

1. ***Leadership Commitment to Safety Values and Actions.*** *Leaders demonstrate a commitment to safety and environmental stewardship in their decisions and behaviors;*

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[911] For a description of "Active Monitoring" in the context of major accidents, although the principles have wider application, see: http://www.csb.gov/assets/1/7/Wilkinson_Active_Monitoring.pdf Accessed 31 December 2015.

[912] Wilkinson, P., 2016, Culture: Values and Practices—can you have one without the other? p 3, available at the CSB.gov website.

[913] Andrew Hopkins gives the example of legal requirements for seatbelts in vehicles; this practice was initially rejected and challenged, seen as a burden. Over time, as financial consequences for not wearing them became prevalent, it gradually became habitual to wear one. Now wearing seatbelts is perceived to be sensible. Hopkins, Andrew, *Why safety cultures don't work,* Future Media Training Resources, p 1.

[914] Wilkinson, P., 2016, Culture: Values and Practices—can you have one without the other? p 3, available at the CSB.gov website.

[915] [Online]; http://www.nrc.gov/about-nrc/safety-culture/sc-policy-statement.html#dev (accessed October 7, 2015).

[916] 76 Fed. Reg. 34773-34778 (June 14, 2011).

[917] BSEE, *Safety Culture Policy Statement,* http://www.bsee.gov/Safety/Safety-Culture-Policy/ (accessed October 7, 2015).

[918] BSEE, *Safety Culture Policy Statement,* http://www.bsee.gov/Safety/Safety-Culture-Policy/ (accessed October 7, 2015).

2. ***Hazard Identification and Risk Management.*** *Issues potentially impacting safety and environmental stewardship are promptly identified, fully evaluated, and promptly addressed or corrected commensurate with their significance;*
3. ***Personal Accountability.*** *All individuals take personal responsibility for process and personal safety, as well as environmental stewardship;*
4. ***Work Processes.*** *The process of planning and controlling work activities is implemented so that safety and environmental stewardship are maintained while ensuring the correct equipment for the correct work;*
5. ***Continuous Improvement.*** *Opportunities to learn about ways to ensure safety and environmental stewardship are sought out and implemented;*
6. ***Environment for Raising Concerns.*** *A work environment is maintained where personnel feel free to raise safety and environmental concerns without fear of retaliation, intimidation, harassment, or discrimination;*
7. ***Effective Safety and Environmental Communication.*** *Communications maintain a focus on safety and environmental stewardship;*
8. ***Respectful Work Environment.*** *Trust and respect permeate the organization with a focus on teamwork and collaboration; and*
9. ***Inquiring Attitude.*** *Individuals avoid complacency and continuously consider and review existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action.*

[CALL-OUT BOX END]

BSEE's *Safety Culture Policy Statement* is a commendable first step. It could be improved by explicitly acknowledging the role that all levels in an organization play in influencing how the culture promotes process safety, including the role of the board of directors. This includes ownership of process safety risk from the top down, with the board leading and supporting the initiative, engaging the workforce to promote health and safety, and identifying key performance safety indicators to monitor efforts.

Future BSEE culture efforts could also require that companies formally assess their organizational cultures and whether the culture has sufficient focus on process safety. Culture assessments have the potential to identify the safety perceptions of employees and the commitment of individuals from all levels of the organization to the formally-adopted corporate process safety goals, policies, procedures, and practices. A variety of culture assessment methods can be used to explore willingness to report incidents and near-misses, the effectiveness of workforce participation efforts, and organizational drifts from safety policies and procedures. The assessment results can be the basis of conversation between the industry, workforce/management, and the regulator to create, "a qualitative shift in industry and regulatory safety cultures from the minimalist compliance … to the philosophy of best practice and continuous improvement."[919] While companies can employ assessment approaches specific to their own safety

[919] Department of Industry, Science, and Resources: Offshore Safety and Security, Petroleum and Electricity Division, Report of the Independent Review Team, Australian Offshore Petroleum Safety Case Review, February-March 2000 Stakeholder Survey, http://www.industry.gov.au/resource/Documents/upstream-petroleum/safety/Australian_Offshore_Petroleum_Safety_Case_Review_Feb-Mar_2000.pdf (accessed March 2, 2015).

management systems and policies, it would be useful for BSEE to work with industry, workforce, and culture experts to develop culture assessment methods that can be used industrywide to gain further insights into safety perceptions offshore. Creating and using such validated methods will allow for collecting information to support improvements, not only within each organization, but also broadly across the US offshore industry.

6.4 Conclusion

There will be situations when "individual behavior [i]s inconsistent with the organization's commitment to safety."[920] However, one individual did not cause the Macondo event. A multitude of decisions and actions up and down the organizational chains of both companies impacted the events of April 20, 2010, and those decisions and actions are influenced by the invisible and often unstated basic assumptions and shared values of the involved companies.

Identifying incongruities between proclaimed values and the actual basic assumptions and values of the organization is one step toward understanding and working with culture. Culture assessments could be a useful tool to help organizations understand their culture and whether it adequately promotes safety. This information would also be useful for regulators in helping to identify potential issues and their mitigation in the interest of accident prevention. The assessments need to be conducted with a multifaceted approach that (1) addresses worker perceptions, (2) delves into the context of those perceptions as they relate to the values of the organization, d an(3) identifies the basic assumptions of the organization. The information must be assessed in conjunction with an examination of how the artifacts (e.g. actual practices) reflect those values and assumptions.

All levels of culture require monitoring and modification for change to occur. Indicators monitoring the actual implementation of process safety policies and practices can shed light on where actual practices differ from stated policies and values—a first step for an organization to identify potential conflicts. Having a better understanding of their organizational culture, management, the workforce, and the regulator can take proactive steps to remediate inadequacies while reinforcing effective practices, thus driving more sustainable, long-term safety improvements.

[920] Expert report of Kathleen M. Sutcliffe, October 17, 2011, for the United States District Court for the Eastern District of Louisiana, MDL No. 2179, Section: J, re. Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010, p.91.

7.0 Volume 3 Conclusion

Chapter 1.0 describes how, due to the tightly coupled interdependencies, complex systems like offshore drilling operations are susceptible to performance variability and organizational drift, and the adaptability and flexibility of the humans within the system determine operational success. To successfully minimize undesirable consequences, therefore, industry must shift from correcting individual "errors" identified post-incident to a systematic approach for managing human factors. Such a risk management approach would include a proactive process for assessing human factors for major accident prevention, concentrated focus on minimizing the gap between work-as-imagined and work-as-done, and a concerted effort to improve the non-technical skills of both workforce and management.

Major catastrophes, fortunately, are infrequent. For this reason, investigations of those rare events, and the more frequent near-misses, provide critical insight into potential safety gaps for those operating offshore. Yet, as Chapter 2.0 highlights, organizational learning poses many challenges for industry, including the effective culling and disseminating of lessons between operators and leaseholders, the successful sharing of those lessons across global corporations, and the still all-too-frequent focus on technical causes without sufficient focus on systemic and organizational factors. Actual implementation of corrective actions, and not just dissemination of incident facts and findings, is imperative, and the regulator has an opportunity to influence companies in this endeavor.

History has repeatedly proven that personal safety indicators are inaccurate predictors for major accident events. Chapter 3.0 demonstrates that, at the time of the Macondo incident, both BP and Transocean collected, measured, and rewarded personal safety metrics and, correspondingly, both companies achieved low personal worker injury rates. However, process safety did not receive the same attention from either company. Further work is needed on developing and implementing effective performance metrics that indicate the health of major accident barriers and the safety management systems meant to ensure their reliability. While Chapter 3.0 provides suggested potential indicators based on findings from the CSB's Macondo investigation, appropriate process safety KPIs for the individual company and industrywide needs additional focus from numerous stakeholders, including management, workforce, and regulators.

Chapter 4.0 demonstrates how the complexities of multi-party risk management in the offshore industry led to vaguely established safety roles and responsibility between the operator (BP) and the drilling contractor (Transocean). Ultimately, while both companies had corporate policies for risk management, neither BP nor Transocean assumed responsibility for implementing those policies at Macondo, and no regulatory requirements or oversight ensured that such policies were upheld and that the major accident risks inherent in their operations were effectively managed.

Chapter 5.0 explores the influential role of corporate governance in deciding what and how safety is managed throughout the organizational hierarchy, as well as the influential role shareholders and the regulator could have in ensuring corporate boards are conversant in the major hazards influencing their business.

Chapter 6.0 uses the numerous examples of operational practices of both BP and Transocean from preceding chapters to illustrate that both companies were perpetuating a culture of minimal compliance. Both companies exhibited failures to follow internal risk management policies, safety management system programs and provisions for risk reduction to ALARP, despite organizational requirements to do so.

As a result of the analyses presented in this volume, and in pursuit of major accident prevention, Chapter 8.0 lists several recommendations addressing human factors, corporate governance, safety performance indicators, and culture.

The analyses presented in this volume provide the evidentiary foundation for the regulatory analysis presented in Volume 4. These two final volumes work in tandem to argue for further safety improvements to industry risk management practices through additional regulatory provisions and authorities that place the onus of major accident prevention squarely on industry while improving the oversight capabilities of the regulator.

8.0 Recommendations

Volume 3 issues one recommendation to the American Petroleum Institute (CSB2010-I-OS-R5), three recommendations to the US Department of Interior (CSB-2010-10-I-OS-R6 and –R8), one to the Sustainability Accounting Standards Board (CSB-2010-10-I-OS-R9), and one to the Ocean Energy Safety Institute (CSB-2010-10-I-OS-R10).

CSB2010-I-OS-R5 Recommends Augmenting API 75 to include the various process safety concepts and major accident prevention (MAP) management systems

American Petroleum Institute

Based on the analysis presented in the CSB Macondo investigation report, Volumes 3 and 4, and the requirements listed in R10, revise Recommended Practice 75, *Development of a Safety and Environmental Management Program for Offshore Operations and Facilities, 3rd ed*., May 2004 (reaffirmed May 2008), to require a specific focus on major accident prevention and address the following issues:

a. Incorporate the following listed safety management system issues as explicit program elements and include language throughout API 75 regarding each element's explicit and defined applicability to all of the other existing program elements:
    1. Human factors program requirements for the design, planning, execution, management, assessment, and decommissioning of well operations for the prevention of major accidents, as well as in the investigation of accidents and near-misses;
    2. Corporate governance and Board of Director responsibilities for major accident risk management;
    3. Workforce involvement and engagement in all aspects of the SEMS program;
    4. Contractor oversight and effective coordination for major accident prevention; and
    5. Leading and lagging key performance indicators that drive major accident prevention.

b. Define and expand the roles and responsibilities for major accident prevention among the primary parties engaged in offshore drilling and production (i.e., the leaseholder/operator *and* owner/drilling contractor) by expanding applicability of this standard to the parties with primary control over major hazard operations and day-to-day activities and thus best positioned to implement and oversee a safety and environmental management system (SEMS) program to control major accident hazards.

c. Incorporate into the Principles section of the document, as well as within the Setting Objectives and Goals section, as overarching provisions for the overall successful implementation and execution of a SEMS program:
    1. Management of major accident risk to As Low As Reasonably Practicable or similar risk-reduction target;
    2. Use the hierarchy of controls for identifying, establishing, and implementing barriers meant to prevent or mitigate major accident hazards.

CSB2010-I-OS-R6 Recommends Development of Human Factors Guidance for Major Accident Prevention

United States Department of Interior

Drawing upon best available global standards and practices, develop guidance to assist industry in the incorporation of human factors principles into the systematic analysis of their major accident hazards, development of their SEMS programs, and in the preparation of their major hazards report documentation. This standard shall provide guidance on topics including, but not limited to, safety critical task assessment and the development and verification of non-technical skills. Include the participation of diverse expertise in the development of the standard including industry, workforce, and subject matter expert representatives.

CSB2010-10-I-OS-R7 Recommends Development of Corporate Governance Guidance and the Engagement of Corporate Boards and Executives for Risk Management and Major Accident Prevention

United States Department of Interior

Drawing upon best available global standards and practices, develop guidance addressing the roles and responsibilities of corporate board of directors and executives for effective major accident prevention. Among other topics, this standard shall provide specific guidance on how boards and executives could best communicate major accident safety risks to their stakeholders, as well as corporate level strategies to effectively manage those risks.

CSB2010-I-OS-R8 Recommends Regulatory Requirements for Safety Culture Improvements

United States Department of Interior

Expand upon the principles of the BSEE Safety Culture policy and establish a process safety culture improvement program for responsible parties as defined in R11(a) that periodically administers process safety culture assessments and implements identified major accident prevention improvements. The process safety culture improvement program shall include a focus on items that measure, at a minimum, willingness to report incidents and near-misses, effectiveness of workforce participation efforts, organizational drift from safety policies and procedures, and management involvement and commitment to process safety.

CSB2010-10-I-OS-R9 Recommends Strengthening and Finalizing the Sustainability Accounting Standards Board's Oil & Gas Exploration & Production Sustainability Accounting Standard (Provisional, dated June 2014)

Sustainability Accounting Standards Board

Update, strengthen, and finalize the SASB's provisional Oil & Gas Exploration & Production Sustainability Accounting Standard by enhancing standard NR0101-18. Expand recommended coverage of "Process Safety Event rates for Loss of Primary Containment of greater consequences" in accordance with the findings of this report. Specifically, this expanded coverage shall:

a. Recommend the disclosure of additional leading and lagging indicators and emphasize the greater preventive value of disclosure of a company's use of leading indicators to actively monitor the health and performance of major accident safety barriers and the management systems for ensuring their effectiveness. Specifically add:
    1. Indicators addressing the health of safety barriers to be communicated to the workforce, and to shareholders in required SEC disclosures, and also to be made readily available to the regulator.
    2. Guidance emphasizing and promoting the concept that personal safety metrics such as those captured in NR0101-17 (total recordable injury rate, fatality rate, near-miss frequency rate) are important but separate from leading and lagging process safety performance indicators, which better correlate to major accident prevention.
        - Accomplish this communication within NR0101-18.
        - Supplement this effort within the SASB's Oil & Gas Exploration & Production Research Briefs, based on the findings of this report as well other current safety scholarship that demonstrates the lack of correlation between personal safety efforts and process safety and major accident prevention initiatives.

<u>CSB2010-10-I-OS-R10 Recommends further study to advance industry's understanding of the gas-in-riser hazard.</u>

Ocean Energy Safety Institute

Conduct further study on riser gas unloading scenarios, testing, and modeling and publish a white paper containing technical guidance that communicates findings and makes recommendations for industry safety improvements.

By the

U.S. Chemical Safety and Hazard Investigation Board

Vanessa A. Sutherland
Chairperson

Manuel Ehrlich
Member

Rick Engler
Member

Kristen Kulinowski
Member

Date of Board Approval: