REPUBLIC OF THE MARSHALL ISLANDS

Office of the Maritime Administrator

DEEPWATER HORIZON MARINE CASUALTY INVESTIGATION REPORT

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Image Courtesy of Transocean

CONDOLENCES

The Republic of the Marshall Islands Maritime Administrator offers its sincere condolences to the families and friends of the 11 individuals who perished in the 20 April 2010 casualty.

ACKNOWLEDGEMENTS

The Republic of the Marshall Islands Maritime Administrator commends the surviving members of the crew and visitors of the DEEPWATER HORIZON and the crew of the DAMON B. BANKSTON for their heroic efforts to mitigate the casualty and evacuate 115 persons from the DEEPWATER HORIZON. Acknowledgement and appreciation is also extended to the United States Coast Guard personnel and the numerous organizations and individuals who immediately responded to assist in the search for the missing crew members, the treatment and evacuation of the injured, and the mitigation of the environmental consequences of the casualty.

Published by: Republic of the Marshall Islands Maritime Administrator on 17 August 2011

DISCLAIMER

In accordance with national and international requirements, the Republic of the Marshall Islands Maritime Administrator ("Administrator") must report, or cause to be reported, the causal factors of all serious and very serious marine casualties. While every effort has been made to ensure the accuracy of the information contained in this Report, the Administrator and its representatives, agents, employees, or affiliates accept no liability for any findings or determinations contained herein, or for any error or omission, alleged to be contained herein.

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AUTHORITY

An investigation under the authority of Republic of the Marshall Islands laws and regulations, including all international instruments to which the Republic of the Marshall Islands is a Party, was conducted to determine the cause of the casualty.

Office of the
Maritime Administrator

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EXECUTIVE SUMMARY

On 20 April 2010 the Mobile Offshore Drilling Unit (MODU)[1] DEEPWATER HORIZON (hereinafter, the "DEEPWATER HORIZON" or the "Unit") was completing drilling operations at the Macondo well, Mississippi Canyon Block 252 OCS-G 32306 #1, oil exploration project in the Gulf of Mexico on the United States (US) Outer Continental Shelf (OCS) in preparation to temporarily abandon the well. During these operations, there was a loss of well control that resulted in a release of liquid and gaseous hydrocarbons, which culminated in explosions, fire, the loss of 11 lives, the eventual sinking and total loss of the DEEPWATER HORIZON, and the continuous release of hydrocarbons into the Gulf of Mexico. The flow was stopped on 15 July 2010 and the well declared sealed on 19 September 2010.

Pursuant to section 710 of the Republic of the Marshall Islands Maritime Act 1990, as amended (hereinafter, the "Maritime Act"), the United Nations Convention on the Law of the Sea, 1983 (UNCLOS), the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS), and the Code of the International Standards and Recommended Practices for a Safety Investigation into A Marine Casualty or Marine Incident (hereinafter, the "Casualty Investigation Code"), the Republic of the Marshall Islands Maritime Administrator (hereinafter, the "Administrator") has conducted an independent flag State marine casualty investigation of the DEEPWATER HORIZON casualty. In conducting the investigation, the Administrator drew upon documents submitted to the US Department of the Interior and the US Department of Homeland Security Joint Investigation (hereinafter, the "Joint Investigation") team, testimony before the Joint Investigation team, its own investigators' findings, and, where necessary, outside experts. To assist in its understanding and analysis of engineering and technical aspects, the Administrator retained drilling, engineering, and fire science consultants whose reports, entitled *Casualty Investigation of MODU DEEPWATER HORIZON: Fire Origin Investigation* (hereinafter, the "Fire Origin Report") and *Report of the Loss of Well Control and Assessment of Contributing Factors for the Macondo Well Mississippi Canyon Block 252 OCS-G 32306 #1 Well* (hereinafter, the "Well Control Report"), have been drawn upon in determining relevant details and conclusions regarding the casualty.[2]

This casualty investigation report contains findings of fact, conclusions, and recommendations, focusing on the marine operations of the Unit, which are the purview of the flag State. Although not regulated by the flag State, the industrial operations of the Unit are discussed, in so far as they are necessary to provide a complete picture of the casualty or where they may have impacted the overall safety of the Unit.

Pursuant to this investigation, the primary causal factor conclusions, non-causal factor conclusions, and recommendations are:

CAUSAL FACTOR CONCLUSIONS

- Although the Administrator does not have oversight responsibility for drilling operations on the US OCS, based on its assessment of the evidence in the investigative record and the attached Well Control Report, the Administrator concludes that the proximate cause of the casualty was a loss of well control resulting from:

1 A complete list of acronyms and abbreviations used in this report may be found at Annex A.

2 The Fire Origin Report and Well Control Report may be found in their entirety at Annexes B and C, respectively.

- deviation from standards of well control engineering;
- deviation from the well abandonment plans submitted to and approved by the Minerals Management Service (MMS); and
- failure to react to multiple indications that a well control event was in progress.

- The above factors contributed to the substantial release of liquid and gaseous hydrocarbons, which culminated in explosions, fire, the loss of 11 lives, the eventual sinking and total loss of the DEEPWATER HORIZON, and the release of hydrocarbons into the Gulf of Mexico.

NON-CAUSAL FACTOR CONCLUSIONS

- Better communication and coordination between the flag State and the coastal State regarding inspections and surveys could help to ensure that both the flag and coastal States are aware of conditions or requirements that could affect the safety of MODUs and their personnel.

- The Unit withstood the forces of the explosions and resulting fire, providing a sufficiently stable and protected platform to facilitate the evacuation of 115 of the 126 persons on board.

- The electrical power failed at the time of the first explosion or immediately thereafter. The failure of the primary power source added to the confusion during evacuation and complicated evacuation of the Unit.

- The total loss of electrical power compromised the functioning of the fire suppression systems; however, any attempts at suppression would have been futile given the intensity and magnitude of the fire and the uncontrolled fuel supply. It is unlikely that any ship borne system would have been effective at extinguishing the fire onboard the DEEPWATER HORIZON.

- The Emergency Disconnect System (EDS) did not function as intended and the Unit was unable to disconnect. Without any ability to stop or reduce the flow of hydrocarbons, and without power for vital systems, the crew was forced to evacuate the Unit.

- There were instances of confusion regarding decision making authority during the casualty. While such instances highlight the fact that the integration of drilling and marine operations presents challenges for maintaining a clear command hierarchy, especially in emergency situations, there is no indication that any confusion as to the chain of command was a causal factor in the casualty.

- Ideally, the evacuation of a unit occurs in phases. However, the speed at which the casualty progressed provided limited time for reaction, control, mitigation efforts, and response. That 115 individuals were able to safely evacuate the DEEPWATER HORIZON is due in part to the robustness of the underlying regulatory system, including requirements for redundancy of life saving equipment, routine fire and emergency drills, and safety orientations for all visitors to the Unit.

- The proximity of the DAMON B. BANKSTON and the timely and effective response of its crew substantially contributed to the successful evacuation of the DEEPWATER HORIZON.

RECOMMENDATIONS FOR IMPROVEMENT

- It is recommended that a communication system be developed between the relevant flag and coastal

State regulatory bodies to address issues regarding units operating within the coastal State's jurisdiction.

- While provisions of the International Maritime Organization (IMO) Code for the Construction and Equipment of Mobile Offshore Drilling Units (hereinafter, the "MODU Code"), 1989 contributed to the safety and evacuation of the crew, specific provisions of the 2009 MODU Code should be reviewed in light of the casualty.

- It is recommended that all unit operators ensure that the initial orientation for new crew members, contracted personnel, and visitors includes a discussion of the respective roles and leadership responsibilities of the Master and the Offshore Installation Manager, including how those roles change based on unit operations and emergency conditions.

- While not regulated by the Administrator, it is recommended that the operators and regulators review and amend, as appropriate, emergency procedures for activating the EDS and maintaining the Blowout Preventer (BOP).

Additional findings, conclusions, and recommendations are contained in the body of this Report.

Location of the DEEPWATER HORIZON in the Gulf of Mexico, on the US OCS.

PROLOGUE

REGULATORY STRUCTURE[3]

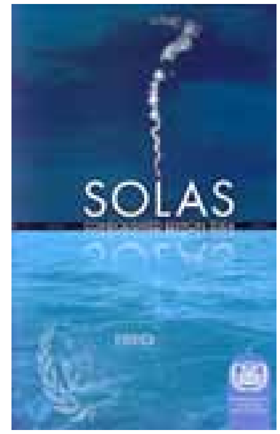
MODUs are uniquely regulated and operated vessels "capable of engaging in drilling operations for the exploration for or exploitation of resources beneath the [seabed] such as liquid or gaseous hydrocarbons, sulphur, or salt."[4] The Preamble of the 1989 MODU Code[5] states, "[t]his Code has been developed to provide an international standard for mobile offshore drilling units of new construction which will facilitate the international movement

3 A general overview of international codes and conventions applicable to MODUs may be found at Annex D.

4 1989 MODU Code, § 1.3.1.

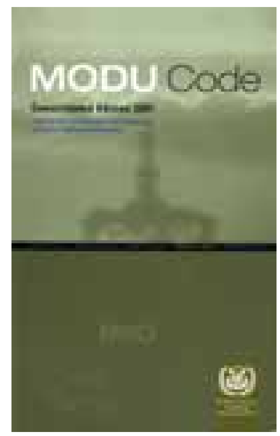
5 There are three MODU Codes: the 1979 MODU Code, applicable to units constructed on or after 31 December 1981 and prior to 1 May 1991; the 1989 MODU Code, applicable to units constructed on or after 1 May 1991 and prior to 1 January 2012; and the 2009 MODU Code, applicable to units constructed on or after 1 January 2012. According to the accompanying Resolutions, the existing MODU Codes are superseded by each new Code. However, in practice, the previous Codes remain applicable to those units constructed in accordance with those Codes and the safety certificates identify the Code to which the unit is certified. As the DEEPWATER HORIZON was built in 2000, the 1989 MODU Code was applicable to the Unit. All references to the 1989 MODU Code are to the Code for the Construction and Equipment of Mobile Offshore Drilling Units, 1989, Resolution A.649(16), as amended. The 1989 MODU Code will be superseded by the 2009 MODU Code on its effective date, 1 January 2012.

and operation of these units and ensure a level of safety for such units, and for personnel onboard, equivalent to that required by [SOLAS], and the International Convention on Load Lines, 1966, for conventional ships engaged on international voyages." The 1989 MODU Code is based on SOLAS and specifically addresses the marine operations of MODUs.[6] It does not include requirements for the drilling of subsea wells or the procedures for their control. The 1989 MODU Code recognizes the overlapping jurisdictional regulations and responsibilities between the flag State of the MODU and the coastal State in whose waters the MODU is operating, but it does not address procedures for coordination of those regulatory regimes.



Flag State

A flag State establishes rules and regulations for vessels that fly its flag and implements enforcement measures to secure the observance of all applicable national and international regulations.



Article 94 of UNCLOS, to which the Republic of the Marshall Islands is a signatory,[7] states in part:

> 3. *Every State shall take such measures for ships flying its flag as are necessary to ensure safety at sea with regard, inter alia, to:*
>
>   (a) *the construction, equipment and seaworthiness of ships;*
>
>   (b) *the manning of ships, labour conditions and the training of crews, taking into account the applicable international instruments;*
>
>   (c) *the use of signals, the maintenance of communications and the prevention of collisions.*
>
> 4. *Such measures shall include those necessary to ensure:*
>
>   (a) *that each ship, before registration and thereafter at appropriate intervals, is surveyed by a qualified surveyor of ships, and has on board such charts, nautical publications and navigational equipment and instruments as are appropriate for the safe navigation of the ship;*
>
>   (b) *that each ship is in the charge of a master and officers who possess appropriate qualifications, in particular in seamanship, navigation, communications and marine engineering, and that the crew is appropriate in qualification and numbers for the type, size, machinery and equipment of the ship;*
>
>   (c) *that the master, officers and, to the extent appropriate, the crew are fully conversant with and required to observe the applicable international regulations concerning the safety of life at sea, the prevention of collisions, the prevention, reduction and control of marine pollution, and the maintenance of communications by radio.*
>
> 5. *In taking the measures called for in paragraphs 3 and 4 each State is required to conform to generally accepted international regulations, procedures and practices and to take any steps which may be necessary to secure their observance.*

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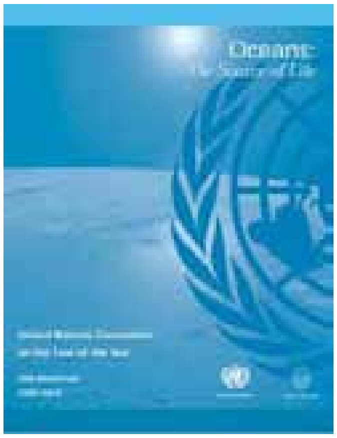
6 Internationally, the MODU Codes are not mandatory, and SOLAS remains the principal governing convention of MODUs. The Republic of the Marshall Islands became a Party to SOLAS on 26 July 1988.

7 The Republic of the Marshall Islands became a Party to UNCLOS on 9 August 1991.



In accordance with UNCLOS, the Republic of the Marshall Islands has an established and uniform national program of marine safety, inspection, and documentation, through the Maritime Act, including the creation of the Administrator, to "administer all matters pertaining to vessels of the Republic [of the Marshall Islands];...promulgate Rules and Regulations to carry out the provisions of the [Maritime] Act; and ensure the seaworthiness and proper manning conditions of such ships, yachts and fishing vessels registered under the laws of the Republic [of the Marshall Islands]."[8]

The Republic of the Marshall Islands is a Party to all major IMO conventions and other related international maritime instruments,[9] and implements these through its national laws and regulations, which include: issuing certificates of registry, seafarer's documentation, manning certificates and radio station licenses; conducting safety inspections; investigating marine casualties; providing technical assistance, including utilizing Classification Societies to monitor vessel compliance with all national and international standards; and issuing Marine Notices, Marine Guidelines, and Marine Safety Advisories. To this effect, the Administrator has been audited by the IMO under the Voluntary Member State Audit Scheme and has been deemed compliant with its responsibilities under the Code for the Implementation of Mandatory IMO Instruments.[10] The Republic of the Marshall Islands has specifically adopted the 1979 and 1989 MODU Codes as national regulation and mandated compliance with those Codes and additional requirements found in the Republic of the Marshall Islands Mobile Offshore Drilling Unit Standards.[11]

The Administrator has a variety of enforcement mechanisms that it can impose on vessel owners and operators for non-compliance with applicable national and international laws and regulations. Vessels that fail to maintain compliance with applicable national and international requirements, and fail to correct any identified deficiency in a timely manner, may be detained, removed from the Registry of the Republic of the Marshall Islands, or otherwise penalized by the Administrator.

Coastal State

The exploration and exploitation of mineral resources in a coastal State's waters are regulated solely under the jurisdiction of that coastal State. Therefore, the design and drilling of subsea wells are subject to the exclusive and sole control of the coastal State and are not regulated by international conventions or codes under the purview of the IMO or the flag State.[12] The coastal State may also impose additional requirements on the marine operations of a vessel or unit operating on its OCS.

Section 1.2.2 of the 1989 MODU Code states that "the coastal State may impose additional requirements regarding the operation of industrial systems not dealt with by the Code." Additionally, section 1.7.6 of the 1989 MODU Code provides that the survey and certification requirements under the 1989 MODU Code "are without prejudice

8 Republic of the Marshall Islands Maritime Act (MI-107), §§ 102, 103.

9 Republic of the Marshall Islands Marine Notice 2-011-1, International Maritime Conventions and Other Instruments Adopted by the Republic of the Marshall Islands.

10 Code for the Implementation of Mandatory IMO Instruments, Resolution A.973(24).

11 Republic of the Marshall Islands Mobile Offshore Drilling Unit Standards (MI-293).

12 As defined by the 1989 MODU Code, § 1.3.6, states: "*Coastal State* means the Government of the State exercising administrative control over the drilling operations of the unit."

to any rights of the coastal State under international law to impose its own requirements relating to the regulation, surveying and inspection of units engaged, or intending to engage, in the exploration or exploitation of the natural resources of those parts of the [seabed] and subsoil over which that [coastal] State is entitled to exercise sovereign rights."

Pursuant to the Outer Continental Shelf Lands Act (OCSLA),[13] the US maintains regulatory authority over all activities occurring on the US OCS. "[T]he Secretary [of the Interior], the Secretary of the Department in which the Coast Guard is operating, and the Secretary of the Army shall enforce safety and environmental regulations promulgated pursuant to [the OCSLA]."[14]

The US Department of Homeland Security and the US Department of the Interior delineated these responsibilities pursuant to a Memorandum of Understanding (MOU), effective 30 September 2004.[15] This MOU provides the regulatory division of effort between the United States Coast Guard (USCG) and MMS.[16] Pursuant to the MOU, "Memorandum of Agreements (MOA[s]) developed under the terms of this MOU will provide specific guidance on each agency's role and shared responsibilities for regulating various OCS activities and OCS facilities." MMS/USCG MOA: OCS-04, dated 28 February 2008,[17] provides an update to certain sections of MMS/USCG MOA: OCS-01, dated 30 September 2004, and clearly defines, in its Annex 1, Floating Offshore Facility System/Sub-System Responsibility Matrix, each agency's responsibilities.

Pursuant to the MOU, MOAs, and US regulations, the USCG requires foreign flagged MODUs conducting activities on the OCS to comply with one of three regulatory schemes.[18] As outlined in the MMS/USCG MOA: OCS-04, "the USCG, within the U.S. Department of Homeland Security…, is responsible for protecting the marine environment, promoting the safety of life and property and ensuring security on the OCS." MMS/USCG MOA: OCS-04 goes on to state, "the USCG regulates OCS facilities, [MODUs] and vessels engaged in OCS activities, including, but not limited to, tank vessels, offshore supply vessels, and other vessels involved in OCS activities or transfers of certain cargoes." The USCG performs annual inspections to ensure compliance with US standards.[19] At the time of the DEEPWATER HORIZON casualty, the US Department of Interior, through its

13 43 U.S.C. § 1331, et seq. (2007).

14 43 U.S.C. § 1348 (2007).

15 MMS/USCG MOU: OCS-01, 30 September 2004, states: "The MMS, within the US Department of Interior…, is responsible for managing the nation's natural gas, oil, and other mineral resources on the OCS in a safe and environmentally sound manner. The MMS is responsible for management of mineral leasing on the OCS and, in general, the regulation of industrial activities such as mineral exploration, development, pipeline transportation, storage, production, drilling, completion, and workover activities on lands under its jurisdiction." It goes on to state, "The USCG, within the Department of Homeland Security…, regulates the safety of life and property on OCS facilities and vessels engaged in OCS activities, and the safety of navigation. In addition, the USCG is responsible for promoting workplace safety and health by enforcing requirements related to personnel, workplace activities, and conditions and equipment on the OCS."

16 On 19 May 2010, MMS was abolished, per Order No. 3299, issued by Secretary of the Interior Ken Salazar, and reorganized into the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). BOEMRE is responsible for the development of the OCS conventional and renewable energy resources, including resource evaluation, planning, and other activities related to leasing; the Bureau of Safety and Environmental Enforcement, which is "responsible for ensuring comprehensive oversight, safety, and environmental protection in all offshore energy activities;" and the Office of Natural Resources Revenue, which is responsible for the royalty and revenue management function including "royalty and revenue collection, distribution, auditing, and compliance." See US Department of the Interior Secretarial Order No. 3299, 19 May 2010. For consistency, throughout this report, the Administrator refers to the agency as the MMS, as this was the name of the agency at the time of the casualty.

17 MMS/USCG MOA: OCS-04 is attached hereto as Annex E.

18 33 C.F.R. § 146.205 states: "Each mobile offshore drilling unit that is documented under the laws of a foreign nation must, when engaged in OCS activities, comply with one of the following: (a) The operating standards of 46 [C.F.R.] Part 109. (b) The operating standards of the documenting nation if the standards provide a level of safety generally equivalent to or greater than that provided under 46 [C.F.R.] Part 109. (c) The operating standards for mobile offshore drilling units contained in the International Maritime Organization…(IMO) Code for the Construction and Equipment of Mobile Offshore Drilling Units (IMO Assembly Resolution A.414(XI)) which has been incorporated by reference and the requirements of 46 [C.F.R.] Part 109 for matters not addressed by the Code."

19 46 C.F.R. § 147.269 (2005).

agency, the MMS, oversaw drilling operations on the US OCS,[20] including monthly inspections in accordance with MMS/USCG MOA: OCS-01 of MODUs operating on the OCS.

SURVEYS, INSPECTIONS, AND CERTIFICATION

Flag State Inspections

In addition to statutory surveys, the Administrator conducts inspections of Republic of the Marshall Islands flagged units through its network of qualified marine inspectors, similarly qualified contract inspectors, and Recognized Organizations (ROs).[21] Republic of the Marshall Islands Maritime Regulations, section 5.34.3, requires each unit to undergo an annual safety inspection. The purpose of these inspections is to ensure that Republic of the Marshall Islands registered units are maintained in compliance with international regulations and flag State requirements with respect to: safety, security, and environmental protection; the overall condition of the vessel; and crew certification and training.

Republic of the Marshall Islands MODU Standards and MODU Safety Certificates

The Republic of the Marshall Islands' standards for the construction, arrangement, equipment, and operation of MODUs are established in Mobile Offshore Drilling Unit Standards, MI-293. The Republic of the Marshall Islands Mobile Offshore Drilling Unit Standards, MI-293, specifically adopts the 1979 and 1989 MODU Codes as national regulation and mandates compliance with the applicable MODU Code, while also imposing additional requirements on Republic of the Marshall Islands flagged MODUs.[22]

Mobile Offshore Drilling Unit Standards, MI-293, separates MODUs subject to Republic of the Marshall Islands regulation into three categories:

1. MODUs constructed on or after 1 May 1991, which must meet the requirements of the 1989 MODU Code;
2. MODUs constructed on or after 31 December 1981 and prior to 1 May 1991, which must meet the requirements of the 1979 MODU Code; and
3. MODUs constructed before 31 December 1981, which are considered existing units and must meet National Requirements specified in Part V of the Republic of the Marshall Islands Mobile Offshore Drilling Unit Standards.

The first two categories are issued a MODU Safety Certificate in accordance with the applicable version of the MODU Code to which they were certified. Units in the last category are issued a National MODU Document of Compliance. Operators of older units may choose to comply with newer MODU Codes and, if shown to be in

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20 Department of the Interior, Departmental Manual, part 118: Minerals Management Service, Ch. 1: Creation, Objectives, and Functions, 2008 states: "The MMS assesses the nature, extent, recoverability, and value of leasable minerals on and energy-related or other authorized marine-related purposes across the OCS. It ensures the orderly and timely inventory and development—as well as the efficient recovery—of mineral resources and energy-related or other authorized marine-related purposes; encourages use of the best available and safest technology; provides for fair, full, and accurate returns to the Federal Treasury for produced commodities; manages and administers the program for disbursement of coastal impact assistance to qualified recipients; and safeguards against fraud, waste, and abuse. MMS ensures the protection of life, health, and the natural environment in the course of private sector activities on leased Federal OCS lands. It promotes cooperative relationships between the Federal Government, the States, and Indian feeholders, with respect to national, regional, or local issues related to the full scope of its responsibility."

21 Use of an RO requires specific accommodation under the Republic of the Marshall Islands procedures for Alternate Safety Inspection Program, established by the Republic of the Marshall Islands Marine Notice 5-034-2, Alternate Safety Inspection Program.

22 Republic of the Marshall Islands Marine Notice 2-011-9, Mobile Offshore Drilling Units, provides supplemental guidance on the implementation of Republic of the Marshall Islands Mobile Offshore Drilling Unit Standards (MI-293). The Administrator is currently revising Republic of the Marshall Islands Mobile Offshore Drilling Unit Standards (MI-293) to adopt the 2009 MODU Code, which will become effective on 1 January 2012.

compliance, are issued a MODU Safety Certificate according to the applicable MODU Code. In all cases, the certificates are issued to a unit for a period of five years, subject to periodic and renewal surveys, in accordance with the latest MODU Code.

Coastal State

The USCG provides regulatory oversight of the marine operations of all MODUs that operate in US waters and on the US OCS. Before a non-US flagged MODU can operate on the US OCS, it must be deemed equivalent by the USCG to a unit certified in accordance with US standards. Non-US flagged MODUs must comply with a number of US regulations and the regulations of their flag State.

In 2002, the USCG compared the Republic of the Marshall Islands' MODU Standards, MI-293, to the 1979 and 1989 MODU Codes and the US requirements for existing MODUs. The USCG confirmed in a letter dated 9 August 2002 (Annex F)[23] that the Republic of the Marshall Islands standards "provide a level of safety that is generally equivalent to the applicable international and US requirements to operate on the US OCS." Accordingly, the USCG accepts the Republic of the Marshall Islands issued MODU Safety Certificates as evidence of compliance with the 1979 and 1989 MODU Codes and with USCG requirements for MODUs under 33 C.F.R. section 143.207(c) and 33 C.F.R. section 146.205(c). Based on US regulation, and the MOAs between the USCG and MMS, the USCG performs annual inspections on foreign flagged MODUs to ascertain their continued compliance while operating on the US OCS.[24] Based on satisfactory compliance, a Certificate of Compliance is issued by the USCG to the MODU.

ROs

The use of ROs for statutory survey, inspection, and audit work is an internationally recognized system for verifying compliance with international, flag State, and coastal State requirements.[25] SOLAS authorizes flag States to delegate ship inspections and statutory certification surveys to nominated surveyors or ROs, subject to oversight by the flag State.[26] Additionally, the IMO codified the longstanding practice of delegating flag State surveys and inspections to ROs in Resolutions A.739(18) and A.789(19), recognizing that Classification Societies often act as ROs under powers delegated by the flag State to perform technical and survey work. Recognizing this relationship, Resolutions A.739(18) and A.789(19) establish standards for ROs that act on behalf of flag States to conduct vessel examinations, issue international certificates, perform surveys, and determine vessel tonnage.[27]

With respect to MODUs, only those organizations that are members of the International Association of Classification Societies (IACS) are recognized and authorized by the Administrator to act on its behalf as an RO.

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23 USCG Letter, G-MOC Letter 16703, from J. A. Servidio, Commander, USCG, Chief, Office of Compliance.

24 43 U.S.C. § 1348(c) requires that: "The Secretary and the Secretary of the Department in which the Coast Guard is operating shall individually, or jointly if they so agree, promulgate regulations to provide for (1) scheduled onsite inspection, at least once a year, of each facility on the Outer Continental Shelf which is subject to any environmental or safety regulations promulgated pursuant to this subchapter, which inspection shall include all safety equipment designed to prevent or ameliorate blowouts, fires, spillages, or other major accidents; and (2) periodic onsite inspection without advance notice to the operator of such facility to assure compliance with such environmental or safety regulations."

25 To ensure the highest level of expertise and quality in its safety inspection and compliance regime, the Republic of the Marshall Islands has entered into written agreements with Classification Societies as ROs for the performance of surveys, assessments, audits, and inspections and to issue statutory and class certificates to Republic of the Marshall Islands registered vessels, including MODUs.

26 SOLAS, Ch. I, Regulation 6, states: "(a) The inspection and survey of ships, so far as regards the enforcement of the provisions of the present regulations and the granting of exemptions therefrom, shall be carried out by officers of the Administration. The Administration may, however, entrust the inspection and surveys either to surveyors nominated for the purpose or to organizations recognized by it" and that "(c) the Administration shall notify the Organization [IMO] of the specific responsibilities and conditions of the authority delegated to nominated surveyors or recognized organizations."

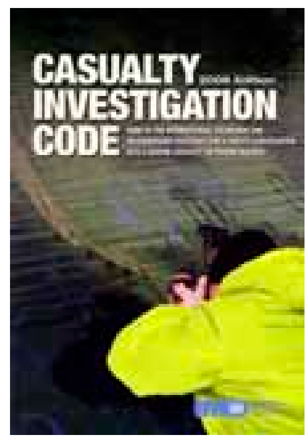
27 Resolution A.739(18), Guidelines for the Authorization of Organizations Acting on Behalf of the Administration, 4 November 1993; Resolution A.789(19), Specifications on the Survey and Certification Functions of Recognized Organizations Acting on Behalf of the Administration, 23 November 1995.

The Administrator has a rigorous oversight program for its ROs and marine inspectors, which has been audited and verified by the IMO under the Voluntary Member State Audit Scheme.

The USCG also utilizes Classification Societies as ROs to perform inspections and surveys on US flagged MODUs operating on the OCS pursuant to the USCG's Alternate Compliance Program (ACP).[28] On 2 November 2004, the USCG published a Notice of Policy stating, "[t]he criteria for classification society approval is based, in part, on the IMO Resolution A.739(18), 'Guidelines for the Authorization of Organizations Acting on Behalf of the Administration.'…[a]fter review and consideration, the [USCG] deems Resolution A.739(18) to provide a sound and internationally recognized standard from which to base the review and approval program required by 46 U.S.C. 3316(c)."[29] On 23 April 2010, three days after the DEEPWATER HORIZON casualty, the USCG and US Department of Homeland Security published a Notice of Proposed Rulemaking again stating that, "the [USCG] deems the [IMO] Resolution A.739(18), 'Guidelines for the Authorization of Organizations Acting on Behalf of the Administration,' to provide sound and international[ly] recognized standard[s] from which to base the [USCG's] review and approval program.…IMO Resolution A.739(18) is consistent with our minimum standards for a recognized classification society in 46 [C.F.R.] Part 8, 'Vessel Inspection Alternatives.'"[30]

CASUALTY INVESTIGATIONS

Further to SOLAS[31] and UNCLOS[32] and pursuant to the Republic of the Marshall Islands Maritime Act and Maritime Regulations, marine casualty investigations shall be conducted "in every instance where a ship documented under the Republic of the Marshall Islands is involved in a serious Marine Casualty or where the [Republic of the Marshall Islands] is conducting…[an] investigation as a substantially interested state."[33]



Under the Casualty Investigation Code, marine casualty investigations are conducted to determine the causal factors of the casualty and to determine what steps may be recommended to prevent similar future casualties or to mitigate their effects, but "do not seek to apportion blame or determine liability."[34]

28 46 U.S.C. § 3316, *et seq*. (2007). "The [USCG's] Alternate Compliance Program (ACP) is one of the most significant regulatory reinvention programs of the 1990s. As contained within Title 46 of the Code of Federal Regulations [C.F.R.], Part 8, Subpart D, the ACP is intended to reduce the regulatory burden on the maritime industry while maintaining existing levels of safety and providing increased flexibility in the construction and operation of U.S. flagged vessels. In this voluntary program, Classification Society Rules, International Conventions, and an approved U.S. Supplement provide an alternative that is equivalent to the [C.F.R.]. Compliance with this equivalent alternative standard is administered through survey and inspection conducted by authorized classification society surveyors. A Certificate of Inspection…is issued by the Coast Guard to a vessel enrolled in the ACP based upon the classification society reports." USCG, US Department of Homeland Security, Alternate Compliance Program (ACP), http://www.uscg.mil/hq/cg5/acp/ (last visited 7/13/2011).

29 69 Fed. Reg. 63548 (2004).

30 75 Fed. Reg. 21213 (2010).

31 SOLAS, Ch. I, Regulation 21 *Casualties*, (a) states: "Each Administration undertakes to conduct an investigation of any casualty occurring to any of its ships subject to the provisions of the present Convention when it judges that such an investigation may assist in determining what changes in the present regulations might be desirable."

32 UNCLOS, Article 94, part 7 states: "Each State shall cause an inquiry to be held…into every marine casualty or incident of navigation on the high seas involving a ship flying its flag and causing loss of life or serious injury to nationals of another state or serious damage to ships or installations of another State or to the marine environment. The flag State and the other State shall co-operate in the conduct of any inquiry held by that other State into any such marine casualty or incident of navigation."

33 Republic of the Marshall Islands Maritime Regulations (MI-108), § 6.38.1(b).

34 Casualty Investigation Code, § 1.1 (2008). The 1989 Casualty Investigation Code was amended in 2008 by IMO Resolution MSC.255(84) which entered into force on 1 January 2010.

Image Courtesy of USCG

THE DEEPWATER HORIZON MARINE CASUALTY INVESTIGATION

FLAG STATE

Pursuant to section 710 of the Republic of the Marshall Islands Maritime Act, the Administrator has conducted an independent flag State marine casualty investigation of the DEEPWATER HORIZON casualty. The investigation fulfills the Republic of the Marshall Islands' obligations as a flag State under UNCLOS, SOLAS, and the Casualty Investigation Code.[35]

The Administrator began the investigation into the DEEPWATER HORIZON casualty on 21 April 2010. The primary purpose of the Administrator's investigation was: to determine, as closely as possible, the cause of or any contributing factors to the casualty; whether there was any act of misconduct, inattention to duty, or negligence on the part of any Republic of the Marshall Islands certificated person; any violation of law or regulation; to identify

35 UNCLOS, Article 94, § 7; SOLAS, Reg. I/21; Casualty Investigation Code, Ch. 1, 6, 7.

marine safety issues that may or may not have contributed to the casualty; and where appropriate, recommend actions to be taken based on the investigation results that will improve the safety of MODUs and personnel.[36] Findings, conclusions, and recommendations are based on information developed through the Administrator's independent investigative efforts and on documentary evidence and testimony presented at the Joint Investigation hearings. The Administrator's independent investigation included review and analysis of the Administrator's records for the Unit, participation in the examination of the BOP and the Remotely Operated Vehicle (ROV) examination of the Unit, interviews with representatives of Transocean's technical and safety management staff, as well as interviews with technical experts from American Bureau of Shipping (ABS), Det Norske Veritas (DNV), Wärtsilä North America, Inc., and Kongsberg Maritime, Inc.

As part of the flag State investigation, the Republic of the Marshall Islands engaged experts to assist in the understanding of the sequence of events leading to the loss of well control and to attempt to ascertain the possible sources of ignition that initiated the explosions and fire. The resulting Fire Origin Report and Well Control Report may be found in their entirety at Annexes B and C, respectively. The Administrator has determined that these reports are unbiased, credible, and reliable and, therefore, adopts their findings and conclusions and has incorporated the key findings and conclusions into this Report.

COASTAL STATE

On 27 April 2010, the US Department of the Interior and the US Department of Homeland Security issued a joint Convening Order,[37] formally directing the USCG and MMS to conduct a joint investigation pursuant to the powers granted under OCSLA, and in accordance with the process for conducting investigations pursuant to the MMS/USCG MOA: OCS-05,[38] dated 27 March 2009.[39] The Convening Order directed the Joint Investigation team to issue a single report containing "the evidence adduced, the facts established thereby, and its conclusions and recommendations" within nine months of the date of the Convening Order.

The USCG released its half of the report on 22 April 2011 regarding the aspects of the casualty related to marine operations, which is preliminary until final action is taken by the USCG Commandant.[40] The second half of the report and final agency action is unpublished as of the date of this Report.

JOINT INVESTIGATION

In accordance with section 2.20.1 and Chapter 7 of the Casualty Investigation Code, the Administrator participated in the proceedings of the Joint Investigation as a Substantially Interested State.[41] The Administrator committed to working with the Joint Investigation team in order to identify the causal factors of this very serious marine

36 Republic of the Marshall Islands Maritime Regulations (MI-108), § 6.38.2(a).

37 Joint Department of the Interior and Department of Homeland Security Statement of Principles and Convening Order Regarding Investigation Into the Marine Casualty, Explosion, Fire, Pollution, and Sinking of Mobile Offshore Drilling Unit Deepwater Horizon, with Loss of Life in the Gulf of Mexico 21-22 April 2010 ("Convening Order").

38 Convening Order at 1 stating "As set forth in the MOA [MMS/USCG MOA: OCS-05], the MMS investigates incidents associated with, *inter alia*, exploration and drilling operations for hydrocarbons on the OCS, and the USCG investigations, *inter alia*, deaths, injuries, property loss, and environmental damage arising from such incidents."

39 The US notified the IMO on 29 June 2009 by US Embassy Note Verbale, reference number 055, that "the Government of the United States of America objects to the amendments [adopted by MSC.257(84) which made parts I and II of the Casualty Investigation Code mandatory] because, in its opinion, certain provisions of the Code do not directly promote maritime safety and conflict with important aspects of [US] domestic law and practice."

40 USCG Report of Investigation into the Circumstances Surrounding the Explosion, Fire, Sinking and Loss of Eleven Crew Members Aboard the Mobile Offshore Drilling Unit DEEPWATER HORIZON in the Gulf of Mexico April 20-22, 2010.

41 Casualty Investigation Code, § 2.20.1 states: "*Substantially Interested State* means a State…which is the flag State of a ship involved in a marine casualty or marine incident…."

casualty, the consequences of the casualty, and any related changes to regulatory regimes or management practices that could help prevent or mitigate the effects of marine casualties and incidents of a similar nature in the future.

The Joint Investigation team recognized the Republic of the Marshall Islands as a Substantially Interested State.[42] Despite this recognition, the Administrator was not provided timely access to all of the investigation materials held by the Joint Investigation team, nor was it provided a similar ability as the coastal State to follow-up with the questioning of witnesses. While the Casualty Investigation Code investigation process was designed to be collaborative and cooperative, implementation in this instance by the Joint Investigation team was inconsistent.

42 5/26/10 Marine Board of Investigation Transcript (MBI Tr.) at 6-7 (Nguyen). "Since the DEEPWATER HORIZON was flagged under Marshall Islands, Marshall Islands has been designated as a substantially interested state."

Image Courtesy of Transocean

PART 1: BACKGROUND OF THE CASUALTY

VESSEL PARTICULARS[43]

1.1 The DEEPWATER HORIZON was registered in the Republic of the Marshall Islands as a MODU on 29 December 2004; from the time of its construction until that date, it had been registered in the Republic of Panama. At the time of the casualty, the Unit was current on all of its required flag State inspections and certifications and possessed all requisite international, flag State, and coastal State documents of compliance.

1.2 At the time of the casualty, the registered owner of the DEEPWATER HORIZON was Triton Asset Leasing GmbH; the Unit was operated by Transocean Offshore Deepwater Drilling Inc. (hereinafter, "Transocean") for BP Exploration & Production Inc. (hereinafter, "BP"), which acquired the lease to the

43 General arrangement diagrams of the DEEPWATER HORIZON may be found at Annex H.

VESSEL PARTICULARS

Vessel Name
DEEPWATER HORIZON

Registered Owner
Triton Asset Leasing, GmbH

Operator
Transocean Offshore Deepwater Drilling Inc.

Charterer
BP Exploration & Production Inc.

Flag State
Republic of the Marshall Islands

IMO No.
8764597

Official No.
2213

Vessel Type
Self-propelled, dynamic positioned, semi-submersible, column stabilized MODU

Built By
Hyundai Heavy Industries Co., Ltd.

Date of Build
21 March 2000

Call Sign
V7HC9

Length
114.0 m

Breadth
78.0 m

Gross Tonnage
32,588 tons

Engine Power
43,740 kW

Classification Society
American Bureau of Shipping

Classification
✠A1, Column Stabilized Drilling Unit; ✠AMS; ✠ACCU; ✠DPS-3

Persons Onboard
126

Location at Time of Casualty
Macondo well
28.7 N 88.4 W
Mississippi Canyon Block 252
OCS-G 32306 #1

Mississippi Canyon Block 252, including the Macondo well on 19 March 2008;[44] and operating on the US OCS.

1.3 The DEEPWATER HORIZON was a self-propelled, dynamically positioned[45] semi-submersible,[46] column stabilized MODU built for R&B Falcon Drilling Co. by Hyundai Heavy Industries Co., Ltd. (Ulsan, South Korea) in 2000. The DEEPWATER HORIZON was built in accordance with the 1989 MODU Code; the ABS Rules for the Building and Classing of Mobile Offshore Drilling Units, 1997; the International Convention on Load Lines, 1966, regulation 10(2), Annex 1; and USCG requirements, as the DEEPWATER HORIZON was originally intended to be registered in the US.[47]

1.4 ABS[48] was the classification society for statutory, survey, inspection, and certification of the DEEPWATER HORIZON. ABS classified and certified the DEEPWATER HORIZON as an ✠A1, Column Stabilized Drilling Unit, ✠AMS, ✠ACCU, ✠DPS-3 (the highest rating for dynamically positioned vessels).

1.5 The DEEPWATER HORIZON was certified under the International Safety Management (ISM) Code and the International Ship and Port Facility Security (ISPS) Code by DNV[49] on behalf of the Republic of the Marshall Islands. The Unit maintained ISM and ISPS Code certification the entire time it was registered under the Republic of the Marshall Islands flag.

44 MODUs are most often contracted by entities that own or have rights to drill on a coastal State's OCS.

45 Dynamic positioning is a method of maintaining position over the well by underwater thrusters, guided by computer-controlled global positioning systems, rather than by a fixed mooring system.

46 Semi-submersible units are kept afloat and upright by watertight pontoons located below the surface of the water, and are usually used in water depths greater than 200 m where bottom-bearing units are not practical.

47 Drilling Contract RBS-8D, Semisubmersible Drilling Unit, Contract No. 980249 dated December 9, 1998, Exhibit B-1 at 6 (TRN-USCG_MMS-00040537).

48 "Founded in 1862, ABS is a leading international Classification Society devoted to promoting the security of life, property and the marine environment through the development and verification of standards for the design, construction and operational maintenance of marine related facilities," http://www.dnv.com/moreondnv/profile/about_us/ (last visited 08/15/2011).

49 "DNV is an independent foundation with the purpose of safeguarding life, property, and the environment. [DNV's] history goes back to 1864, when the foundation was established in Norway to inspect and evaluate the technical condition of Norwegian merchant vessels," http://www.eagle.org/eagleExternalPortalWEB/appmanager/absEagle/absEagleDesktop?_nfpb=true&_pageLabel=abs_eagle_portal_our_mission_page (last visited 08/15/2011).

1.6 The DEEPWATER HORIZON was capable of operating in harsh environments and drilling "up to 35,000 ft [10,670 m] at a water depth of 10,000 ft [3,048 m]."[50] While drilling the Macondo well, the DEEPWATER HORIZON was operating in just over 4,900 ft (1,500 m) of water. The upper deck area of the DEEPWATER HORIZON was 53,506.74 sq ft in area (approximately 1.2 acres). The Unit was designed to function 24 hours a day while drilling with its crew operating the complex drilling machinery, propulsion equipment, and hotel services on a 12-hour-on and 12-hour-off basis. Individual crew members normally worked for 21-days-on and 21-days-off.

VESSEL SYSTEMS[51]

Dynamic Positioning

1.7 Dynamic positioning is a computer-controlled system to automatically maintain a vessel's position and heading by using its own propulsion mechanism. The DEEPWATER HORIZON was propelled and kept on station by means of eight 5,500 kW azimuthing thrusters. The thrusters were controlled by the Simrad Dynamic Positioning System which was classified to ABS ✠DPS-3 requirements. These are defined as the ability to maintain position after the failure of any single system or component including the loss of any compartment due to fire or flooding. The Simrad Dynamic Positioning System functions were divided into a manual function and several automatic functions.[52] Those functions could be selected at the Simrad Dynamic Positioning System panel, but the automatic functions required that at least one position reference system had been selected by the operator and accepted by the Simrad Dynamic Positioning System. It was possible to use the Simrad Dynamic Positioning System in a semi-automatic function, which was a combination of manual, semi-automatic, or automatic function.

- Manual Function: By selecting this function, the operator could control the Unit manually by using the axis joystick and rotate controller located at the Simrad Dynamic Positioning System panel. The operator could select automatic heading control when the gyrocompass was in use.
- Semi-Automatic Function: This was a combination of manual and automatic functions and required a positioning reference system in use. The operator could freely select automatic control in any of the three axis of freedom by using the surge, sway, and yaw buttons. When automatic control in all three axis was selected, the system would automatically switch over to automatic function.
- Automatic Function: When a positioning reference system was in use, the operator could select the automatic function and the Simrad Dynamic Positioning System would control the position and heading of the Unit. The operator could then select a new position and heading for the Unit.

50 DEEPWATER HORIZON Operations Manual, Vol. 1, § 3.2.1 (BP-HZN-MBI-00011607).

51 This section contains general descriptions and capacities of the various vessel systems onboard the DEEPWATER HORIZON and is based on the following: DEEPWATER HORIZON Operations Manual (BP-HZN-MBI-00011533- BP-HZN-MBI00012679); Operator Manual, Kongsberg Simrad SSS Fire and Gas System (TRN-HCEC-00101093-00101202); Kongsberg Safety System Design Philosophy RBS8D Project "Deepwater Horizon" (KMI_PI 001156-1172); Functional Design Specifications, Kongsberg Fire & Gas Systems (KMI_PI 000173-230); Functional Design Specifications, Emergency Shutdown System (KMI_PI 000231-280); Kongsberg ESD Operator Manual (KMI_PI 000138-172); Interview with Bob Miller, Wärtsilä North America, Inc., 16 November 2010; Report of Interview with Jan Simonsen, Kongsberg Maritime, Inc., 16 November 2010; and other documents and plans to which the Administrator had access as well as interviews and testimony taken as part of the Joint Investigation. The vessel systems described herein do not reflect undocumented changes or documented changes to which the Administrator did not have access.

52 Position reference inputs provide information to the computer about the Unit's position and the amount and direction of environmental forces affecting its position. On the DEEPWATER HORIZON, the system consisted of a triple redundant dynamic positioning system and had inputs from transponders placed on the seabed, four different Differential Global Positioning Satellite sources, three gyrocompasses, three vertical reference units, and three wind sensors, as well as operator input.

Bilge and Ballast

1.8 The DEEPWATER HORIZON had four ballast pumps, one located in each lower pump room. When de-ballasting, the ballast pumps took suction from the ballast tanks and discharged overboard through the side shell or, when taking on ballast, took suction from their respective sea chests and discharged into the ballast tanks. Pumps were interconnected to headers which allowed any pump to fill or empty any ballast tank. They could be operated from the local ballast control panels or from the Kongsberg Integrated Automation and Control System (KIACS) in either the Command Control or Engine Control Rooms.

1.9 The ballast system was also interconnected with the seawater service, bilge, and drill water systems. The ballast pump could also act as an emergency bilge pump for the respective pump rooms.

1.10 All ballast tanks were isolated from the main header by remotely operated (hydraulic) valves. The valves could be operated from the local ballast control panel or the KIACS. They were fitted with position indicators, indicating at each control location. The pumps and valves all had the capability of local operation. Each tank was furnished with a remote reading level gauge at each of the operating locations.

1.11 The ballast system also included stripping pumps. All pumps were furnished with local and remote pressure gauges indicating pressure at the suction and discharge flanges.

1.12 The DEEPWATER HORIZON had four bilge pumps, one located in each lower pump room. The discharge from the bilge pumps was routed to the bilge holding tanks located in the aft pump rooms, and then sent for further processing in the oily water separator. Permanently installed bilge lines were located in the stairwells, elevator and utility trunks, access tunnels, pump rooms, thruster rooms, all levels in each of the columns, and all void spaces in the pontoons. An independent bilge pump suction line, connected directly to the pump section, was provided for each pump room. Each bilge line was furnished with a screw down check valve in a remotely operated (hydraulic) valve. The valves could be operated from a local ballast control panel or the KIACS. Each valve was equipped with position indicators at the control locations and all pumps and valves could be operated locally, if needed. Each space with bilge suction had a level switch to alert the operator. The alarms were sounded at the local ballast control panel and the KIACS. The pump in each thruster room was furnished with two pairs of level indicating switches. Level switches were fitted into each of the 12 compartments of the double bottom spaces of each pontoon. These double bottom spaces did not have permanent bilge suctions and were pumped utilizing portable pumps.

Communications

1.13 The DEEPWATER HORIZON was equipped with the required Global Maritime Distress and Safety System (GMDSS) equipment for service in sea areas A1, A2, and A3. The Unit was operating in sea area A3.[53] Radio communications equipment on the Unit included: very high frequency (VHF) radio, medium frequency (MF) radio fitted with digital selective calling (DSC), satellite communications systems, and a satellite Emergency Position Indicating Radio Beacon (EPIRB).[54] These systems were intended to

53 SOLAS, Ch. IV, Reg. 2, § 1.14 states, "*Sea area A3* means an area, excluding sea areas A1 and A2, within the coverage of an Inmarsat geostationary satellite in which continuous alerting is available."

54 A Republic of the Marshall Islands Radio Station License, valid for four years, was issued to DEEPWATER HORIZON, 17 December 2009; DEEPWATER

enable the Unit to transmit and receive safety and emergency related information with coastal stations as well as other vessels.

1.14 The DEEPWATER HORIZON's internal communication systems included two sound powered telephone systems, a telephone system, and a public address system.[55] In the event of a loss of electrical power from the 480 v main ring bus distribution system, there was a source of transitional power for the radio communication equipment and the Public Address/General Alarm system.[56] The transitional power source would provide power until power to the 480 v main ring bus distribution system was restored. In addition, these systems could receive power from the standby generator.[57]

Subdivision and Stability

1.15 The intact and damage stability of the DEEPWATER HORIZON was classed by ABS for operation in the Gulf of Mexico and for operation in the North Sea under the United Kingdom Health and Safety Executive Rules. The design document "RBS8D Stability Analysis," referenced in the Unit's Operations Manual, contained detailed stability calculations and information used to calculate day-to-day stability on the DEEPWATER HORIZON. This information included:

- hydrostatic properties;
- location of down flooding points;
- intact and damage stability criteria for area of operation;
- results of intact stability analysis; and
- typical loading conditions.

1.16 The routine stability calculations are based on parameters established during the original construction of the Unit. It is therefore critical that substantial weight changes and significant modifications be accounted for throughout the life of a MODU. Accordingly, the 1989 MODU Code states that a deadweight survey should be conducted on column-stabilized units at five year intervals. Should the deadweight survey indicate a change from the calculated light ship displacement greater than 1% of the operating displacement, an inclining test would then be conducted. On 8-9 June 2006, a Deadweight Survey was conducted by Noble Denton Consultants in accordance with an ABS approved procedure and to the satisfaction of the attending ABS surveyor.

Structural Fire Protection

1.17 The DEEPWATER HORIZON was designed to comply with the 1989 MODU Code and met the requirements concerning utilization of non-combustible construction. The design philosophy segregates spaces by relative fire hazard potential and provides time barriers against thermal spread of fire both vertically and horizontally by means of bulkhead integrity and insulation value. Separation of spaces by A, B, or C class bulkheads were appropriately insulated where required.

1.18 The system utilized a comprehensive set of design measures to incorporate the required structural

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HORIZON Operations Manual, Vol. I, § 9.3.2 (BP-HZN-MBI00012070–12071).

55 DEEPWATER HORIZON Operations Manual, Vol. I, § 9.3.6 (BP-HZN-MBI00012073–12076).

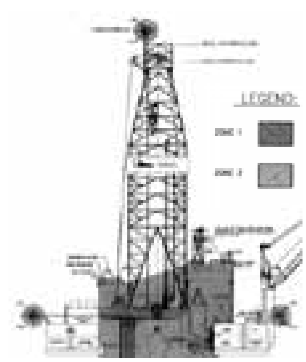
56 DEEPWATER HORIZON Operations Manual, Vol. I, § 8.1.5 (BP-HZN-MBI0011871).

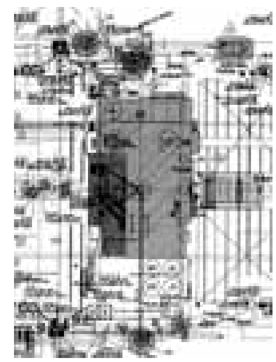
57 DEEPWATER HORIZON Operations Manual, Vol. I, §§ 8.1.2, 8.1.3 (BP-HZN-MBI00011868-11870).

fire protection which consisted of a combination of passive (noncombustible construction) and active systems (sprinklers in the accommodation spaces).

Hazardous Locations

1.19 Hazardous locations are those areas where a potential for fire and explosion may exist because of the possible presence of flammable gases and/or vapors. The DEEPWATER HORIZON was built, and spaces classified, in accordance with Chapter 6 of the 1989 MODU Code. Spaces on the DEEPWATER HORIZON were divided and identified as classified or unclassified based on the probability or possibility of the space containing an explosive gas/air mixture. The amount and classification of any electrical equipment or machinery allowed in these spaces is then specified in accordance with hazard level to mitigate possible ignition sources. Only those industrial areas where gas would normally be present were classified as hazardous.





Machinery and Electrical Power, and Protection Devices

1.20 Electrical power for all services on the DEEPWATER HORIZON was provided by six Wärtsilä Vasa 32 engines connected to six ABB AMG 0900 alternating current (AC) generators. Power could be supplied by a single or multiple generators, depending upon the load, and generators were capable of being started and stopped by the automation system as operations changed. The Wärtsilä Vasa 32 engines were medium speed diesel engines that operated at 720 RPM; they were rated to produce 7,290 kW. The engines were designed to run on heavy fuel oil or diesel fuel. The ABB AMG 0900 AC generators were rated to produce 7,000 kW of power at 11 kV. Each engine/generator set was mounted on a common base and foundation and was installed in a separate engine room. Ship service power was distributed through four transformers (11 kV:480 v). Engine auxiliaries, thrusters, and industrial (drilling) loads were supplied by separate transformers.

1.21 Each engine was fitted with a fuel oil pump for each cylinder, a lube oil pump, and a cooling water pump. These pumps were mechanically driven and would operate while the engine was running. Each engine was also fitted with an electrically driven pre-lube pump, which was designed to circulate lubricating oil continuously through the engine so that it would be ready to be started automatically.

1.22 The start air system included two air tanks, with one tank per three engines. The air from this system was also used to provide control air. The operating pressure of this system was 30-32 bar. Each engine was also fitted with a dedicated air receiver that was kept continuously charged by the start air system. The purpose of the air in this receiver was for shutting the engine down by stopping the cylinder fuel oil pumps and activating the solenoid to close the charge air damper. These air receivers were configured to auto-drain any condensed water on engine start up.

1.23 Each of the engines drew their combustion air from the air inside the engine room in which it was

mounted. The air intakes for the engine rooms were fitted with ventilation dampers. The dampers were held open pneumatically using air from the engine start air tanks. The dampers used springs to close so that in the event of a loss of air pressure the louvers would close. The electric control signal for the ventilation dampers was provided by the Unit's automated control system.

1.24 Each engine was fitted with two turbochargers. The exhaust was routed from the turbochargers through exhaust pipes that led to exhaust gas silencers and spark arrestors. The engine exhausts were located on the aft end of the DEEPWATER HORIZON. The exhaust temperature when it entered the turbochargers was 380° C at 30-40% load and 500° C at 100% load. The exhaust temperature after passing through the turbochargers was approximately 100° C lower than when it entered the turbochargers. The exhaust pressure when the engines were running at 30% load would be approximately 1.5 bar and at 100% load approximately 2-2.5 bar. At 100% load, the Vasa 32 required approximately 15 kg of combustion air per second.[58]

1.25 Fuel for the main engines was delivered to the Unit's eight diesel oil storage tanks through a deck filling line. Four rotary diesel oil transfer pumps, two located in each fuel oil pump room, moved the fuel from the storage tanks and into the settling tanks or day tanks. Each pump was rated to supply enough fuel oil for three engines at full capacity. Therefore, two pumps running in parallel could supply engine required fuel in order to meet ABS ✠DPS-3 requirement and the 1989 MODU Code emergency power requirements. Fuel oil purifiers, one settling tank and one service tank were located at each side of the Unit on the third deck.

1.26 Each engine was fitted with two electronic systems that, among other functions, provided overspeed protection, a Diesel Engine Speed Measuring System (DESPEMES), and a Woodward 723 Plus solid state speed and load controller system.[59] Each engine was also fitted with a mechanical overspeed protection device. These overspeed devices were set to shut the engines down at the following limits:

- DESPEMES — 13% over normal operating speed;
- Woodward 723 — 15% over normal operating speed; and
- Mechanical device — 18% over normal operating speed.

1.27 The DESPEMES would initiate a shutdown of an engine in an overspeed condition by sending a low voltage signal to the KIACS.[60] The engine would stop within seconds after an overspeed device, electronic or mechanical, was activated. The DESPEMES monitored engine speed using a low voltage signal generated by pickups on the engine shaft. The KIACS was configured to send an emergency shutdown signal to the associated stop solenoids on the engine. These solenoids would then trigger the electro-pneumatic overspeed devices on each cylinder's fuel injection pump as well as activate the charge air cut-off valves mounted in the engine air intake system. The DESPEMES power supply was provided by a 24 v direct current system that had a battery backup. The KIACS would display an alarm if the DESPEMES lost the speed signal from the engine.

58 Interview with Bob Miller, Wärtsilä North America, Inc., 16 November 2010.

59 The Woodward 723 was hard wired to a Woodward PG-EG proportional throttle governor/actuator (Woodward PG-EG), which is physically located on the engine and controls the fuel rack position.

60 The KIACS is frequently referred to as the SIMRAD.

1.28 In the event of an overspeed, the Woodward 723 was programmed to send an electric signal to a Woodward PG-EG proportional throttle governor/actuator mounted on the engine to move the fuel rack to zero. It was also programmed to send a signal to the KIACS, alerting it to the overspeed condition. The Woodward 723 was fitted with two magnetic pickups mounted on the engine shaft to measure engine speed. These pickups were not the same ones used by the DESPEMES. The Woodward 723 was designed to shut the engine down if the speed signal from the engine was lost. The Woodward 723 received power from a 24 v direct current system that had battery backup.

1.29 The mechanical overspeed device would automatically stop the engine independent of the DESPEMES and the Woodward 723. The mechanical overspeed trip device was a centrifugal force tripping mechanism that was fastened to the engine camshaft that did not require an external power source in order to operate. When tripped, the entire fuel rack would be mechanically moved to zero. Provided power was available, an electrical signal would then be sent to the KIACS notifying it of the shutdown. The mechanical overspeed device did not require electrical power to operate and in the event that both electrical overspeed protection systems failed, the mechanical system would still be operational.[61]

1.30 The generators and switchboard connected to the Vasa 32 engines had an independent safety system that protected it against engine overspeed. This system monitored various generator conditions, and its protective devices would trigger if the generator's frequency exceeded a certain set point. If generator frequency was too high, or low, a breaker would trip and disconnect the generator from the electrical system.

Emergency Power

1.31 The DEEPWATER HORIZON did not have a dedicated emergency generator, but was arranged to provide emergency power with its main generators in accordance with section 5.3.5 of the 1989 MODU Code. Pursuant to section 5.3.5, a separate emergency generator is not required on "units where the main source of electrical power is located in two or more spaces which have their own systems, including power distribution and control systems, completely independent of the systems in the other spaces and such that a fire or casualty in one of the spaces will not affect the power distribution of the others…."[62] Although not required, an additional 400 kW diesel powered standby generator was also provided. It was designed and configured to start automatically in the event that the electrical power was out for more than 10 seconds.

Battery Backup

1.32 Should main, emergency, and standby power fail, lighting and power was to be maintained for essential locations throughout the Unit by battery powered backup in addition to lighting normally powered by the emergency system. This essential power and lighting by backup power was designed to last approximately 1.5 hours. This essential power and lighting was provided for the:

- lifeboat embarkation areas;
- drilling control systems;

61 Interview with Bob Miller, Wärtsilä North America, Inc., 16 November 2010.

62 1989 MODU Code, § 5.3.5.

- radio communications equipment;
- BOP system;
- Fire and Gas (F&G) Detection and Alarm System (F&G System);
- Emergency Shutdown (ESD);
- KIACS system;
- warning horns;
- thruster control;
- Public Address/General Alarm; and
- electrical distribution control gear.

F&G System

1.33 The Unit was equipped with an F&G System, approved in accordance with the 1989 MODU Code. The F&G System was powered by main and emergency power as well as a transitional power source (battery).

1.34 The fire component of the F&G System was installed with a combination of manual alarm stations and heat, smoke, and flame detectors located throughout the Unit. Fire detection included detectors of a type appropriate to space protected and manual pull stations. The manual stations, smoke detectors, and heat detectors were of the individually addressable type, and arranged in loops connected to a fire alarm panel. Each compartment or space on the Unit was an independent fire zone/area to allow quick identification of the alarm point.

1.35 Fire detector alarm response was initiated according to a set of pre-designated responses. Normally, a fire alarm would be acknowledged by the Central Control Room Watchstander, the Dynamic Positioning Officer, under the direction of the Officer in Charge, who would then direct other personnel to respond to the alarm or to investigate the cause of an alarm and report on the situation. Based on information received by the Dynamic Positioning Officer or the Officer in Charge, subsequent alarms could be manually issued and ESD actions could be initiated or inhibited. Audible and visual alarms could be issued automatically or manually in accordance with pre-designated responses. A detailed matrix of responses to alarms or other conditions was established in the Safety System Cause and Effects Table (C&E Table) for the Unit. This document established the monitoring and control logic for each space on the Unit and for all alarm conditions.

1.36 The gas component of the F&G System consisted of both combustible gas and toxic gas detectors installed at various locations throughout the Unit. These detectors were monitored by the F&G detection portion of the Safety System. Gas detectors were located along the drilling mud path and in other locations where gas could have been expected to appear as a result of drilling activities or where the presence or accumulation of gas posed exceptional risk. Combustible gas detectors were located on the compartment overhead to detect gasses normally lighter than air and toxic gas detectors located near the compartment deck to detect hydrogen sulfide, which is heavier than air. The F&G System and the Unit's KIACS were connected to the Safety System network and the separate dual redundant KIACS network. This communicated information regarding the gas detectors' status, including Trouble, Alarm, and High Alarm conditions. The data was displayed graphically and in tabular form on the KIACS consoles. The

location and severity of the gas alarm was presented as an alarm banner at the top of the control screens. All gas alarm events were automatically logged in the KIACS history.

1.37 Gas detector alarm response would have been in accordance with the established C&E Table of responses. Activation of a gas detector would result in immediate audible and visual alarms in the Engine Control Room and Drilling Work Station. Alarms were to be acknowledged from the Drilling Work Station or the alternate stations if the Drilling Work Station was inaccessible. Gas alarms would have been acknowledged by the Driller, who may direct other personnel to investigate and report, based on the location and severity of the gas alarm. Based on the reports received by the Driller, subsequent alarms, including the General Alarm would have been manually activated.

Ventilation Control

1.38 Ventilation shutdowns would have been affected by group or individual output points in the F&G System. These circuits would be normally de-energized 120 v AC output circuits (with line monitoring) connected to interposing relays in the applicable motor starter or control panel. All control power for these circuits would have been derived within the F&G System. Fire dampers were fail-safe, spring closed, and pneumatically opened. The fire dampers could be opened by unit air pressure, applied through normally energized solenoid valves with 120 v AC coils, which in turn were connected to normally energized output points in the F&G System. All control power for these circuits was derived within the F&G System.

1.39 For the accommodation spaces, the heating, ventilation, and air conditioning (HVAC) fresh air intakes and exhaust outlets were fitted with automatic fire dampers. The F&G System was designed to close these dampers, and turn off the fans and blowers in the event of fire or gas being detected.

1.40 For the engine spaces, supply fresh air intakes and exhaust outlets were fitted with fire dampers which could be actuated manually or automatically. Automatic actuation was controlled by a signal from the KIACS that closed the dampers based on the logic described in the C&E Table. Consistent with the dynamic positioning design philosophy, the dampers were not programmed to close on high gas conditions which could risk losing power to other vital systems.[63]

Emergency Alarms

1.41 The Safety System and the Public Address/General Alarm system included provisions to periodically test the visual and audible alarms. Additionally, the systems included provisions to suppress all alarms during tests or system maintenance. Alarm suppression was controlled by a key-operated switch, and generated a recurring alarm in the KIACS system as long as the audible and visual alarms were suppressed.

1.42 The Unit had an integrated visual and audible alarm system to communicate emergency conditions to all appropriate personnel, regardless of background conditions. Visual and audible alarm enunciators were located in all machinery, shop, working, office, storage, and accommodations areas of the Unit.

1.43 Audible alarms were generated by the Unit's Public Address/General Alarm system, and consisted of separate sounds for Abandon Unit, Fire and General Alarm, Combustible Gas, and Toxic Gas. The Public

63 Safety System Design Philosophy RBS8D Project "Deepwater Horizon" KMI_PI 001168 at 13.

Address/General Alarm system had sufficient amplifiers and speakers so that all alarms were audible in all normally manned and unmanned spaces. Audible alarm tones or sounds were:

- Abandon Unit — equivalent to the continuous sounding of a bell;
- Fire and General Alarm — equivalent to the intermittent sounding of a bell;
- Combustible Gas — continuous alarm tone; and
- Toxic Gas — warble tone.

1.44 Visual alarms were located so that they were visible under normal ambient light levels, and designed to be visible from all working areas, particularly high noise areas such as engine rooms, pump rooms, compressor rooms, and others. Visual alarms consisted of individual high intensity strobe lights for areas outside of the accommodations block. Within the accommodations block, visual alarms consisted of strobe lights arranged in signal columns. The signal columns were located at each end of the transverse and longitudinal corridors, visible from the doorway of each office, recreation room, stateroom, common use room, and the hospital. Additional signal columns were located inside the mess room and other common use rooms such as the cinema, recreation rooms, and gymnasium. Visual alarms were as follows:

- Fire or General Alarm — Red;
- Combustible Gas — Blue;
- Toxic Gas — Yellow or Amber; and
- Carbon Dioxide (CO_2) Fire Extinguishing Agent Release — White or Clear.

1.45 The F&G System was equipped with the ability to automatically sound the General Alarm in the event of system response to an alarm condition. This automatic function of sounding the General Alarm was not utilized and the system was set to only sound when manually operated. Some Administrations, including the USCG,[64] have considered it more desirable and safer to have the General Alarm only sounded manually, initiated from a continually manned space such as the Bridge or other Control Room, to provide the crew on watch with the opportunity to further investigate the actual alarm condition and determine the proper course of action before alerting crew or passengers.

ESD

1.46 The overall Safety System also included an independent ESD. The main objective of the ESD was to minimize the consequences of an emergency situation related to uncontrolled release of hydrocarbons or outbreak of fire. It was a fully dual redundant computer system with fault monitoring. The ESD was, under normal working conditions, not dependent on any other computer system. The ESD system processed input signals from manual shutdown stations, level switches and the F&G System. The functions provided by the ESD were, in addition to the alarm and HVAC shutdown systems, provided as a part of the F&G System to control fire and gas incidents. Other machinery shutdowns included in the Simrad Vessel Control and Simrad Dynamic Positioning System portions of the KIACS. The centralized portion of the ESD was located in the starboard process equipment room, adjacent (aft) to the command control room. The F&G System was interfaced with the ESD to allow operation of certain

64 USCG, COMDTINST M16000.9, MARINE SAFETY MANUAL, VOLUME IV – TECHNICAL, 3.G.20.b: "...The General Alarm must only be initiated manually and is intended to be sounded by the person on watch or other responsible member of the crew only after the determination has been made that an emergency situation exists which warrants mustering the crew and passengers (if any). SOLAS II-2 Regulation 13.1.4 permits the General Alarm to be sounded automatically by a safety monitoring system, such as a fire detection and alarm system, if an initiating fire alarm is not acknowledged within a reasonable time (two minutes). This is permitted for spaces other than passenger spaces."

HVAC shutdown or fire damper control functions from the ESD. Remote ESD stations were combined with the F&G control panels, providing the Unit's crew with a quick summary of the nature and location of the safety event and the means to effect any ESD action(s). Remote ESD stations consisted of a series of pushbuttons that were hard-wired to provide the functions listed in the Unit's C&E Table. ESD pushbutton wiring was normally de-energized with line monitoring to protect against line break, short circuit, or ground fault. Additionally, the ESD could be controlled from any Safety System console of the KIACS. Although password protection was available for the system a password was not required to operate any of the ESD functions on the DEEPWATER HORIZON.

1.47 It is important to note that the ESD responses on a dynamically positioned unit are different from the ESD philosophy employed on units that are not dynamically positioned. On a dynamically positioned unit, there is generally not a single top shutdown level that stops all engines and disconnects all possible sources of ignition in the case of an event such as an uncontrolled well blowout. Instead of this type of shutdown, a dynamically positioned unit is intended to perform an emergency disconnect from the wellhead and escape the hazardous area.

1.48 The ESD was divided into four levels of operation to form the shutdown hierarchy representing a staged response to increasing levels of hazard. ESD levels 1, 2, and 3 are divided into sub-shutdown levels. Level 4 is not broken into sub-shutdown levels.

- *ESD 1-1 to 1-7 — Engine Room Shutdown*. This was the highest shutdown level, though there was not a single top level shutdown level that stopped all engines and disconnected all possible sources of ignition in case of emergency. The intent for ESD 1-1 to 1-7, upon activation, was to ensure that the Unit's power plants were shutdown. These shutdowns were manual activation only from push buttons, which were marked and protected against undesirable operation, located in the:
    - Central Control Room matrix panel;
    - Engine Control Room matrix panel; and
    - Drilling Work Station matrix panel.
- *ESD 2-1 to 2-8 — Propulsion Shutdown*. This was the second highest shutdown level, and it shutdown all thrusters on the Unit. There were also individual shutdowns for each of the eight thrusters (ESD 2-1 to 2-8). The intent for ESD 2-1 to 2-8, upon activation, was to ensure that the Unit's propulsion systems were shutdown. These shutdowns were manual activation only, from pushbuttons located in the:
    - Central Control Room matrix panel;
    - Engine Control Room matrix panel; and
    - Drilling Work Station matrix panel.
- *ESD 3-1 to 3-11 — HVAC Shutdown*. This shutdown level was designed to shutdown HVAC on the Unit. There were also individual shutdowns for HVAC sections ESD 3-1 to 3-11. The intent for ESD 3 and 3-1 to 3-11, upon activation, was to ensure that the Unit's HVAC systems were in a safe position, based on the indicated conditions. Some of these shutdowns were only

possible to activate in a combination with a confirmed fire signal from the F&G System. These shutdowns were manual activation only from pushbuttons located in the:

- Central Control Room matrix panel;
- Engine Control Room matrix panel; and
- Drilling Work Station matrix panel.

- *ESD 4 – Drill Floor Shutdown*. This shutdown level was designed to shutdown drilling transformers and other drilling equipment. The intent for ESD 4 was to ensure that the Unit's drilling equipment was shutdown and put in a safe situation. This shutdown was manual activation only from pushbuttons located in the:
  - Central Control Room matrix panel;
  - Engine Control Room matrix panel; and
  - Drilling Work Station matrix panel.

Well Control Systems

BOP

1.49 The BOP was designed to control an unbalanced well via choke and kill lines and also prevent a blowout in extreme situations. The BOP was designed to be able to fully close the well or only the annulus around various sizes of drill strings or wire lines. The BOP was also designed to shear the drill string in an emergency situation. Two 18¾" annular preventers with a working pressure of 10,000 psi were supplied, mounted on the lower marine riser package (LMRP). The annular preventers contained a specially designed elastomer to seal around tubular objects passing through them or to seal the open hole. Two 18¾" double and one single style modular style ram preventers were supplied with a working pressure of 15,000 psi. The rams were supplied with an automatic locking system when closed.

Diverter

1.50 Complementary to the BOP, the diverter was designed to relieve well bore flow accidentally passed above the BOP by directing the flow overboard, outside the path of normal drilling mud circulation or through the Vertical Mud Gas Separator and back through the process mud system.

EDS

1.51 The EDS was managed by the surface MUX[65] control system. A single-button activation initiated a pre-defined sequence of functions on the BOP stack to secure the well and disconnect the LMRP. EDS was to be used to avoid damage to the BOP and wellhead if a dynamically positioned rig unexpectedly moves off location.

1.52 The EDS function had two separate command sequences Blind Shear Ram Close, and Casing Shear Ram Close. The latter sequence was used when casing is being run into the hole; otherwise the Blind Shear Ram Close was used as the default sequence. The auto-shear mechanically activated the high-

65 An electro-hydraulic/multiplex control system (MUX) transmitted electrical command signals to operate functions on the BOP. Commands from the surface control panels were sent through cables to two subsea control pods located on the LMRP. The signals were then processed by the electronics located in the pods and converted to hydraulic signals to operate control valves directing operating fluid to the BOP stack.

pressure shear circuit to close the blind shear rams and Stack Bonnet Removal Tool (ST Locks) if the LMRP unexpectedly disconnected from the BOP stack. The automatic mode function was an emergency backup located in the subsea control pods that activates the high-pressure shear circuit to close the blind shear rams and ST Locks if hydraulic pressure and electrical power were lost to the BOP stack (e.g., in the case of riser failure).[66]

LMRP

1.53 The LMRP consisted of a frame containing the BOP control subsea equipment, the 18¾," 10,000 psi working pressure hydraulic riser connector and both of the 18¾," 10,000 psi working pressure annular preventers. The LMRP was connected at the bottom of the marine riser via a flex joint assembly. The flex joint compensated for the lateral movement of the drilling rig. The assembly was self-contained, self-centering, friction free, and required no lubrication.

Fire Suppression Systems

CO_2

1.54 Fixed CO_2 fire suppression systems were arranged to protect the engine rooms, electrical switchgear rooms, fuel oil rooms, and mudpit room. CO_2 was deployed as the active fire extinguishing agent from a central storage location, with fixed piping supplying the CO_2 to the spaces and discharged through connected diffuser nozzles. Additional independent systems were provided for protection of the Central Control Room, Standby Generator Room, and Paint Locker. These systems functioned identically as the central system, but the supply of CO_2 was stored locally and dedicated to that space.

1.55 To avoid accidental activation, release of the CO_2 for any of these protected spaces required two separate and distinct manual actions, such as opening an enclosure door and pulling a handle, or operating two manual controls in sequence. These controls were accessible from a location directly outside the protected space or from the centralized CO_2 storage location serving the protected space.

1.56 The main generators and thruster motors were constructed to be a totally enclosed water-cooled design. To protect the motors and the Unit in case of fire within the enclosure, independent CO_2 machine enclosure flooding was provided.

1.57 The fixed CO_2 fire suppression systems for total flooding were connected to and monitored by the F&G System but in all cases required manual activation.

1.58 Activation of the CO_2 release controls would initiate immediate audible and visual alarms and shutdowns of ventilation to the space. Audible alarms were actuated by the actual flow of CO_2 pressure into the space; visual indicators, e.g. lights, were controlled by the F&G System.

Sprinkler System

1.59 The DEEPWATER HORIZON was outfitted with an automatic sprinkler system in the accommodation areas and a separate, manually activated, fire protection deluge system to protect the drill floor support structure within the moon pool area. The sprinkler system and deluge system included

66 *Macondo Well Incident*, Transocean Investigation Report June 2011 ("Transocean Investigation Report"), Ch. 3.4 at 146-147.

pressure and flow monitoring switches connected to the F&G System to indicate if either of these systems were activated and to automatically sound alarms and shutdown ventilation in the affected area if the sprinkler or deluge system was activated. A limited supply of pressurized freshwater is connected to these systems to provide the initial flow of water. Upon detection of automatic flow, in either of these systems, the dedicated sprinkler pump would automatically start to maintain flow in the system with seawater.

Foam System

1.60 The DEEPWATER HORIZON was outfitted with a foam fire extinguishing system serving the helideck, fire monitors, and the helicopter fuel storage area. Fixed foam discharge heads provided coverage for the helicopter fuel area and portable and fixed monitors provided coverage for the helideck. Flow and pressure monitoring and foam pump condition indicators were connected to the F&G System to indicate when this system was actuated.

Fire Extinguishers

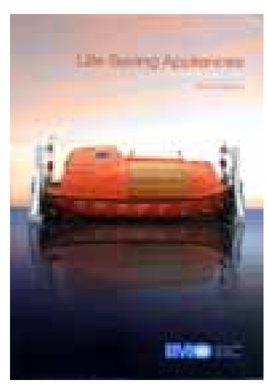
1.61 The DEEPWATER HORIZON was equipped with the following, distributed throughout the Unit:

- 169 portable extinguishers;
- 3 semi-portable dry chemical extinguishers;
- 16 semi-portable CO_2 extinguishers; and
- 1 portable foam applicator.

Fire Main System

1.62 The Unit was equipped with a fire main system pressurized by the salt water service pumps and the ballast salt water pumps boosting water to the fire pumps and the foam pumps as described below. Fire hydrants were located such that any part of the Unit could be reached by at least two streams of water from hoses as normally connected, each stream from a separate outlet. The DEEPWATER HORIZON was equipped with:

- 6 pumps connected to the fire main system, consisting of
    - 2 fire pumps,
    - 2 foam/fire pumps, and
    - 2 fire/seawater pumps;
- 17 - 2½" hydrant/fire stations (23 m hose);
- 58 - 1½" hydrant/fire stations (23 m hose);
- 3 fixed installation foam/water monitors; and
- 1 fixed installation water monitor.

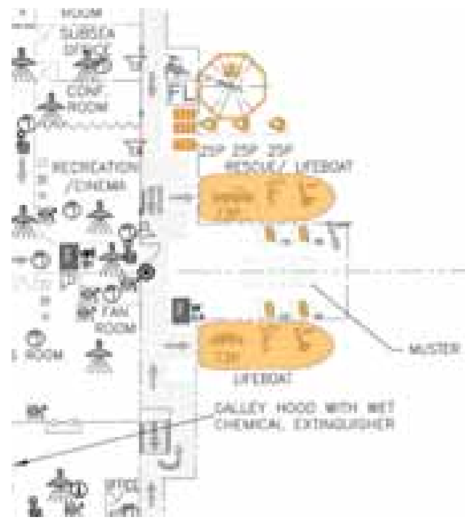


Lifesaving Systems

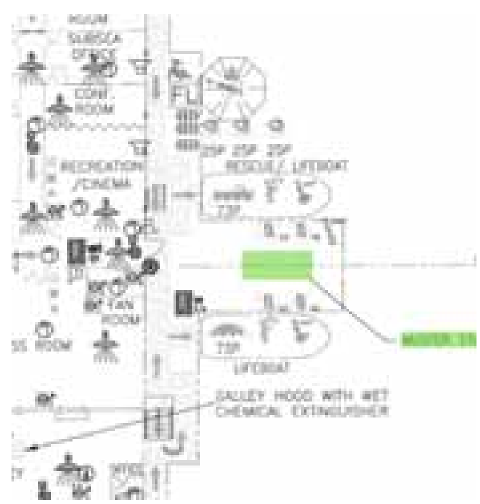
1.63 The DEEPWATER HORIZON was fitted with four enclosed davit launched lifeboats fitted with an external water spray fire protection system and a self-contained air support system. The lifeboats were type approved to SOLAS requirements and each lifeboat had a rated

capacity of 73 persons.[67] The rated capacity, pursuant to Section 4.4.2 of the International Life-Saving Appliances (LSA) Code, was based on "the number of persons having an average mass of 75 kg [165 lbs], all wearing lifejackets, that can be seated in a normal position without interfering with the means of propulsion or the operation of any of the lifeboat's equipment."[68] The lifeboats were fitted with safety belts at each seating position. The color of the belts at each seating position contrasted with the color of the belts for the seats immediately adjacent (red/yellow/red/yellow).[69]

1.64 The Unit was also fitted with six liferafts, configured to be davit launched, dropped over the side, or arranged to float free. Three liferafts served by one launching davit were located at each embarkation station.[70] The launching davit was configured with electrically powered means to retrieve the fall, which is a cable that suspends and lowers the liferaft. In the event of a loss of electrical power, the falls could only be retrieved manually. Each liferaft had a capacity of 25 persons. The liferafts were approved to the applicable SOLAS requirements. Although liferafts were required equipment, the carriage of davit launched liferafts was in excess of the requirements established in section 10.2.5 of the 1989 MODU Code.



1.65 There were two embarkation areas, which, as required by section 10.2.4 of the 1989 MODU Code, were widely separated by being located at different ends of the Unit. Lifeboats No. 1 and No. 2 were located at the forward embarkation area, which was on the centerline immediately forward of the accommodation spaces on the second deck. Lifeboats No. 3 and No. 4 were located at the aft embarkation area, which was on the centerline immediately aft of the Engine Control Room on the second deck. Both embarkation areas could be accessed from the main deck without entering the interior of the vessel.



1.66 In addition to the primary lifesaving systems, the DEEPWATER HORIZON carried a lifejacket for every person assigned to the Unit, which were stowed in the accommodation spaces. Additional

67 DEEPWATER HORIZON Operations Manual, § 9.6.2 (ABSDWH000597).

68 LSA Code, § 4.4.2.

69 LSA Code, § 4.6.3.1.

70 To launch more than one liferaft, it was necessary for the crew to retrieve the fall and then connect it to the next liferaft to be launched.

lifejackets were stowed in boxes at each embarkation station. A total of 201 USCG and SOLAS approved lifejackets were provided onboard the Unit.[71]

1.67 Based on the location of its operations, the DEEPWATER HORIZON was exempted from carrying immersion suits.[72]

MANNING, EMERGENCY DRILLS, AND LEADERSHIP

Manning

1.68 Section 3.1 of IMO Resolution A.890(21), Principles of Safe Manning, states that "the purpose of determining the minimum safe manning level of a ship is to ensure that its complement includes the grades/capacities and number of persons required for the safe operation of the ship and the protection of the marine environment."[73] A minimum manning level for safe operation of the Unit was established by the Republic of the Marshall Islands and indicated on the Minimum Safe Manning Certificate.[74]

1.69 The Minimum Safe Manning Certificate application submitted by Transocean to the Administrator identified the DEEPWATER HORIZON as an ✠A1, Column Stabilized Drilling Unit, ✠AMS, ✠ACCU, ✠DPS-3. The DEEPWATER HORIZON was issued a Minimum Safe Manning Certificate for a self-propelled MODU and, at all times prior to and at the time of the casualty, was manned to the standards established by the Administrator[75] and as would be required by the USCG.[76]

1.70 All required marine crew positions were filled by mariners holding appropriate credentials. Each officer onboard the DEEPWATER HORIZON held a license, certificate, or document issued by the USCG. The Administrator issued Republic of the Marshall Islands officer endorsements based on the USCG license, certificate, or document in accordance with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended[77] and IMO Resolution A.891(21). Of the 126 persons onboard the DEEPWATER HORIZON, 124 were US citizens, including the Master and the Offshore Installation Manager.

Emergency Drills

1.71 The DEEPWATER HORIZON Operations Manual, which includes Emergency Procedures in section 10 and Evacuation procedures in section 10.2, was reviewed and approved by ABS and was required to be submitted to the USCG for the Unit to receive authorization to operate on the US OCS.[78]

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71 DEEPWATER HORIZON Operations Manual, Vol. I, § 9.6.4 (BP_HZN-MBI00012087).

72 SOLAS Exemption Certificate, 28 May 2008. This exemption was valid as long as the Unit remained within the latitude limits of 32° N and 32° S.

73 IMO Resolution A.890(21) § 3.1.

74 The manning requirements increased when the DEEPWATER HORIZON transferred registry from the Republic of Panama to the Republic of the Marshall Islands. The Panama Maritime Authority had required the Unit to be manned with a Master or Offshore Installation Manager, two Able Seamen, an Ordinary Seaman, and eight Survival Craft Crewmen. The Republic of the Marshall Islands required a Master, an Offshore Installation Manager, a Chief Mate, a 3rd Mate, two Able Seamen, an Ordinary Seaman, a Chief Engineer, a Maintenance Supervisor, a 1st Assistant Engineer, an Oiler/Motorman, and eight Survival Craft Crewmen. Republic of the Marshall Islands Marine Notice 7-038-2, *Minimum Safe Manning Requirements for Vessels*.

75 As the flag State does not regulate drilling operations, the manning level set by the Administrator did not address industrial crew requirements.

76 46 C.F.R. § 15.520.

77 STCW, Regulation I/10, Recognition of Certificates. In accordance with MSC.1/Circ. 1163/Rev.6, "Parties to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended, confirmed by the Maritime Safety Committee to have communicated information which demonstrates that full and complete effect is given to the relevant provisions of the Convention." The Republic of the Marshall Islands does not recognize all countries that are recognized on this list and only recognizes those with which the Republic of the Marshall Islands has entered into an undertaking.

78 USCG Navigation and Vessel Inspection Circular No. 3-88, Change 1, Part 9 states "OPERATING MANUALS. All foreign units should have operating

1.72 Weekly emergency drills were conducted as required by the 1989 MODU Code and described in the DEEPWATER HORIZON Operations Manual.[79] Fire drills included response to a simulated fire, running out at least two fire hoses, and operating the fire pumps as well as demonstrating the proper operation of portable fire extinguishers and portable breathing apparatus.[80]

1.73 There were two fire team muster points on the DEEPWATER HORIZON, one at the Transit Room (helicopter waiting room), which is near the Main Temporary Refuge and one near the aft CO_2 Room (aft, main deck, amidships). Fire team emergency equipment was located in Emergency Lockers at the designated muster areas, as shown on the Unit's General Arrangement and Emergency Plan drawings. Abandon ship drills included a complete muster of the crew and training on the operation and launching of the lifeboats.[81] Based on testimony from the Master, drills were conducted to provide maximum training without placing the crew at undue risk.[82] Personnel onboard testified that the regular training and drills contributed to ensuring the crew was prepared for an emergency.[83]

1.74 Safety drills for fire and abandon ship drills conducted between February and April 2010 indicate that drills were conducted using a variety of scenarios and that the crew received regular training in the launching and operation of the lifeboats. The Safety Drill Reports also indicate that the senior management onboard DEEPWATER HORIZON assessed the effectiveness of each drill and documented areas for improvement.

Command and Control

1.75 There are four categories of personnel on a MODU:[84] the marine crew, the drilling crew, representatives of the leaseholder, and contract/support personnel. Transocean was responsible for providing the drill, marine, and maintenance crew of the DEEPWATER HORIZON.[85] BP contracted Transocean to provide the physical unit and the personnel to operate it and to drill the Macondo well.[86] BP was responsible for providing all materials for completing the well and for supervising the design, construction and

manuals complying with the applicable provisions specified in 33 [C.F.R. §] 146.205. Prior to the initial Certificate of Compliance, the operating manual is to be submitted to the cognizant OCMI for review. The contents of the manual must be in English in addition to any other language understood by personnel routinely aboard."; USCG Navigation and Vessel Inspection Circular No. 3-88, Change 1, Part 12 states, "EMERGENCY EVACUATION PLAN. All foreign units should have an approved Emergency Evacuation Plan (EEP) complying with the applicable provisions specified in 33 [C.F.R.] 146.210. Prior to the initial Certificate of Compliance, the EEP is to be submitted to the cognizant CMI for review. The contents of the manual must be in English in addition to any other language understood by personnel routinely aboard;" *see also* 33 C.F.R. § 146.140, "(a) The operator of each manned OCS facility shall develop an Emergency Evacuation Plan (EEP) for the facility which addresses all of the items listed in paragraph (d) of this section. The EEP may apply to more than one facility, if the facilities are located in the same general geographic location and within the same [OCMI] zone; if each facility covered by the EEP is specifically identified in the EEP; and if the evacuation needs of each facility are accommodated. The EEP must be submitted to the OCMI having jurisdiction over the facility, 30 days before placing the facility in operation. The OCMI reviews the EEP to determine whether all items listed in paragraph (d) of this section are addressed for each facility included in the EEP. If the OCMI determines that all items in paragraph (d) of this section are addressed, the OCMI stamps the EEP "APPROVED"' and returns it, together with a letter indicating Coast Guard approval, to the operator. If the OCMI determines that any item is not addressed, the OCMI stamps the EEP "RETURNED FOR REVISION'" and returns the EEP, together with an explanation of the EEP's deficiencies, to the operator."

79 DEEPWATER HORIZON Operations Manual, Vol. 1, § 9.8 (BP-HZN-MBI00012111). § 7.41.6 of the Marshall Islands Maritime Regulations requires "the crew to be exercised at fire and/or abandon ship drills or safety training at least once in every week." It is also noted that SOLAS, Ch. III, Regulation 19.3, requires that crew members participate in at least one abandon ship drill and one fire drill every month.

80 DEEPWATER HORIZON Operations Manual, Vol. 1, § 9.8.1 (BP-HZN-MBI00012111).

81 DEEPWATER HORIZON Operations Manual, Vol. 1, § 9.8.2 (BP-HAN-MBI00012111).

82 5/27/10 MBI Tr. at 178-81 (Kuchta). Due to the risks associated with launching lifeboats, IMO has issued guidance stating that lifeboats are not required to be launched with the crew onboard during drills and operational testing. MSC.1/Circ.1206/Rev.1 and MSC.1/Circ.1326.

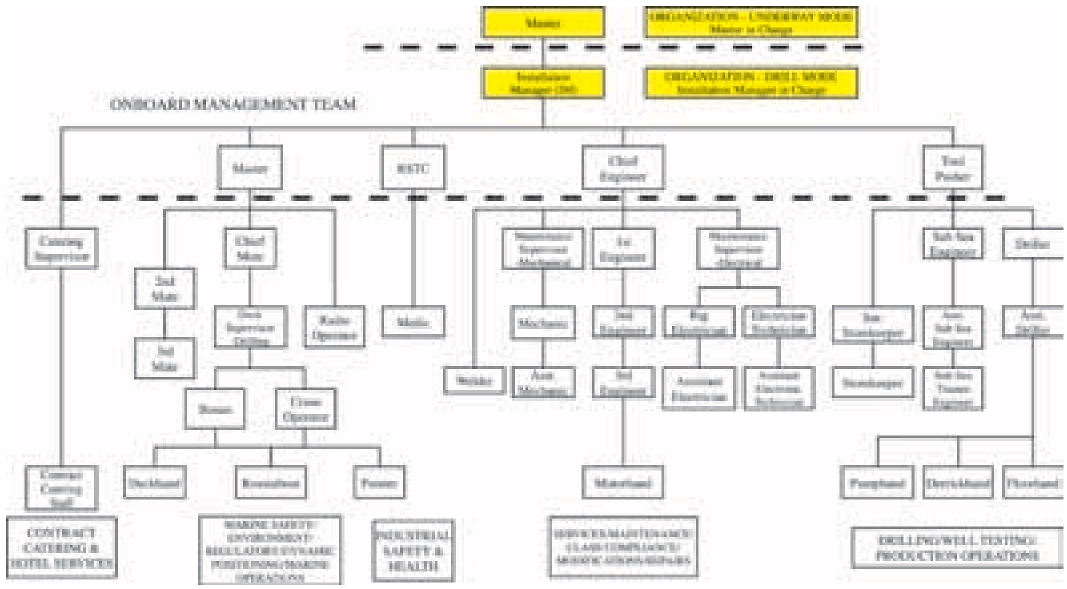
83 5/28/10 MBI Tr. at 221 (Meche); 5/28/10 MBI Tr. at 253 (Haire); 5/29/10 MBI Tr. at 77 (Burgess).

84 A complete list of the personnel onboard the DEEPWATER HORIZON on 20 April 2010 is attached at Annex I.

85 Transocean Investigation Report at 17.

86 Transocean Investigation Report at 17.

completion of the well, and obtaining regulatory approval required for construction of the well.[87] Contract support personnel were hired either by Transocean or BP depending on the nature of the support required.[88] A hierarchy and decision making structure was in place which was dependent on the operating mode and whether normal or emergency conditions existed.[89] During routine drilling operations, the specifications for drilling are provided by the BP Well Site Leader. Transocean personnel carried out those specifications under the direction of the Senior Tool Pusher.



1.76 The US requirements applicable to MODUs are located, in part, in the Code of Federal Regulations (C.F.R). Pursuant to 33 C.F.R. section 140.10, an "OCS facility…includes mobile offshore drilling units when in contact with the seabed of the OCS for exploration or exploitation of seabed resources."[90] In addition, USCG regulations state that "[w]hen vessels are fixed to or submerged onto the seabed…they become structures as described in [33 C.F.R. section] 67.01-5."[91] The term "structure" includes "all drilling platforms, Mobile Offshore Drilling Units (MODUs) when attached to the bottom…and all other piles, pier clusters, pipes or structures erected in the waters."[92]

87 BP, *Deepwater Horizon Accident Investigation Report*, 8 September 2010, Appendix F at 207.

88 Transocean Investigation Report at 17-18.

89 DEEPWATER HORIZON Operations Manual, Vol. 1, Figure 2.1 (ABSDWH000065).

90 33 C.F.R. § 140.10 (2010).

91 33 C.F.R. § 67.15-1.

92 33 C.F.R. § 67.01-5.

1.77 Pursuant to section 811(d) of the Maritime Act[93] and section 5.2 of Part A of the ISM Code,[94] the Master is in command while the MODU is underway and during all emergencies. As required by Chapter 14, sections 14.1.2.2 and 14.8.1 of the 1989 MODU Code, the Master's responsibilities are set forth in section 2.1 of the DEEPWATER HORIZON Operations Manual, which states, "[i]n accordance with the ISM Code, the Master has overriding authority and responsibility to make decisions with respect to the safety and pollution prevention and request all internal company assistance as necessary."[95]

1.78 During the conduct of drilling operations, the Offshore Installation Manager was in charge of the drilling operations of the MODU. The day-to-day management of the MODU was controlled by the Onboard Management Team which consisted of the Offshore Installation Manager, Master, Tool Pusher, Chief Engineer, and Rig Safety and Training Coordinator.[96] The Offshore Installation Manager established the daily schedules, routines, and objectives in consultation and coordination with the Well Site Leader.

1.79 Three persons were on duty on the Bridge during the 0600 to 1800 watch and two persons were on duty on the Bridge during the 1800 to 0600 watch. The watchstanders at the time of the casualty consisted of the Senior Dynamic Positioning Operator and the Dynamic Positioning Officer. The Dynamic Positioning Officer was also a licensed Officer in Charge of a Navigation Watch (3rd Mate/GMDSS).[97]

1.80 The Transocean organizational chart identified the Master as the Person in Charge when the Unit was underway. The Senior Dynamic Positioning Officer and the Dynamic Positioning Officer testified that at the time of the casualty, the Unit was underway but not making way by virtue of the dynamic positioning operations.[98] However, the Offshore Installation Manager and the Master testified that, at the time of the casualty, the MODU was not underway but on location as it was latched up to the wellhead and conducting drilling operations.[99] Under these operating conditions, as established by the Transocean organizational chart, the Offshore Installation Manager was considered the Person in Charge. All of the personnel involved in drilling operations were reporting to the Offshore Installation Manager. While conducting drilling operations, the Master was understood to be the Person in Charge only in cases of an emergency.

1.81 According to the DEEPWATER HORIZON Operations Manual, a well control event that resulted in an uncontrolled release of hydrocarbons was considered an emergency event. Management of the initial response to drilling related emergencies, including a well control event that results in an uncontrolled release, is the responsibility of the Offshore Installation Manager.[100] Section 10.4, Emergency Procedures

93 Republic of the Marshall Islands Maritime Act (MI-107), § 811(d) states, "[t]he Master shall…assume full responsibility for the safety of the members of the crew and passengers, if any, and to take all necessary and appropriate steps in connection therewith."

94 ISM Code, § 5.2 states, "[t]he master has the overriding authority and the responsibility to make decisions with respect to the safety and pollution prevention…."

95 DEEPWATER HORIZON Operations Manual, Vol. 1, § 2.1 (BP-HZN-MBI00011579).

96 DEEPWATER HORIZON Operations Manual, Vol. 1, § 2.2 (ABSDWH000065).

97 10/5/10 MBI Tr. at 129-133 (Keplinger).

98 10/5/10 MBI Tr. at 211, 311-312 (Keplinger) and 10/5/10 MBI Tr. at 69 (Fleytas). This position was supported by an expert witness called by the USCG before the Joint Board. 5/26/10 MBI Tr. at 18, 33, 39-40 (Smith).

99 5/27/10 MBI Tr. at 144-146 (Harrell); 5/27/10 MBI Tr. at 171 (Kutcha). USCG NAVRULES FREQUENTLY ASKED QUESTIONS, "What is Outer Continental Shelf activity?" http://www.navcen.uscg.gov/?pageName=navRulesFAQ#0.3_20 (last visited 6 August 2011). *See also,* USCG Commandant Instruction M16672.2D, NAVIGATION RULES: International-Inland, Rule 3(i) (1999) "The word 'underway' means that a vessel is not at anchor, or made fast to the shore, or aground."

100 DEEPWATER HORIZON Operations Manual, Vol. 1, § 10.4.2 (BP-HZN-MBI00012140).

for Uncontrolled Escape of Hydrocarbons, of the DEEPWATER HORIZON Operations Manual, includes three discrete phases for securing and identifying an escalating series of actions and reactions for responding to such an uncontrolled release. In section 10.4.1, the Offshore Installation Manager is in charge of well control procedures to control the release.

1.82 Section 7 of the DEEPWATER HORIZON Emergency Response Manual also addresses three levels of well control emergencies and describes the "organizational structure, responsibilities, and duties of personnel during a hydrocarbon gas emergency."[101] The Offshore Installation Manager is in charge of well control procedures to control the release.[102] Section 10 of the DEEPWATER HORIZON Emergency Response Manual states, "[t]he decision to abandon the MODU will be made by the Master."[103]

1.83 The overall command over the Unit in an emergency was assigned to the Master. Section 2.1 of the DEEPWATER HORIZON Operations Manual is explicit with respect to the clear delineation of command, the transition of the Person in Charge, and the ultimate authority of the Master. Each of the crew members who testified before the Joint Investigation indicated that the Master was in charge during emergency operations.[104]

101 DEEPWATER HORIZON Emergency Response Manual, Vol. 1, § 7, subsection 1 (BP-HZN-MBI00001006).

102 DEEPWATER HORIZON Emergency Response Manual, Vol. 1, § 7, subsection 5.2 (BP-HZN-MBI00001008).

103 DEEPWATER HORIZON Emergency Response Manual, Vol. 1, § 10, subsection 2 (BP-HZN-MBI00001126).

104 A table of the testimony of personnel before the Joint Investigation is provided at Annex J.

Image Courtesy of USCG

PART 2: FINDINGS OF FACT

OVERVIEW

2.1 On 20 April 2010, the DEEPWATER HORIZON was completing drilling operations in preparation to temporarily abandon the well at the Macondo oil exploration project at Mississippi Canyon Block 252 in the Gulf of Mexico on the US OCS. The Unit was ballasted to its 23 m Gulf of Mexico operating draft.[105] Engines No. 3 and No. 6 were providing electrical power for the Unit.[106] There were 126 personnel onboard the Unit on the day of the casualty, including four visiting Transocean and BP executives.

2.2 At approximately 2052,[107] a loss of well control resulted in a release of liquid and gaseous hydrocarbons onto and around the DEEPWATER HORIZON. This release culminated in explosions and fire that resulted in the loss of 11 lives.

105 DEEPWATER HORIZON Operations Manual, § 5.3 (BP-HZN-MBI00011717-719); MI-109, Report of Vessel Casualty or Accident at 1 (RMI00178).

106 05/29/10 MBI Tr. at 30 (Meinhart).

107 GL Noble Denton and AGR FJ Brown, "Report of the Loss of Well Control and Assessment of Contributing Factors for the Macondo Well Mississippi Canyon Block 252 OCS-G 32306 #1 Well" ("Well Control Report"), at 21.

2.3 115 persons, including 17 who were injured in the explosions, evacuated the burning Unit and were recovered by the offshore support vessel, the DAMON B. BANKSTON, which was maintaining position nearby. Approximately 36 hours after the initial release of hydrocarbons, the DEEPWATER HORIZON capsized and sank. The loss of well control and eventual total loss of the DEEPWATER HORIZON resulted in the uncontrolled release of hydrocarbons into the Gulf of Mexico that continued until the well was capped on 15 July 2010. The well was declared sealed after being intercepted by a relief well and cemented on 19 September 2010.

INSPECTIONS AND OPERATIONS PRIOR TO 20 APRIL 2010

2.4 On 15 and 16 May 2007, DNV attended the Unit offshore to conduct an ISM Code ship renewal audit. The audit was completed without non-conformities but three observations were noted. The observations included tracking of planned maintenance tasks, review of marine publications, and crew training.

2.5 On 16 May 2007, a DNV Auditor attended the Unit offshore to conduct a renewal ISPS audit. The Unit was due for an intermediate audit, but the renewal was requested by the operators for harmonization with the ISM audits.[108] The auditor found no non-conformities. Two observations were recorded, one regarding a pending update to the Ship Security Plan and the other with regard to recording internal audits.

2.6 From 13-17 September 2009, a rig and marine assurance follow-up audit was conducted by the BP Rig Audit Group. The issues that resulted from this audit were addressed between Transocean and BP in accordance with the contract that existed between the two organizations. This audit was conducted during a non-drilling period and the DEEPWATER HORIZON was not brought back into service until the findings of the audit were satisfactorily addressed.

2.7 Flag State inspections were conducted annually from the time the Unit was registered in the Republic of the Marshall Islands. The last flag State annual safety inspection[109] prior to the incident was conducted on 17 December 2009 by an ABS inspector on behalf of the Administrator. During that inspection, the DEEPWATER HORIZON was found to be in compliance with applicable safety, security, and environmental protection requirements under the Republic of the Marshall Islands national requirements, as well as international requirements, including SOLAS, the International Convention for the Prevention of Pollution from Ships, 1973, as amended by the Protocol of 1978 (MARPOL), STCW, and the ISM and ISPS Codes. The attending ABS inspector determined the overall condition of the DEEPWATER HORIZON to be satisfactory, but did note two areas requiring attention. The bilges in thruster rooms No. 3 and 4 were found with oil; both crane engine spaces were found with oil and were observed to be unacceptable.[110] The Master and the Designated Person Ashore were advised of the inspection results.[111]

108 The Republic of the Marshall Islands requirements for compliance with the ISM Code are published by the Administrator through Marine Notice 2-011-13, International Safety Management (ISM) Code, to provide policy interpretations and guidelines to the Republic of the Marshall Islands' shipowners and ROs. The Administrator requires self-propelled MODUs, such as the DEEPWATER HORIZON, to comply with the ISM Code and flag State requirements. Compliance with the ISM Code is closely monitored and enforced by the Administrator itself and through its appointed ROs and nautical inspectors.

109 A flag State annual safety inspection had been conducted on an annual basis since the DEEPWATER HORIZON was registered in the Republic of the Marshall Islands.

110 Report of Safety Inspection for MODU/MOU (RMI 00151).

111 ABS conducted a follow-up inspection on 23 February 2010, during which the ABS surveyor re-inspected the areas noted in the 17 December 2009 annual safety inspection report and determined the items to have been rectified.

2.8 On 14 January 2010, the MMS approved BP's application for a revised well design. The application updated the original permit for the Mississippi Canyon Block 252 calling for the DEEPWATER HORIZON to replace the TRANSOCEAN MARIANAS.[112]

2.9 On 31 January, the DEEPWATER HORIZON arrived at the Mississippi Canyon Block 252 in approximate position 28° 22' N, 088° 42' W and began six days of pre-drilling maintenance, including maintenance of the BOP.[113]

2.10 On 6 February, the DEEPWATER HORIZON was connected to the wellhead and began drilling operations.[114] The DEEPWATER HORIZON maintained position over the well using the Unit's dynamic positioning system.

2.11 On 17 February, two MMS inspectors attended the DEEPWATER HORIZON to conduct a routine monthly inspection. No deficiencies were issued.[115]

2.12 On 23 February, an ABS surveyor attended the DEEPWATER HORIZON to commence the automation, hull, and machinery annual statutory surveys. During the automation, hull and machinery annual statutory surveys, the two outstanding statutory deficiencies regarding the bilges in thruster rooms No. 3 and No. 4 and both crane engine spaces issued during the flag State annual safety inspection on 17 December 2009 were verified as being corrected.[116] Additionally, five ABS recommendations were verified as being corrected and were closed out; one recommendation remained open regarding the operational status of thruster No. 2.[117]

2.13 On 3 March, MMS inspectors attended the DEEPWATER HORIZON to conduct a routine monthly inspection. No deficiencies were issued.[118]

2.14 On 7 March, the lifeboat engines were not run during a regular lifeboat drill due to the risk of high gas levels from the well.[119] The muster during the drill took an extended amount of time due to confusion related to the use of a new style of muster lists.[120] Questions related to the new muster lists were addressed and it was noted that the time required to complete the muster would be monitored during future drills.[121]

2.15 On 14 March, during the drill, it was noted that it was necessary to continue improvements for taking a timely muster.[122]

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112 The TRANSOCEAN MARIANAS had been damaged during Hurricane Ida and needed to be moved to a shipyard for repairs in November 2009.

113 Daily Drilling Report No. 1, 31 January 2010 (TRN-USCG_MMS-00011510–TRN-USCG_MMS-00011511).

114 Daily Drilling Report No. 7, 6 February 2010 (TRN-USCG_MMS-00011531).

115 5/11/10 MBI Tr. at 323 (Neal).

116 ABS Survey Report MC1794166, 23 February 2010 (ABSDWH004088-ABSDWH004094).

117 ABS Survey Report MC1794166, 23 February 2010 (ABSDWH004088-ABSDWH004094). The open recommendation was for thruster No. 2, which was not operational. The cause of the malfunction was being investigated. ABS Survey Report MC1767269, 18 December 2009 (ABSDWH004022-ABSDWH004031).

118 5/11/10 MBI Tr. at 346-47 (Neal).

119 DEEPWATER HORIZON Safety Drill Report, 7 March 2010.

120 DEEPWATER HORIZON Safety Drill Report, 7 March 2011 (DWH-2010-Mar-017-SAF).

121 DEEPWATER HORIZON Safety Drill Report, 7 March 2011 (DWH-2010-Mar-017-SAF).

122 DEEPWATER HORIZON Safety Drill Report, 14 March 2011 (DWH-2010-Mar-023-SAF).

2.16 During drills conducted on 21 and 28 March, it was observed that the muster was conducted in a timely manner.[123]

2.17 On 1 April, an MMS inspector attended DEEPWATER HORIZON to conduct a routine monthly inspection. No deficiencies were issued.[124]

2.18 On 1 April, a Rig Condition Assessment audit was conducted by ModuSpec (a member of Lloyds Register Group) at the request of Transocean.[125] This audit included an assessment of drilling equipment, mud systems, well control equipment, marine equipment, hull, structure, power plant, electrical equipment, and safety equipment. The findings of the audit, including a number of items listing equipment and systems which required maintenance and/or immediate repair, were reported to Transocean and DEEPWATER HORIZON senior unit management on 12 April.[126]

2.19 On 9 April, the well was drilled to the total depth of 18,360 ft.[127]

2.20 On 16 April, Transocean submitted an Application for Permit to Modify (APM) plans for the temporary abandonment of the well to MMS; which was approved by MMS the same day.[128] The approved APM included the steps for conducting a negative pressure test without a drill string in the well and using the "kill line" conduit that extends from the BOP stack up to the Unit to monitor the test results; followed by lowering the drill string into the upper section of the casing string to replace drilling mud with seawater in the riser and a portion of the wellbore.[129]

2.21 On 16 April, one of the two BP Well Site Leaders onboard DEEPWATER HORIZON was replaced so that he could attend a well control course.[130] His replacement was not a regular part of the Unit's Onboard Management Team and did not have an established working relationship with the crew.[131]

2.22 By approximately 1335 on 19 April, the final casing was run to a well depth of 18,303 ft.[132]

OPERATIONS ON 20 APRIL

2.23 During the regular 0730 morning planning meeting, in accordance with the predetermined decision-tree, it was decided that a bond log test of the cemented well would not be conducted.[133]

123 DEEPWATER HORIZON Safety Drill Reports, 21 March 2011 (DWH-2010-Mar-028-SAF) and 28 March 2010 (DWH-2010-Mar-031-SAF).

124 5/11/10 MBI Tr. at 318-320 (Neal).

125 ModuSpec Audit Report (TRN-USCG_MMS-00038609, TRN-USCG_MMS-00038617).

126 ModuSpec Audit Report § 3.3 at 9 (TRN-USCG_MMS-00038617).

127 Daily Drilling Report No. 23, 9 April 2010 (TRN-USCG_MMS-00011597); M-I Swaco Synthetic-Based Mud Report No. 69, 9 April 2010 (MIe 100001 001 0000041); Well Control Report at 7.

128 Application for Permit to Modify, 16 April 2010 (BP-HZN-MBI00021239 - BP-HZN-MBI00021241).

129 Well Control Report at 12.

130 7/20/10 MBI Tr. at 10-12 (Sepulvado).

131 7/22/10 MBI Tr. at 108-109 (Guide); BP interview of Kaluza, 28 April 2010 (BP-HZN-MB100129616). Kaluza was assigned to BP's THUNDERHORSE production platform, but was reassigned to the DEEPWATER HORIZON temporarily.

132 Well Control Report at 9.

133 7/22/10 MBI Tr. at 23, 132 (Guide). A planning meeting was held each morning at 0730. The meeting was a conference call with the Unit and included representatives from the Operations and Technical groups from the BP office in Houston as well as the Offshore Installation Manager, Master, Senior Tool Pusher, and other specialists onboard the Unit. The purpose of these meetings was to review safety, the day's operations, and any upcoming issues.

2.24 At 1043, a BP Drilling Engineer emailed an Operations Note to the BP Well Site Leaders onboard DEEPWATER HORIZON as well as other personnel in the BP operations and technical groups.[134] This Operations Note described procedures for conducting a negative test that varied from the procedures in the APM.[135] Specifically, these new procedures called for sequencing the test within the displacement operation, rather than prior to it.[136]

2.25 Between approximately 1030 and 1230, a positive pressure test of the production casing was conducted; the test was reported to be successful.[137] Following this test, preparations were made to conduct a negative differential pressure test and displace the mud in the riser with seawater.[138]

2.26 The regular pre-tour meeting, held to brief watchstanders on operations expected to occur during the next shift, was held from 1100 until approximately 1130. It was reported that there was a disagreement between the Offshore Installation Manager, Jimmy Harrell; the BP Well Site Leader, Robert Kaluza; the Tool Pusher, Randall Ezell and the Driller, Dewey Revette about displacing the riser.[139] The Offshore Installation Manager testified that there was not a disagreement, but rather that he wanted to ensure a negative pressure test was conducted before they began to displace with seawater.[140]

2.27 At approximately 1328, the DEEPWATER HORIZON started offloading mud to the DAMON B. BANKSTON. The DAMON B. BANKSTON was maintaining position off the port side of the DEEPWATER HORIZON. Mud was pumped from the Unit until approximately 1717. A total of 3,100 barrels of 14 ppg mud was reported transferred during this period. The transfer hose was not disconnected because more mud was scheduled to be transferred; the total volume that the Master of the DAMON B. BANKSTON, Alwin Landry, expected to receive was between 4,500 and 5,000 barrels of mud.[141]

2.28 At approximately 1430, Patrick O'Bryan, BP, Vice President Drilling and Completions, Gulf of Mexico, Deepwater; David Sims, BP, Drilling and Completion Operations Manager; Daun Winslow, Transocean Division Manager; and Buddy Trahan, Transocean Asset Manager, arrived onboard the DEEPWATER HORIZON for a scheduled visit.[142]

2.29 The initial displacement of mud from the wellbore was started at 1557 and continued until 1653.[143] At this time the negative differential pressure test was begun, "leaving the riser partially displaced with a segment of mud, and a segment of water-based spacer."[144] This left the hydrostatic pressure inside the

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134 Email from Brian Morel to Don Vidrine, Robert Kaluza, *et al*, 20 April 2010 (BP-HZN-CE0008574). The test procedure consisted of two elements. During testimony before the DEEPWATER HORIZON Joint Investigation team it was stated that BP does not have established written procedures for conducting negative pressure tests. 7/22/10 MBI Tr. at 162 (Guide).

135 Well Control Report at 12.

136 Well Control Report at 13.

137 Well Control Report at 13.

138 Well Control Report at 13.

139 5/26/10 MBI Tr. at 91-92 (Brown).

140 In his testimony, the Offshore Installation Manager stated that the BP Well Site Leader had shown him a plan that did not include reference to a negative pressure test. 5/27/10 MBI Tr. at 27 (Harrell).

141 5/11/10 MBI Tr. at 95-97 (Landry).

142 7/20/10 MBI Tr. at 9 (Sepulvado); Email from David Sims to Ronald Sepulvado, 14 April 2010 (BP-HZN-MBI 00127131); 8/23/10 MBI Tr. at 440 (Winslow); 8/26/10 MBI Tr. at 365 (O'Bryan).

143 Well Control Report at 14.

144 Well Control Report at 15.

well greater than the reservoir pressures in the formation, "a condition that would prevent flow from the formation into the wellbore."[145]

2.30 Between approximately 1653 and 1658, the negative differential pressure test[146] commenced by closing the lower annular BOP around the drill string, isolating the marine riser and its hydrostatic head from the wellbore.[147] "The kill line, isolated by closed valves at the BOP and at the surface, contained 'trapped pressure' of 645 psi;" pressure was then relieved by opening a valve in the kill line at the surface and a valve near the top of the drill string.[148] Pressure in the kill line dropped to 0 psi and pressure inside the drill string dropped from 2,325 psi to 250 psi.[149] By isolating the marine riser and reducing pressure in the drill string, the hydrostatic head at the bottom of the wellbore was reduced to a value lower than the measured formation pressure.[150]

2.31 "At 1705 one or more valves at the top of the drill string were operated and pressure measured in the drill string increased to 1,250 psi;" the negative differential pressure test was continued.[151]

2.32 Until 1726, "pressure in the drill string remained at 1,250 psi but the kill line pressure continued to read 0 psi…the status of kill line valves is not clear."[152] In the described configuration, the drill string and the kill line were expected to be on each side of a "U-tube." "Since they 'connect' at the bottom of the U, in this case the end of the drill string at 8,367 [ft], the drill string and kill line should be expected to be at the same pressure."[153]

2.33 Between 1708 and 1726, a drop in the mud level within the riser was observed.[154] "The closing pressure on the annular preventer was increased and then 50 barrels of drilling mud were pumped into the riser to re-establish the desired fluid level."[155]

2.34 At approximately 1726, "a valve was opened and pressure inside the drill string was relieved to 0 psi. Approximately 15 barrels of seawater flowed into the cementing unit."[156]"…[T]he negative differential pressure test was continued. The pressure gauge on the kill line continued to read 0 psi."[157]

2.35 A brief pressure rise to 270 psi in the drill string occurred at 1733 hours.[158] "Kill line pressure continued

145 Well Control Report at 15.

146 The purpose of the negative pressure test is to determine if the float collar and cement inside the casing are holding. 7/22/10 MBI Tr. at 137-138 (Guide).

147 Well Control Report at 16.

148 Well Control Report at 16.

149 Well Control Report at 16.

150 Well Control Report at 16. Based on testimony before the DEEPWATER HORIZON Joint Investigation team there is uncertainty about how the negative pressure tests were conducted. 7/22/10 MBI Tr. at 163-166 (Guide); 8/25/10 MBI Tr. at 185 (Hay).

151 Well Control Report at 17.

152 Well Control Report at 17.

153 Well Control Report at 17.

154 Well Control Report at 17.

155 Well Control Report at 17.

156 Well Control Report at 18.

157 Well Control Report at 18.

158 Well Control Report at 18.

to read 0 psi." To evaluate these anomalies, operations were halted at about this time for discussions among rig personnel.[159]

2.36 Between approximately 1733 and 1800, both BP representatives and both drillers were discussing the negative pressure test on the drill floor; this was concurrent with the arrival of the visiting BP and Transocean personnel as part of a tour of the Unit.[160] The Senior Tool Pusher testified it appeared that "they were having a little bit of a problem."[161] The Offshore Installation Manager and Senior Tool Pusher joined the discussion and were informed that mud had been lost from the riser.[162] The Offshore Installation Manager directed an increase in pressure on the lower annular.[163] This was done and, according to the Offshore Installation manager, "it [held]," meaning that no further loss of mud from the riser was observed.[164] It was determined a second negative pressure test would be conducted.[165]

2.37 Between 1752 and 1754, the drill string pressure increased to 780 psi.[166] A few minutes later a valve at the surface was opened and pressure inside the drill string decreased to 60 psi; the kill line pressure continued to read 0 psi.[167]

2.38 A valve at the surface was then closed and from approximately 1800 to 1832; pressure inside the drill string increased first to 1,265 psi and then to 1,400 psi.[168] "During this period, the weight of the drill string, measured at the hook suspending the string, decreased."[169]

2.39 The decision was made by BP representatives to complete the negative differential pressure test by monitoring the kill line rather than the drill string.[170] "Monitoring of the kill line was, in fact, specified in the approved APM."[171]

2.40 Fluid was then pumped into the kill line and an almost immediate increase in pressure was interpreted as a full line.[172] Pumping was stopped and when the line was vented .25 barrels of seawater flowed back.[173] "The kill line was [then] routed to the mini trip tank in the mud system and the tank was vented to the atmosphere. During a 30 minute period, no additional flow was observed into the tank."[174]

2.41 At approximately 1900, in preparation for monitoring the negative pressure test on the kill line,

159 Well Control Report at 18.

160 5/28/10 MBI Tr. at 279-280 (Ezell); 8/23/10 MBI Tr. at 443 (Winslow).

161 5/28/10 MBI Tr. at 279 (Ezell).

162 The tour for the visiting BP and Transocean representatives continued without the Offshore Installation Manager and Senior Tool Pusher. 5/28/10 MBI Tr. at 279 (Ezell).

163 5/27/10 MBI Tr. at 123-124 (Harrell).

164 5/27/10 MBI Tr. at 123-124 (Harrell).

165 5/28/10 MBI Tr. at 280 (Ezell); 5/27/10 MBI Tr. at 117 (Harrell).

166 Well Control Report at 18.

167 Well Control Report at 18.

168 Well Control Report at 18.

169 Well Control Report at 18.

170 Well Control Report at 19; 5/27/10 MBI Tr. at 26, 32-34, 116-119 (Harrel).

171 Well Control Report at 19.

172 Well Control Report at 19.

173 Well Control Report at 19.

174 Well Control Report at 19.

Halliburton Service Supervisor, Christopher Haire was told to "shut in from the well."[175] When the well was first shut in, flow continued and Haire was directed to open the well; approximately five minutes later Haire was directed to shut in from the well again.[176]

2.42 From approximately 1900, to sometime between 2100 and 2115, the Offshore Installation Manager, Jimmy Harrell; Master, Curt Kuchta; Chief Engineer, Stephen Bertone; and Senior Tool Pusher, Randell Ezell met with the visiting BP and Transocean personnel in the conference room to discuss the Unit's upcoming operations and maintenance requirements as well as the Unit's safety record.[177]

2.43 At approximately 1950, the negative pressure test was considered successful and the crew began to prepare cement for the surface plug.[178]

2.44 Pressure within the drill string remained at 1400 psi.[179] From this time until about 2001, "interval drill string weight measurements were erratic, decreasing by as much as 15,000 lbs."[180] This discrepancy between the pressure measurements for the drill string and kill line, both connected to the same hydraulic conditions, was reportedly explained by some rig personnel as a function of the "bladder effect" or "annular compression."[181]

2.45 Between approximately 2030 and 2100, the trip tank was dumped.[182]

2.46 At approximately 2100, the Master of the DAMON B. BANKSTON called the DEEPWATER HORIZON to determine when they would resume pumping mud.[183] He was told that they were getting ready to displace mud in the riser with seawater and the remainder of the mud would then be transferred to the DAMON B. BANKSTON.[184]

2.47 At approximately 2100, the Sperry-Sun Mud Logger, Joseph Keith, called the drill shack from the Measurements While Drilling Unit and asked Assistant Driller, Steve Curtis to monitor the mud returns.[185] Keith went to the smoke room[186] and was out of the Measurements While Drilling Unit for approximately 10 to 15 minutes.[187] Keith testified that prior to going on break he had not seen anything unusual.[188]

2.48 Between 2108 and 2114, there was an increase in the drill pipe pressure although the mud pumps were stopped.[189]

175 5/28/10 MBI Tr. at 246-247 (Haire); Internal BP document (BP-HZN-MBI00142484).

176 5/28/10 MBI Tr. at 246-247 (Haire); Internal BP document (BP-HZN-MBI00142484).

177 5/27/10 MBI Tr. at 10, 40 (Harrell); 8/23/10 MBI Tr. at 444 (Winslow); 8/26/10 MBI Tr. at 364-365 (O'Bryan).

178 5/28/10 MBI Tr. at 247 (Haire).

179 Well Control Report at 20.

180 Well Control Report at 20.

181 Well Control Report at 20. 12/7/10 MBI Tr. at 35-36 (Gisclair); 5/28/10 MBI Tr. at 136 (Pleasant); 12/08/10 MBI Tr. at 88 (Robinson).

182 12/7/10 MBI Tr. at 212-213 (Keith).

183 5/11/10 MBI Tr. at 97 (Landry).

184 5/11/10 MBI Tr. at 97 (Landry).

185 The Measurements While Drilling Unit is located midship on the starboard side of the DEEPWATER HORIZON approximately 20 to 30 ft from the center of the drill floor and is a deck above the main deck. There is a firewall between the Measurements While Drilling Unit and the drill floor.

186 The smoke room is outboard on the port side at the aft end of the accommodations spaces on the second deck.

187 12/7/10 MBI Tr. at 49-50, 100-102, 183-185 (Keith).

188 12/7/10 MBI Tr. at 115 (Keith).

189 Sperry-Sun data; 12/7/10 MBI Tr. at 112 (Gisclair).

WELL CONTROL EVENT AND BLOWOUT

2.49 At approximately 2110, Subsea Supervisor, Chris Pleasant, left the drill floor and went to the moon pool to check equipment. For approximately 10 to 15 minutes, Pleasant checked equipment and vented the tensioners,[190] then checked the regulators for the BOP controls and adjusted the lower annular pressure from 1,900 psi back to 1,500 psi.[191]

2.50 At approximately 2116, the M-I Swaco Mud Engineer, Greg Meche, obtained a sample of the returns from the riser in order to conduct a static sheen test.[192] The sample, which was taken based on the stroke count during the riser displacement, was timed to correspond with when the drill mud would have been displaced from the riser and the spacer would be arriving onboard.[193] The pumps were shut down while the static sheen test was being conducted. The pumps were restarted after the test was completed and considered successful.[194]

2.51 Between approximately 2100 and 2115, the visiting BP and Transocean personnel arrived on the Bridge with the Offshore Installation Manager and the Master. Transocean Division Manager, Daun Winslow, asked the on tour Senior Dynamic Positioning Officer, Yancy Keplinger, to set up the dynamic positioning simulator for use by the visitors.[195]

2.52 At 2120, the Senior Tool Pusher who was in his office, called the Tool Pusher who was on the drill floor, to determine how the negative pressure test had gone.[196] Anderson reported that it was good; he elaborated that they held it for 30 minutes and did not observe any flow.[197] Anderson was also reported to have said the displacement was going fine and that they expected to have the spacer soon.[198]

2.53 Between approximately 2120 and 2130, the Halliburton Service Supervisor went to the rig floor to pour the surface cement plug.[199] The Service Supervisor was told by the Driller that it would be a couple of hours before they would be ready to pour the cement plug, so he went below to his room to print out the procedure.[200]

2.54 The Offshore Installation Manager remained on the Bridge until sometime prior to 2130, reviewing work permits.[201] The Offshore Installation Manager then went below to his office and subsequently to his quarters.[202] At approximately 2130, the Subsea Supervisor was in the Offshore Installation Manager's office for approximately five minutes to have the Offshore Installation Manager sign documents related

190 5/28/10 MBI Tr. at 119-120 (Pleasant).

191 5/28/10 MBI Tr. at 120 (Pleasant).

192 5/28/10 MBI Tr. at 207-209 (Meche). The purpose of the static sheen test was to demonstrate that there was not any mixing of the oil based drill mud with the spacer, which was going to be discharged overboard.

193 5/28/10 MBI Tr. at 215 (Meche).

194 BP internal interview of Vidrine, 27 Apr 2010 (BP-HZN-MBI 21415); 10/8/10 MBI Tr at 131 (Gisclair).

195 10/5/10 MBI Tr. at 149 (Keplinger); 5/27/10 MBI Tr. at 10 (Harrell).

196 5/28/10 MBI Tr. at 281-282 (Ezell).

197 5/28/10 MBI Tr. at 282 (Ezell).

198 5/28/10 MBI Tr. at 282 (Ezell).

199 USCG statement of Haire, 21 April 2010.

200 USCG statement of Haire, 21 April 2010. Haire's room was inboard, on the starboard side, immediately forward of the moon pool.

201 5/27/10 MBI Tr. at 10 (Harrell).

202 5/27/10 MBI Tr. at 10 (Harrell).

to the casing test.[203]

2.55 At approximately 2130, the Chief Mate, David Young, arrived on the drill floor to discuss the planned cement job for the surface top plug with Tool Pusher, Jason Anderson.[204] According to the Chief Mate, Anderson and the Driller were concerned with the differential pressure and that it would take a little bit longer "to figure out."[205] The Chief Mate said that he was told it was not likely that the cement job would be conducted on schedule "due to the issue with the well."[206] The Chief Mate went from the drill floor to his office on the Bridge; he then went below to the Subsea Office[207] to talk with the Subsea Engineer "about the fact they appeared to be having well control issues."[208]

2.56 At approximately 2130, the Chief Electronics Technician, Michael Williams, was in the Electronic Technician's Shop, talking with his wife by telephone.[209] At some point during the call, his wife heard an announcement through the telephone and asked if he needed to get off the phone. Williams told his wife that it was just an indication to make everyone aware of gas levels.[210]

2.57 Murray stated that sometime between approximately 2140 and 2200[211] he tagged out the No. 2 mud pump so that the pop off valve could be replaced.[212] Approximately 10 minutes later, Murray went back to the mud pump room to de-isolate the pump.[213] After de-isolating the pump, he went to the electrical shop[214].[215] He reported that after entering the shop he heard a high pressure noise, felt the Unit vibrate and then heard a loud boom coming from the direction of the Mud Pump Room, after which the power went out.[216] He reported leaving the shop and returning to the Mud Pump Room. According to Murray, Wyatt Kemp, Shane Roshto, Don Clark, and Adam Weise were in the pump room between the No. 2 and No. 3 pumps when he left the space.[217]

2.58 The Subsea Supervisor, Christopher Pleasant, entered the Subsea Office[218] a few minutes after 2140, after having the Offshore Installation Manager sign off on the negative differential pressure test results.[219] The Assistant Driller, Allen Seraile, was in the Subsea Office watching the closed circuit television

203 5/28/10 MBI Tr. at 120-121 (Pleasant).

204 5/27/10 MBI Tr. at 258-259 (Young).

205 5/27/10 MBI Tr. at 259 (Young).

206 USCG statement of Young, 22 April 2010.

207 The Subsea Office is on the second deck, port side, forward.

208 USCG statement of Young, 22 April 2010; 5/27/10 MBI Tr. at 260-261 (Young).

209 7/23/10 MBI Tr. at 9 (Williams).

210 7/23/10 MBI Tr. at 10 (Williams). In regard to the alarms, Williams further testified that "We had gotten them so frequently that I had actually become somewhat immune to them." 7/23/10 MBI Tr. at 10 (Williams).

211 Based on the time when the last Sperry-Sun data was transmitted from DEEPWATER HORIZION (approximately 2149), the time when Coast Guard District Command Center received the DSC alert from DEEPWATER HORIZON (2203) and testimony of the Master of the DAMON B. BANKSTON, as well as from other personnel onboard DEEPWATER HORIZON, the pump was most likely tagged out sometime between 2130 and 2140.

212 USCG statement of Murray, 21 April 2010.

213 USCG statement of Murray, 21 April 2010.

214 The Electrical Shop is on the third deck, midships outboard, on the port side.

215 USCG statement of Murray, 21 April 2010.

216 USCG Statement of Murray, 21 April 2010.

217 5/27/10 MBI Tr. at 335-336 (Murray).

218 The Subsea Office is on the second deck, port side, forward.

219 5/28/10 MBI Tr. at 121-122, 140 (Pleasant).

(CCTV) and reported seeing mud on the drill floor via the CCTV.[220] Pleasant immediately tried calling the drill floor on three different extensions; the calls were not answered.[221] Pleasant and Seraile left the Subsea Office after the calls to the drill floor went unanswered.[222]

2.59 A Sperry-Sun Mud Logger, Joseph Keith, who was in the Measurements While Drilling Unit, felt the Unit begin to vibrate and what sounded like rain falling on the Unit.[223] According to his testimony, this was immediately followed by gas entering the Unit.[224] He indicated that the vibration then increased.[225]

2.60 According to Keplinger, after the visitors had been using the dynamic positioning simulator for approximately half an hour, between approximately 2140 and 2145,[226] the Master asked "what that noise was."[227] Keplinger said that he then turned and saw mud spraying out under great force from one of the lines on the starboard side of the DEEPWATER HORIZON via the CCTV monitor No. 6,[228] which was displaying feed from camera 21.[229]

2.61 The Dynamic Positioning Officer, Andrea Fleytas, reported feeling a jolt almost at the same time that Keplinger was seeing mud on the CCTV. Fleytas testified that immediately after feeling the jolt, the combustible gas alarms for the Shaker House and then the drill floor were activated and showed magenta.[230] After these alarms were received, the drill floor called to report they had a well control situation.[231] This call was followed by a call from the Engine Control Room asking what was going on.[232] Fleytas further testified that within seconds of the call from the Engine Control Room there were additional combustible gas alarms.[233] Keplinger testified that there was "a lot of gas" in the Shale Shaker Room.[234] He did not know if anyone was in the Shale Shaker Room but tried calling; the call was not answered.[235]

2.62 The Master stated that upon hearing the alarms he looked out the port side Bridge window and saw mud on the water.[236] He then looked out the starboard window and saw mud coming out of the diverter

220 USCG statement of Seraile, no date.

221 5/28/10 MBI Tr. at 143 (Pleasant).

222 5/28/10 MBI Tr. at 143 (Pleasant).

223 12/7/10 MBI Tr. at 61-62 (Keith).

224 12/7/10 MBI Tr. at 61-62 (Keith).

225 12/7/10 MBI Tr. at 61-62 (Keith).

226 The estimate of approximately 2140 to 2145 is based on the written statements from Pat O'Bryan and Daun Winslow that they went directly from the meeting, which was reported to have ended between 2100 and 2115, with the DEEPWATER HORIZON's senior management to the Bridge, and Keplinger's testimony (10/5/10 MBI Tr. at 149 (Keplinger)) that there was a question and answer session with the visitors before they started using the simulator. Keplinger testified that the visitors had been using the simulator for approximately 30 minutes before mud was seen on the starboard side. 10/5/10 MBI Tr. at 149 (Keplinger).

227 10/5/10 MBI Tr. at 149 (Keplinger). Keplinger also testified that the visitors were on the Bridge for approximately 45 minutes to an hour. *Ibid*, p. 162.

228 10/5/10 MBI Tr. at 149-150 (Keplinger).

229 10/5/10 MBI Tr. at 202 (Keplinger). Camera 21 was mounted on the starboard side, forward, and directed aft, toward the starboard gantry crane.

230 10/5/10 MBI Tr. at 13-14 (Fleytas). An alarm showing a magenta light is a critical alarm that requires immediate attention. *See* OPERATOR MANUAL Kongsberg Simrad Vessel Control System at 70 (KMI-PI 000757).

231 10/5/10 MBI Tr. at 13-14 (Fleytas).

232 10/5/10 MBI Tr. at 13-14 (Fleytas).

233 10/5/10 MBI Tr. at 40, 47 (Fleytas). Fleytas testified that there were "hundreds of combustible gas alarms."

234 10/5/10 MBI Tr. at 151 (Keplinger).

235 10/5/10 MBI Tr. at 151 (Keplinger).

236 5/27/10 MBI Tr. at 187 (Kuchta).

line[237].[238]

2.63 Haire, who was in his room, stated that he heard noises coming from the Sack Room. He then heard the General Alarm.[239]

2.64 According to Williams, he then heard a loud hissing noise and a thump, at which time he hung up the phone.[240] Within seconds, he started hearing a beeping sound that became nearly continuous, which he said was coming from the control panel in the Engine Control Room.[241] Williams testified that he then heard the No. 3 engine start to speed up.[242] He stated that the engine stopped and was followed by the first explosion and then a second explosion.[243]

2.65 At approximately 2140, the Deckpusher, Dennis Martinez, was in his office, located forward on the second deck, starboard side outboard, when he heard a loud blowing noise.[244] The Deckpusher called the starboard crane operator, Dale Burkeen, to find out what was going on.[245] According to Martinez, Burkeen stated that he thought the well had blown out and there was mud flying everywhere.[246] Martinez then left his office to go up to the main deck.[247]

2.66 Between approximately 2140 and 2145, the Mate on watch onboard the DAMON B. BANKSTON stated that he observed material coming from underneath the DEEPWATER HORIZON.[248] The Mate said that mud began to rain down on the DAMON B. BANKSTON and then very soon thereafter he saw an eruption of fluid from the aft end of the derrick, main deck level, of the DEEPWATER HORIZON.[249]

2.67 The DAMON B. BANKSTON's Master called the DEEPWATER HORIZON to advise them of the situation and to find out what was going on.[250] He was informed by the DEEPWATER HORIZON that they were having a well control situation and that the DAMON B. BANKSTON should move to 500 m standby.[251]

2.68 Personnel in the Engine Control Room reported hearing what sounded like a very loud air leak, which was followed by a combustion gas alarm and the radio transmission to the DAMON B. BANKSTON indicating that the DEEPWATER HORIZON was having a well control situation.[252] It is not known

237 The diverter line is located midship and extends from the moon pool to the starboard side.

238 5/27/10 MBI Tr. at 187-88 (Kuchta). In a written statement Kuchta reported that the time was 2130 when he first heard the gas alarms. USCG statement of Kuchta, 21 April 2010. In his testimony before the JIT, he indicated that the time (2130) was not accurate. 5/27/10 MBI Tr. at 224 (Kuchta).

239 USCG statement of Haire, 21 April 2010.

240 7/23/10 MBI Tr. at 12 (Williams).

241 7/23/10 MBI Tr. at 11-12 (Williams).

242 7/23/10 MBI Tr. at 12-13 (Williams).

243 7/23/10 MBI Tr. at 13 (Williams).

244 USCG statement of Martinez, 21 April 2010.

245 USCG statement of Martinez, 21 April 2010.

246 USCG statement of Martinez, 21 April 2010.

247 USCG statement of Martinez, 21 April 2010.

248 USCG statement of Erickson, 22 April 2010; 5/11/10 MBI Tr. at 246 (Erickson).

249 5/11/10 MBI Tr. at 232 (Erickson).

250 5/11/10 MBI Tr. at 99 (Landry); 5/11/10 MBI Tr. at 232 (Erickson).

251 5/11/10 MBI Tr. at 99 (Landry); 5/11/10 MBI Tr. at 232 (Erickson).

252 5/28/10 MBI Tr. at 338 (Stoner); 5/29/10 MBI Tr. at 24 (Meinhart); 5/26/10 MBI Tr. at 93, 107 (Brown).

to which space the gas alarm light was applicable.[253] A Motorman reported that three to four more combustible gas alarm lights lit up soon after the first one.[254]

2.69 Almost immediately after personnel in the Engine Control Room reported hearing and seeing combustible gas alarm lights, the Motor Operator reported hearing a roaring sound overhead, which was followed by hearing the No. 3 engine speeding up and then shutting down.[255] Concurrently, he saw the combustible gas alarms light up and, within approximately 15 to 20 seconds, saw three to five ESD lights on the bottom of the ESD panel flashing.[256]

2.70 At approximately 2145, an Assistant Driller, Don Clark, who was working with representatives from Weatherford, Brandon Boullion, and Dril-Quip, Charles Credeur, at the bucking station,[257] received a call asking him to come to the mud pits.[258] It is not known why the Assistant Driller was called to the pits. 30 to 60 seconds after Clark left, Credeur saw mud flowing from the drill floor.[259] Boullion saw mud flying out of the derrick.[260] Both Credeur and Boullion immediately proceeded forward on the port side toward the Bridge.[261] Credeur stated that mud was falling down on them as they went forward.[262]

2.71 The Port Gantry Crane Operator, Micah Sandell, who was in the Gantry Crane on the port aft deck, had just finished making up one tool and was preparing to start on another, when he saw mud shooting straight up the derrick.[263] Sandell saw the mud stop for several seconds and then saw it coming out of the degasser vent[264].[265] According to Sandell, the material coming out of the vent covered the back deck with a "gassy smoke" and it was extremely loud.[266]

2.72 The Chief Engineer, Stephen Bertone, was in his room[267] when he heard a noise that sounded like the tensioners being bled off.[268] Bertone then heard a thumping sound and felt the DEEPWATER HORIZON begin to shake.[269]

2.73 The Electrical Supervisor, Stanley Carden, was in his room[270] when he felt the Unit start to shake and

253 The Chief Mechanic reported that the alarms "just kept piling up on top of each other." 5/26/10 MBI Tr. at 93 (Brown).

254 5/29/10 MBI Tr. at 29 (Meinhart).

255 5/28/10 MBI Tr. at 340-341 (Stoner); 5/29/10 MBI Tr. at 29-30 (Meinhart); 5/26/10 MBI Tr. at 93-94 (Brown).

256 5/28/10 MBI Tr. at 341 (Stoner).

257 The Bucking Station is located on the main deck, port side, aft, approximately 50 ft from the rig floor.

258 5/29/10 MBI Tr. at 62 (Credeur). The time 2145 is based on written statements of Charles Credeur and Brendon Bullion. USCG statement of Credeur, 21 April 2010; USCG statement of Boullion, 21 April 2010.

259 In his testimony he stated that the mud looked "like a waterfall coming off the rig floor onto the main deck." 5/29/10 MBI Tr. at 62-63 (Credeur).

260 USCG statement of Boullion, 21 April 2010.

261 5/29/10 MBI Tr. at 63 (Credeur).

262 5/29/10 MBI Tr. at 63 (Credeur).

263 5/29/10 MBI Tr. at 8-9 (Sandell).

264 The degasser is located immediately above the degasser pit, aft of the moon pool. DEEPWATER HORIZON Rig General Arrangements, Second Deck, Drawing No. A-AA 1003. The degasser vent, which is a vacuum breaker, is a six inch pipe that extends approximately one-third up the derrick. At the top of the vent is a gooseneck that points back to the deck.

265 USCG statement of Sandell, 21 April 2010; 5/29/10 MBI Tr. at 9-10 (Sandell).

266 5/29/10 MBI Tr. at 10 (Sandell).

267 The Chief Engineer's room is located on the third deck, centerline, forward.

268 Bertone stated that the sound got louder until it sounded like "a freight train." 7/19/10 MBI Tr. at 34-35 (Bertone).

269 7/19/10 MBI Tr. at 34-35 (Bertone).

270 Carden's room was located on the third deck, starboard side, forward.

then heard a noise that sounded like high pressure air.[271]

2.74 At approximately 2145, the Senior ROV Technician, Darren Costello, heard an air leak and felt rumbling while in the ROV control van.[272] He opened the door to the van and saw gas coming up.[273]

2.75 At approximately 2145, "the lower annular BOP; an essential device for regaining well control, started to close around the drill string. Post incident analysis indicates that before this operation started a mixture of well fluids and gas had already entered the riser. Even though the annular BOP was able to substantially reduce or stop further well fluids and gas from entering the riser, liquids above the BOP were accelerated toward the MODU by the rapidly expanding gas."[274]

2.76 At approximately 2149, "pressure inside the drill string rapidly increased to 5,780 psi, [indicating] that one or more pipe rams in the BOP stack may also have been operated by the rig crew.[275] The hook load measured the drill string weight at 352,000 lbs."[276]

2.77 Between approximately 2148 and 2153, the Master of the DAMON B. BANKSTON heard a hissing sound coming from the DEEPWATER HORIZON, which was like the release of high pressure air or gas, and lasted for approximately 30 seconds[277].[278] After hearing the hissing sound, mud began to fall on the DAMON B. BANKSTON. Mud was seen by the Master coming from the top of the derrick of the DEEPWATER HORIZON.[279]

2.78 At approximately 2150,[280] the Senior Tool Pusher, Randall Ezell, was in his cabin[281] and received a phone call from the Assistant Driller, Steve Curtis.[282] Curtis was reported to have said that the well had blown out, that mud was going to the crown of the derrick, and that they needed his help.[283] Ezell was told by Curtis that the well was being shut in.[284]

271 USCG statement of Carden, 21 April 2010.

272 The ROV Control Van is located on the main deck, starboard side, forward, stacked on top of the ROV work van.

273 USCG statement of Costello, 21 April 2010.

274 Well Control Report at 23-24.

275 The Republic of the Marshall Islands notes that an analysis of the BOP was recently conducted by DNV in connection with the multidistrict litigation No. 2179, *In re: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010, involving the DEEPWATER HORIZON*. The analysis has not been made available to the Administrator and the Administrator may revisit findings, conclusions, or recommendations in this investigation report if or when this BOP analysis is made available.

276 Well Control Report at 24.

277 The Master of the DAMON B. BANKSTON stated in testimony that he had heard a similar sound before, both at the Macondo well and at other wells. However, he stated that in this case the sound was distinguished by its duration, which was longer than those he had heard in the past. 5/11/10 MBI Tr. at 103 (Landry).

278 5/11/10 MBI Tr. at 152-153 (Landry).

279 5/11/10 MBI Tr. at 136 (Landry).

280 Based on other testimony as well as the time when the Sperry-Sun system stopped (between 2149 and 2150), it is likely that this phone call occurred prior to 2150.

281 Ezell's cabin was on the second deck, starboard side, immediately forward of the Sack Room.

282 5/28/10 MBI Tr. at 282-283 (Ezell).

283 5/28/10 MBI Tr. at 283 (Ezell).

284 5/28/10 MBI Tr. at 283 (Ezell).

FIRE AND EXPLOSIONS

2.79 Between 2150 and 2152,[285] and almost immediately after the eruption of liquid aft of the derrick, a flash of fire on top of the liquid was witnessed by the Master of the DAMON B. BANKSTON.[286] Seconds later, and immediately prior to the first and second explosions onboard the DEEPWATER HORIZON, the Master of the DAMON B. BANKSTON stated that he saw a green flash just aft of the derrick on the main deck of the DEEPWATER HORIZON.[287]

2.80 The Master of the DAMON B. BANKSTON directed his crew to disconnect the mud transfer hose and then moved the vessel to a position approximately 100 m off the DEEPWATER HORIZON's port bow.[288]

2.81 According to Keplinger, the first major explosion occurred almost immediately after he tried calling the Shale Shaker Room.[289]

2.82 According to Stoner, a Motorman, the initial explosion blew the port side door inward; "it just folded over and blew inward instead of outward, which way it opens."[290]

2.83 After the initial explosion, the first alarms (Shale Shaker Room and drill floor) were quickly followed by a "series of combustible gas alarms."[291] The drill floor called the Bridge saying that "we were under a well control situation;" no other details were provided.[292] Immediately after this call, there was a call from the Engine Control Room asking what was going on and the Engine Control Room was told there was a well control situation.[293] The Dynamic Positioning Officer testified that within seconds of the call from the Engine Control Room there were "hundreds" of combustible gas alarms.[294]

2.84 According to testimony from the personnel in the Engine Control Room, the alarms and the revving up and shutting down of the No. 3 engine was immediately followed by the first explosion, after which the Unit went dark.[295]

2.85 At approximately 2148, a crew member in the ROV Control Van, reported hearing the first explosion[296] and reported seeing a stream of fire extending 50 ft off the starboard side of the DEEPWATER HORIZON.[297] Witness accounts indicate that the sound of gas blowing out[298] was followed by a "tremendous explosion"

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285 5/11/10 MBI Tr. at 232, 235, 243, 246-249 (Erickson) stating that the eruption was higher than eight feet.

286 USCG statement of Landry, 21 April 2010. The Bridge of the DAMON B. BANKSTON was approximately level with the main deck of the DEEPWATER HORIZON.

287 5/11/10 MBI Tr. at 137 (Landry).

288 11/10 MBI Tr. at 183 (Gervasio); 5/11/10 MBI Tr. at 104 (Landry).

289 10/5/10 MBI Tr. at 151 (Keplinger).

290 05/28/10 MBI Tr. at 341 (Stoner).

291 10/5/10 MBI Tr. at 13 (Fleytas).

292 USCG statement of Fleytas, 21 April 2010.

293 USCG statement of Fleytas, 21 April 2010; 10/5/10 MBI Tr. at 13-14 (Fleytas).

294 10/5/10 MBI Tr. at 40, 47 (Fleytas).

295 5/28/10 MBI Tr. at 341 (Stoner); 5/29/10 MBI Tr. at 29-30 (Meinhart); 5/26/10 MBI Tr. at 93-94 (Brown).

296 In his written statement, Costello reported that the first explosion was three minutes after he first heard the air leak, which he reported occurred at 2145. USCG statement of Costello, 21 April 2010.

297 USCG statement of Costello, 21 April 2010.

298 USCG statement of Young, 22 April 2010.

that appeared to occur in the vicinity of the degasser.[299] Haire stated the first explosion came from the direction of the Sack Room.[300] A crew member in the Measurements While Drilling Unit testified that after the vibration of the Unit increased, he heard an explosion.[301] On the main deck, a loud boom occurred over the motor shed and the drill floor.[302] Mud was raining down on the deck.[303] The two Motormen stated that the port side door to the Engine Control Room was blown open during the first explosion.[304]

2.86 The Senior Tool Pusher stated that after hanging up the phone he went from his cabin to the Tool Pusher's office,[305] and that there was a "tremendous explosion that pushed him across the office and the lights were out."[306]

2.87 Murray stated that after leaving the Pump Room he went back to the Electrical Shop.[307] He said that after entering the shop he heard a high pressure noise, felt the Unit vibrate and then heard a loud boom coming from the direction of the Mud Pump Room, after which the power went out.[308] Murray left his shop and returned to the Pump Room.[309] Murray reported that when he opened the Pump Room door, smoke rolled out and that it was "dark, smoky, [with] stuff just scattered everywhere" and that "[Wyatt Kemp, Shane Roshto, Don Clark and Adam Weise] didn't make it."[310] He stated that he did not smell gas or see fire.[311] The Subsea Supervisor left his office to proceed aft to the moon pool but was told by Murray as they were in the passageway that "something bad had happened in there" and that he should not go that way.[312]

2.88 Between 2149 and 2150, Sperry-Sun data transmission was lost.[313]

2.89 After the first explosion, the lights on the DEEPWATER HORIZON went out and a total loss of power occurred.[314] However, the transition power supply for radio communications equipment and the Public Address/General Alarm system functioned and enabled personnel to utilize the system.[315] One witness testified that there were just emergency lights after the first explosion.[316] Immediately after the power

299 5/29/10 MBI Tr. at 10-11, 16 (Sandell). The degasser is located immediately above the degass pit and is starboard and aft of the moon pool.

300 USCG statement of Haire, 21 April 2010. The Sack Room is located on the second deck, starboard side midships.

301 12/7/10 MBI Tr. at 62, 106 (Keith).

302 USCG statement of Martinez, 21 April 2010. Martinez did not specify where on the main deck he was; however, based on the location of his office and the locations of the stairways, he would have been on the main deck, starboard side forward.

303 USCG statement of Young, 22 April 2010.

304 5/28/10 MBI Tr. at 342 (Stoner); 5/29/10 MBI Tr. at 29-30 (Meinhart).

305 The Tool Pusher's Office is on the second deck, outboard on the starboard side forward of the Sack Room.

306 5/28/10 MBI tr. at 284 (Ezell).

307 USCG statement of Murray, 21 April 2010.

308 USCG statement of Murray, 21 April 2010.

309 USCG statement of Murray, 21 April 2010.

310 5/27/10 MBI Tr. at 335-336 (Murray).

311 5/27/10 MBI Tr. at 314 (Murray).

312 5/28/10 MBI Tr. at 122 (Pleasant).

313 Sperry-Sun real time data, 20 April 2010.

314 5/28/10 MBI Tr. at 284 (Ezell); 12/7/10 MBI Tr. at 62, 106 (Keith); USCG statement of Martinez, 21 April 2010; USCG statement of Costello, 21 April 2010; 7/19/10 MBI Tr. at 35; *see however,* 10/5/10 MBI Tr. at 151 (Keplinger) stating "the first major explosion, which was the second explosion, blacked out the rig"; 5/29/10 MBI Tr. at 64 (Credeur). Credeur stated the lights went out before the first explosion.

315 USCG statement of Fleytas, 21 April 2010; USCG statement of Keplinger, 21 April 2010.

316 USCG statement of Carden, 21 April 2010.

went out, the Master directed Keplinger to make an announcement for the crew to go to their muster stations; this announcement was followed by sounding the General Alarm.[317]

2.90 A "Mayday" was broadcast via the DEEPWATER HORIZON's VHF Channel16 and the distress buttons were hit.[318] The Master of the DAMON B. BANKSTON heard the GMDSS alarms and Mayday of "the rig's on fire, abandon ship."[319] As the initial muster station was taken out by an explosion, the muster announcement was modified to direct the crew to the alternate muster station in the vicinity of the lifeboat embarkation deck.[320]

2.91 Witness testimony indicated that after the first explosion, areas of the Unit were covered with debris and filled with smoke and that they could smell, feel, and/or taste fuel or methane in the air.[321] Martinez reported that the door for the starboard crane was open but that the crane operator was not seen in the cab; the fire and ongoing explosions prevented closer inspection of the starboard crane cab.[322] The electrical breaker box in the Measurements While Drilling Unit was sparking for a brief period.[323] There was fire on the deck between the Measurements While Drilling Unit and the Mud Logger van, outboard of the Measurements While Drilling Unit, and on top of the Motor Shed, starboard of the derrick.[324]

2.92 Approximately 5-20 seconds after the first explosion, a second large explosion occurred followed by a whooshing sound.[325] This second explosion covered the back deck and ignited a fire whose flames extended to the top of the derrick[326] and, according to the Mud Logger, caused the paneling in the Measurements While Drilling Unit to buckle due to the heat, the roof mounted air conditioning unit to catch fire, and material inside begin to burn.[327] The starboard side door to the Engine Control Room blew inward[328] and a watertight door leading from the accommodations space to the lifeboat deck was blown open by the explosion.[329] A stream of fire extending 50 ft off the starboard side of the DEEPWATER HORIZON was seen.[330]

2.93 After the second explosion, spot fires occurred on deck and fire could be seen on camera, though the exact location of the fire seen on camera was not known.[331] Fire was also visible on the starboard side

317 10/5/10 MBI Tr. at 152, 259-260 (Keplinger); 10/5/10 MBI Tr. at 14 (Fleytas).

318 USCG statement of Keplinger, 21 April 2010; 10/5/10 MBI Tr. at 152 (Keplinger); USCG statement of Fleytas, 21 April 2010; 10/5/10 MBI Tr. at 14 (Fleytas).

319 05/11/10 MBI Tr. at 105 (Landry).

320 USCG statement of Fleytas, 21 April 2010; USCG statement of Keplinger, 21 April 2010; 5/29/10 MBI Tr. at 84 (Burgess).

321 5/28/10 MBI Tr. at 285 (Ezell) (stating "I could actually feel…droplets. It was moist on the side of my face."); 7/19/10 MBI Tr. at 35 (Bertone); 5/27/10 MBI Tr. at 10, 64-65 (Harrell).

322 USCG statement of Martinez, 21 April 2010.

323 12/7/10 MBI Tr. at 63 (Keith).

324 5/29/10 MBI Tr. at 10-11 (Sandell).

325 12/7/10 MBI Tr. at 63-64 (Keith); 5/28/10 MBI Tr. at 341 (Stoner); 5/29/10 MBI Tr. at 29-30 (Meinhart); 7/19/10 MBI Tr. at 35 (Bertone).

326 5/29/10 MBI Tr. at 10-11 (Sandell).

327 12/7/10 MBI Tr. at 63-64 (Keith).

328 5/28/10 MBI Tr. at 342 (Stoner), "As soon as [the port door] blew in within a matter of seconds the starboard side blew in as soon as you heard the second explosion." *See also*, 5/29/10 MBI Tr. at 29-30 (Meinhart); 5/26/10 MBI Tr. at 94 (Brown).

329 5/29/10 MBI Tr. at 64 (Credeur). Based on the General Arrangement drawing, the door that blew open was most likely located on the second deck, centerline forward; this door led from the accommodations space to the lifeboat deck.

330 USCG statement of Costello, 21 April 2010.

331 10/5/10 MBI Tr. at 150 (Keplinger).

main deck.[332] Fire was seen from the starboard window of the Bridge that covered the width and height of the derrick.[333] The main stairs, which were on the centerline, and the starboard stairs were blocked by debris; the port side spiral staircase was passable.[334] The passageway aft of the transformer room was blocked with debris and ceiling panels and walls in the galley were knocked down.[335] The Offshore Installation Manager testified that there were no walls or ceiling left in the living quarters, (second deck) on the starboard side, after the explosion.[336] The Offshore Installation Manager reported that after the explosion he had insulation and methane in his eyes.[337] The sprinkler system was activated after the explosion and there was smoke in the accommodations spaces and a great deal of debris.[338] The decks were covered with a slippery substance that could have been mud or oil and gas.[339] The starboard side crane operator, Dale Burkeen, was discovered lying face down on the main deck and did not have a pulse.[340]

2.94 The Chief Mechanic stated that the watertight door at the aft end of the Engine Control Room had also been blown inward.[341] Some personnel in the Engine Control Room proceeded to the bridge where the Master instructed them to "go to the lifeboats."[342] According to testimony, there was extensive damage to the aft end of the DEEPWATER HORIZON in the way of the No. 3 engine room.[343] Williams testified that once on deck the hissing noise that he had heard while in the Engine Control Room increased in intensity to a "full-blown roar."[344]

2.95 Winslow testified that he was in the coffee shop/smoking area when he heard what he described as "probably the loudest bang I've heard offshore in many years."[345] He proceeded to the forward athwartship passage where it was possible to see across to the starboard side.[346] Winslow testified that he observed, "explosive force coming along, the walls were sucking in and the roof panels looked like they were coming down" and he felt a "whoosh of kind of high pressure air" go by.[347] He proceeded through the accommodation space to the lifeboat embarkation deck, where he saw the derrick ablaze.[348]

2.96 The Motor Operator in the Engine Control Room testified to seeing "three, maybe five" ESD lights

332 USCG statement of Young, 22 April 2010.

333 7/19/10 MBI Tr. at 36 (Bertone); 5/27/10 MBI Tr. at 65-66 (Harrell); 7/23/10 MBI Tr. at 16 (Williams).

334 USCG statement of Carden, 21 April 2010; 7/19/10 MBI Tr. at 35 (Bertone).

335 5/27/10 MBI Tr. at 328 (Murray).

336 5/27/10 MBI Tr. at 10, 53 (Harrell).

337 5/27/10 MBI Tr. at 49 (Harrell). Daun Winslow testified that when he saw the Offshore Installation Manager on the Bridge following the explosions, it appeared that he was having difficulty seeing and hearing. 8/23/10 MBI Tr. at 451 (Winslow).

338 5/28/10 MBI Tr. at 261-264 (Haire).

339 5/27/10 MBI Tr. at 66 (Harrell).

340 12/7/10 MBI Tr. at 65 (Keith).

341 5/26/10 MBI Tr. at 94 (Brown).

342 5/26/10 MBI Tr. at 95 (Brown).

343 7/23/10 MBI Tr. at 16 (Williams). An examination of photographs taken of the DEEPWATER HORIZON on 21 and 22 April 2010 before the Unit sank show all of the exhausts in place and do not reveal any extensive damage to the aft bulkhead.

344 7/23/10 MBI Tr. at 16 (Williams).

345 8/23/10 MBI Tr. at 447 (Winslow).

346 8/23/10 MBI Tr. at 447 (Winslow).

347 8/23/10 MBI Tr. at 447-448 (Winslow).

348 8/23/10 MBI Tr. at 448 (Winslow).

flashing seconds before the first explosion. He described them as being on the "bottom of the panel."[349]

INITIAL EMERGENCY RESPONSE

2.97 At 2204, the USCG Eighth District Command Center reported receiving a DSC alert from the DEEPWATER HORIZON reporting an explosion onboard.[350] At approximately the same time, the USCG Eighth District Command Center received a call from an unidentified unit that was 25 NM away reporting that the DEEPWATER HORIZON was on fire, persons were jumping into the water, and that they would send five vessels to assist.[351] At 2206, the USCG Eighth District Command Center received a call from a vessel providing a radio relay reporting that the DEEPWATER HORIZON was engulfed in flames.[352]

2.98 As the muster announcement was being made by Keplinger, the Chief Mate went to Fire Gear Locker No. 1, which is on the main deck just aft of the Bridge.[353] The Chief Mate said that when he got to the gear locker he was told by a member of the crew that there was an unknown person down by the starboard crane.[354] The Chief Mate went to investigate and confirmed someone was down; he then went to the Bridge and asked Mike Mayfield to assist him, as he was not able to move the person by himself.[355] Upon returning to the Fire Gear Locker No. 1, there was another explosion and the fire on deck made it impossible for them to get back to the person who was down.[356] The Chief Mate and Mayfield went to the lifeboat deck.[357] The Chief Mate saw that the crew was being mustered, and then went to the Bridge.[358] Mayfield went to lifeboat No. 2; he was assigned as the coxswain.[359]

2.99 Pleasant, the Subsea Supervisor, testified that upon reaching the Bridge he immediately announced that he was going to activate the EDS.[360] According to testimony and written statements, there was some discussion on the Bridge regarding who had the authority to order the EDS be activated.[361] Pleasant testified that he did not require authorization from the Master to activate the EDS.[362] Pleasant also testified that after activating the EDS he did not see any indication of hydraulic pressure.[363] According to Winslow, Pleasant stated, "There's nothing here."[364]

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349 5/28/10 MBI Tr. at 341 (Stoner).

350 USCG, Final Action Report on the SAR Case Study into the Mass Rescue of Personnel off the Mobile Offshore Drilling Unit DEEPWATER HORIZON, CG-53, 16106 at 2.

351 USCG Incident Management Activity, Activity No. 3721000 at 1.

352 USCG Incident Management Activity, Activity No. 3721000 at 1.

353 5/27/10 MBI Tr. at 262 (Young).

354 5/27/10 MBI Tr. at 265 (Young).

355 USCG statement of Mayfield, 22 April 2010.

356 5/27/10 MBI Tr. at 265-266 (Young); USCG statement of Mayfield, 22 April 2010.

357 USCG statement of Mayfield, 22 April 2010.

358 5/27/10 MBI Tr. at 267 (Young).

359 USCG statement of Mayfield, 22 April 2010.

360 5/28/10 MBI Tr. at 123 (Pleasant).

361 8/23/10 MBI Tr. at 450-451 (Winslow); 5/28/10 MBI Tr. at 123 (Pleasant).

362 5/28/10 MBI Tr. at 124 (Pleasant).

363 5/28/10 MBI Tr. at 123 (Pleasant). The absence of hydraulic pressure is an indication that the signal from the EDS panel was not sent to controls for the BOP, which are in the vicinity of the moon pool.

364 8/23/10 MBI Tr. at 451 (Winslow).

2.100 The Offshore Installation Manager testified that he reached the Bridge after the distress call was made.[365] He also testified that he ordered the Subsea Supervisor to activate the EDS, but that it did not do anything and that the lights on the EDS panel did not appear to be normal.[366]

2.101 Personnel onboard DEEPWATER HORIZON testified the fire was considered too large for the crew to fight.[367] There was testimony that until the source of the fuel was secured and the flow from the well was stopped, the fire onboard DEEPWATER HORIZON could not be extinguished.[368]

2.102 Ezell, Carden, and Murray stated they found Wyman Wheeler lying covered with debris in the starboard passageway and Buddy Trahan lying covered with debris in the Maintenance Office.[369] Ezell was removing the debris from the two injured men.[370] After determining both Wheeler and Trahan were seriously injured, Carden and Murray went out and asked personnel at the lifeboats for two stretchers.[371] Carden and Murray removed Trahan by stretcher to the lifeboat deck and then returned to help Ezell move Wheeler.[372] Trahan was loaded into lifeboat No. 1 on the stretcher; the stretcher was then thrown overboard.[373] Both lifeboats had been launched by the time Carden, Murray, and Ezell reached the lifeboat deck with Wheeler.[374]

2.103 After arriving on the Bridge, the Chief Engineer asked for and received permission from the Master to start the standby generator.[375] The Chief Engineer, accompanied by Williams and Meinhart, preceded to the Standby Generator Room, which is located on the main deck, port side, midships.[376] Multiple attempts to start the standby generator were not successful as the engine did not turn over.[377] The Chief Engineer, Williams and Meinhart then returned to Bridge.[378] The Chief Engineer testified that when he returned to the Bridge, lifeboats No. 1 and No. 2 had already been launched and were moving away from the DEEPWATER HORIZON.[379]

2.104 The Chief Mate testified that he went back and forth between the Bridge and lifeboat deck a couple of times and that the last time he went to the Bridge the first lifeboat was being launched.[380] When he got back to the lifeboat deck he began to prepare a davit launched liferaft to be launched.[381]

365 5/27/10 MBI Tr. at 105 (Harrell).

366 5/27/10 MBI Tr. at 21, 67-68 (Harrell).

367 5/29/10 MBI Tr. at 105 (Burgess); 5/29/10 MBI Tr. at 145-146 (Morales).

368 10/4/10 MBI Tr. at 195-196, 218 (Martin).

369 USCG statement of Carden, 21 April 2010; USCG statement of Murray, 21 April 2010; USCG statement of Ezell, 21 April 2010.

370 USCG statement of Ezell, 21 April 2010.

371 USCG statement of Carden, 21 April 2010; USCG statement of Murray, 21 April 2010.

372 5/28/10 MBI Tr. at 285, 287 (Ezell); USCG statement of Carden, 21 April 2010; 5/27/10 MBI Tr. at 327 (Murray).

373 USCG statement of Winslow, 26 April 2010.

374 5/28/10 MBI Tr. at 285, 287 (Ezell); USCG statement of Carden, 21 April 2010; 5/27/10 MBI Tr. at 327 (Murray).

375 7/19/10 MBI Tr. at 40 (Bertone).

376 7/19/10 MBI Tr. at 41-42 (Bertone).

377 7/19/10 MBI Tr. at 41-42 (Bertone); 7/23/10 MBI Tr. at 20 (Williams); 5/29/10 MBI Tr. at 40-41 (Meinhart).

378 7/19/10 MBI Tr. at 43 (Bertone).

379 7/19/10 MBI Tr. at 43 (Bertone).

380 5/27/10 MBI Tr. at 266 (Young).

381 5/27/10 MBI Tr. at 265 (Young).

EVACUATION

2.105 The Master gave the order to abandon the DEEPWATER HORIZON within minutes of the General Alarm first being sounded.[382]

2.106 The Master of the DAMON B. BANKSTON stated he saw people gathering on the lifeboat deck and that he saw three people jump into the water and immediately ordered the DAMON B. BANKSTON's fast rescue craft to be launched.[383] According to the Master of the DAMON B. BANKSTON's testimony, the fast rescue craft was launched at 2212 and immediately proceeded to recover crew members who had jumped from the DEEPWATER HORIZON.[384]

2.107 An effort was made to take muster of the crew onboard the DEEPWATER HORIZON before loading the lifeboats, but the situation was chaotic.[385] Three crew members were reported to have jumped into the water before the lifeboats were launched;[386] at least one crew member testified that he did not think there was much time due to the ongoing explosions and the fire, smoke and heat, and decided to jump into the water.[387] Some crew members reported that muster was also taken inside the lifeboats and that, given the extreme nature of the situation, the muster and loading of the lifeboats went well.[388]

2.108 The space inside the lifeboats was described as being very tight.[389] One individual stated that once inside the lifeboat he "had to wedge himself in to get a seat."[390] In part, this was attributed to injured persons laid out on the seats as they occupied more space than they normally would.[391] It was also reported that personnel either were not able to strap themselves in or did so incorrectly because of difficulties with the colored straps.[392] There was also testimony that the lifeboats were "pretty full."[393]

2.109 While the crew were arriving at the lifeboats, Winslow, the Transocean Division Manager, saw the traveling equipment and drilling blocks, which were at the top of the derrick, fall.[394] He stated that this equipment weighs approximately 150,000 lbs and could not be heard as it fell.[395] After seeing the equipment fall from the top of the derrick, Winslow directed the port lifeboat (No. 2) to be lowered.[396]

382 10/5/10 MBI Tr. at 152, 259-260 (Keplinger); 10/5/10 MBI Tr. at 14 (Fleytas).

383 5/11/10 MBI Tr. at 104-106 (Landry).

384 5/11/10 MBI Tr. at 104, 108 (Landry).

385 5/27/10 MBI Tr. at 48 (Harrell); 5/29/10 MBI Tr. at 12-13 (Sandell); 5/28/10 MBI Tr. at 225 (Meche).

386 5/11/10 MBI Tr. at 104 (Landry).

387 5/28/10 MBI Tr. at 222 (Meche).

388 5/28/10 MBI Tr. at 224-225 (Meche); 5/29/10 MBI Tr. at 13 (Sandell).

389 8/26/10 MBI Tr. at 396 (O'Bryan).

390 8/26/10 MBI Tr. at 396 (O'Bryan).

391 8/26/10 MBI Tr. at 396 (O'Bryan).

392 12/7/10 MBI Tr. at 71-72 (Keith).

393 12/7/10 MBI Tr. at 74 (Keith); *see also*, 5/28/10 MBI Tr. at 26 (Haire) and 5/28/10 MBI Tr. at 364 (Stoner). Approximately 100 of the 115 personnel evacuated the DEEPWATER HORIZON in lifeboat No. 1 and No. 2; both boats have a capacity of 73 persons.

394 8/23/10 MBI Tr. at 452 (Winslow).

395 8/23/10 MBI Tr. at 452 (Winslow).

396 8/23/10 MBI Tr. at 452 (Winslow).

After seeing the Master come down from the Bridge and head toward the liferafts, Winslow directed the starboard lifeboat (No. 1) to be lowered.[397] According to one crewmember, lifeboat No. 2 started to be loaded at approximately 2215 and was launched at approximately 2228.[398] Lifeboat No. 1 was launched a short time later.[399] Both lifeboats proceeded directly to the DAMON B. BANKSTON.[400]

2.110 The crew in the DAMON B. BANKSTON's fast rescue craft recovered three or four[401] crew members from the DEEPWATER HORIZON who had jumped into the water. The Master of the DAMON B. BANKSTON was shining the vessel's spotlight on the persons in the water to assist the crew of the fast rescue craft.[402] After transferring these crew members to the DAMON B. BANKSTON, the crew of the fast rescue craft then conducted a search of the water around the DEEPWATER HORIZON.[403] No additional persons were seen in the water.[404] Lifeboats No. 1 and No. 2 were clear of the DEEPWATER HORIZON and the fast rescue craft proceeded to the lifeboats and directed them to the starboard side of the DAMON B. BANKSTON.[405]

2.111 Approximately 11 personnel mustered at the forward davit launched liferafts, including Wyman Wheeler, who was in a stretcher.[406] The Chief Electronics Technician noticed that a rope attached to the releasing hook was secured to the davit by means of a shackle, which prevented the davit and liferaft from rotating clear of the DEEPWATER HORIZON.[407] After he removed the shackle pin with a small tool, the davit finally rotated to allow the liferaft to be deployed.[408]

2.112 The Chief Mate began preparing the davit launched liferaft to be launched.[409] When the davit launched liferaft had been inflated and hung at the rail, the Chief Mate and the Senior Tool Pusher got in the raft.[410] The stretcher carrying Wheeler was then passed into the liferaft.[411] As the liferaft was being loaded it filled with smoke and the air became hot; the liferaft was launched[412] before all personnel were onboard.[413] The Chief Mate testified that it was not possible to see the brake handle but that someone pulled it and the liferaft began to lower.[414] He further testified that when the liferaft was about halfway

397 8/23/10 MBI Tr. at 453 (Winslow).

398 USCG statement of Benton, 21 April 2010.

399 8/23/10 MBI Tr. at 452 (Winslow).

400 USCG statement of Rupinski, 21 April 2010.

401 The Master of the DAMON B. BANKSTON testified that he saw three people jump into the water while a fast rescue craft crew member reported seeing three or four people jump into the water. 5/11/10 MBI Tr. at 107 (Landry); 5/11/10 MBI Tr. at 190 (Gervasio).

402 5/11/10 MBI Tr. at 105-106 (Landry).

403 5/11/10 MBI Tr. at 190-191 (Gervasio).

404 5/11/10 MBI Tr. at 191 (Gervasio).

405 5/11/10 MBI Tr. at 191 (Gervasio).

406 Not including the missing crew members, the crew known to be remaining onboard immediately after the lifeboats were launched included: Alwin Landry, David Young, Stephen Bertone, Yancy Keplinger, Andrea Fleytas, Michael Williams, Paul Meinhart, Stanley Carden, Chad Murray, Randall Ezell, and Wyman Wheeler. 7/19/10 MBI Tr. at 44 (Bertone).

407 7/19/10 MBI Tr. at 44-45 (Bertone).

408 7/19/10 MBI Tr. at 44-45 (Bertone).

409 5/27/10 MBI Tr. at 266 (Young).

410 5/27/10 MBI Tr. at 268 (Young); 5/28/10 MBI Tr. at 288 (Ezell).

411 5/27/10 MBI Tr. at 268 (Young); 5/28/10 MBI Tr. at 288 (Ezell).

412 There is conflicting testimony as to who was lowering the liferaft. 5/27/10 MBI Tr. at 268-69 (Young); 5/28/10 MBI Tr. at 289 (Ezell); *but see* 5/27/10 MBI Tr. at 193 (Kutcha).

413 5/27/10 MBI Tr. at 268-269 (Young).

414 5/27/10 MBI Tr. at 269 (Young).

to the water it tilted 90 degrees and went the rest of the way to the water.[415] Chad Murray stated in his testimony that the sea painter "got left tied to the hand rail and once it tightened up, it jerked the raft up and it [threw] us all down to one side."[416] The Dynamic Positioning Officer testified that she fell out of the raft when it hit the water.[417] According to the Chief Mate, the sea painter[418] was still attached to the DEEPWATER HORIZON when the liferaft was lowered.[419]

2.113 The Master, the Senior Dynamic Positioning Officer, Motor Operator, and Chief Electronics Technician remained onboard the DEEPWATER HORIZON and decided to jump after the liferaft was launched rather than to manually retrieve the fall so that a second liferaft could be launched.[420] Once the liferaft had been launched, the Master stated to the Senior Dynamic Positioning Officer, "I don't know about you, but I'm going to jump," and jumped off the Unit.[421]

2.114 The crew of the DAMON B. BANKSTON's fast rescue craft reported seeing "a couple more people" jump from the vicinity of the DEEPWATER HORIZON's Bridge after the lifeboats were launched.[422] While they were picking up these individuals they saw a liferaft being launched and three more people jump from the DEEPWATER HORIZON.[423] The personnel in the water began to pull the raft away from the Unit until the fast rescue craft arrived and threw them a line.[424]

2.115 The fast rescue craft proceeded to take the liferaft in tow.[425] While trying to tow the liferaft away from the DEEPWATER HORIZON, it was discovered that the sea painter was still tied to the Unit.[426] When the knife in the liferaft could not be located, the Master swam to the fast rescue craft and was given a knife; he swam back to the liferaft and cut the sea painter.[427] The fast rescue craft returned to the DAMON B. BANKSTON with the crew members that were recovered from the water and with the liferaft in tow.[428]

2.116 All of the personnel rescued from the water by the DAMON B. BANKSTON's fast rescue craft had a lifejacket on.[429]

2.117 When the liferaft was alongside the DAMON B. BANKSTON, the Chief Mate testified that the straps inside the raft were cut to facilitate getting the stretcher with Wheeler out of the raft.[430] According to the

415 5/27/10 MBI Tr. at 269 (Young).

416 5/27/10 MBI Tr. at 333 (Murray).

417 10/5/10 MBI Tr. at 15 (Fleytas).

418 The sea painter is a line used to keep the survival craft (lifeboat or raft) near the MODU to allow remaining crew to enter the survival craft. The sea painter can be disconnected from the survival craft to allow movement away from the MODU.

419 5/27/10 MBI Tr. at 270-271 (Young).

420 5/27/10 MBI Tr. at 193 (Kuchta); 10/5/10 MBI Tr. at 154 (Keplinger); USCG Statement of Meinhart, 21 April 2010; 7/23/10 MBI Tr. at 24 (Williams).

421 10/5/2010 MBI Tr. at 266-268 (Keplinger); 5/27/10 MBI Tr. at 193 (Kuchta).

422 5/11/10 MBI Tr. at 191-192 (Gervasio).

423 5/11/10 MBI Tr. at 192 (Gervasio).

424 5/27/10 MBI Tr. at 334 (Murray); 5/11/10 MBI Tr. at 192 (Gervasio).

425 5/11/10 MBI Tr. at 192-193 (Gervasio).

426 5/11/10 MBI Tr. at 192 (Gervasio).

427 5/27/10 MBI Tr. at 194 (Kuchta). According to the Chief Mate's testimony, the liferaft knife was later found where it was supposed to be inside the liferaft. 5/27/10 MBI Tr. at 270 (Young).

428 5/11/10 MBI Tr. at 193 (Gervasio).

429 5/11/10 MBI Tr. at 200 (Gervasio).

430 5/27/10 MBI Tr. at 289-290 (Young).

Chief Mate's testimony, the straps were intact when the liferaft was launched from the DEEPWATER HORIZON.[431]

POST EVACUATION RESPONSE

2.118 Muster of the DEEPWATER HORIZON's crew was taken onboard the DAMON B. BANKSTON after all of the survivors were onboard.[432] Initially, it was reported that 111 personnel from the DEEPWATER HORIZON were on the DAMON B. BANKSON.[433] It was subsequently determined that 115 personnel had been safely evacuated from the Unit and that 11 personnel were missing.[434]

2.119 The most seriously injured personnel were taken to the hospital area onboard the DAMON B. BANKSTON, where they were attended to by the medics from the DEEPWATER HORIZON.[435]

2.120 A recreational fishing vessel, the RAMBLING WRECK, was reported to arrive on scene at approximately 2230.[436] At the request of the DEEPWATER HORIZON's Master, this vessel began to search for persons who might be in the water in the vicinity of the Unit.[437] No additional survivors were found.[438]

2.121 At 2322, the first USCG helicopter arrived on-scene and lowered a rescue swimmer to the DAMON B. BANKSTON.[439] The rescue swimmer conducted an assessment of the injured and coordinated the evacuation of those who were the most severely injured.[440] Additional rescue swimmers were put onboard the DAMON B. BANKSTON as additional USCG helicopters arrived on scene.[441]

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2.122 At 0006, the first of the most seriously injured DEEPWATER HORIZON personnel were medevaced by USCG helicopter from the DAMON B. BANKSTON.[442]

2.123 At 0139, the DEEPWATER HORIZON began to list to the starboard side.[443]

2.124 At approximately 0300, the GULF PRINCESS was reported to have found an overturned lifeboat.[444] No persons were reported in the lifeboat or the water in the vicinity of the lifeboat.[445]

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431 5/27/10 MBI Tr. at 289-290 (Young).

432 5/11/10 MBI Tr. at 163 (Landry).

433 USCG Incident Management Activity, Activity No. 3721000 at 122.

434 USCG, Final Action Report on the SAR Case Study into the Mass Rescue of Personnel off the Mobile Offshore Drilling Unit DEEPWATER HORIZON, CG-53, 16106 at 9.

435 5/11/10 MBI Tr. at 113 (Landry).

436 Per the USCG Incident Management Activity, Activity No. 3721000, at 2215, the RAMBLING WRECK reported it would arrive on scene in approximately 15 minutes.

437 5/11/10 MBI Tr. at 111 (Landry).

438 5/11/10 MBI Tr. at 111 (Landry).

439 5/11/10 MBI Tr. at 112 (Landry).

440 5/11/10 MBI Tr. at 112-113 (Landry).

441 5/11/10 MBI Tr. at 112 (Landry).

442 5/11/10 MBI Tr. at 114 (Landry).

443 USCG Incident Management Activity, Activity No. 3721000.

444 5/11/10 MBI Tr. at 117 (Landry).

445 5/11/10 MBI Tr. at 117 (Landry).

2.125 By 0425, the last of the most seriously injured DEEPWATER HORIZON personnel were medevaced from the DAMON B. BANKSTON.[446] A total of 16 individuals from the DEEPWATER HORIZON were medevaced by helicopter.[447]

2.126 At 0720, the USCG cutter, ZEPHYR, arrived and informed the Master of the DAMON B. BANKSTON that he did not need to remain on scene.[448] Upon departing the scene, the DAMON B. BANKSTON proceeded to the OCEAN ENDEAVOR, where additional injured personnel were transferred to and medevaced from the OCEAN ENDEAVOR. BP and Transocean personnel were then transferred from the DAMON B. BANKSTON to the MAX CHOUEST.[449] Two medics were brought onboard DAMON B. BANKSTON to assist with treating the DEEPWATER HORIZON's crew.[450] At the direction of the USCG, the DAMON B. BANKSTON then preceded enroute to the MATTERHORN, where investigators from the USCG and MMS boarded the DAMON B. BANKSTON.[451]

2.127 At 0813, the USCG Eighth District Command Center received notification that two burned out lifeboats had been located in approximate position 38° 45.9'N, 088° 21.2' W.[452] One of the boats was upright, the other was overturned.[453] There were no signs of persons in either boat.[454]

2.128 During the incident two sources of fluid made it onto the decks of the Unit. The first is fluid from the well itself; and the second is water sprayed by the reportedly uncoordinated firefighting vessels on the scene.[455]

Image Courtesy of USCG

2.129 The DEEPWATER HORIZON's starboard list continued to increase. The USCG reported that the vessels spraying water onto the Unit were "backing off, due to safety concerns."[456] The Unit was listing 10° and the "fire and smoke were out of control."[457]

446 5/11/10 MBI Tr. at 114 (Landry).

447 5/11/10 MBI Tr. at 114 (Landry); *see also* USCG Incident Management Activity, Activity No. 3721000 at 136.

448 5/11/10 MBI Tr. at 119 (Landry).

449 5/11/10 MBI Tr. at 120 (Landry).

450 5/11/10 MBI Tr. at 120 (Landry).

451 5/11/10 MBI Tr. at 120 (Landry).

452 USCG Incident Management Activity, Activity No. 3721000 at 130.

453 USCG Incident Management Activity, Activity No. 3721000 at 148.

454 USCG Incident Management Activity, Activity No. 3721000 at 130.

455 5/11/10 MBI Tr. at 120 (Landry); 8/23/10 MBI Tr. at 468-474 (Winslow).

456 USCG Incident Management Activity, Activity No. 3721000 at 10.

457 USCG Incident Management Activity, Activity No. 3721000 at 10.

2.130 Images from the casualty show the derrick to have collapsed on top of the Sack Room.

22 APRIL

2.131 At 0127, the DAMON B. BANKSTON arrived in Port Fourchon and disembarked the remaining survivors from the DEEPWATER HORIZON.[458]

2.132 At 1026, the DEEPWATER HORIZON capsized and sank.[459]

23 APRIL

2.133 At 1900, the USCG suspended the search for the 11 missing crew members from the DEEPWATER HORIZON.[460]

458 5/11/10 MBI Tr. at 125-126 (Landry).

459 USCG, Final Action Report on the SAR Case Study into the Mass Rescue of Personnel off the Mobile Offshore Drilling Unit DEEPWATER HORIZON, CG-53, 16106 at 11.

460 5/11/10 MBI Tr. at 61 (Robb).

PART 3: CONCLUSIONS

The following conclusions are based on the documentary evidence and testimony presented at the Joint Investigation hearings, the Republic of the Marshall Islands' investigation into the casualty, and the Fire Origin Report and Well Control Report which have been drawn upon in determining relevant conclusions regarding the casualty.

In accordance with section 2.12 of the Casualty Investigation Code, the conclusions address safety and equipment systems as well as mechanical, human, and organizational factors.

CAUSAL FACTOR CONCLUSIONS[461]

Cause of the Casualty

3.1 Although the Republic of the Marshall Islands Maritime Administrator does not have oversight

461 Conclusions regarding the causal factors of the casualty and the subsequent fire and explosions are drawn from the annexed consultant reports, Fire Origin Report and Well Control Report, as these topics are outside the purview of the flag State.

responsibility for drilling operations on the US OCS, based on its assessment of the evidence in the investigative record and the attached Well Control Report, the Administrator concludes that the proximate cause of the casualty was a loss of well control resulting from:

- deviation from the standards of well control engineering;
- deviation from the well abandonment plan submitted to and approved by MMS; and
- failure to react to multiple indications that a well control event was in progress.

3.2 The above factors contributed to a loss of well control that resulted in a substantial release of liquid and gaseous hydrocarbons, which culminated in explosions, fire, the loss of 11 lives, the eventual sinking and total loss of the DEEPWATER HORIZON, and the release of hydrocarbons into the Gulf of Mexico.

Loss of Well Control

Insufficient Barriers

3.3 Insufficient barriers to well flow were maintained during critical operations.[462] "A fundamental contributing factor to the loss of well control was the removal of one of the two barriers from the well — hydrostatic pressure applied by drilling mud — in order to conduct the negative differential pressure test without applying a replacement barrier."[463] "The written instructions for conducting the negative differential pressure test included reducing hydrostatic pressure in the bottom of the wellbore to a value below the highest measured formation pressure.[464] After the test, appropriate hydrostatic pressure was briefly restored. The instructions for the displacement operation conducted after the [negative differential pressure] test included reducing hydrostatic pressure in the bottom of the wellbore to a value below the highest measured formation pressure. Neither instruction included applying a replacement barrier [during these operations]."[465]

Unorthodox Testing Protocol

3.4 A testing protocol was employed that diverged from the APM, which sequenced the negative differential pressure test as a part of the displacement operation, rather than prior to it.[466] The approved APM "specified that two sequential tasks were to be conducted – a negative differential pressure test without drill pipe in the well, followed by drilling mud displacement operations.... [d]isplacement operations started first, with the booster, choke and kill lines being displaced to seawater, followed by partial displacement of the wellbore and riser, using water-based spacer and seawater. In order to conduct the partial wellbore and riser displacement, drill string was placed through the BOP assembly. Displacing drilling mud from the wellbore and placing drill string in the BOP stack each limited the well control options available once uncontrolled flow started. By themselves, those limits may not have been significant if other contributing factors had not occurred. However, since other factors were present, these limits were significant."[467]

462 Well Control Report at 26.

463 Well Control Report at 27.

464 Well Control Report at 27.

465 Well Control Report at 27.

466 Well Control Report at 28.

467 Well Control Report at 28-29.

Ability to Control Hydrostatic Pressure

3.5 "At the conclusion of the partial displacement of the marine riser, the fluid column (mud, spacer, seawater) on the outside of the drill string provided an over-balanced condition at the bottom of the well,"[468] preventing the well from flowing. "The closure of the lower annular preventer isolated this hydrostatic fluid pressure" and created an underbalanced state.[469] "With [the] open-ended drill string located 3,300 [ft] below the sub-sea wellhead, there were not any feasible means to ensure the wellbore fluids remained segregated, before, during, and after the test."[470]

Incorrect Interpretation of Test Results

3.6 The crew "on the MODU monitored pressure…inside the drill string, as well as pressure in and flow from the kill line. Both the drill string and kill line were configured to connect to the wellbore. Differences in pressure measured at these two locations were not well understood."[471] Discussions included reference to possible explanations that were offered — a "bladder effect" or "annular compression."[472] These "were provided without any further description of their meaning and specific application to measured conditions."[473] Neither a "bladder effect" nor an "annular compression" have been validated to have been present by post-incident analysis.[474]

3.7 "Post-incident analysis indicates that during the negative differential pressure test the kill line was isolated from the wellbore. The cause of the isolation cannot be conclusively determined."[475] During these operations, the choke line, also configured to connect to the wellbore, "could have been monitored for pressure or flow and its reading used to confirm actual wellbore conditions. There is no indication from the record that observations of the choke line were made.…In the time interval 2052 hours to 2108 hours, flow rate out exceeded flow rate in and pump pressure increased. Additionally, the trending slope of drill string pressure changed; the direction of the slope increased rather than decreased. In the time interval 2108 hours to 2114 hours, pressure within the drill string increased and fluid flowed from the well, even though the pumps had been stopped. In the time interval 2112 hours to 2131 hours, measured hook load fluctuated in a manner that was inconsistent with wellbore fluid density changes caused by the displacement operation. Since well fluids were being directly discharged overboard at this time, bypassing the mud system tanks, monitoring hook load became a principal means for detecting formation flow into the wellbore. At approximately 2133 hours, pressure in the drill string increased by more than 500 psi to 1,765 psi. Taken individually, any of these events could have been interpreted as indicating increased risk of, or actual, loss of [well] control."[476] That the drilling crew was dealing with a "well control event"

468 Well Control Report at 29.
469 Well Control Report at 29.
470 Well Control Report at 29.
471 Well Control Report at 30.
472 Well Control Report at 30.
473 Well Control Report at 30.
474 Well Control Report at 30.
475 Well Control Report at 31.
476 Well Control Report at 31.

at 2130 hours "suggests that one or more of these events was being evaluated. However,…no well control measures were taken until after uncontrolled flow was observed at the rig floor."[477]

3.8 "Although analysis indicates that the DEEPWATER HORIZON's crew may have regained control of the well, a portion of the initial gas bubble soon ignited, [which] compromised the safety and control systems…."[478]

Fire and Explosion

3.9 During the displacement operations, an "uncontrolled flow of [liquid and gaseous hydrocarbons]occurred, starting at the formation and continuing up through the casing, drill string, wellhead, BOP and riser up to" the DEEPWATER HORIZON,[479] "which was apparent to rig personnel, at approximately 2140-2143, as mud began to flow onto the drill floor. The well fluids were diverted to a mud/gas separator which vented above the main deck, resulting in a large release of hydrocarbons onto the main deck which quickly engulfed the vessel in a hydrocarbon gas cloud. At approximately 2149, ignition of the gas cloud occurred resulting in several explosions and a fire."[480]

3.10 Although there are some differences in the reported location of the initial fire or explosion, there is general agreement that it was located aft of the derrick. Several people were in the Engine Control Room and reported that, around 2150, the initial explosion blew the port door of the Engine Control Room inward and the second explosion blew the starboard door inward. This would indicate the initial ignition and explosion was in the aft section of the vessel, below the main deck level. The crane operator in the gantry crane on the port side, aft at the time of the incident, thought the initial fire and explosion occurred in the vicinity of the degassing column, which was located on the main deck aft of the derrick. The Master of the DAMON B. BANKSTON was on the Bridge along with the Chief Mate of the DAMON B. BANKSTON, Paul Erickson, both reported seeing a flash of fire from the area aft of the derrick.

3.11 The most likely source of ignition was a spark from an unclassified electrical component in an engine room or adjacent electrical room. "The overspeed of the diesel engines makes it almost certain that there was a concentration of flammable gas in the engine rooms."[481] However, the fact that unclassified electrical equipment was able to create a spark does not, in and of itself, indicate that a spark was created when the flammable mixture was present. Had the circuit breaker opened in response to the generator overspeed, it would have most likely created a spark as it opened. "This increases the likelihood that the opening of a circuit breaker to protect the generator (or any other control device working to protect the generator) could have been the initial source of ignition."[482]

3.12 Based on the entire investigative record, including the available information concerning the last known locations of the personnel immediately prior to the explosions and fire, the probable locations of the two initial explosions, the witness testimony concerning the identification and location of deceased crew

477 Well Control Report at 31.
478 Well Control Report at 5.
479 Well Control Report at 5.
480 Fire Origin Report at 2.
481 Fire Origin Report at 14.
482 Fire Origin Report at 12.

members during the evacuation, the ability of the surviving crew members to successfully evacuate the rig from all decks and locations forward and aft, as well as port and starboard, and the ability of the surviving individuals to transport all wounded personnel to the lifeboats and liferafts, the Administrator finds that it is reasonable to presume that the two initial explosions and fire caused the death of the 11 individuals onboard the DEEPWATER HORIZON who were initially listed as missing.

3.13 Given the extent of the fire, the speed at which it developed, and the uncontrolled fuel source, the lack of electrical power necessary to deploy active fire suppression systems did not contribute to the severity of the casualty.

NON-CAUSAL FACTOR CONCLUSIONS

Flag State/Coastal State Coordination

3.14 The Republic of the Marshall Islands had limited contact with the USCG and no official contact with the MMS prior to the casualty. Although nothing in the record indicates that this lack of communication contributed to the cause of the casualty, better communication and coordination of inspections and surveys would ensure both the flag and coastal States are aware of conditions or requirements that could affect the safety of MODUs and their personnel.

3.15 The Republic of the Marshall Islands is responsible for the international certification of MODUs in its registry and marine personnel onboard. While the regulation and oversight of drilling operations are outside the purview of the flag State, the complexity of and interdependence between the drilling and marine systems and personnel suggests a need for increased communication and coordination between the flag State and coastal State drilling regulators.

Lifesaving Procedures

Evacuation

3.16 Ideally the evacuation of a vessel occurs in phases: an alert to notify the crew to prepare for abandonment, a notification to report to muster stations, a mustering process to account for the crew, entry into the lifesaving appliances, and launching of the lifesaving appliances. The speed at which the casualty progressed provided limited time for reaction, control, mitigation efforts, and response. The total elapsed time from uncontrolled release until all evacuees were on the DAMON B. BANKSTON was approximately 43 minutes. In the casualty, despite the catastrophic, chaotic, and life threatening situation faced by the crew, the evacuation was successful in that 115 people were able to evacuate the Unit.

3.17 Some personnel evacuated the DEEPWATER HORIZON by jumping approximately 50 ft or more to the water rather than wait for the lifeboats to be launched or for a second liferaft to be launched. The fact that the DAMON B. BANKSTON's Master saw the first personnel jump into the water, was able to keep a spotlight trained on them, and ordered the immediate launching of the DAMON B. BANKSTON's fast rescue craft, contributed significantly to the safe rescue of those who jumped from the Unit.

Muster Process

3.18 The alarm and announcement system functioned under emergency power and was capable of being heard in spite of the fire, explosions, and chaotic conditions. This allowed the Dynamic Positioning Officer to effectively sound the General Alarm and the Senior Dynamic Positioning Officer to make two announcements directing the crew to the appropriate muster stations.

3.19 There were a number of attempts to take a muster but, due to the circumstances of the casualty and the decision of some personnel to jump from the Unit, it was extremely difficult to accurately account for personnel before they entered the lifeboats. As the conditions were deteriorating rapidly, conducting a full muster would have put additional lives at risk and, as such, a complete muster did not occur. Absent a complete muster, it was not possible to determine if all personnel had successfully evacuated off the Unit.

3.20 An account of all personnel was completed when a full muster was conducted onboard the DAMON B. BANKSTON.

3.21 While the casualty was exceptionally violent and there was an immediate threat to the safety of all personnel while they remained onboard, the completion of a muster is essential for ensuring all personnel onboard are accounted for prior to launching lifesaving appliances. Taking a muster in an extreme case such as that experienced on the DEEPWATER HORIZON may not always be practical or safe. On the other hand, launching only partially full lifesaving appliances endangers the safety of personnel who may be engaged in onboard emergency response activities, or who are still attempting to reach the embarkation area. However, the lack of a conclusive muster did add confusion to the search and rescue operations and the accounting of personnel.

Lifesaving Appliances

Lifeboats/Liferafts

3.22 The ability to safely launch lifeboats and liferafts is an essential part of any lifesaving system. Two lifeboats and one liferaft were successfully launched from the DEEPWATER HORIZON and were utilized for egress from the vessel in a timely manner. The requirement to have widely separated muster and embarkation stations, each fitted with redundant lifesaving appliances (lifeboats and liferafts) capable of accommodating over 100% of the crew, was a critical factor in saving lives and in the evacuation of the Unit.

Image Courtesy of Transocean

3.23 Approximately 107 of the 115 personnel that evacuated the DEEPWATER HORIZON were in the two lifeboats and the one liferaft that were launched. Each lifeboat had a rated capacity of 73 persons. According to crew testimony, the lifeboats were crowded even though they were not loaded to capacity. Some of the available space in lifeboat No. 2 was reduced because injured personnel were laid out on the seats.

3.24 Based on testimony, some personnel were confused regarding how to use the color-coded restraints inside the lifeboats.

3.25 Although the Master ordered the abandon ship, the order to launch the first lifeboat was given by the Transocean Division Manager and not a crew member of the DEEPWATER HORIZON. Although the order to launch the first lifeboat was given by a person who was not part of the DEEPWATER HORIZON crew, the Administrator does not find that this had an adverse impact on the evacuation process and, in view of the extreme risks posed by the continuing explosions and intense fire onboard the Unit, the decision by the Transocean Division Manager to order the launch of the first lifeboat was an understandable and prudent reaction to the emergency conditions that threatened the lives of persons in the lifeboat.

3.26 The liferafts were configured to be davit launched, dropped over the side, or arranged to float free. A liferaft was inflated and the davit hook attached to the raft, however, personnel encountered problems releasing the davit arm because of a shackle that was difficult to remove without a tool, which delayed the deployment of the liferaft.

3.27 The liferaft sea painter was connected to the Unit when the liferaft was launched. The liferaft tipped during the descent to the water and stabilized when it hit the water and was still attached to the Unit. Knives are supplied in the liferafts to cut the sea painter from the Unit. The knife in the liferaft could not be found, but the crew members of the fast rescue craft were able to hand the Master of the DEEPWATER HORIZON a knife to cut the sea painter and release the raft from the Unit.

3.28 The liferaft davits installed onboard the DEEPWATER HORIZON were designed to lower a loaded liferaft from the embarkation deck to the water line and then rewind the fall to launch another liferaft; this process had to be repeated to launch the liferafts served by an individual davit. The complete loss of electrical power onboard the Unit made it necessary to manually rewind the falls so a second liferaft could be launched. The Master and other personnel remaining onboard after the first liferaft was launched decided to jump from the Unit rather than rewind the fall to launch a second liferaft. Based on the testimony of those who jumped, this decision was based on the time that would be required to manually rewind the fall and the impending threat posed to their safety by the smoke and heat from the fires, which were spreading.

Lifejackets

3.29 Based on testimony and written statements from personnel who were onboard the DEEPWATER HORIZON and the testimony of the crew of the DAMON B. BANKSTON's fast rescue craft, all evacuated personnel donned lifejackets prior to abandoning the Unit. For persons who jumped from the Unit and the one person who fell into the water when the liferaft tipped, the location and availability of lifejackets were instrumental in ensuring their safety.

3.30 The fact that the DEEPWATER HORIZON was equipped with extra lifejackets stored near the embarkation stations, in addition to those assigned to each crew member stored in the accommodations, was essential to ensuring all crew had access to lifejackets. This contributed to the evacuation of the Unit.

Standby Vessel/Rescue Boat

3.31 The proximity, speed, and agility of the DAMON B. BANKSTON's fast rescue craft, and the response of its crew, substantially contributed to the rescue of DEEPWATER HORIZON personnel and enabled the davit launched liferaft to be towed clear of the burning Unit.

3.32 The DAMON B. BANKSTON provided a safe location to which the evacuated personnel could be transferred, and facilitated basic medical care of the injured.

Emergency Systems

EDS

3.33 After the loss of well control, the EDS was initiated. However, it did not function as intended and the Unit was unable to disconnect. The crew's inability to activate the EDS was likely a result of the damage to the control umbilicals caused by the initial explosions. Without any ability to stop or reduce the flow of hydrocarbons, and without power for vital systems, the crew's only option was to evacuate.

ESD

3.34 There was no evidence on the record which would indicate that any of the ESD functions were activated by the crew in response to the events of the casualty. The Motor Operator on watch in the Engine Control Room testified to seeing three to five ESD lights flashing on the bottom of the panel seconds before the first explosion. According to the layout of the ESD matrix panel, these could likely have been for the Drill Floor Shutdown and one or multiple Ventilation Shutdowns.

3.35 The watchstanders in the Engine Control Room and Central Control Room reported an overwhelming number of gas alarms moments before the first explosion. It is not apparent that a selective ESD could have isolated a problem area and maintained availability of power to the thrusters. It is likewise not apparent that a full ESD activation would have prevented or delayed ignition of the gases accumulating from the blowout.

Power — Emergency and Standby

3.36 The electrical power failed as a result of the initial explosion(s) or immediately thereafter. There is no testimony of generators starting up or attempting to restart after this initial failure. The root cause for the primary power failure could not be definitively determined and it is assumed that damage from these explosions prevented the power management system from re-establishing electrical power.

3.37 The standby generator failed to automatically start and the crew was unable to start it manually. Although designed and intended to start automatically if the power system failed to provide electrical power after an initial power failure, in this instance, the standby generator did not start automatically. A team consisting of the Chief Engineer, Chief Electronics Technician, and a Motor Operator tried, unsuccessfully, to

manually initiate the starting of the generator.

3.38 As the blowout occurred, the Motor Operator on watch at the time testified the No. 3 engine revved up then appeared to slow down or trip shortly before the first explosion. This was consistent with the protection scheme to protect the system from over-frequency and the engines from over-speeding.

3.39 The main and emergency electrical power arrangement was in compliance with applicable regulations. However, the DEEPWATER HORIZON emergency electrical power system failed to provide emergency electrical power and lighting during the incident and throughout the evacuation.

3.40 Transition power supplies for radio communications equipment as well as the Public Address/General Alarm system worked in areas where it was not damaged by the explosions and fire.

3.41 The failure of the primary power source, while not contributing to the cause of the casualty, did add to the confusion during the evacuation and complicated the evacuation of the Unit.

Safety Management

ISM Audits

3.42 After a review of the ISM audit history of the DEEPWATER HORIZON, the Administrator concludes that the two observations noted for the Unit were appropriately classified by the auditor and were followed up by the Unit's management in a timely manner. These observations were not a factor in the casualty.

BP and Transocean Audits

3.43 Internal and external audits which focused on operational and maintenance requirements had been initiated by both BP and Transocean. These audits were in addition to statutory requirements, and therefore not shared with the coastal or flag States. A review of the audit results, post-casualty, indicates that the conditions observed had no bearing on the direct cause of the casualty.

Compliance and Surveys

3.44 The Administrator concludes that the Unit was current on all of its required flag State inspections and certifications and possessed all requisite international, Republic of the Marshall Islands, and US documents of compliance.

3.45 Classification records show the Unit was regularly surveyed and was current on all statutory surveys.

Annual Safety Inspections

3.46 ABS, on behalf of the Administrator, conducted flag State safety inspections annually on the DEEPWATER HORIZON from the time it was registered in the Republic of the Marshall Islands, the most recent of which was on 17 December 2009. These inspections were reviewed by flag State marine safety personnel in line with the normal and internationally accepted practices of the maritime industry.

Emergency Drills

3.47 Although emergency drills were conducted at the same time each week and the on-duty drilling crew was excused from the drills to ensure that the well was properly monitored, there is no evidence on the record to support a conclusion that the regularity of such drills had any adverse impact on the ability of the crew to safely evacuate the Unit or contributed to the casualty. The routine fire and emergency drills, and the required safety orientation for visitors were effective in ensuring that personnel onboard were able to successfully evacuate the Unit.

Manning

3.48 The lack of a clear definition of "on location" versus "underway" with respect to dynamically positioned MODUs attached to the seabed created a difference of opinion between the drill crew, the marine crew, and the Master as to whether the Unit was on location, underway but not making way, or underway when attached to the seabed, but using dynamic positioning to maintain position.

3.49 At the time of the casualty, the DEEPWATER HORIZON was crewed in accordance with its Minimum Safe Manning Certificate.

3.50 All required marine crew positions were filled by mariners holding appropriate credentials demonstrating their qualifications and competence. Each officer onboard the DEEPWATER HORIZON held a license, certificate, or document issued by the USCG, and the Administrator issued Republic of the Marshall Islands officer endorsements based on the USCG license, certificate, or document.

Command, Control, and Organizational Structure

3.51 The leadership and management structure unique to MODU operations while in a drilling mode played a role in both the decision making concerning the actions prior to the loss of well control and the actions taken thereafter.

3.52 Pursuant to the Maritime Act, the ISM Code, and the DEEPWATER HORIZON Operations Manual, as well as being traditional marine practice, the Master is in command during normal operations while the MODU is underway and is in command during all emergency conditions.

3.53 As evidenced by testimony at the Joint Investigation hearings, there were instances of confusion regarding decision making authority during the casualty. Specifically, that there was uncertainty as to who had the authority to activate the EDS and that the lifeboat launching took place without following the Emergency Procedures of the Operations Manual. While such instances highlight the fact that the integration of drilling and marine operations presents challenges for maintaining a clear command hierarchy, especially in emergency situations, there is no indication that any confusion as to the chain of command was a causal factor in the casualty.

Fire Protection

F&G System

3.54 Methane or other gaseous hydrocarbons entered enclosed spaces on or below the main deck in sufficient quantities to activate the Unit's installed combustible gas alarms in multiple spaces. The installed gas detection system functioned properly to detect combustible gas at multiple locations

on the Unit and alerted the watchstanders in the Central Control Room and Engine Control Room to high gas levels. It is therefore likely that the alarm conditions were also indicated audibly and visually at the Driller's Shack. As the gas detection alarms were activated, the drilling crew and the crew in the Engine Control Room advised the Central Control Room watchstanders of a well control situation.

3.55 The F&G System was capable of automatically sounding the General Alarm in the event of a fire or high gas indication, but this feature had not been enabled as a matter of practice. There is merit in a delayed automation of the General Alarm, allowing time for an initial assessment of the alarm condition if the circumstances should prevent the crew from actuating the alarm. On the DEEPWATER HORIZON, the high gas alert sounded in a location continuously manned with crew members who were responsible for evaluating the alarm condition. This allowed the crew on watch to rule out false alarms or to take appropriate action and make notifications as necessary. In this incident, the crew members on watch in the Central Control Room were using the CCTV monitors, evaluating the situation, and attempting to contact the other watchstanders over the phone and radios as alarms indicated. However, the lack of automation of the alarm did not in itself contribute to the casualty as the on-watch crew did sound the General Alarm in response to the emergency.

Hazardous Locations

3.56 The Unit was designed, and operated, in accordance with the hazardous space classification system required by the 1989 MODU Code. The requirements provided by current regulations regarding hazardous locations were adequate to protect against gases present during controlled drilling operations. However, the volume of flammable gas and other hydrocarbons that inundated the DEEPWATER HORIZON after the loss of well control was so large that a source of ignition, likely outside of the declared hazardous locations, ignited the vapor cloud. It is reasonable to conclude that the air handling units for the engine and switchgear rooms facilitated the spread of gas into non-classified areas which contained electrical equipment and machinery not rated for hazardous locations. The location of these ventilation intakes were in close proximity to but outside the drill floor hazardous locations, in accordance with the applicable standards.

Structural Fire Protection

3.57 The structural fire protection of the DEEPWATER HORIZON was in compliance with the appropriate regulations. The utilization of noncombustible construction and structural fire protection allowed the Unit to remain structurally sound long enough for the evacuation of the individuals onboard the Unit.

Suppression Systems

3.58 The total loss of electrical power compromised the functioning of the fire suppression systems; however, any attempts at suppression would have been futile given the intensity and magnitude of the fire and the uncontrolled fuel supply. It is unlikely that any ship borne system would have been effective at extinguishing the fire onboard the DEEPWATER HORIZON. Given this, and based on the evidence within the record, there is nothing to indicate that the inability of the crew to apply firefighting efforts contributed to the casualty or reduced the effectiveness of the evacuation.

However, it can be envisaged that under similar but less severe circumstances, the ability to engage in effective firefighting efforts may be essential.

3.59 The sprinkler systems activated in the accommodation areas sometime after the first explosion. There is no conclusive evidence to determine what specifically caused the system to actuate, but was likely due to physical damage from the explosions or thermal energy from the blast. As the system was arranged for the fire/sprinkler pump to start automatically upon a reduction in fresh water charge pressure, without electrical power for the fire/sprinkler pump, water discharged by this system would have been limited to that contained in the freshwater charge and would not have significantly mitigated the casualty.

MODU Structure and Stability

3.60 The Unit withstood the forces of the explosions and resulting fire, fed by the continuous release of hydrocarbons, which likely caused extensive damage to the superstructure. Although being subjected to intense heat and dynamic loading, the Unit provided a sufficiently stable and protected platform to facilitate the evacuation of 115 individuals.

3.61 External efforts to cool the DEEPWATER HORIZON structure or extinguish the fire led to, or at least accelerated, the eventual capsizing and sinking of the DEEPWATER HORIZON.


Image Courtesy of USCG

3.62 The DEEPWATER HORIZON capsized and sank approximately 36 hours after the ignition occurred. It is probable that decks, bulkheads, ventilators, and weather/water tight doors and windows were damaged and or distorted by falling debris and heat providing paths for fluids to flow below deck. The damage caused by the falling derrick increased the probability that the fluids collected in the Sack Room, causing the Unit to heel to starboard. Once the heel to starboard was established, the flow of fluid continued to favor the starboard side and collect in any accessible space. Once the heel had increased to the point of deck edge immersion, other openings, which would normally be well away from the water, were submerged under the sea's surface and flooding accelerated.

Drilling Personnel Qualifications

3.63 Control and regulation of drilling crew is specifically the responsibility of the coastal State. Drilling is a specialized vocation requiring expertise and competence in a variety of situations, however, there are links between the marine and the drilling crews to ensure the overall safety of the Unit. For example, the Offshore Installation Manager is required to obtain training to become familiar with the marine aspects of the MODU, and the drilling crew and other contract individuals onboard are required to undergo specific safety training for the purpose of safe and orderly evacuation of the MODU in case of an

emergency. There are no specific international standards that establish a minimum level of competency for drilling personnel. This contrasts with the clear and specific competencies required of the marine crew.

Actions of Personnel Onboard the DEEPWATER HORIZON

3.64 While there were instances of individual confusion and panic, there were also examples of organization, heroism, and leadership during what was a catastrophic event. That 115 persons were able to evacuate the DEEPWATER HORIZON is attributed to the preparation, skill, and training of all persons onboard. The crew was regularly drilled in abandon unit procedures and all visitors briefed on evacuation muster points, which created the opportunity for those 115 persons to safely evacuate.

3.65 The Master is commended for his role in training the crew and visitors to respond in an emergency. The records and testimony indicate that the emergency drills effectively prepared the personnel onboard. The Administrator finds that the Master carried out these duties with care and responsibility. However, the Master's performance with regard to attention to the details of the evacuation was troubling. In his final moments on the Unit, his decision to leave a subordinate behind was not befitting of a master's responsibility. The Administrator has evaluated the testimony and other evidence regarding concerns about the Master's conduct and performance during the evacuation of the DEEPWATER HORIZON. While the Administrator does not take these concerns lightly, in balance, given the magnitude of what he and his crew were facing, and the ultimate evacuation of 115 individuals, it is concluded that no administrative action by the Administrator is warranted.

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PART 4: RECOMMENDATIONS

The recommendations contained below address lessons learned from the DEEPWATER HORIZON casualty and opportunities for improvement. These recommendations do not address the causal factors of the casualty are outside the purview of the flag State.

FLAG STATE/COASTAL STATE COORDINATION

4.1 It is recommended that a communication system be developed between the relevant flag and coastal State regulatory bodies to address issues regarding units operating within the coastal State's jurisdiction.

LIFESAVING PROCEDURES

4.2 The Administrator recommends that all unit operators review and revise the muster process onboard units in its fleet with the understanding that, in a worst case scenario, conditions may exist that prevent

an accurate muster. Consideration should be given to alternate ways to facilitate muster taking and accounting of personnel during egress in an emergency.

4.3 The Administrator recommends that all unit operators reinforce the importance of completing an accurate muster as quickly as possible during emergency drills in accordance with section 14.10 of the 2009 MODU Code.

LIFESAVING APPLIANCES

4.4 It is recommended that the Administrator present a submission to the IMO proposing the lifeboat capacity criteria in section 4.4.2 of the LSA Code be reviewed to account for the space required for personnel on a stretcher or injured persons needing to lie down.

4.5 The Administrator recommends that all unit operators review how davits are secured for launching davit launched liferafts to ensure that they can be deployed without tools in an emergency.

4.6 The Administrator recommends that all unit operators review the training procedures for launching davit launched liferafts onboard units in their fleet to address the lessons learned from the launching and loading of the davit launched liferaft during the evacuation of DEEPWATER HORIZON.

POWER — EMERGENCY AND STANDBY

4.7 It is recommended that the Administrator present a submission to the IMO proposing the 2009 MODU Code be amended to add additional criteria for power generating equipment, providing for a greater level of redundancy and availability for those units not equipped with an additional source of emergency electrical power as per section 5.4.5 of the 2009 MODU Code (section 5.3.5 of the 1989 MODU Code).

SAFETY MANAGEMENT

4.8 It is recommended that all unit operators review the lessons learned from the evacuation of the DEEPWATER HORIZON with the senior deck officers on units in their fleet with an emphasis on highlighting the importance of maintaining situational awareness during evacuation operations.

COMMAND, CONTROL, AND ORGANIZATIONAL STRUCTURE

4.9 It is recommended that all unit operators ensure that the initial orientation for new crew members and contracted personnel includes a discussion of the respective roles and leadership responsibilities of the Master and the Offshore Installation Manager, including how those roles change based on unit operations and emergency conditions.

4.10 It is recommended that the Administrator present a submission to the IMO proposing that consideration be given to defining "on location," "underway but not making way," and "underway" with respect to MODUs attached to the seabed and using dynamic positioning to maintain position.

VESSEL ALARM SYSTEMS

4.11 It is recommended that the Administrator present a submission to the IMO proposing that consideration

be given to amending the 2009 MODU Code to require automatic sounding of the General Alarm system if, after a short time period, the watchstanders at the central control location have not canceled or manually sounded the General Alarm.

FIRE PROTECTION — PREVENTION

4.12 It is recommended that the Administrator present a submission to the IMO to consider amending the 2009 MODU Code with particular regard to the requirements for the location of ventilation intakes with respect to their proximity to hazardous locations.

FIRE PROTECTION SUPPRESSION SYSTEMS

4.13 It is recommended that the Administrator present a submission to the IMO to consider amending the 2009 MODU Code to require MODUs to have at least one fire pump capable of being powered independently of a unit's main and emergency electrical systems.

POST-EVACUATION RESPONSE

4.14 It is recommended that the Administrator present a submission to the IMO to consider amending the 2009 MODU Code with particular attention to section 14.9 regarding the Emergency Procedures detailing provisions for salvage and firefighting operations. Such provisions should address planning and drills, coordination with coastal State response organizations, and post-evacuation incident response.

RESPONSE TO WELL CONTROL EVENTS

The recommendations contained below address the industrial systems of the DEEPWATER HORIZON. The industrial systems fall outside of the expertise and regulatory purview of the Administrator, and are therefore addressed separately here. The Administrator has chosen to make the below recommendations as they potentially impact the overall safety of units, and with the intent that such recommendations may be of assistance to the responsible regulatory bodies and to the industry as a whole.

4.15 The Administrator recommends that an analysis of vessel EDS mechanical systems be undertaken in order to determine possible points of failure as well as developing steps to minimize that risk.

4.16 As a primary system for the safety of drilling operations, the ability of the crew to quickly detach a MODU from the subsea well has tremendous implications. It is recommended that the operator review and amend, as appropriate, emergency procedures for activating the EDS on each unit in its fleet. Procedures should identify who is authorized to activate or order activation and contain clear but flexible guidelines for when it should be activated. Crews, particularly those standing watch in the control locations and those whose emergency duties are at the control locations, should be trained and practiced in these procedures. Drills should give particular regard to lines of authority and conditions under which the EDS should be activated.

4.17 While not regulated by the Administrator, a properly functioning and operable BOP is essential to the safety of units; therefore, the Administrator recommends that MODU operators and regulators ensure that BOPs are maintained in accordance with classification requirements.

LIST OF ANNEXES

ANNEX A: List of Acronyms and Abbreviations

Acronym/Abbreviation	Description
”	Inches
1989 MODU Code	Code for the Construction and Equipment of Mobile Offshore Drilling Units, 1989
2009 MODU Code	Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2009
ABS	American Bureau of Shipping
AC	Alternating current
ACP	Alternate Compliance Program
Administrator	Republic of the Marshall Islands Maritime Administrator
APM	Application for Permit to Modify
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BOP	Blowout Preventer
BP	BP Exploration & Production Inc.
°C	Degrees Celsius
C&E Table	Safety System Cause and Effects Table
Casualty Investigation Code	Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident
CCTV	Closed circuit television
Ch.	Chapter
C.F.R.	Code of Federal Regulations
CO_2	Carbon dioxide
Convening Order	Joint Department of the Interior and Department of Homeland Security Statement of Principles and Convening Order Regarding Investigation Into the Marine Casualty, Explosion, Fire, Pollution, and Sinking of Mobile Offshore Drilling Unit Deepwater Horizon, with Loss of Life in the Gulf of Mexico 21-22 April 2010
DEEPWATER HORIZON	Mobile Offshore Drilling Unit DEEPWATER HORIZON
DESPEMES	Diesel Engine Speed Measuring System
DNV	Det Norske Veritas
DSC	Digital selective calling
EDS	Emergency Disconnect System
EPIRB	Emergency Position Indicating Radio Beacon

Acronym/Abbreviation	Description
ESD	Emergency Shutdown
F&G	Fire and Gas
F&G System	Fire and Gas Detection and Alarm System
Fire Origin Report	Casualty Investigation of MODU DEEPWATER HORIZON: Fire Origin Investigation
ft	Feet
GMDSS	Global Maritime Distress and Safety System
HVAC	Heating, ventilation and air conditioning
IACS	International Association of Classification Societies
IMO	International Maritime Organization
ISM	International Safety Management
ISM Code	International Safety Management Code
ISPS Code	International Ship and Port Facility Security Code
Joint Investigation	US Department of the Interior and the US Department of Homeland Security Joint Investigation
kg	Kilograms
KIACS	Kongsberg Integrated Automation and Control System
kV	Kilovolts
kW	Kilowatts
lbs	Pounds
LMRP	Lower marine riser package
LSA Code	Life-Saving Appliances Code
m	Meters
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973, as amended by the Protocol of 1978
Maritime Act	Republic of the Marshall Islands Maritime Act 1990, as amended (MI-107)
Maritime Regulations	Republic of the Marshall Islands Maritime Regulations (MI-108)
MF	Medium frequency
MI-293	Republic of the Marshall Islands Mobile Offshore Drilling Unit Standards, MI-293
MMS	Minerals Management Service
MOA	Memorandum of Agreement
MODU	Mobile Offshore Drilling Unit

Acronym/Abbreviation	Description
MOU	Memorandum of Understanding
MUX	Electro-hydraulic/multiplex control system
NM	Nautical mile
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
ppg	Pounds per gallon
psi	Pounds per square inch
RO	Recognized Organization
ROV	Remotely Operated Vehicle
RPM	Rotations per minute
SOLAS	International Convention for the Safety of Life at Sea, 1974, as amended
sq ft	Square feet
ST Lock	Stack Bonnet Removal Tool
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended
Tr.	Transcript
Transocean	Transocean Offshore Deepwater Drilling Inc.
UNCLOS	United Nations Convention on the Law of the Sea, 1983
Unit	Mobile Offshore Drilling Unit DEEPWATER HORIZON
US	United States
U.S.C. (or USC)	United States Code
USCG	United States Coast Guard
v	Volts
VHF	Very high frequency
Vol.	Volume
Well Control Report	Report of the Loss of Well Control and Assessment of Contributing Factors for the Macondo Well Mississippi Canyon Block 252 OCS-G 32306 #1 Well

ANNEX B: Fire Origin Report

CASUALTY INVESTIGATION OF MODU DEEPWATER HORIZON: FIRE ORIGIN INVESTIGATION

HAI Project: 1WPW00024.001

April 2011

By

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Contents

1.0 INTRODUCTION

This report provides an analysis of the cause of the explosions and fire that occurred aboard the mobile offshore drilling unit (MODU) DEEPWATER HORIZON on April 20, 2010. The scope of this analysis is limited to a review of potential causes of the explosions and fire that occurred and does not include any review of the factors leading to the incident, including the drilling operations themselves, the design of the MODU, safety procedures, etc.

The sinking of the vessel precludes an examination of the incident scene. This analysis is therefore based in part upon eyewitness accounts, information on the original design of the vessel, various reports of the investigation, and other reports. This includes reports of audits conducted by BP [Ref 1] and ModuSpec [Ref 2], the testimony of witnesses who appeared before the Joint United States Coast Guard/Bureau of Ocean Energy Management, Regulation and Enforcement Board of Investigation, BP's internal investigation report of the incident [Ref 3], the report [Ref 13] and recommendations [Ref 14] of the National Commission on the BP DEEPWATER HORIZON Oil Spill and Offshore Drilling, as well as statements and interview reports from other witnesses. A complete list of references reviewed is included in Section 8.

This report and analysis was prepared at the request of and for the use of the Maritime Administrator of the Republic of the Marshall Islands in connection with its casualty investigation of this incident. The purpose of this analysis is to identify the likely initial source(s) of ignition of the hydrocarbon release.

2.0 INCIDENT OVERVIEW

On April 20, 2010, the DEEPWATER HORIZON was preparing to temporarily abandon a well that had been drilled and prepared for future production operations.[1] During these operations, control of the well was lost allowing a large flow of well fluids up the riser. By approximately 9:40-9:43 pm this was apparent to rig personnel as mud began to flow onto the drill floor.[2] The well fluids were diverted to a mud/gas separator (MGS) which vents above the main deck. This resulted in a large release of hydrocarbons onto the main deck which quickly engulfed the vessel in a hydrocarbon gas cloud.

At approximately 9:49 pm,[3] ignition of the gas cloud occurred resulting in several explosions and a fire. The fire continued to be fueled by hydrocarbons venting from the well eventually resulting in sinking of the vessel.

[1] BP, Deepwater Horizon Accident Investigation Report, September 8, 2010, at pg. 33.
[2] Report to the President, Deep Water – The Gulf Oil Disaster and the Future of Offshore Drilling, ("National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling report") at pg. 113.
[3] Report to the President, Deep Water – The Gulf Oil Disaster and the Future of Offshore Drilling, ("National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling report") at pg. 114.

3.0 AREA OF ORIGIN

Before attempting to identify the most likely causes of ignition, it is important to determine the area of origin. Although there are some differences in the reported location of the initial fire or explosion, there is general agreement that it was located aft of the derrick. Several people were in the engine control room and reported that, around 9:50 pm, the initial explosion blew the port door of the engine control room inward and the second explosion blew the starboard door inward.[4] This would indicate the initial ignition and explosion was in the aft section of the vessel, below the main deck level. Micah Sandell, a crane operator, was in the gantry crane on the port side, aft at the time of the incident. He thought the initial fire and explosion occurred in the vicinity of the degassing column,[5] which was located on the main deck aft of the derrick.

The DAMON B. BANKSTON, a supply boat, was stationed off the port side of the DEEPWATER HORIZON, in position to receive mud. Captain Alwin Landry was on the bridge of the DAMON B. BANKSTON at the time along with Paul Erickson, Chief Mate. Both reported seeing a flash of fire from the area aft of the derrick.[6,7] The height of the bridge of the DAMON B. BANKSTON is close to the elevation of the main deck of the DEEPWATER HORIZON,[8] which gave those on the bridge of the BANKSTON a good view of the aft end of the DEEPWATER HORIZON.

However, these reports from the crew members of the two vessels are not necessarily inconsistent with one another. The air inlets to the below deck engine and electrical rooms are located on the main deck aft of the derrick. Micah Sandell also indicated that he did not actually see the initial explosion. As he stated, "Then something exploded. I'm not sure what exploded, but just looking at it, it was where the degaser was sitting…".[9] If he was to the port side, the air intakes for several of the engine rooms and machinery spaces would be located between him and the degassing tank. It is possible that he may have seen fire venting from the vents, which is

[4] 5/28/10 MBI Tr. at 341 (Stoner).
[5] 5/29/10 MBI Tr. at 10 (Sandell).
[6] 5/11/10 MBI Tr. at 137 (Landry).
[7] 5/11/10 MBI Tr. at 232 (Erickson).
[8] 5/11/10 MBI Tr. at 137 (Landry).
[9] 5/29/10 MBI Tr. at 10 (Sandell).

consistent with the other reports indicating the initial explosion was in the engine room/electrical room area.

At the time of the incident, two of the vessel's six diesel engine/generators, numbers 3 and 6, were operating. Each engine pulled air for combustion from its respective engine room. The air intakes for the engine rooms were located above the main deck level. Gas released from the MGS vent stack was very likely pulled into the engine room air intakes and subsequently into the diesel engines. Both running diesels were reported to be over speeding shortly before the initial explosion.[10] William Stoner, who was in the engine control room, reported a number of gas alarms activated, the running engines began to speed up and then quickly started to shutdown (load down), several emergency shutdowns activated, and then quickly the first explosion occurred.[11] This explosion caused the port side door of the engine control room to be damaged and open inward against its normal functioning direction.

Testimony was provided by a number of crew members who were in the living quarters area of the vessel at the time of the explosion. They reported damage to the living quarters that could indicate the possibility of ignition and an explosion in that area. For example, Mark Hay was in his room at the time of the explosion and reported being unable to use a set of stairs to escape because the stairs were blocked by "dunnage and ceiling tiles and stuff".[12] Miles Ezell reported that he was thrown by the explosion, buried under debris[13] and that "that end of the living quarters was pretty well demolished".[14] He also describes helping unbury others who were buried under debris in the living quarters.[15]

This testimony does not necessarily demonstrate that the initial explosion, or any subsequent explosion, actually occurred in the living quarters. An explosion in the engine room area or machinery spaces could have exerted force through the adjacent compartments resulting in the damage described. An actual explosion within the confines of the living quarters would have

[10] 5/28/10 MBI Tr. at 340 (Stoner).
[11] 5/28/10 MBI Tr. at 341 (Stoner).
[12] 5/25/10 MBI Tr. at 186 (Hay).
[13] 5/28/10 MBI Tr. at 284 (Ezell).
[14] 5/28/10 MBI Tr. at 285 (Ezell).
[15] 5/28/10 MBI Tr. at 287 (Ezell).

been expected to result in fatalities in the quarters. None of the persons reported to be in the quarters at the time of the explosions were reported missing.[16] On the second deck level, starboard side, there was essentially one room, the sack storage room, between the machinery area and the living quarters.[17]

Based on the eyewitness accounts, including the reported damage occurring from the initial explosion, it is reasonable to conclude that ignition occurred on the aft end of the vessel. Further, the initial ignition occurred most likely in the machinery spaces, on the 2nd and 3rd deck levels, most likely in engine room #3 or the adjacent electrical room.

[16] Deepwater Horizon, General Arrangement Drawings, A-AA-1000/1011/1002/1004, showing locations of missing crewmen.

[17] HRBS-180-U01-H005, Rev 1A1, Arrangement of Fire/Gas System for Upper Hull, Second Deck.

4.0 HYPOTHESIS OF FIRE CAUSE

Explosions and fire result from bringing together, in the right combination, a source of fuel, an oxidizer (air), and a source of heat (ignition source). Due to the release of mud and hydrocarbon gases from the MGS vent stack and potentially other locations, fuel (hydrocarbon gas) and air were in abundance on the aft end of the vessel at the time of the incident. The remaining item required was the initial ignition source.

Based on the reported location, several hypotheses can be formulated as to the initial ignition source.[18] These are:

H1 - Impact ignition on the main deck;
H2 - Ignition due to malfunction of electrical equipment on the main deck;
H3 - Ignition due to a hot object, in this case the exhaust manifold from a diesel engine;
H4 - Overspeed of a diesel engine resulting in mechanical damage (friction) causing ignition;
H5 - Spark/arc from electrical equipment in an engine room or adjacent electrical room; and,
H6 - Ignition due to static electricity.

[18] There are a number of typical ignition sources that can be discounted for this incident. These include natural causes (i.e., lightning) and open flames, such as from an operating mud burner or hot work activity. Lightning is being excluded as an ignition source because at the time of the incident, the weather was reported good, with no storms or lightning activity reported. Although the vessel drawings indicate provisions for a mud burner, there was no evidence to indicate that it had been installed. Also, there was no testimony from any of the crew members indicating any hot work (welding, grinding, etc.) activity underway at the time of the incident.

5.0 HYPOTHESIS EVALUATION

This section addresses each of the hypotheses developed in the previous section. The objective is to determine if each hypothesis is consistent with the known facts and principles of explosion and fire science. If not, it is eliminated from further consideration. The remaining hypotheses are candidates for being the cause of the explosions and fire.

H1 - Impact ignition on the main deck

Statements from crew members did indicate that there were heavy objects falling shortly before the initial explosion. Caleb Holloway reported hearing heavy objects hit the roof of the heavy tool room shortly before hearing the first explosion.[19] Under worst-case conditions, friction caused by the impact of two hard, normally metallic, objects can result in sparks. These sparks can be at a temperature greater than the ignition temperature of flammable liquids or gases. However, mechanical sparks are usually very small, limiting their ignition potential. They also cool very quickly and would cause an explosion or fire under favorable conditions.[20] The low probability of metal-on-metal impacts as an ignition source for flammable materials is an opinion shared by the American Petroleum Institute (API), which issued a recommended practice indicating that the danger is overstated and that the use of non-sparking tools is not justified by experience.[21]

In addition to the low probability of spark ignition, the eyewitness accounts report significant overpressure damage to internal bulkheads and compartments. If the initial ignition had occurred on the main deck, overpressure resulting from the ignition would have been freely vented resulting in less damage below decks. This adds to the low probability of impact ignition occurring on a deck area and no need for further analysis.

[19] USCG statement of Hollaway, April 21, 2010.
[20] D. D. Drysdale, "Chemistry and Physics of Fire – Friction Sparks", *NFPA Fire Protection Handbook*, National Fire Protection Association, Quincy, MA, 19th ed., pg. 2-67.
[21] API, Recommended Practice 2214, Spark Ignition Properties of Hand Tools, 4th ed., pg. 2.

H2 - Ignition due to malfunction of electrical equipment on the main deck

The main deck contained numerous pieces of electrical equipment. The majority of the deck area was electrically unclassified[22] and any spark-producing equipment in this area could have acted as a source of ignition. Some of the deck areas were classified and electrical equipment in these areas is therefore required to be designed to minimize the potential of the equipment to ignite flammable materials. An audit conducted on behalf of Transocean[23] the week before the incident contained a finding that certain electrical equipment in the hazardous (classified) areas was dirty and in poor condition, but the audit did not recommend that use of the equipment be discontinued until its suitability for the area could be ascertained.

Although ignition by electrical equipment on the main or drilling decks cannot be totally ruled out, this hypothesis is also considered less likely due to the eyewitness accounts reporting the initial explosion and overpressure damage internally.

H3 - Ignition due to the hot exhaust manifold of a diesel engine

Ignition of a flammable or combustible material from a hot surface is a realistic potential. However, for the following reasons, it is considered unlikely in this case and ruled out of further consideration. The hottest object in the engine room would most likely have been the diesel exhaust manifold prior to cooling in the turbochargers. At full load, the temperature of the manifold was reportedly as hot as 500 deg C.[24]

Hydrocarbon vapors were pulled into the engine room. The composition of the vapors was predominately light gases, such as methane, ethane, and propane. These three accounted for 85% of the released materials, by volume.[25] The ignition temperature of the hydrocarbon gases that were likely pulled into the room probably ranged from 287 C to 632 C (methane=537 C;

[22] HRBS-E81-000-H0015, Electrical Area Classification Drawing, Main Deck, Rev 1B.
[23] ModuSpec, Rig Condition Assessment – Deepwater Horizon, Audit report reference US2147-1, April 1-14, 2010, pg. 81.
[24] Interview with Bob Miller, Wärtsilä North America, Inc., November 16, 2010, at pg. 3.
[25] Prospect Report Number 102H006-004R-D, Deepwater Horizon Investigation – Gas Dispersion studies, Revision D, March 31, 2011, Table 4, pg. 16.

ethane=472 C; propane=450 C; butane=287 C; natural gas=482 - 632 C). The engine room air intakes were designed to minimize liquids from entering the engine room.

The API has concluded that ignition of a flammable substance is unlikely unless the surface temperature is approximately 182 C above the minimum ignition temperature of the hydrocarbon involved.[26] Based on the maximum exhaust temperature of approximately 500 C, this would have indicated the potential to ignite hydrocarbons with an ignition temperature from approximately 318 C or lower. This may have been higher than the ignition temperature of some of the heavier hydrocarbon gases (e.g., butane) that may have been in the hydrocarbon vapor pulled into the engine room.

However, another factor important to ignition of a hydrocarbon from a hot surface is residence time. It is easier to ignite hydrocarbon liquids that spill onto a hot surface and stay there sufficiently long to heat up and ignite. Vapors that come into contact with a hot surface tend to become more buoyant and move away from the hot surface. Therefore, the temperature of a hot surface has to be considerably higher than the ignition temperature to have a realistic chance of igniting hydrocarbon vapors.

Liquid hydrocarbons are easier to ignite than vapors and the longer the liquid is in contact with the hot surface, the lower the temperature required (i.e., closer to the reported ignition temperature of the liquid). However, it is still considered unlikely that this is a practical scenario given that, a) the design of the air intakes minimized the likelihood of liquids being pulled into the engine room (high efficiency energy louvers),[27] b) any liquids that were entrained into the engine room through the air intake would have been entering the room away from the exhaust end,[28] and c) the time between release of the mud and vapor from the degassing system vent until the first explosion was reported was short relative to the anticipated time to heat up liquids to ignition on a hot surface.

[26] API, Recommended Practice 2216, Ignition Risk of Hydrocarbon Liquids and Vapors by Hot Surfaces in the Open Air, 3rd ed., pg. 4.
[27] Operations Manual – Deepwater Horizon, Chapter 8, Section 8.5.3, pg. 8.145.
[28] Operations Manual – Deepwater Horizon, Chapter 8, Section 8.5.3, pg. 8.145.

H4 - Overspeed of a diesel engine resulting in mechanical damage (friction) causing ignition

The potential for a diesel engine to overspeed possibly resulting in damage to the engine, and subsequently acting as a source of ignition, is a known concern.[29] Pulling hydrocarbon vapors in with the engine combustion air will provide additional energy potentially causing the engine to overspeed. This was reported to have happened by several eyewitnesses. William Stoner, on duty in the engine control room, reported hearing the number 3 engine overspeed then begin to shutdown.[30] This was followed shortly by an explosion that blew the port side door to the engine control room inward. The number 3 engine was located on the port side. A second explosion occurred shortly thereafter causing the starboard side door of the engine control room to blow inward. The number 6 engine, which was also running at the time of the incident, was located on the starboard side.

The diesel engines took their combustion air from the air within their respective engine room. The air to each engine room was drawn in through air intakes located on the main deck, aft of the derrick. For example, the air inlet for the engine room for number 3 diesel/generator was on the main deck, aft of the derrick, on approximately the centerline of the vessel.[31] This was the area where the mud and gas from the mud-gas separator was venting. A scenario involving overspeeding of the engine and damage to the engine resulting in ignition of the gas drawn into the room is consistent with the eyewitness's reports of hearing the engines over speed and a potential origin of the initial ignition/explosion.

The diesel engines are provided with three levels of shutdown protections[32] designed to, or capable of, protecting the engine due to an overspeed situation. These include a diesel engine speed measuring system (DESPEMES), a solid state speed and load controller system (Woodward 723

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[29] API, Recommended Practice 14J, Recommended Practice for Design and Hazards Analysis for Offshore Production Facilities, American Petroleum Institute, 2nd ed. recommends that, "Air intakes of fire process equipment, combustion engines, air compressors and HVAC systems should be located so as to provide the greatest amount of isolation from sources of flammable gas."
[30] 5/28/10 MBI Tr. at 341 (Stoner).
[31] Operations Manual – Deepwater Horizon, Chapter 8, pg. 8.160, drawing HRBS-H68-000-H1010, Ventilation System Diagram, Except L/Q, Main Deck, Sheet 6.
[32] Interview with Bob Miller, Wärtsilä North America, Inc., November 16, 2010, at pg. 3.

Plus), and a mechanical overspeed protection device. Each of these 3 systems use different means to monitor the speed (or overspeed) of the engine and initiate a shutdown of the engine. The engine speed monitoring system works with the vessel's Kongsberg Integrated Automation and Control System (KIACS). When the engine speed is approximately 13% above normal, the system sends a signal to the KIACS which in turn shuts off the fuel pumps to the engine and closes the air intake valve. Closure of the air intake valve would essentially starve the engine, whether the fuel supply shut off or not, causing the engine to stop running.

The speed and load controller (Woodward 723 Plus) used independent measuring points to monitor the engine speed. At approximately 15% over the normal speed, this system would also send a signal to the KIACS initiating a shutdown of the engine.

The third shutdown is mechanical, independent from the other two, and requires no power to operate. It is based on centrifugal force. When the engine overspeeds approximately 18% above normal, the trip mechanically moves the fuel control rack to zero cutting off fuel to the engine.

This hypothesis cannot be ruled out. However, the multiple levels of shutdown provided, along with the eyewitness account by William Stoner that he noticed the engine begin to shutdown just prior to the first explosion,[33] lower the likelihood of this hypothesis relative to others.

H5 - Spark/arc from electrical equipment in an engine room or adjacent electrical room

This hypothesis also assumes a flammable hydrocarbon air mixture exists in the engine room or adjacent switchgear room. This hypothesis is also supported by the previously mentioned observations that indicate a gas mixture was in the rooms and the location of the initial ignition/explosion occurred in one of the engine rooms.

The engine rooms and associated electrical equipment rooms were not electrically classified areas.[34] The likelihood of an ignitable mixture of flammable vapors in the rooms was considered

[33] 5/28/10 MBI Tr. at 340 (Stoner).

sufficiently low that requiring electrically classified equipment was not considered justified. The air intakes for several rooms were located on the main deck,[35] where, during this incident, hydrocarbon vapors were being vented, thereby providing a path for drawing flammable gas into the rooms. Once the gas was drawn in, it is expected that numerous electrical ignition sources would exist in the rooms.[36]

As the diesels began to overspeed the speed of the associated generator would be too high and the generator was arranged to trip off line.[37] This would involve opening a circuit breaker. Opening a circuit breaker operating at the generated voltage would be likely to create a spark within the equipment. Since the room and potentially the equipment contained flammable gas, the opening of a circuit breaker could have ignited the gas.

There was presumably other electrical equipment in the machinery rooms that was also capable of igniting the gas. However, the fact that such equipment was capable of creating a spark does not, by itself, mean that a spark was created at the relevant time. The fact that the circuit breaker would have opened in response to the generator overspeed and most likely created a spark as it opened increases the likelihood that the opening of a circuit breaker to protect the generator (or any other control device working to protect the generator) could have been the initial source of ignition.

H6 - Ignition due to static electricity

For static electricity to be the source of ignition of a flammable gas or liquid, four conditions must occur:[38]

1) There must be an effective means of separating charge;

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[34] Deepwater Horizon area classification drawings, HRBS-E81-000-H0015, Sheets 6 & 7, Rev A.
[35] Operations Manual – Deepwater Horizon, Chapter 8, pg. 8.160, drawing HRBS-H68-000-H1010, Ventilation System Diagram, Except L/Q, Main Deck, Sheet 6, Rev 2.
[36] The Handbook of Fire and Explosion Protection Engineering Principles for Oil, Gas, Chemical, and Related Facilities, page 151, discusses the risk of ignition from internal combustion engines, including due to the instrumentation associated with the engine.
[37] Operations Manual – Deepwater Horizon, Chapter 8, pg. 8.105, Section 8.2.8.j.
[38] Don R. Scarbrough, et al., "Control of Electrostatic Ignition Hazards", *NFPA Fire Protection Handbook*, National Fire Protection Association, Quincy, MA, 19th ed., pg. 6-55.

2) The separated charges must be accumulated and a suitable difference of electrical potential maintained;
3) A discharge (release of the accumulated charges) must occur; and,
4) The discharge must occur within a flammable mixture.

The generation (separation) of electrical charges could have occurred due to the flow of liquid and gases from the MGS vent or other release points. Separation of charges can occur when a relatively non-conductive liquid flows out of a pipe. It is generally accepted that when the liquid conductivity is greater than 50 pS/m, a charge will dissipate as quickly as it is created, as long as the surfaces are grounded/bonded.[39]

The conductivity of typical crude oil is >1000 pS/m.[40] The vessel construction is primarily metal and the metal surfaces are in contact with the sea. Therefore it would be expected that the likelihood of generating and accumulating static charges would be low. Also, where the liquid/gases were flowing it is likely that the flammable mixture was quickly above the flammable limit. This would have necessitated a charge being accumulated sufficiently far from the release point to be in an area where the flammable mixture was in the explosive range.

[39] Don R. Scarbrough, et al., "Control of Electrostatic Ignition Hazards", *NFPA Fire Protection Handbook*, National Fire Protection Association, Quincy, MA, 19th ed., pg. 6-60.
[40] API, Recommended Practice 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents, 6th ed., Appendix A, pg. 36.

6.0 DISCUSSION OF UNELIMINATED HYPOTHESIS

Of the hypotheses presented, none can be totally ruled out. However, the hypotheses (H1, H2, and H6) involving the initial ignition occurring on the main deck are considered less likely and are not considered further.

Of the hypotheses (H3, H4, H5) involving ignition in the engine room or adjacent electrical room, the most likely is ignition from an unclassified electrical component (H5). This is supported by the lack of barriers to prevent such an occurrence once a flammable mixture occurred in the engine/electrical rooms. Sparks or arcs from operating electrical equipment are known potential sources of ignition. Many electrical motors and other electrical equipment bear a label indicating that they should not be operated in the presence of flammable vapors. However, it is generally believed that electrical equipment, such as a circuit breaker, will not serve as an ignition source, because it is assumed that a flammable gas mixture will not occur within the unclassified rooms. The overspeed of the diesel engines makes it almost certain that there was a concentration of flammable gas in the engine rooms.

Mechanical damage due to overspeeding of a diesel engine is also a potential source of ignition. This is considered a lower probability since the diesels are provided with multiple, independent systems to prevent such an occurrence. Although it is possible that all these protective barriers failed, or were out of service at the time, this likelihood is considered low. Also, even if the engine overspeeds, it is not a certainty that the resulting damage would be sufficient, or of a nature, to cause ignition.

There is a possibility that the gas could have been ignited by contact with the hot exhaust from the diesel. This is considered the least likely of these three hypotheses.

7.0 CONCLUSION

Based on the information available, the most likely cause of ignition of the gas was a spark from a piece of electrical equipment in the engine room or adjacent electrical rooms.

The loss of the vessel precludes any examination of the scene that might have assisted in identifying the actual cause of ignition. This analysis is therefore entirely dependent upon eyewitness accounts and the other sources cited previously.

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4. Deepwater Horizon Hazardous Area Classification Drawings, HRBS-E81-000-H0015, Rev 1B
   - Sheet 3 – Above Main Deck Level
   - Sheet 4 – Drill Floor
   - Sheet 5 – Main Deck (El 41500)
   - Sheet 6 – Second Deck (El 38000) (Rev 1)
   - Sheet 7 – Third Deck (El 34500)
   - Sheet 8 – Midship Section
5. Deepwater Horizon Drawings – Arrangement of Electrical Equipment For Switchgear/Motor Control Center Rooms, HRBS-E58-U01-H0022, Rev A
   - Sheet 3 – 2nd Deck, Mid Aft Plan, El 38000
   - Sheet 4 – 2nd Deck, Mid Aft Elev, El 38000
   - Sheet 5 – Port Aft, El 36700 SWGR Room
   - Sheet 6 – Stbd Aft, El 36700 SWGR Room
   - Sheet 7 – 3rd Deck, Mid Aft Plan, El 34500
   - Sheet 8 – 3rd Deck, Mid Aft, El 34500
6. Deepwater Horizon Drawings – Arrangement of Electrical Equipment For Living Quarters, HRBS-E58-U01-H0023, Rev A
   - Sheet 3 – 2nd Deck Port Fwd, El 38000
   - Sheet 4 – 2nd Deck Stbd Fwd, El 38000

- Sheet 5 – 3rd Deck Port Fwd, El 34500
- Sheet 6 – 3rd Deck Stbd Fwd, El 34500

7. Deepwater Horizon Drawings – Arrangement of Fire/Gas System For Lower Hull, HRBS-I80-H01-H0004, Rev 1A1
    - Sheet 4 - Column
    - Sheet 5 – Pontoon
8. Deepwater Horizon Drawings – Arrangement of Fire/Gas System For Upper Hull, HRBS-I80-H01-H0005, Rev 1A1
    - Sheet 4 – Drill Floor
    - Sheet 5 – Levels Above Main Deck
    - Sheet 6 – Main Deck
    - Sheet 7 – Second Deck
    - Sheet 8 – Third Deck
9. Fire Fighting & Lifesaving Plan, Deepwater Horizon
    - File no. 6087aUN1000_1, Alt 5 – Lower Hull
    - File no. 6087aUN1000_2, Alt 5 – Upper Hull
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25. Fire Protection Handbook, National Fire Protection Association, Quincy, MA, 19th edition, 2003.
26. Testimonies to the US Coast Guard/Mineral Management Services Marine Board of Investigation, particularly the following:

Date	Name	Company	Title
5/11/10	Anthony Gervasio	Tidewater Marine	Relief Chief, Damon B. Bankston

Date	Name	Company	Title
5/11/10	Capt Alwin Landry	Tidewater Marine	Master, Damon B. Bankston
5/11/10	Paul Erickson	Tidewater Marine	Dynamic Positioning Officer, Damon B. Bankston
5/26/10	Arinjit Roy	ABS	Surveyor
5/26/10	Douglas Brown	Transocean	Chief Mechanic
5/27/10	Capt. Curt Kuchta	Transocean	Master
5/27/10	Chad Murray	Transocean	Chief Electrician
5/27/10	David Young	Transocean	Chief Mate
5/27/10	Jimmy W. Harrell	Transocean	Offshore Installation Manager
5/28/10	Christopher Haire	Halliburton	Service Supervisor
5/28/10	Christopher Pleasant	Transocean	Subsea Supervisor
5/28/10	Gregory Meche	M-I Swaco	Compliance Specialist
5/28/10	Mark Hafle	BP	Drilling Engineer
5/28/10	Miles Randall Ezell	Transocean	Senior Toolpusher
5/28/10	William Stoner	Transocean	Oiler Motorman
5/29/10	Allen Seraile	Transocean	Assistant Driller
5/29/10	Charles Credeur	Dril-Quip	Service Technician
5/29/10	Micah Burgess	Transocean	Driller
5/29/10	Micah Sandell	Transocean	Crane Operator
5/29/10	Paul Meinhart, III	Transocean	Motorman
8/25/10	Mark David Hay	Transocean	Senior Subsea Engineer
8/26/10	David Sims	BP	Drilling & Completions Operations Manager,

27. Written statements given by crew members to the USCG while onboard the MV Damon Bankston, particularly Caleb C. Hollaway, Floorhand, Transocean, given April 21, 2010.

ANNEX C: Well Control Report

REPORT OF THE LOSS OF WELL CONTROL

AND

ASSESSMENT OF CONTRIBUTING FACTORS

FOR THE

MACONDO WELL

MISSISSIPPI CANYON BLOCK 252

OCS-G 32306 #1 WELL

Prepared for the Maritime Administrator of the Republic of the Marshall Islands

By GL Noble Denton and AGR FJ Brown

This document was prepared on behalf of the Maritime Administrator of the Republic of the Marshall Islands (RMI) and is based upon witness testimony presented at the investigative hearings conducted by the Bureau of Ocean Energy, Management, Regulation, and Enforcement (BOEMRE) and the United States Coast Guard (USCG), and from various documents and data posted on the Homeport secured website of the Joint BOEMRE/USCG Investigation Team (JIT).

I. Overview of Marine Drilling Operations

Oil wells are drilled and prepared for completion using a combination of mechanical, hydraulic and chemical processes. At deepwater locations, these processes are conducted from Mobile Offshore Drilling Units (MODUs), which are marine vessels equipped with the pipe handling, fluids pumping and mixing equipment required for the various phases of drilling.

MODUs typically operate at a wellsite from the start of drilling to the conclusion of placing steel casing all the way to the producing formation. At that time, the well is temporarily plugged in a safe condition and the MODU is moved to another wellsite. (Completion and production operations are conducted by other structures, such as a tethered platform.)

The overriding safety concern in drilling a well and placing casing to the bottom is preventing uncontrolled flow of oil or gas to the surface. Multiple well control measures are used throughout operations, including:

- Adjusting hydrostatic head inside the wellbore with the use of weighted drilling fluids.
- Preventing loss of drilling fluids to weak zones by physically or chemically adjusting drilling fluids to maintain their integrity.
- Installing blowout preventers (BOPs) immediately above the wellhead as safety devices and to assist with testing well integrity.
- Placing physical barriers such as seals, plugs or valves at selected locations within the wellbore during selected operations.

For effective well control, a minimum of two well control measures must be in place at all times.

Although casing design, casing components and cement placed inside and outside of the casing are essential for establishing the integrity of the well, they are not considered well control measures.

Well control measures are developed and applied on the recognition that these elements may fail to secure the well at any time. For that reason, well control measures must be independent of, and not compromised by, any of the devices or procedures used to complete or test the well.

Prior to drilling a well, especially for high-pressure, high-volume formations in deepwater areas, comprehensive plans are developed based on expected subsurface conditions. These plans specify hole sizes, drilling fluid composition, casing sizes, cementing techniques and other critical design features. Plans may be adjusted as the well is drilled and changed conditions are determined.

Once the wellhead and BOP are installed on the sea floor, drilling is conducted in 'casing intervals.' That is, a section of hole is drilled at a constant hole diameter for a predetermined distance, then steel casing is inserted into the hole to maintain an open wellbore, isolate formations and control flow of fluids during subsequent drilling.

After that casing interval is cemented into place, the next hole interval is drilled with a slightly smaller diameter and protected with a slightly smaller steel casing. The process repeats until total depth (TD)

is reached. TD is at or slightly below the lowest formation from which production is expected. The final casing placement isolates the high-pressure oil and gas producing formation(s).

Drilling takes place by lowering the drill string (an assembly of drill pipe and thick-walled pipe called drill collars) and bit from the MODU, through the riser (a large diameter steel tube that connects the MODU to the seafloor wellhead), through the BOP and wellhead and into the formations. The bit is rotated while a multi-purpose fluid called "drilling mud" is circulated down through the pipe, out of the bit and back up to the MODU. In the formations, the return flow is through the annular space between the outside of the drill string and the inside wall of the wellbore or installed casing. From the top of the casing string, flow continues through the wellhead, BOP and riser to the MODU, where it is reconditioned and recycled for pumping back down the well.

An engineered slurry, drilling mud is designed to:

- Transport the rock chips created by the drill bit out of the well for collection on the MODU during mud recycling.
- Exert pressure on the wellbore wall to keep it from collapsing before the next protective casing section is installed.
- Exert pressure on any gas, oil or water formations to prevent their flow into the wellbore.

The proper hydraulic function of mud is critical. A principal means for controlling how much pressure the mud column exerts on the well is adjusting its weight, as measured in pounds per gallon (ppg). Mud weight is adjusted by varying the concentration of solids and chemicals in the slurry. It is easily determined by taking a one gallon sample and weighing it or by pumping it through a small tank section that continually monitors the net weight of the tank.

The combination of mud weight and height of the mud column determines the hydrostatic pressure applied by the mud at any point in the wellbore. In a simple example, 10,000 feet of well-bore 8 inches in diameter contains about 26,000 gallons of fluid. If each gallon weighed 14 pounds, then the pressure applied at the bottom of the well is about 7,300 pounds per square inch (psi).

The actual pressure applied can be higher or lower, depending on properties such as temperature, fluid viscosity and fluid velocity. For instance, increasing mud flow in the wellbore increases the resistance between the mud and wellbore walls. One effect of this is to increase the apparent density of the mud. That is, faster flowing mud acts like heavier mud, increasing the mud's resistance to flow from a formation. This is described as equivalent circulating density (ECD).

Another objective is to make sure that mud loss, or flow INTO a formation, is prevented or minimized. Losing mud flow to a formation compromises safety by reducing the volume of mud in the wellbore and therefore the pressure exerted to keep unwanted oil or gas from flowing into the well during drilling.

The difference in mud weight between being too light (allowing flow of formation fluids into the well) or too heavy (causing mud loss) is sometimes only a few tenths of a ppg. Maintaining the correct mud weight is a critical factor in controlling the hydraulic conditions in the well.

During all wellbore operations, mud flow volume into and from the well is measured by monitoring multiple tanks in the mud recycling system. Additional indication of mud flow is provided by flowmeters that can be observed by the rig crew or the mud supply contractor. Under normal conditions, volumes in and out are equivalent. Any increase in volume coming from the wellbore is usually interpreted as an indication that fluids or gas from the formation are flowing into the well and that well control measures should be implemented.

Finally, a common pipe configuration during drilling operations presents additional challenges to maintaining proper hydraulic conditions – a tube within a tube. As noted above, mud flows down through the inside and back up around the outside of the drill string. At the end of drilling operations, mud in the wellbore is recovered on the MODU by lowering the drill string into the wellbore and pumping another fluid such as seawater into the well. This configuration, a tube within a tube, has the hydraulic characteristics of a U-tube. Flowing liquids through a U-tube – especially one more than 18,000 feet in height containing fluids of different densities and exposed to pressurized formations – can create conditions of localized high pressure and temporary reversals of flow as pressures in the U-tube equalize.

Given its importance, the pressure, volume, flow rate and composition of mud are carefully monitored. Similar to measuring someone's blood pressure and pulse, monitoring mud flow and volume are principal means of assessing the health of a complex well drilling operation.

When the final casing section is placed and cement has isolated the formation, then the drilling mud can be partly or completely replaced with another fluid (e.g., seawater), provided that the fluids remaining in the wellbore apply hydrostatic head that is greater than formation pressure. At this point, the well is 'temporarily abandoned' until the next phase, completion and production.

II. Background of the Macondo Well

The Mississippi Canyon Block 252, OCS-G 32306 well is located in the Gulf of Mexico approximately 41 miles off the coast of Louisiana in 4,992 feet of water. Named the Macondo Prospect, the target formations in this area are approximately 18,000 feet deep and pressured to more than 13,000 psi.[1] [2]

In October 2009 the moored semi-submersible drilling rig *Transocean Marianas* started drilling the Macondo #1 well.[3] [4] The original drilling plan called for seven casing intervals. During the upper three casing sections, operations were relatively routine. However, drilling problems occurred in the

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[1] BP Power Point Presentation MC 252 #1 (Macondo) – TD Forward Plan Review (BP-HZN-CEC 022030)

[2] Email from Jonathan Bellow to John Guide, re: MMS Presentation, (April 26, 2010) (BP-HZN-MBI00020889)

[3] (1) IADC Report <Transocean MARIANAS> October 21ST to November 14TH, 2009

[4] (2) BP Daily Operation Report <MC 252 #1 well> May 3RD to December 20th, 2009

fourth hole interval, delaying work about one week. On November 8, the vessel was evacuated for Hurricane Ida, which caused enough damage to the rig to require shipyard repairs. The well was temporarily suspended in accordance with regulatory requirements on November 21 and the *Transocean Marianas* was towed from the site on November 27.

On January 31, 2010, Transocean's *Deepwater Horizon*, a dynamically positioned, semi-submersible MODU, arrived on location to complete drilling the Macondo #1 well. Total depth of 18,360 feet was reached on April 9, 2010.

Following extensive assessment of the wellbore to determine actual pressure, temperature and formation conditions, a full-length casing was installed from the wellhead to just below the high-pressure formations. Cementing operations were conducted with the objective of isolating those pressurized zones. A negative differential pressure test was then conducted to verify that the well was secure.

At the time, responsible parties assessed that the test was successful and that conditions warranted taking the next steps: removing some of the drilling mud from the well and installing an additional cement plug to meet regulatory requirements for extra isolation.

During the mud removal operation, an uncontrolled flow of gas and oil occurred, starting at the formation and continuing through the casing, drill string, wellhead, BOP and riser up to the MODU *Deepwater Horizon*. Two-phase gas-oil flow is especially dangerous. At the bottom of the well, high pressure compresses the gas, dissolving it into the oil. As the gas-oil mixture travels to the surface, the gas expands into large bubbles, substantially increasing the velocity of the flow. Blowouts of this type are extremely difficult to control.

Although analysis indicates that *Deepwater Horizon*'s crew may have regained control of the well, a portion of the initial gas bubble soon ignited. This compromised the safety and control systems, ultimately leading to the loss of eleven men and *Deepwater Horizon*.

III. *Deepwater Horizon* Operations

Deepwater Horizon operations started in early February 2010.[5] [6] Under a modified drilling plan, five additional casing intervals were drilled, for a total of nine. (Refer to *Appendix A: Wellbore Schematic*.) Although seven casing intervals had been originally planned for this well,[7] well design

[5] (3) IADC Report <Transocean DEEPWATER HORIZON> January 31st to April 20th, 2010

[6] (4) BP Daily Operation Report <MC 252 #1 well> January 31st to April 19th, 2010

[7] (7) Testimony of Mark Hafle, May 28, 2010, page 80:19-25 // page 81:1-2

changes are expected[8] in response to measurements and observations gained during drilling such as formation pressure and rock properties.

Of the five intervals drilled by *Deepwater Horizon* , two were relatively routine, However, in the other intervals incidents occurred such as mud losses, drill pipe or casing components becoming stuck, brief periods of uncontrolled formation flow (or, "kicks") and retrieving damaged equipment from inside the wellbore (or, "fishing").[9] [10] These incidents are neither uncommon nor unusual for ultra-deepwater operations in the Gulf of Mexico.

Events that occurred in the final hole interval are relevant to understanding the Macondo well control incident:

- Wellbore Conditions in the Final Hole Interval.
- Placing the Casing in Position.
- Cementing the Casing.
- Well Abandonment, which included:
    - Partial Displacement of Mud with a Water-based Spacer and Seawater.
    - Conducting the Negative Differential Pressure Test.
    - Resuming Displacement of Drilling Mud from the Riser.
    - Well Monitoring and Loss of Control.

Each of these is discussed below in this section, citing available records, witness accounts and testimony before the Joint BOEMRE/USCG Investigation Team. Assessment of these events, which includes post-incident engineering analyses, is discussed in the following section.

Wellbore Conditions in the Final Hole Interval

The ninth, and final, hole interval was the source of the uncontrolled flow. On April 2, drilling started this section at 17,168 feet with an 8 ½" drill bit and 9 ⅞" reamer tool. Located above the bit, the reamer tool creates a slightly larger hole in this interval to assist with placing and cementing the casing.

The drilling mud used for this interval was a synthetic oil-based mud (SOBM). At the start of drilling this section, a pressure test was conducted to determine the maximum allowable mud weight. A maximum allowable weight of 16.0 ppg was determined and a mud weight of 14.5 ppg was selected.

While drilling at a depth of 17,751 feet mud loss occurred. Loss control materials (LCM) "pills" were added, reducing the mud loss to the formation. Drilling continued to 17,835 feet, in order to measure pressure at a formation located at 17,723 feet (Drilling beyond a zone before measuring is required to provide working room for the measurement tool.)

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[8] (7) Testimony of Mark Hafle, May 28, 2010, page 80:19-25 // page 81:1-2

[9] (5) Halliburton (Sperry Drilling Services) – End of Well Report [BP-HZN-MBI 00195198 thru 00195279]

[10] (6) MI Swaco Mud Report – April 1, 2010 through April 19, 2010 [MIe 100001 001 0000001 thru 0000093]

Based on three measurements made at this time, mud density was decreased from 14.5 ppg to 14.3 ppg, flow rate reduced from 500 gallons per minute (gpm) to 400 gpm, and drilling continued.

At a bit depth of 18,260 feet, severe mud losses occurred in the hole. Conventional LCM pills were pumped, but these products were unsuccessful in reestablishing circulation. A more robust LCM pill of cross-linked polymers, cellulose and fibrous materials was pumped in the well and full mud circulation was regained. To reduce the risk of further losses, mud weight was decreased to 14.0 ppg (as measured at the surface), and the flow rates were lowered to 300 gpm. At bottom hole conditions, temperature and pressure effects create an equivalent mud weight of 14.2 ppg, resulting in a narrow "operating window"[11] [12] throughout the open hole section.

Drilling continued without the reamer, reaching TD of an 8 ½' diameter hole at 18,360 feet on April 9. [13] [14] Well logging operations[15] [16] started an April 10 and by April 15 at 0800 hours eight different runs had been completed to assess conditions in the well.[17] During this period, the well was stable; there were no further mud losses and no indication of flow into the well. Since there is no drill string in the hole for this period, the mud is static – no circulation occurs.

On April 15 a "wiper trip" [18] [19] was made by lowering the drill string and bit into the well to clean and condition the hole for casing installation. This operation re-establishes circulation such that the static mud is circulated out and replaced with reconditioned drilling mud.

The mud returning from the bottom of the hole, near the target formations, contained some dissolved gas.[20] Industry practice allows for a semi-quantitative measurement, which yielded a value of 1,120 gas units, and a density reduction measurement, which was determined as 0.2 ppg.[21]

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[11] Email from Robert Bodek to Michael Beirne, re: Macondo TD, dated April 13, 2010 [BP-HZN-MBI 00126338]

[12] Email from Michael Beirne to Nick Huch and Naoki Ishii, re: Macondo TD & Draft Sub. Op. AFE, dated April 13, 2010 [BP-HZN-MBI 00178357]

[13] IADC Report <Transocean DEEPWATER HORIZON> April 1st to April 9th, 2010

[14] BP Daily Operation Report <MC 252 #1 well> April 1st to April 9th, 2010 [BP-HZN-MBI 00018895 thru 18915]; [BP-HZN-MBI 00013905 thru 13910]; [BP-HZN-MBI 00019353 thru 19382]

[15] IADC Report <Transocean DEEPWATER HORIZON> April 9th to April 15th, 2010

[16] BP Daily Operation Report <MC 252 #1 well> April 9th to April 15th, 2010 [BP-HZN-MBI 00019377 thru 19411]

[17] Halliburton (Sperry Drilling Services) – End of Well Report [BP-HZN-MBI 00195247]

[18] IADC Report <Transocean DEEPWATER HORIZON> April 15th to April 17th, 2010

[19] BP Daily Operation Report <MC 252 #1 well> April 15th to April 17th, 2010 [BP-HZN-MBI 00018568 thru 18583]

[20] Halliburton (Sperry Drilling Services) – End of Well Report [BP-HZN-MBI 00195248]

[21] MI Swaco Mud Report – April 16, 2010 [MIe 100001 001 0000076]

After approximately three hours of circulation[22] gas levels returned to previously-measured background readings of 30 to 40 units. (Refer to *Appendix B: Gas Readings – Wiper Trip.*)

On April 16, after circulating mud for about 10 hours, the drill string was pulled out of the well. No mud losses were observed during either circulation or drill string removal.

Placing the Casing in Position

Early on April 18 *Deepwater Horizon* began preparations to install the final casing section. Two sizes of casing, a "tapered string," were used – 9 ⅞" diameter on top and 7" diameter on bottom.

The top of the tapered string was fixed to a casing hanger, the device that rests in and can be sealed against the wellhead. The bottom of the string contained a casing shoe, a rounded device that helps guide the string into position and directs fluid out of the casing during cementing operations. The casing string was also equipped with a double flapper, check-valve type device called an auto-fill float collar.

Auto-fill float collars serve two functions during casing installation. While the casing is being lowered into position, the collar ALLOWS mud within the wellbore to flow up inside the casing. Without this feature, the casing would have to be filled with mud as each section is lowered into the well. The second function occurs after the casing is in position and cement is pumped into place for isolating the formation. In this operation, cement is pumped down the casing and through the casing shoe, where it is then directed back up through the annular space between the outside of the casing and the wall of the wellbore. In this case, the float collar must PREVENT cement from flowing backward and re-entering the casing. The double flapper valves help hold the cement in the proper position until it hardens.

In order to switch from one function to another, the float collar must be converted just prior to cementing operations. Conversion occurs by temporarily increasing the pressure generated at the mud pump located on the MODU. For this application the expected pressure range was 500 to 700 psi.

The casing string was lowered into the hole using a 6 ⅝" "landing string" of drill pipe.[23] [24]

Across the lower nine sections of casing, a total of 423 feet, six bow spring centralizers subs were installed.[25] Provided that hole enlargement does not occur during drilling, centralizer subs position the casing in the middle of the wellbore for more uniform cement placement around the casing.

Measured at the hook that lowered the assembly into place, the weight of the landing string and tapered casing was 848,000 pounds. (Weight in air would be greater, as drilling mud creates

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[22] Sperry Sun Gas Readings, (April 15-20, 2010) (BP-HZN-MBI00013444 – Log.txt)

[23] IADC DWH Report April 18-19, 2010

[24] BP Daily Operation Report MC 252 #1 well, (April 18-19, 2010) (BP-HZN-MBI00018584 thru 18595)

[25] Weatherford Tubular Running Services – Job Report (WFT 000038-000042)

buoyancy for the suspended pipe.) When the casing hanger was inserted into place, 398,000 pounds of the load was transferred to the wellhead and 450,000 pounds was carried by the hook. Casing placement was completed at 1335 hours on April 19.

With casing hanger in the wellhead, the float collar was positioned at 18,114 feet and the casing shoe was positioned at 18,303 feet, leaving 57′ of open hole below the shoe.

Upon landing the casing hanger, the surge reduction tool at the bottom of the 6 ⅝" landing string was shifted closed in order to conduct the float collar conversion step.[26] When mud circulation through the casing could not be established at the recommended pressure range (i.e., 500 to 700 psi), pressure was gradually increased.[27] At 1621 hours, application of 3,142 psi established circulation.[28] (Post-incident calculation determined that up to 92,000 pounds of force may have been exerted on the float collar at this applied pressure.) This condition can be caused by debris plugging the device.[29] However, plugging has not been conclusively determined.

At this point, flow indicated that the mud circulation path had been established as follows:

- Down the inside of the casing,
- Through the float collar and out through the casing shoe,
- Up the outside of production casing in the annular space between the casing wall and formation,
- Into the previously-cemented casing strings in the annular space between the production casing and earlier casing strings,
- Up around the outside of the casing hanger, which had not yet been sealed to the wellhead,
- Up the riser to the mud recycling system.

Cementing the Casing

Pilot tests of cement formulations were conducted in February, focusing on adjusting additives to maintain pumpability. These pilot tests were conducted using product taken from the cement contractor's inventory onshore and city water.

In April, the cementing contractor obtained samples of product from *Deepwater Horizon's* onboard inventory, as well as samples of rig water, to prepare additional test lots. The April tests were conducted, in part, for the following reasons:

- New information indicated that downhole temperatures would be lower than the values used for the February tests. Temperature influences pumpability.

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[26] Allamon Tool Company – Job Summary (BP-HZN-MBI00020808)

[27] Weatherford Drawing – 7" M45AP Float Collar (BP-HZN-MBI00013436)

[28] Halliburton – Production Casing Post Job Report, (April 20, 2010) by Nathaniel Chaisson (BP-HZN-MBI00170988 thru 170989)

[29] 7/22/10, MBI Tr. at 147-148 (Guide)

- Recommended practice is to confirm properties using the actual on-board materials and water, as these may exhibit different properties compared to the materials and water used in the February tests.

Two of the several properties typically measured in these tests are:

- Thickening time, or the number of hours required for the cement slurry to remain in a pumpable state. Thickening time is determined by preparing a sample and measuring the increase in fluid viscosity over time. The desired thickening time is one that maintains flow properties for the time required to pump the cement into place, allowing for possible delays, yet allows subsequent operations to start as quickly as possible.
- Compressive strength, or the maximum load a material can resist before crushing, also measured over time. Once cement hardens, its strength increases over time. Understanding the hardening time and increase in strength after that provides guidance on when a cemented section is capable of resisting formation pressure when the hydrostatic head in the wellbore drops below formation pressure.

The expected job time required for cement placement was 4.5 hours. The thickening time for the cap cement and tail cement was determined to be 7.5 hours. A thickening time test was not performed for the nitrified foam cement. Compressive strength was measured for both and determined to be acceptable.

Primary cementing operations began on April 19 at 1851 hours by circulating 111 barrels of mud to prepare the wellbore.[30] [31] Full returns were obtained at the surface while pumping the 14.0 ppg drilling mud at 4 barrels per minute (bpm), or about 168 gpm. Cement mixing was started at 2028 hours on April 19.

The selected design consisted of pumping three intervals of cement:

- A "cap" cement that was pumped first for placement above the producing formation.
- A nitrified foam cement that was pumped second for placement across the formation.
- A "tail" cement that was pumped last for placement in the casing shoe and up to the float collar. (The distance from the casing shoe to the float collar was 189 feet.)

Cement was placed as follows:[32]

- A fluid spacer was pumped into the well as a "buffer" between the mud in the well and the cement. Allowing drilling mud and cement to mix contaminates the cement.
- A bottom wiper plug is launched to clean mud from the pipe wall ahead of the cement.

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[30] IADC Transocean DWH Report, (April 19, 2010)

[31] BP Daily Operation Report MC 252 #1 well, (April 19, 2010) (BP-HZN-MBI00018589 thru 18595)

[32] BP Daily Operation Report MC 252 #1 well, (April 19, 2010) (BP-HZN-MBI00018589-18595)

- 5 barrels (bbls) of cap cement (mixed at 16.7 ppg) was pumped into the well, followed immediately by
- 48 bbls of nitrogen-foam cement (mixed at 14.5 ppg), followed immediately by
- 7 bbls of tail cement (mixed at 16.7 ppg), followed immediately by
- A top wiper plug that prevents cement from mixing with the mud that is pumped in after the cement, which forces the cement slurry into place.

The bottom wiper plug travels as far as the float collar, where it "bumps" into place and temporarily stops the cement flow. Flow is resumed by rupturing the wiper, accomplished by temporarily increasing pressure to 1,000 psi at the pump on the MODU. However, 2,932 psi was required to rupture the plug (as measured on the cementing contractor's gauge). The cause of this anomaly is not known. The top wiper plug bumped on schedule at 1,150 psi pump pressure.[33] Cement placement was completed at 0035 hours on April 20.

No problems were observed during cement mixing and placement; full mud returns were obtained throughout the entire job.[34] [35] At the end of the cement displacement, a slight amount of lift pressure (80 to 100 psi) was observed.[36] [37] (Refer to Appendix C: *Cement Displacement – Primary Job.*) Lift pressure is a phenomenon related to the U-tube hydraulics mentioned above. Fluid density differences from one side of the tube to the other can cause a brief period of pressure fluctuation, as measured at the top of one side of the U. The lift pressure observed was within range expected by rig personnel.

Pressure was held on the casing for a few minutes, and then allowed to bleed back.[38] A small amount of flow-back volume was observed, followed by a slight "*pencil stream*" of fluid flow for approximately 20 minutes. The flow then ceased.[39]

The casing hanger metal-to-metal seal assembly, one of the required isolation features in the wellhead assembly, was energized and twice successfully tested to 6,500 psi.[40]

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[33] Halliburton – Production Casing Post Job Report, (April 20, 2010) by Nathaniel Chaisson (BP-HZN-MBI00170986-170999),

[34] MI Swaco Mud Report – April 19, 2010 (MIe 100001 001 0000090)

[35] Allamon Tool Company – Job Summary (BP-HZN-MBI00020808)

[36] 7/22/10 MBI Tr. 319 (Guide)

[37] Halliburton – Production Casing Post Job Report, (April 20, 2010) by Nathaniel Chaisson (BP-HZN-MBI00170986 thru 170999)

[38] Halliburton – Production Casing Post Job Report, (April 20, 2010) by Nathaniel Chaisson (BP-HZN-MBI00170986 thru 170999)

[39] 8/25/10 MBI Tr. at 21-22 (Tabler)

[40] 5/29/10 MBI Tr. at 66 (Credeur)

On April 20 at approximately 0330 hours, *Deepwater Horizon*'s crew started pulling the 6 ⅝" landing string from the wellbore to prepare for the next planned task – temporary abandonment of the well.[41]

Temporary Abandonment of the Well

Well abandonment is conducted to secure the wellbore until a production facility is installed. Abandonment typically involves verifying that the casing installation has isolated the formation, removing some or all of the drilling mud from inside the wellbore and placing a cement plug in the casing as a redundant barrier to prevent uncontrolled flow from the well. (This plug is later drilled out prior to installing production devices.)

As part of the preparation for abandonment, an Application for Permit to Modify (APM) was submitted on April 16 to the US Minerals Management Service (MMS),[42] [43] the predecessor to the Bureau of Ocean Energy, Management, Regulation, and Enforcement (BOEMRE).[44] Approved on the same day it was presented, the APM included the steps of:

- Conducting a negative pressure test without a drill string in the well and using the "kill line" conduit that extends from the BOP stack up to the MODU, followed by
- Lowering the drill string into the upper section of the casing string to replace drilling mud with seawater in the riser and a portion of the wellbore.

A negative differential pressure test is a means for determining whether the well is secured. During this test the hydrostatic head acting on the bottom of the casing string is temporarily reduced to some value below the formation pressure. If the measurement of pressure inside the well doesn't increase, this result is interpreted as a secure well.

Displacement operations[45] are conducted to recover drilling mud, which can be used on a subsequent well. Some portion of the mud may be left, and the remainder of the wellbore is filled with seawater or a weighted fluid to maintain hydrostatic pressure at the bottom of the well that exceeds formation pressure. The requirement for maintaining hydrostatic pressure above formation pressure is specified in the US Code of Federal Regulations, Title 30, Section 250.1715(9).

By 0630 hours on April 20 the landing string was removed from the wellbore. Written instructions were issued on the morning of April 20 that differed from the procedure defined by the approved

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[41] IADC Transocean DWH Report, (April 20, 2010) (TRN-USCG_MMS 00011644 thru 11646),

[42] Application for Permit to Modify <Form MMS-124> Abandonment of Wellbore, (April 16, 2010) (BP-HZN-MBI00021238)

[43] 12/8/10 MBI Tr. 85 (Sprague)

[44] Application for Permit to Modify Form MMS-124 Abandonment of Wellbore, (April 16, 2010) (BP-HZN-MBI00021238-21241)

[45] MI Swaco Displacement Procedure "Macondo" OCS-G 32306 (BP-HZN-MBI00170827)

APM. Instead of conducting the test and displacement procedures separately, one after the other, the steps of those procedures were merged. In the changed instructions, a tapered string was located in the wellbore during the negative differential pressure test.

It is unclear whether all of the impacts of these changes were understood. For instance, placing the tapered string through the BOP will change options available for maintaining well control in the event of a failed test.

Starting at 0800 hours, a tapered drill string consisting of 3 ½" tubing, 5 ½" drill pipe, and 6 ⅝" drill pipe was lowered into the well.[46] [47] Before the string reached the BOP, the operation was stopped to conduct a pressure test on the casing string. This was accomplished by closing the Blind Shear Ram (BSR) BOP and applying 2,500 psi pressure through the kill line, which connects the MODU to a point below the BOP in communication with the casing.[48]

By 1230 hours the test was successfully concluded, the BSR was opened and the operation to lower the tapered string resumed. By 1330 hours the bottom of the tapered string was positioned at 8,367 feet;[49] a distance of 3,300 feet below the subsea wellhead and BOP.

At 1328 hours *Deepwater Horizon* started transferring 14.0 ppg synthetic oil base drilling fluid (~3,100 barrels) to the supply vessel, M/V *Damon Bankston*.[50] [51] [52]

The tapered drill string was held in place by the hook used to raise and lower these assemblies, Drill pipe slips, removable wedges used to temporarily support drill string weight, were not set once the string was in position.[53] In this state, the load on the hook is constantly monitored and the weight measured is displayed on the rig floor. Changes in weight measurements can indicate changes in wellbore conditions.

With the tapered string positioned at the specified depth, equipment on the MODU was configured to conduct the negative differential pressure test and displacement operations. Surface connections were made and tested to 3,000 psi.[54] At 1504 hours the crew started displacement.[55]

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[46] Tally Book – Vince Tabler, (April 20, 2010) (HAL-CG000488)

[47] IADC Transocean DWH Report, (April 20, 2010) (TRN-USCG_MMS 00011644 thru 11646)

[48] IADC Transocean DWH Report, (April 20, 2010) TRN-USCG_MMS 00011644 thru 11646)

[49] Ibid

[50] 5/11/10 MBI Tr. 178 (Gervasio)

[51] 7/19/10 MBI Tr. 274 (Linder)

[52] 5/11/10 MBI Tr. 96 (Landry)

[53] Halliburton (Sperry Sun) Surface Data Time Log, (April 20, 2010) (HAL_0048974)

[54] IADC Transocean DWH Report, (April 20, 2010) (TRN-USCG_MMS 00011644 thru 11646)

[55] Halliburton (Sperry Sun) Surface Data Time Log, (April 20, 2010) (HAL_0048974)

The tasks completed and observations reported from 1504 hours to 2149 hours, the time of the onboard explosion, are provided in the timeline below, which are grouped in the following phases of work:

- Partial Displacement of Mud with a Water-based Spacer and Seawater.
- Conducting the Negative Differential Pressure Test.
- Resuming Displacement of Drilling Mud from the Riser.
- Well Monitoring and Loss of Control.

Partial Displacement of Mud with a Water-based Spacer and Seawater

1504 – 1514 hours Mud in the booster line was displaced with seawater and the booster line valve was closed at the marine riser.[56] (The booster line is a pipe extending from the MODU to the wellhead, running along the outside of the riser. Its main function is to increase mud flow velocity in the riser if needed to suspend drill cuttings.) Removing the mud and closing the valve isolated the booster line and its hydraulic effects from the wellbore.

1522 – 1537 hours Mud in the choke line was displaced with seawater and the choke valve on the BOP stack was closed.[57] (The choke line is a pipe running along the outside of the riser from the BOP to the MODU. It provides access to the wellbore whenever the BOP has closed.) Removing the mud and closing the valve isolated the choke line and its hydraulic effects from the wellbore.

1540 – 1555 hours Mud in the kill line was displaced with seawater and the kill line valve on the BOP stack was closed.[58] (The kill line is a pipe running along the outside of the riser from the BOP to the MODU. It also provides access to the wellbore whenever the BOP has closed.) Removing the mud and closing the valve isolated the kill line and its hydraulic effects from the wellbore.

1557 – 1653 hours The initial displacement of mud from the wellbore was started during this time period. The April 20 instructions called for starting the process by pumping a water-based-spacer, followed by seawater.[59] As these fluids were pumped down the drill string to 8,367 feet, drilling mud above that point was forced up to the MODU where it was collected in a series of tanks. (The operations for

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[56] MI Swaco Displacement Procedure "Macondo" OCS-G 32306 (BP-HZN-MBI00170827)

[57] Ibid

[58] Ibid

[59] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

transferring mud from adjacent tanks on the MODU to M/V *Damon Bankston*, which had started at 1328 hours, continued during this time period.)

The purpose of the 16.0 ppg water-based spacer was to prevent mixing the synthetic oil-based mud with seawater, which would contaminate the mud. Fluid stability of the water-based spacer, which was mixed from drilling fluids available on the MODU,[60] had been assessed by conducting a pilot test on the MODU the evening before.[61] Onshore experts were also consulted regarding the spacer formulation and use.[62] [63]

On the basis of these assessments, the decision to proceed was made and 454 bbls of this spacer was pumped into the drill string. Since the drill string volume was approximately 200 bbl; about 250 bbl of mud was displaced from the end of the drill string at 8,367 feet up toward the MODU. With the spacer in place, pumping resumed with 351 bbl of seawater.

Displacement operations were stopped at 1653 hours[64] to start the negative differential pressure test,[65] [66] leaving the riser partially displaced with a segment of mud and a segment of water-based spacer. At this point, the hydrostatic pressure inside the well was greater than the reservoir pressures in the formation,[67] a condition that would prevent flow from the formation into the wellbore in the event the well was not secure. (As noted above, hydrostatic pressure exerted by fluids in the wellbore is the first line of defense in well control.)

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[60] 7/19/10 MBI Tr. at 276 (Linder)

[61] 7/19/10 MBI Tr.360 (Linder)

[62] Email from Doyle Maxie to John LeBleu (et al), re: Disposal, (April 17, 2010) (BP-HZN-MBI00129044)

[63] 7/22/10 MBI Tr. 323 (Guide)

[64] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[65] Email from John Guide to Brian Morel, re: Negative Test, (April 18, 2010) (BP-HZN-MBI00256247)

[66] Email from Brian Morel to Don Vidrine, Robert Kaluza, (et al), re: Ops Note, (April 20, 2010) (BP-HZN-MBI00129108)

[67] 12/8/10 MBI Tr.133 (Robinson)

Conducting the Negative Differential Pressure Test

1653 – 1658 hours With partial displacement conducted, the procedure moved to starting the negative differential pressure test[68] by closing the lower annular BOP around the drill string.[69] [70] This step isolates the marine riser and its hydrostatic head from the wellbore. (Refer to *Appendix D: Negative Differential Pressure Test – Pressure.*)

At this time pressure was relieved in the kill line and drill string. The kill line, isolated by closed valves at the BOP and at the surface, contained "trapped pressure" of 645 psi. Opening a valve at the surface relieved kill line pressure to 0 psi. Opening a valve near the top of the drill string relieved pressure inside the drill string from 2,325 psi to 250 psi.[71]

The combination of isolating the marine riser and reducing pressure in the drill string resulted in decreasing the hydrostatic head at the bottom of the wellbore to a lower value than the measured formation pressure.[72]

In this configuration, if the well was not secure then pressure or flow from the formation could be detected either at the top of the drill string or at lines that connect to the BOP stack below the annular BOP: either the choke or kill line.

When the kill line valve at the BOP is open, that line is communicating with the same volume of wellbore fluids as the drill string. Understanding the remaining timeline events is complicated by incomplete and conflicting records of when kill line and drill string valves were opened or closed. Post-incident analysis also indicates the possibility of an undetected blockage in the kill line at the BOP. Well control efforts after the explosion included pumping through the kill line, so the actual condition of the kill line or valve on April 20 cannot be determined.

[68] 12/19/10 MBI Tr. 273-274 (Linder)

[69] 8/25/10 MBI Tr. 233 (Hay)

[70] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[71] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[72] 12/8/10 MBI Tr. 133 (Robinson)

1658 – 1705 hours Pressure at the top of the drill string, or Shut-In Drill Pipe Pressure (SIDPP), remained at 250 psi. There are multiple valves that can communicate with the top of the drill string. These valves control whether pressure and flow are vented to other equipment, or whether pressure gauges are connected to or isolated from the wellbore. However the record is not clear which valves remained opened or closed at this point.

1705 – 1708 hours One or more valves at the top of the drill string were operated and pressure measured in the drill string increased to 1,250 psi. Although this can be interpreted as an indication that the high pressure formation is not isolated, the negative differential pressure test continued.

1708 – 1726 hours Pressure in the drill string remained at 1,250 psi but the kill line pressure continued to read 0 psi. The status of kill line valves is not clear.

Measuring pressure in the drill string and in the kill line is equivalent to measuring pressure on each side of a U-tube. Since they "connect" at the bottom of the U, in this case the end of the drill string at 8,367 feet, within a short period of time the drill string and kill line are expected to be at the same pressure.

A drop in the mud level within the riser was observed.[73] Believing that mud had leaked past the annular BOP, the closing pressure on the annular preventer was increased[74] then 50 barrels of drilling mud were pumped into the riser to re-establish the desired fluid level.[75]

By 1717 hours the mud offloading operation that started at 1328 hours had concluded. No additional mud was transferred from *Deepwater Horizon*.[76]

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[73] 5/28/10 MBI Tr. 279 (Ezell)

[74] 5/28/10 MBI Tr. 131-132 (Pleasant)

[75] 5/28/10 MBI Tr. 279 (Ezell)

[76] 5/11/10 MBI Tr. 97 (Landry)

1726 – 1727 hours	A valve was opened and pressure inside the drill string was relieved to 0 psi. Approximately 15 barrels of seawater flowed into the cementing unit. Although this can be interpreted as an indication that the high pressure formation is not isolated, the negative differential pressure test was continued. The pressure gauge on the kill line continued to read 0 psi. The status of the kill line valve is not clear from the record.
1727 – 1752 hours	For most of this time interval, pressure inside the drill string continued to read 0 psi. A brief spike to 270 psi occurred at 1733 hours. Kill line pressure continued to read 0 psi. To evaluate these anomalies, operations were halted at approximately 1730 hours for discussions among rig personnel.[77] [78] [79] The onshore supervisory personnel were not contacted during these discussions.
1752 – 1754 hours	Drill string pressure increased to 780 psi.
1754 – 1800 hours	A valve at the surface was opened; pressure inside the drill string decreased to 60 psi. Kill line pressure continued to read 0 psi.
1800 – 1832 hours	A valve at the surface was closed; pressure inside the drill string increased first to 1,265 psi and then to 1,400 psi.[80] During this period, the weight of the drill string, measured at the hook suspending the string, decreased. Although this can be interpreted as an indication that the high pressure formation is not isolated, the negative differential pressure test was continued.
1832 – 1840 hours	Pressure inside the drill string remained at 1,400 psi; drill string weight decreased slightly.

[77] 5/28/10 MBI Tr. 280 (Ezell)

[78] 5/28/10 MBI Tr. 133-134 (Pleasant)

[79] 5/28/10 MBI Tr. 116 (Pleasant)

[80] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

1840 – 1842 hours	One outcome of this discussion that had been ongoing since 1730 hours was the decision to complete the negative differential pressure test by monitoring the kill line rather than the drill string.[81] Monitoring the kill line was, in fact, specified in the approved APM. Fluid was pumped into the kill line; however an immediate increase in pressure was interpreted as a full line. Pumping was stopped and the line was vented; ¼ bbl of seawater flowed back to the "mini trip tank," a small storage tank.[82]
1842 – 2001 hours	The kill line was routed to the mini trip tank in the mud system and the tank was vented to the atmosphere. During a 30 minute period no flow was observed into the tank.[83] By 1956 hours, the negative differential pressure test was deemed successful,[84] [85] [86] [87] indicating that the well was secure. On this basis, the decision was made to resume displacing mud from the well.

[81] 5/28/10 MBI Tr. 308 (Ezell)

[82] Interview Notes ,Don Vidrine, (April 27, 2010) (BP HZN BLY 00061824)

[83] 7/22/10 MBI Tr. 255 (Guide)

[84] 5/28/10 MBI Tr. 282 (Ezell)

[85] 5/28/10 MBI Tr. 135 (Pleasant)

[86] 12/8/10 MBI Tr. 10 (Robinson)

[87] 7/22/10 MBI Tr. 161 (Guide)

[88] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[89] 12/8/10 MBI Tr. 101 (Robinson)

[90] 12/8/10 MBI Tr. 49 (Robinson)

[91] 12/8/10 MBI Tr. 91-92 (Robinson)

[92]12/8/10 MBI Tr. 88 (Robinson)

However, pressure within the drill string remained at 1,400 psi.[88] (Refer to Appendix E: *Riser Displacement*.) During this time interval drill string weight measurements were erratic, decreasing by as much as 15,000 lbs.[89] [90] (Refer to *Appendix F: Negative Differential Pressure Test – Hookload*.) Although this can be interpreted as an indication that the high pressure formation is not isolated, the negative differential pressure test was continued.

This discrepancy between the pressure measurements for the drill string and kill line, both connected to the same hydraulic conditions, was not reconciled by rig personnel.[91] Some rig personnel described it as a function of the "bladder effect" or "annular compression."[92]

There were no communications with onshore supervisory personnel regarding the measurement discrepancy[93] [94] or the explanations offered on the rig and subsequent decision to proceed.

2001 – 2002 hours To prepare for resuming mud displacement, a valve was opened and pressure within the drill string was reduced to 0 psi.[95] The kill line valve at the BOP stack was closed and the lower annular preventer was opened.[96]

Opening the annular BOP reestablished fluid communication between the marine riser and the wellbore. With the additional weight of the fluid in the riser now part of the fluid column in the wellbore, the hydrostatic head at the formation was greater than the highest recorded formation pressure.[97]

Resuming Displacement of Drilling Mud from the Riser

2003 – 2052 hours Seawater pumping resumed to displace the synthetic oil based drilling mud from the riser.[98] [99] (Refer to Appendix E: *Riser Displacement*.) This operation was conducted to recover the drilling mud, which was routed to several

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[93] 7/22/10 MBI Tr. 117 (Guide)

[94] 12/8/10 MBI Tr. 17-18 (Robinson)

[95] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[96] 5/28/10 MBI Tr. 118-119 (Pleasant)

[97] 12/8/10 MBI Tr. 133 (Robinson)

[98] MI Swaco Displacement Procedure "Macondo" OCS-G 32306 (BP-HZN-MBI00170827)

[99] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

storage tanks on the MODU.[100] [101] However, the water-based spacer was to be discharged overboard, subject to successfully completing a static sheen test, required for environmental compliance.[102]

2052 – 2108 hours

At 2052 hours the fluid pumping rates were reduced from 30 bpm to 12 bpm (1,260 gpm to 504 gpm),[103] anticipating the completion of mud displacement and arrival of the water-based spacer at the MODU.

During this interval, mud displacement was gradually reducing the hydrostatic head at the formation to a value less than the measured formation pressure.[104] [105] [106] Exacerbating pressure control conditions, the reduced pump rate decreased the fluid velocity and friction in the wellbore. Reducing fluid friction has the effect of reducing hydrostatic head.

At the same time, the flow rate out slightly increased compared to flow in[107] and surface pump pressure increased rather than decreased.[108] [109] (Refer to *Appendix E: Riser Displacement*.) Although these events can each be interpreted as an indication that the high pressure formation is not isolated, the displacement operation was continued.

Post-incident analysis indicates that by this time oil and gas had entered the wellbore.[110] As the gas migrated upward it expanded.

At 2108 hours the mud pumps were stopped in order to conduct the static sheen test.[111]

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[100] 10/8/10 MBI Tr. 130-131 (Gisclair)

[101] 12/7/10 MBI Tr. 37 (Gisclair)

[102] 5/28/10 MBI Tr. 208 (Meche)

[103] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[104] MI Swaco Displacement Procedure "Macondo" OCS-G 32306 (BP-HZN-MBI00170827)

[105] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[106] 10/7/10 (PM) MBI Tr. 99-100 (Walz)

[107] 10/8/10 MBI Tr. 134 (Gisclair)

[108] 12/8/10 MBI Tr. 12 (Robinson)

[109] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[110] 12/8/10 MBI Tr. 49 (Robinson)

[111] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

2108 – 2114 hours The static sheen test was conducted and the spacer passed the test criteria.[112] Valves were opened to pump the water-based spacer overboard,[113] [114] bypassing the mud system flowmeter[115] and leaving the rig flowmeter as the sole means for measuring flow from the well.[116] [117] It is not clear from the record whether this flowmeter was monitored or, if so, whether the data was communicated for comparison to measured flow into the well.

During this period, records indicate that pressure within the drill string increased from 1,000 psi to 1,250 psi and fluid flowed from the well, even though the mud pumps were shut down. [118] [119] Although these events can each be interpreted as an indication that the high pressure formation is not isolated, the displacement operation was continued.

2114 – 2131 hours The pumps were re-started and displacement operations resumed. A relief valve on mud pump #2 ruptured and a rig crew was dispatched to repair it.[120] During this time period, pressure measurements at the pump remained erratic.

In addition, the drill string weight (hook load) fluctuated,[121] reflecting changes in fluid density or velocity in the wellbore, or a combination of both. Typically, gradual weight changes are observed during displacement operations, proportional to the change in fluid density caused by pumping the seawater. However, the records indicate that weight measurements fluctuated. Although this can be interpreted as an indication that gas and oil are flowing in the wellbore, the displacement operation continued.

At approximately 2130 hours, rig floor personnel were observed discussing discrepancies in pressure measurements.

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[112] 5/28/10 MBI Tr. 238 (Meche)

[113] 5/28/10 MBI Tr. 216 (Meche)

[114] 5/28/10 MBI Tr. 219 (Meche)

[115] 12/7/10 MBI Tr. 135-136 (Keith)

[116] 12/8/10 MBI Tr. 66 (Robinson)

[117] 12/7/10 MBI Tr. 121 (Keith)

[118] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[119] 10/8/10 MBI Tr. 135 (Gisclair)

[120] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[121] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

Well Monitoring and Loss of Control

2131 hours Coinciding with the estimated pump time required to discharge the water-based spacer overboard,[122] [123] the mud pumps were stopped.[124] (Refer to *Appendix E: Riser Displacement.*) The objective of the displacement operation, replacing mud with seawater from the MODU to a depth of 8,367 feet (e.g., the end of the drill string), appeared to be met.

Pressure inside the drill string was measured at 1,210 psi.

~2133 hours Pressure inside the drill string increased to 1,765 psi. Although this can be interpreted as an indication that gas and oil are flowing in the wellbore, well control operations were not started.

The record of actions from this point forward is incomplete, but indicates that valves at the surface communicating with the drill string were operated. These operations would have increased or decreased pressure in the drill string. There were likely additional factors impacting drill string pressure, related to flow of well fluids and gas up the wellbore and riser.

~2137 hours Pressure inside the drill string decreased to 720 psi.

~2138 hours Pressure inside the drill string increased to 1,360 psi.

~2142 hours Pressure inside the drill string decreased to 340 psi.

~2145 hours Pressure inside the drill string increased to ~800 psi. Uncontrolled flow from the well erupted through the rig floor of the MODU, reaching the top of the derrick[125] [126] and raining down on the nearby M/V *Damon Bankston.*[127]

The lower annular BOP; an essential device for regaining well control, started to close around the drill string.[128] Post-incident analysis indicates that before this operation started a mixture of well fluids and gas had already entered the

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[122] MI Swaco Displacement Procedure "Macondo" OCS-G 32306 (BP-HZN-MBI00170827)

[123] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[124] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[125] 5/29/10 MBI Tr. 9 (Sandell)

[126] 5/11/10 MBI Tr. 136 (Landry)

[127] 5/11/10 MBI Tr. 208 (Gervasio)

[128] 5/28/10 MBI Tr. 145 (Pleasant)

riser.[129] Even though the annular BOP was able to substantially reduce or stop further well fluids and gas from entering the riser, liquids above the BOP were accelerated toward the MODU by the rapidly expanding gas.[130]

As wellbore fluids arrived at the top of the riser, another well control component, the diverter, was activated.[131] While the BOP stack was rated to operate at 15,000 psi, the diverter was rated to 500 psi. A pre-programmed sequence controlling the diverter system[132] routed the well fluids to a gas-liquid separator.[133] [134]

The gas-liquid separator was not designed to manage uncontrolled flow or pressure from the well and did not have the capacity to adequately separate gas under these conditions. Post-incident analysis indicates that gas-liquid mixtures exited the separator both at the liquid outlet to the mud recycling system and at the gas vent located above the rig floor.[135]

2147 hours Pressure inside the drill string increased to 1,200 psi. Fluid flow was observed at the flowmeter located downstream of the overboard discharge point, even though the discharge valve was in an open position.

2149 hours Pressure inside the drill string rapidly increased to 5,780 psi.[136] This indicates that one or more pipe rams in the BOP stack may also have been operated by the rig crew. The hook load measured the drill string weight at 352,000 lbs.

2149:16 hours An explosion and subsequent fire occurred.[137] [138] [139] [140]

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[129] 12/8/10 MBI Tr. 13 (Robinson)

[130] IADC Deepwater Well Control Guidelines <First Edition, October 1998> Danger of Free Gas in Riser, Section 3.5.2, page 3-19

[131] 5/28/10 MBI Tr. 165-166 (Pleasant)

[132] 12/8/10 MBI Tr. 49 (Robinson)

[133] 12/8/10 MBI Tr. 237 (Robinson)

[134] Cameron Controls – Flow Diagram Diverter Unit Interlocks Information 2A and 2B (BP-HZN-MBI00010159)

[135] 5/29/10 MBI Tr. 10 (Sandell)

[136] Halliburton (Sperry Sun) Surface Data Time Log dated April 20, 2010 (HAL_0048974)

[137] 5/27/10 MBI Tr. 65 (Harrell)

[138] 5/27/10 MBI Tr. 65-66 (Harrell)

[139] 12/7/10 MBI Tr. 106 (Keith)

[140] 5/29/10 MBI Tr. 154-155 (Morales)

Post-explosion events

Nine Transocean employees and two contractor employees perished. The rig was fully evacuated and remained afloat until April 22.[141]

An attempt was made to activate the Emergency Disconnect System (EDS) from the bridge, but no response was observed at the control panel.[142] [143] The EDS command function did not activate the sequence required to close the blind shear rams in the BOP stack[144] and then disconnect the Lower Marine Riser Package (LMRP).[145]

Deepwater Horizon was unable to maintain its position and drifted off the well while the riser was still attached and the drill string was still in the well.[146] The vertical angle of the riser's lower flex joint increased beyond the recommended operating limits.[147]

Subsea operations were conducted using remotely-operated vehicles (ROVs) to inspect conditions at the BOP stack and operate the blind shear rams (BSRs).[148] With the drill string still in the well, BSRs are intended to cut through the pipe and seal the well. One ROV intervention did succeed in activating and closing the BSR, however the well continued to flow.[149]

(The BOP stack was subsequently retrieved and analyzed. On March 20, 2011, a forensic report was issued by Det Norske Veritas which indicated that although the BSR functioned, the drill pipe was not completely severed.[150] Forensic work continues to investigate other aspects of the functionality of the blowout preventers and related well control equipment.)

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[141] 8/23/10 MBI Tr. 466 (Winslow)

[142] 5/28/10 MBI Tr. 123 (Pleasant)

[143] 7/19/10 MBI Tr. 119-120 (Bertone)

[144] 5/27/10 MBI Tr. 71(Harrell)

[145] 5/28/10 MBI Tr. 165 (Pleasant)

[146] 5/27/10 MBI Tr. 42 (Harrell)

[147] Transocean Deepwater Horizon Riser Management Plan MC252 #1 Macondo, (January 12, 1010) (RMI 00566 - 579)

[148] 8/25/10 MBI Tr. 234-240 (Stringfellow)

[149] 4/4/11 MBI Tr. 142-143 (Thompson)

[150] DnV Final Report Forensic Examination of Deepwater Horizon Blowout Preventer Volume 1 and 2 March 20, 2011

April 22, 2010 1026 hours	*Deepwater Horizon* sank.[151]

IV. Contributing Factors to Loss of Well Control

Understanding the factors that caused or contributed to the loss of well control has been aided by activities such as:

- Joint Investigation Board hearings including witness accounts and testimony from engineers, scientists and operations personnel that evaluated available data and ongoing testimony to determine plausible explanations for these events.
- Engineering assessments conducted on behalf of RMI.
- Post-incident efforts to control the well.

This discussion of contributing factors is limited to the well control issues during operations from 0800 hours on April 20 to the explosion at 21:49 hours that evening. This discussion does not address the efficacy of the well design or primary cement job and their apparent inability to secure the well.

Well control measures are developed and applied on the recognition that these elements may fail to secure the well at any time. For that reason, well control measures must be independent of, and not compromised by, any of the devices or procedures used to complete or test the well.

The objectives of activities conducted in the time period 0800 hours to 21:49 hours included:

- Verifying that the primary cement job had secured the well.
- Preparing the well for an additional cementing operation that would place a plug in the casing string, as a further measure for securing the well.

The factors contributing to the loss of well control were:

- Insufficient well control barriers during operations, related to flawed test and displacement protocols.
- Incorrect interpretation or insufficient monitoring of test and displacement operations data.

Each is discussed below.

[151] 8/24/10 MBI Tr. 62 (Winslow)

Insufficient barriers during operations related to flawed test and displacement protocols

Accepted drilling practice is to conduct operations with a minimum of two barriers in place at all times.[152] For instance, drilling, casing placement and the primary cement job were all conducted with hydrostatic pressure at the bottom of the wellbore exceeding formation pressure and with the BOP stack in place.

To be considered a barrier, the equipment or condition must be verifiable: drilling mud volume and weight can be measured and BOP systems can be operated for testing.

Cement and casing string components such as float collars cannot be considered barriers for the purposes of well control. Although these elements are placed to secure the well, the purpose of the negative differential pressure test is to assess the performance of these elements as a system and from that performance infer system integrity.

The negative differential pressure test does not test the condition of any single component in the system. In fact, the configuration of the bottom-hole cement and casing components largely prevents component-level testing.

For well control purposes, when a component can't be tested it cannot be considered a barrier. On that basis the casing shoe, float collar and cement are not barriers.[153]

As described more fully below, the written instructions for conducting the negative differential pressure test included reducing hydrostatic pressure in the bottom of the wellbore to a value below the highest measured formation pressure. After the test, appropriate hydrostatic pressure was briefly restored.

The instructions for the displacement operation conducted after the test included reducing hydrostatic pressure in the bottom of the wellbore to a value below the highest measured formation pressure.

Neither instruction included applying a replacement barrier.

A fundamental contributing factor to the loss of well control was the removal of one of the two barriers from the well – hydrostatic pressure applied by drilling mud - in order to conduct the negative differential pressure test without applying a replacement barrier.[154]

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[152] SPE Technical Paper – SPE 124024 <2009> KickRisk – A Well Specific Approach to the Quantification of Well Control Risks, authored by Ø. Arlid, E.P. Ford, T. Løberg, J.W.T. Baringbing, page 1

[153] 12/8/10 MBI Tr. 39 (Robinson)

[154] 12/8/10 MBI Tr. 76 (Robinson)

Discussion of the combined testing and displacement operations

As noted above, the approved permit to modify (APM) specified that two sequential tasks were to be conducted – a negative differential pressure test without drill pipe in the well followed by drilling mud displacement operations. Further, applicable regulations required that fluids remaining within the well after displacement operations create hydrostatic pressure at the bottom of the wellbore that exceeds the highest measured formation pressure. The revised instructions issued on April 20[155] did not comply with either the APM or applicable regulations.

A negative differential pressure test, by definition, temporarily lowers the hydrostatic pressure applied by fluids in the wellbore to a value below the measured formation pressure. In effect, the test is a planned opportunity for uncontrolled flow from the formation. If flow or pressure increase is not detected, the test is interpreted to mean that the well is secure.

Two methods are available to reduce hydrostatic pressure in preparation for a negative differential pressure test:

- Replace fluid in the kill line with a lower weight fluid (e.g., oil base or seawater) allowing it to remain in communication with the wellbore, then completely close a blind ram BOP so that the (heavier) drilling mud in the riser is isolated. All of the drilling mud in the wellbore and riser is the same weight. If flow or pressure increase is detected, opening the BOP quickly applies the additional hydrostatic pressure of the heavier fluid.
- Insert a drill string to a pre-selected depth and circulate a lighter weight fluid into the drill string, This displaces drilling mud above the end of the drill string, which is forced up to the MODU and is stored in tanks. Devices such as retrievable packers with a bypass valve can be installed on the drill string to isolate hole sections and assist with operational control in the event of flow entering the well from the formation. Although this puts two different weights of fluid in the wellbore, the placement of a controllable packer in the bore provides precise control of the operation.

Test operations conducted during April 20[156] [157] did not conform to either of these approaches, with respect to the following conditions:

- Sequencing the test within the displacement operation, rather than prior to it.
- Unorthodox testing protocol, with respect to dissimilar weights of fluid.

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[155] Email from Brian Morel to Don Vidrine, Robert Kaluza, (et al), re: Ops Note, (April 20, 2010) (BP-HZN-MBI00129108)

[156] Email from Brian Morel to John Guide, re: Negative Test, (April 18, 2010) (BP-HZN-MBI00256247)

[157] MC 252 #1 – Macondo Prospect Production Casing Operations, Revision H.2, (April 15, 2010) page 8 of 21 (BP-HZN-CEC 017628)

Sequencing the test within the displacement operation, rather than prior to it.

Displacement operations started first, with the booster, choke and kill lines being displaced to seawater, followed by partial displacement of the wellbore and riser, using water-based spacer and seawater. In order to conduct the partial wellbore and riser displacement, drill string was placed through the BOP assembly.

Displacing drilling mud from the wellbore and placing drill string in the BOP stack each limited the well control options available once uncontrolled flow started. By themselves, those limits may not have been significant if other contributing factors had not occurred. However, since those other factors were present, these limits were significant.

Unorthodox testing protocol, with respect to dissimilar weights of fluid.

The ability to control hydrostatic pressure in the wellbore can be compromised by placing more than two fluid weights in the well and operating without the ability to segregate the fluids.

At the conclusion of the partial displacement of the marine riser, the fluid column (mud, spacer, seawater) on the outside of the drill string provided an over-balanced condition at the bottom of the well. The closure of the lower annular preventer isolated this hydrostatic fluid pressure; therefore the ensuing conditions subjected the entire well to an underbalanced state.

On this well, with open ended drill string located 3,300 feet below the sub-sea wellhead, there were not any feasible means to ensure the wellbore fluids remained segregated, before, during, and after the test. Utilization of a retrievable packer, as part of the overall test methodology, would maintain the fluid segregation, and would additionally provide precise control of the well, whenever the well is placed into an underbalanced condition.

Once flow from the formation is detected, hydrostatic pressure must quickly be increased to a value above formation pressure. Multiple lighter weight fluids in the hole must be circulated out by pumping heavier weight mud through the drill pipe or kill line. If these lines are partially or completely filled with lighter weight fluid, pumping operations may actually decrease hydrostatic pressure for a period of time. This can substantially compromise well control efforts. This situation is exacerbated without a packer installed on the drill string.

Post-test displacement operations

Since a negative differential pressure test may generate a false "pass" result, the work conducted after the test must take into account this possibility. An accepted industry practice, as well as a regulatory requirement, is to establish hydrostatic pressure within the wellbore that exceeds formation pressure.

As noted in the timeline above at 2002 hours on April 20, the BOP that isolated the fluids in the riser from the wellbore was opened, re-establishing hydrostatic pressure at the bottom of the wellbore exceeding the highest measured formation pressure.

However, the displacement operation resumed, replacing (heavier) drilling mud in the riser with (lighter) seawater. Post-incident analysis indicates that during the time interval 2052 hours to 2108 hours, those displacement operations placed the well back into an under-balanced state. At the conclusion of the displacement operation, the calculated hydrostatic head of the fluids in the wellbore was less than the measured formation pressures. In this condition, if other means of isolating the formation (e.g., the cement job) were to fail, formation fluids would flow into the wellbore. It appears this condition may not be in compliance with US Code of Federal Regulations, Title 30, Section 250.1715(9).

Incorrect interpretation or insufficient monitoring of test and displacement operations data

The concepts regarding interpretation of data from a negative differential pressure test are identical to principles taught at industry well control schools.[158] During a well control incident, pressure measured in the drill pipe, or Shut-In Drill Pipe Pressure (SIDPP), is a direct indicator of the magnitude of the kick. Further, comparing the volume pumped into the well (e.g. mud or cement) with the volume returning from the well is a direct indicator of the presence of a kick.

Well control training emphasizes that reaction time is critical for shutting in a well. Not detecting a kick indication, or misinterpreting one that is detected, can substantially increase the volume of formation fluids or gases entering the wellbore. As this influx volume increases, the difficulty of well control and kill operations increases exponentially.

The discussion below summarizes monitoring and interpretation issues identified during the negative differential pressure test and subsequent mud displacement operations.

Monitoring and interpretation during the negative differential pressure test

> Personnel on the MODU monitored pressure in the inside of the drill string, as well as pressure in and flow from the kill line. Both the drill string and kill line were configured to connect to the wellbore.
>
> Differences in pressure measured at these two locations were not well understood[159] and the explanations offered – a "bladder effect" or "annular compression" – were provided without any further description of their meaning and application to measured conditions. Neither term has been validated by post-incident analysis.

[158] 8/27/10 MBI Tr. 80 (Cocales)

[159] 7/22/10 MBI Tr. 166 (Guide)

Post-incident analysis indicates that during the negative differential pressure test the kill line was isolated from the wellbore.[160] The cause of the isolation cannot be conclusively determined.

During this time, a third conduit configured to connect to the wellbore, the choke line, could have been monitored for pressure or flow and its reading used to confirm actual wellbore conditions. There is no indication from the record that observations of the choke line were made.

Monitoring and interpretation during the mud displacement operations.

In the time interval 2052 hours to 2108 hours, flow rate out exceeded flow rate in and pump pressure increased. Additionally, the trending slope of drill string pressure changed; the direction of the slope increased rather than decreased.

In the time interval 2108 hours to 2114 hours, pressure within the drill string increased and fluid flowed from the well, even though the pumps had been stopped.

In the time interval 2112 hours to 2131 hours measured hook load fluctuated in a manner that was inconsistent with wellbore fluid density changes caused by the displacement operation. Since well fluids were being directly discharged overboard at this time, bypassing the mud system tanks, monitoring hook load became a principal means for detecting formation flow into the wellbore.

At approximately 2133 hours pressure in the drill string increased by more than 500 psi to 1,765 psi.

Taken individually, any of these events could have been interpreted as indicating increased risk of, or actual, loss of control. Witness accounts of a rig floor discussion at 2130 hours suggest that one or more of these events was being evaluated. However, the record indicates that no well control measures were taken until after uncontrolled flow was observed at the rig floor.

V. Subsequent Well Control Activities

In response to the loss of the well control incident describe above the following activities took place:

- In May 2010, Transocean MODUs *Development Driller II* and *Development Driller III* were mobilized to Mississippi Canyon Block 252 and commenced drilling two relief wells.[161] [162] The objective was to intercept the Macondo wellbore and pump

[160] 7/22/10 MBI Tr. 166 (Guide)

[161] Article, "BP Spuds Relief Well for Oil Spill," http//www.rigzone.com (last visited 5/4/10)

[162] Article, "BP Spuds Second Relief Well," http//www.rigzone.com (last visited 5/17/10)

mud into the flowing well fluids. Conducting this operation at sufficient depth can allow enough mud to accumulate in the wellbore for re-establishing hydrostatic pressure control.

- In July, a "capping stack" containing three BOP ram elements was installed at the wellhead,[163] successfully sealing it and preventing further flow of well fluids and gas into the Gulf of Mexico.[164]

- In August, an operation to inject drilling mud into the well[165] through the capping stack re-established the hydrostatic pressure at the bottom of the well to a value exceeding the formation pressure. Cement was then pumped into the wellbore, sealing the volume inside the casing.[166]

- In September, *Development Driller II* suspended operations on one of the two relief wells. It was re-positioned to the Macondo well to conduct operations for permanently abandoning the well.[167]

- In September, the relief well drilled from *Development Driller III* successfully intercepted the Macondo well. Cement was pumped into the annulus between the casing and the formation, sealing the volume outside the casing.[168]

- On November 8, 2010, the Mississippi Canyon Block 252, OCS-G 32306 #1 well was plugged and abandoned by *Development Driller II.*[169]

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163 Article, "Capping Stack Installed on MC252 Well," http//www.rigzone.com (last visited 7/13/10)

164 Article, "No Oil Flowing into GOM," http//www.rigzone.com (last visited 7/15/10)

165 Article, "Macondo Well Reaches Static Condition," http//www.rigzone.com (last visited 8/4/10)

166 Article, "BP Completes Cementing Procedure at MC 252 Well," http//www.rigzone.com (last visited 8/5/10)

167 Article, "BP : US Department of Justice Investigates BOP," http//www.rigzone.com (last visited 9/6/10)

168 Article," BP Macondo Well Declared Dead," http//www.rigzone.com (last visited 9/20/10)

169 IADC Report Transocean DEVELOPMENT DRILLER II, (August 28 - November 8, 2010) (TRN-USCG_MMS 00043282 - 43595),

Appendices

Appendix A : Wellbore Schematic

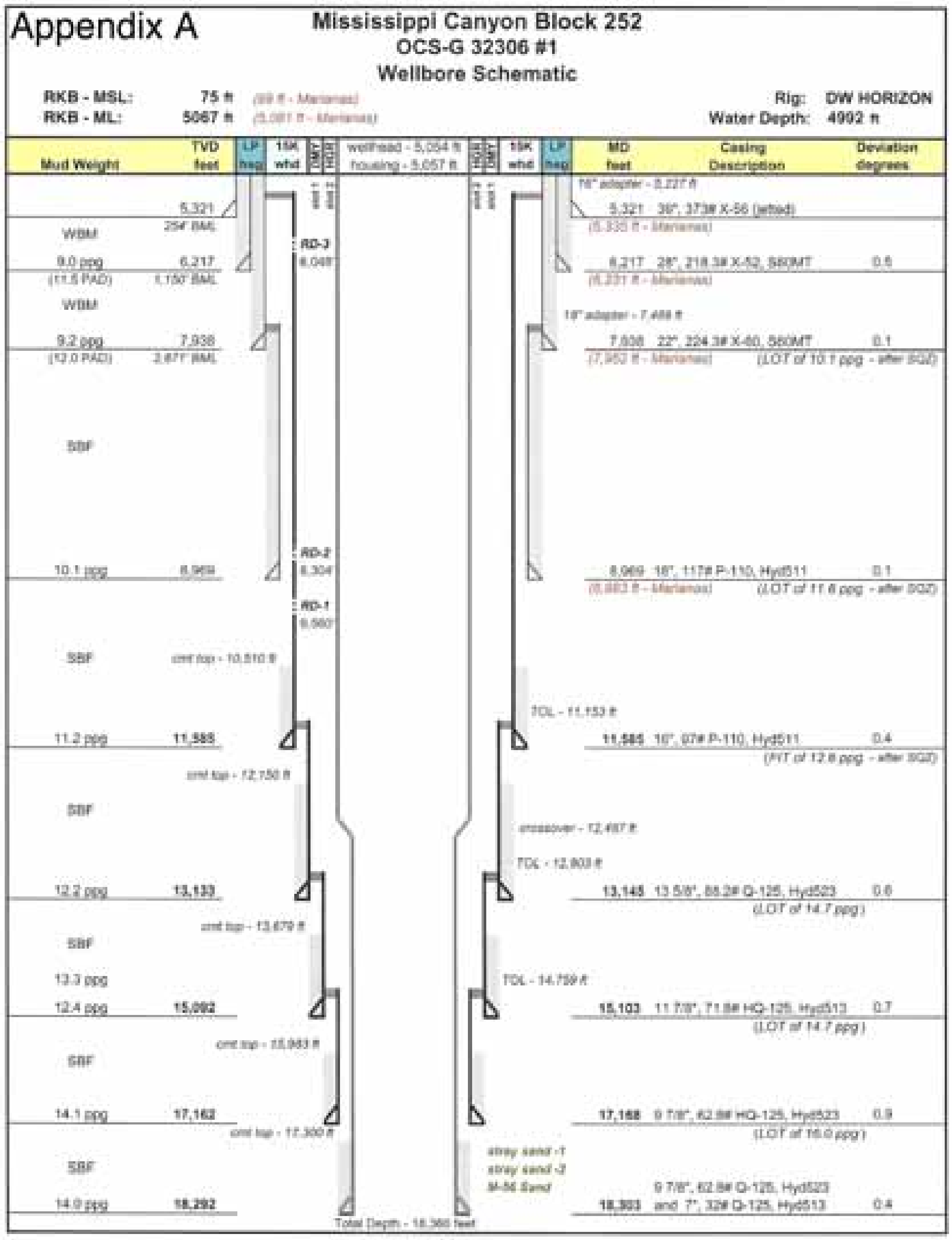
Appendix B : Gas Readings – Wiper Trip

Appendix C : Cement Displacement – Primary Job

Appendix D : Negative Differential Pressure Test – Pressure

Appendix E : Riser Displacement

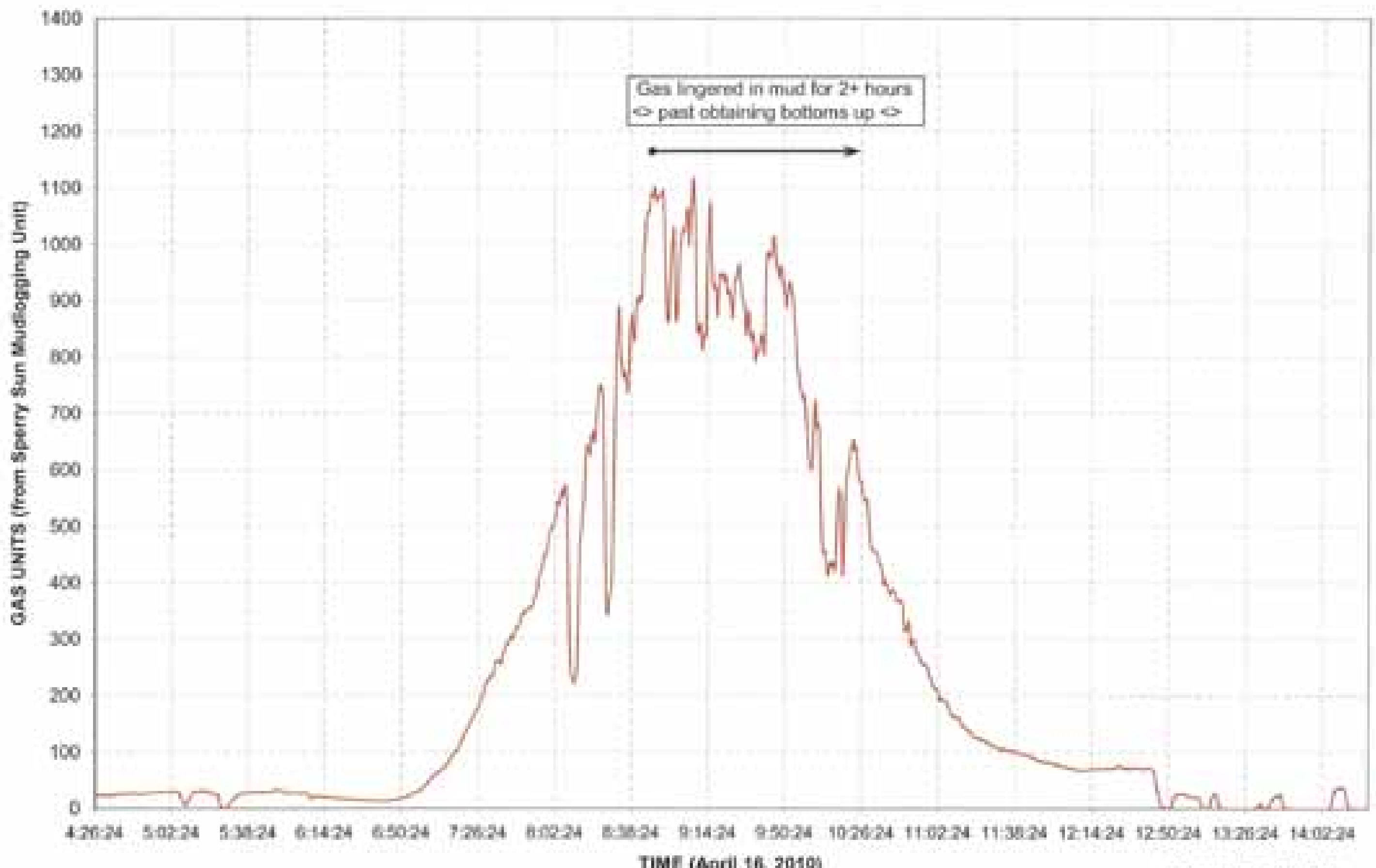
Appendix F : Negative Differential Pressure Test – Hookload



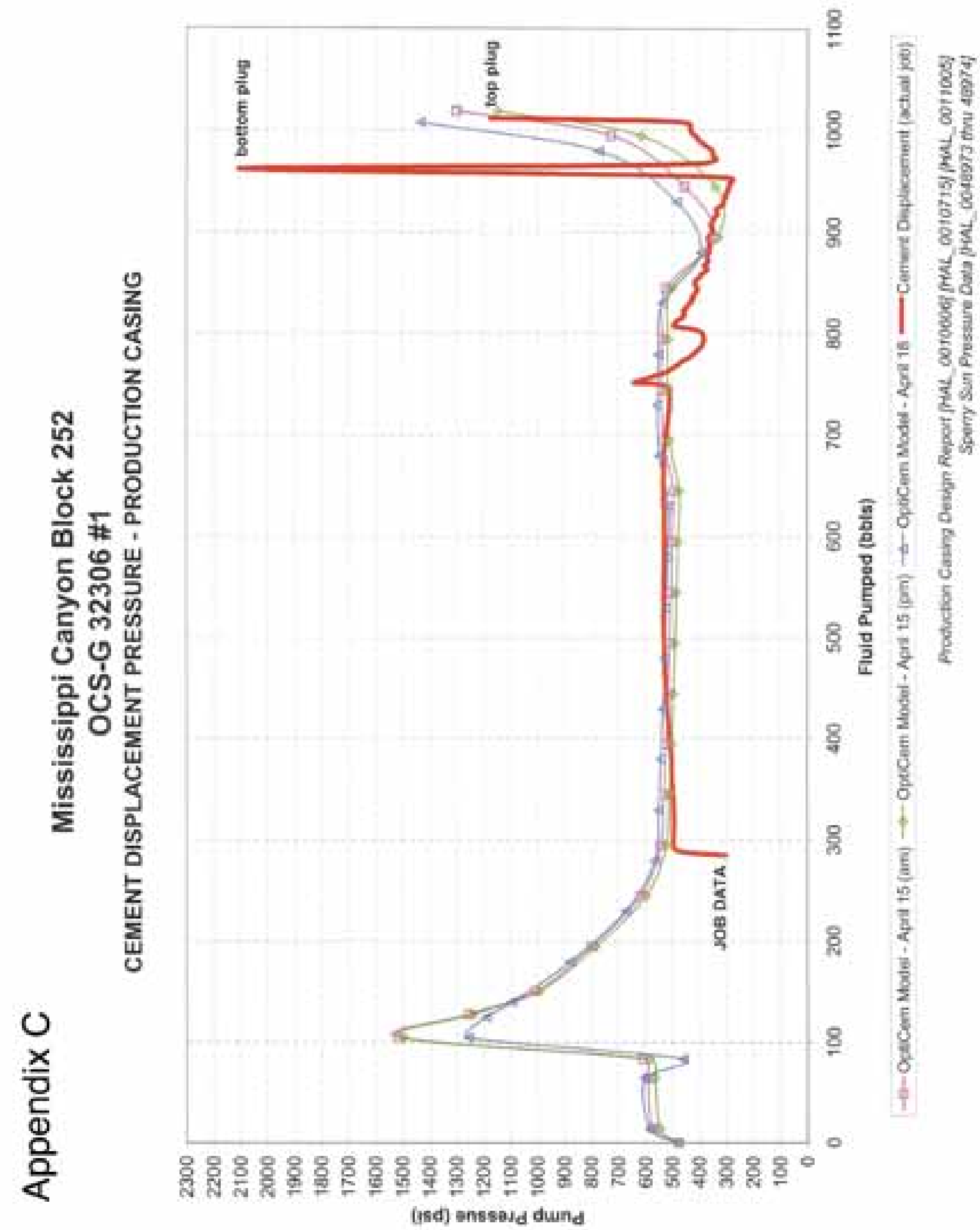
SOURCE DATA : IADC Reports (Marianas <> Deepwater Horizon) / BP Daily Operations Report / BP Casing and Cementing Reports

Appendix B

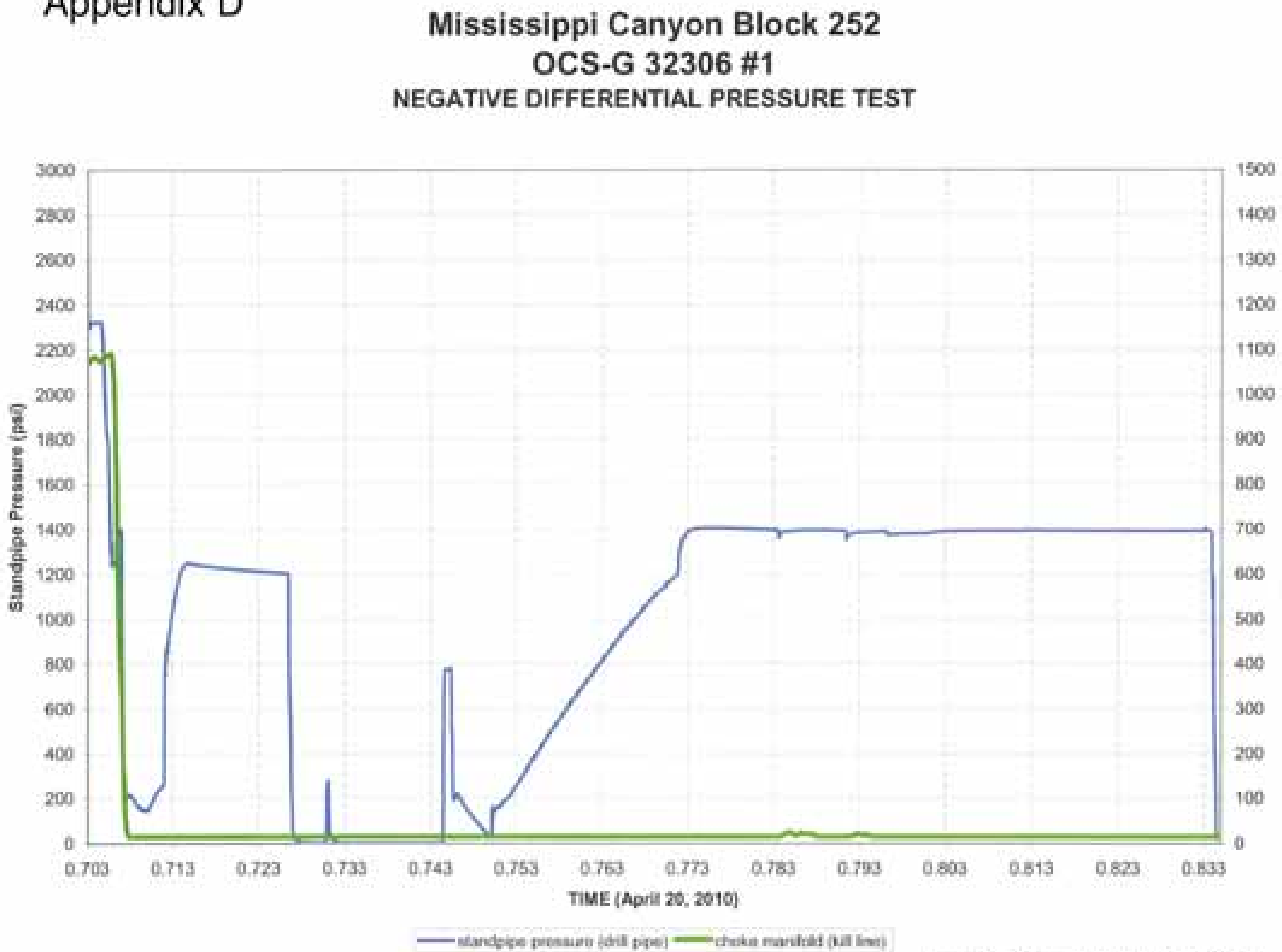
Mississippi Canyon Block 252
OCS-G 32306 #1
TRIP GAS FROM WIPER TRIP



Sperry Sun Gas Data
[BP-HZN-MBI 00013554-Log.txt]


Appendix C
Mississippi Canyon Block 252
OCS-G 32306 #1
CEMENT DISPLACEMENT PRESSURE - PRODUCTION CASING
Pump Pressure (psi)
Fluid Pumped (bbls)
bottom plug
top plug
JOB DATA
OptiCem Model - April 15 (am)
OptiCem Model - April 15 (pm)
OptiCem Model - April 18
Cement Displacement (actual job)

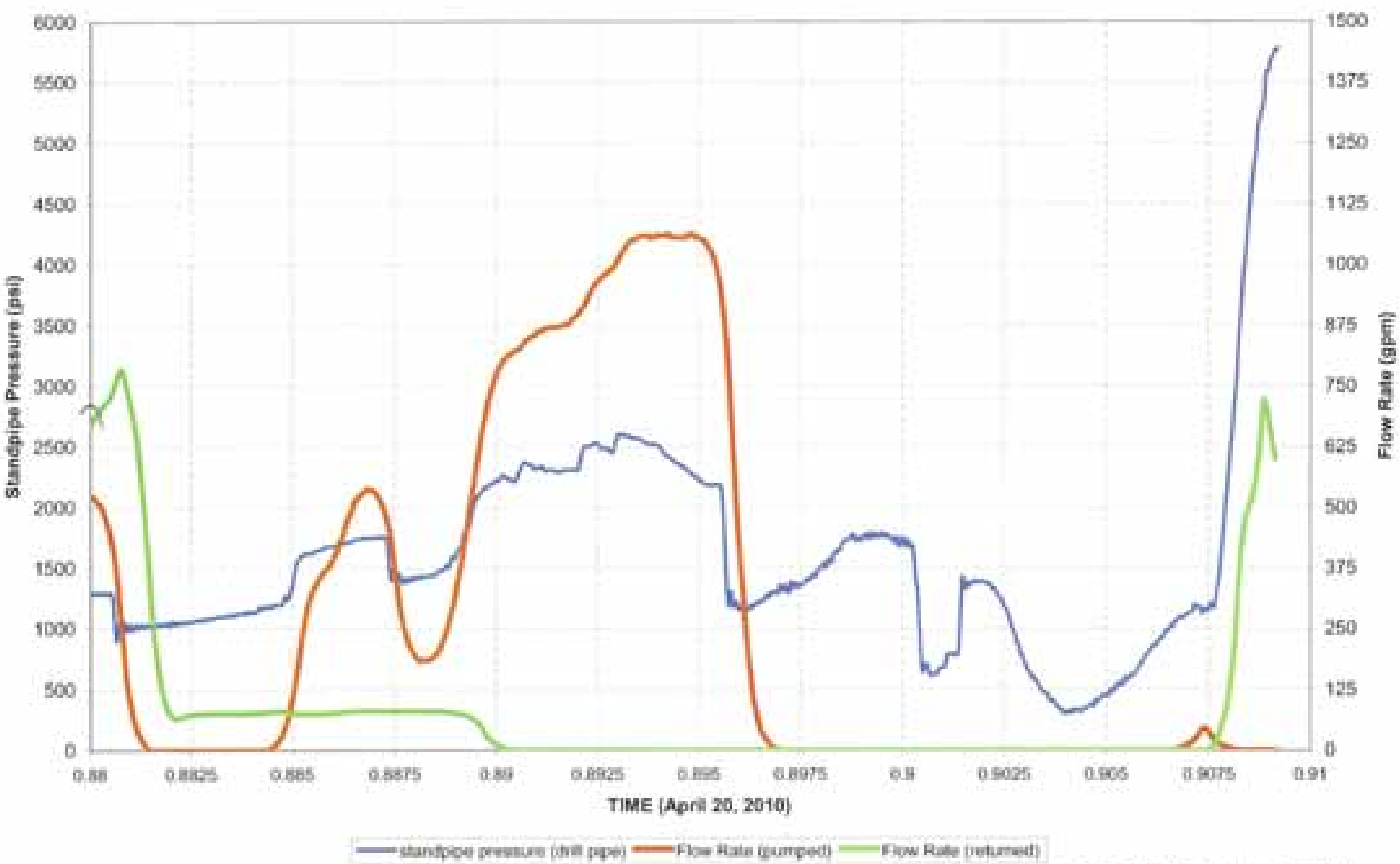
Appendix D



Sperry Sun Pressure Data [HAL_0048974]

Appendix E

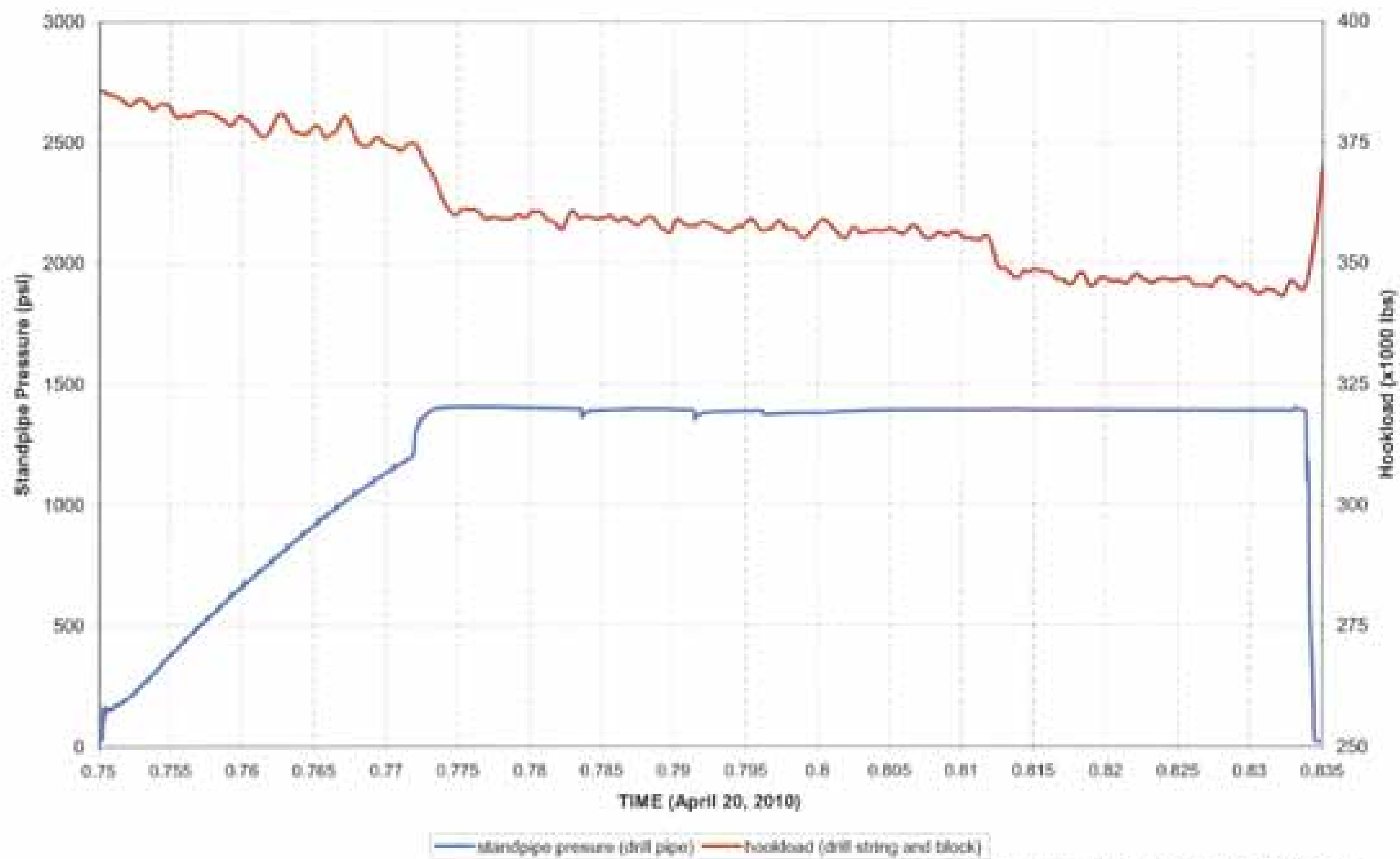
Mississippi Canyon Block 252
OCS-G 32306 #1
RISER DISPLACEMENT



Sperry Sun Pressure / Flow Rate Data [HAL_0048974]

Appendix F

Mississippi Canyon Block 252
OCS-G 32306 #1
NEGATIVE DIFFERENTIAL PRESSURE TEST



Sperry Sun Pressure / Hookload Data [HAL_0048974]

ANNEX D: Overview of International Codes and Conventions

INTRODUCTION

Mobile Offshore Drilling Units (MODUs) are regulated by numerous international regulations and codes. The following is a brief overview of the major international codes comprising the regulatory framework applicable to MODUs.

CODE FOR THE CONSTRUCTION AND EQUIPMENT OF MOBILE OFFSHORE DRILLING UNITS (MODU CODE), 1989

Overview

The MODU Code, in its successive forms, provides standards for operational and personnel safety aboard MODUs that are equivalent to standards required by the International Convention for the Safety of Life at Sea (SOLAS) for ships. The 1989 MODU Code was adopted by International Maritime Organization (IMO) Assembly Resolution A.649(16) and is applicable to MODUs built since 1 May 1991. The 1989 MODU Code superseded the 1979 MODU Code adopted by Assembly Resolution A.414(XI).[1]

Internationally, the MODU Code is not mandatory, and SOLAS remains the principal governing convention of MODUs. The purpose of the 1989 MODU Code is "to recommend design criteria, construction standards and other safety measures for mobile offshore drilling units so as to minimize the risk to such units, to the personnel on board and to the environment."[2] The Code modifies, for units to which they apply, certain requirements of SOLAS, but do not regulate the drilling of subsea wells or procedures for their control.

IMO MODU Code Development

In the late 1960s and early 1970s, as drilling technology advanced and enabled drilling further offshore and in deeper waters, floating units were developed. These units were often towed between sites within different coastal State jurisdictions. As technology progressed, propulsion began to be added to MODUs and they became capable of moving independently between locations. With this development, the units were considered ships and, thus, subject to SOLAS and the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978 (MARPOL). While SOLAS traditionally applied to self propelled ships, the movement of these units internationally, often with personnel on board, caused the IMO to develop deliberate standards of safety for MODUs.[3]

The IMO's initial philosophy was that self propelled MODUs should have sufficient and capable regular marine personnel to crew the MODU when moving between locations and that the life safety and fire protection provided should be sufficiently robust, to the extent possible, to protect against the hazards of the drill floor. As such, lifeboats, capsules and other lifesaving gear were required to accommodate the total number of personnel on board. Lifesaving equipment is required to be duplicated at widely separated embarkation areas and redundant

1 Code for the Construction and Equipment of Mobile Offshore Drilling Units, 1989 ("1989 MODU Code").

2 1989 MODU Code, §1.1.

3 Code for the Construction and Equipment of Mobile Offshore Drilling Units, 1979, Assembly Resolution A.414(XI).

lifesaving appliances are located on opposite sides of the MODU in order to account for the possibility that one embarkation area may be inaccessible due to a casualty.

Since its initial adoption in 1979, a number of amendments have been made to the MODU Code,[4] the latest version of which was approved in 2009 and is due to enter into force on 1 January 2012.[5] These amendments were necessary as MODUs and their operations became more complex. Additionally, as lessons were learned from casualties, changes were made with respect to structural fire protection and lifesaving appliances.

INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA (SOLAS), 1974

SOLAS, in its successive forms, is generally regarded as the most important international treaty concerning the safety of merchant ships.[6] The first version was adopted in 1914, in response to the TITANIC disaster, the second in 1929, the third in 1948, and the fourth in 1960. The SOLAS Convention in force today was adopted on 1 November 1974 and entered into force 25 May 1980.[7]

The main objective of SOLAS is to specify minimum safety standards for the construction, equipment, and operation of ships. Flag States are responsible for ensuring that ships under their flag comply with its requirements through inspections and surveys of ships,[8] and a number of certificates are prescribed by SOLAS to be issued as proof of compliance.[9] Contracting Governments have the right to inspect ships of other nations calling at its ports; this is known as port State control.[10]

INTERNATIONAL SAFETY MANAGEMENT (ISM) CODE[11]

The ISM Code is made mandatory by Chapter IX of SOLAS for all self propelled vessels, including MODUs, over 500 gross registered tons.[12] The ISM Code is an international standard for the safe management and operation of ships, developed and promulgated by the IMO to provide a vehicle for shipowners to create their own programs individually tailored to meet international standards for safety and pollution prevention in the operation of vessels. Its primary goals include ensuring safety at sea, preventing injury or loss of life, and avoiding damage to the environment and property.

The ISM Code does not create specific operating rules and regulations, but provides a broad framework for vessel owners and operators to ensure compliance with existing regulations and codes, to improve safety practices, and to establish safeguards against all identifiable risks. It also sets forth the safety management objectives, which are recommended to be adopted by companies. Recognizing that that ships and MODUs operate under a wide range

4 1989 MODU Code, Assembly Resolution A.649(16), amended by Assembly Resolution A.830(19).

5 IMO, Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2009, Assembly Resolution A.1023(26).

6 IMO, "International Convention for the Safety of Life at Sea (SOLAS)," http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx (last visited 7/11/11).

7 International Convention for the Safety of Life at Sea, 1974, and its Protocol of 1988: articles, annexes and certificates, International Maritime Organization, 2009 ("SOLAS Consolidated Edition 2009"), at v-viii.

8 SOLAS Consolidated Edition 2009, Regulation 6(a).

9 SOLAS Consolidated Edition 2009, Annex 1.

10 SOLAS Consolidated Edition 2009, Regulation 19.

11 International Safety Management Code ("ISM Code") Resolution A.741(18), as amended.

12 SOLAS Consolidated Edition 2009, Ch. IX.

of different conditions and environments, the ISM Code is based on general principles and objectives.[13]

The safety management system is designed to develop and implement practices and procedures for the safe operation of ships, protect against identified risks, ensure a safe working environment, foster continuous improvement of personnel safety management skills, and to prepare for emergencies related to safety and environmental protection. As a structured and documented system that enables company personnel to implement effectively the company safety and environmental protection policy,[14] the safety management system is unique to each company and/or vessel.

INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS (MARPOL)[15]

MARPOL is the main international convention regarding the prevention of pollution of the marine environment by ships from deliberate, negligent, or accidental causes[16] and is applicable to "ships entitled to fly the flag of a Party to the Convention; and ships not entitled to fly the flag of a Party, but which operate under the authority of a Party."[17] A "ship" is defined as "a vessel of any type whatsoever operating in the marine environment and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft and fixed or floating platforms."[18] Thus, MARPOL is applicable to MODUs.

MARPOL incorporates the International Convention for the Prevention of Pollution of the Sea by Oil, which came into force in 1958 and the 1973 MARPOL Convention adopted after the TORREY CANYON ran aground in 1967, causing the largest oil spill ever recorded until that time.[19] The combined instrument is referred to as the International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, and entered into force on 2 October 1983 (Annexes I and II). In 1997 a Protocol was adopted to add a new Annex VI.[20]

UNITED NATIONS CONVENTION ON THE LAW OF THE SEA (UNCLOS)

The 17th century principal of the freedom-of-the-seas doctrine limited national jurisdiction over the oceans to a narrow three mile belt of sea surrounding a nation's coastline. This principal prevailed until the mid-twentieth century, when it became apparent that an international agreement was necessary to determine how ocean resources were to be regulated and partitioned. UNCLOS was adopted as an unprecedented attempt by the international community to regulate all aspects of the resources of the sea and uses of the ocean such as: navigational rights, territorial sea limits, economic jurisdiction, legal status of resources on the seabed beyond the limits of national jurisdiction, passage of ships through narrow straits, conservation and management of living marine resources,

13 ISM Code, Resolution A.741(18) as amended by MSC.104(73), MSC.195(80), and MSC.273(85), Preamble.

14 ISM Code, Resolution A.741(18) as amended by MSC.104(73), MSC.195(80), and MSC.273(85), at 1.1.

15 IMO, "International Convention for the Prevention of Pollution from Ships (MARPOL)," http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx (last visited 7/11/11).

16 MARPOL Consolidated edition 2006. Articles, Protocols, Unified Interpretations of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto; International Maritime Organization, 2006, p. 3.

17 MARPOL, Article 3(1).

18 MARPOL, Article 2(4).

19 The Oxford Companion to Ships and the Sea, Edited by I.C.B. Dear and Peter Kemp, Oxford University Press, New York, 2nd ed. 2005, at 354 .

20 The Oxford Companion to Ships and the Sea, Edited by I.C.B. Dear and Peter Kemp, Oxford University Press, New York, 2nd ed. 2005, at 354, at iii.

protection of the marine environment, marine research, and procedures for settling disputes among nations.[21]

UNCLOS was opened for signature on 10 December 1982 in Montego Bay, Jamaica. This marked the culmination of more than 14 years of work involving participation by more than 150 countries representing all regions of the world, legal and political systems, and the spectrum of socio/economic development. At the time of its adoption, UNCLOS embodied in one instrument traditional rules for the uses of the oceans and at the same time introduced new legal concepts and regimes and addressed new concerns. UNCLOS also provided the framework for further development of specific areas of the law of the sea.

UNCLOS entered into force on 16 November 1994, 12 months after the date of deposit of the 60th instrument of ratification or accession. Today, it is globally recognized as the overarching regime dealing with all matters relating to the law of the sea.[22]

INTERNATIONAL CONVENTION ON STANDARDS OF TRAINING, CERTIFICATION AND WATCHKEEPING FOR SEAFARERS (STCW)[23]

The 1978 STCW Convention was adopted on 7 July 1978 and entered into force on 28 April 1984 and establishes basic requirements on training, certification and watchkeeping for seafarers on an international level. Previously, such standards were established by individual governments, usually without reference to practices in other countries, which resulted in widely varied standards and procedures.

The STCW Convention was drastically amended in 1995 and 2010, in response to a recognized need to clarify and bring the Convention up-to-date. The 1995 amendments entered into force on 1 February 1997. One of the major features of the revision was that it converted the technical annex into regulations and created a new STCW Code, to which many technical regulations were transferred.

Another major change was the requirement under Chapter I, Regulation I/7 for Parties to provide detailed information to the IMO regarding administrative measures taken to ensure compliance with the STCW Convention, including education and training courses, certification procedures, and other factors relevant to implementation. This represented the first time that the IMO took measures to ensure compliance and implementation with a convention; generally, it had been the sole responsibility of the flag and coastal States to ensure implementation and compliance with IMO conventions.

The STCW Code

The STCW Code expands upon the basic requirements contained in the STCW Convention and outlines the minimum standards of competence required for seagoing personnel. Part A of the STCW Code is mandatory, while Part B is recommended and contains guidance intended to help Parties implement the Convention and illustrates how to comply with certain STCW Convention requirements.

21 United Nations, Division for Ocean Affairs and the Law of the Sea, "A Historical Perspective," http://www.un.org/Depts/los/convention_agreements/convention_historical_perspective.htm (last visited 7/11/11).

22 United Nations, "United Nations Convention on the Law of the Sea of 10 December 1982 Overview and Full Text," http://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm. (last visited 7/11/11).

23 IMO, "International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)," http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-on-Standards-of-Training,-Certification-and-Watchkeeping-for-Seafarers-(STCW).aspx (last visited 7/11/11).

The Manila amendments to the STCW Convention and STCW Code were adopted, with major revisions, on 25 June 2010. The 2010 amendments are set to enter into force on 1 January 2012 and are aimed at bringing the STCW Convention and Code up-to-date with developments since they were initially adopted and to address issues that are anticipated to emerge in the foreseeable future.

ANNEX E: MMS/USCG MOA

MEMORANDUM OF AGREEMENT
BETWEEN THE
MINERALS MANAGEMENT SERVICE – U.S. DEPARTMENT OF THE INTERIOR
AND THE
U.S. COAST GUARD – U.S. DEPARTMENT OF HOMELAND SECURITY

MMS/USCG MOA: OCS-04 Effective Date: 28 February 2008

SUBJECT: FLOATING OFFSHORE FACILITIES

A. PURPOSE

The purpose of this Memorandum of Agreement (MOA) is to identify and clarify responsibilities of the Minerals Management Service (MMS) and the U.S. Coast Guard (USCG) and to provide guidance for the appropriate agency approval of systems and sub-systems for floating offshore facilities. For the purposes of this MOA a floating offshore facility is defined as: 1) a buoyant facility that is permanently or temporarily attached to the seabed of the Outer Continental Shelf (OCS), or 2) that dynamically holds position over the OCS and is attached only via flow-lines, umbilicals or similar connections; these facilities are installed for the purpose of exploring for, developing, producing, transporting via pipeline, storing or processing minerals resources from the OCS. This term includes, but is not limited to, tension leg platforms, spars, semi-submersibles and shipshape hulls. For the purposes of this MOA, the term does not include derrick barges, floatels, tenders, mobile offshore drilling units or floating offshore facilities covered by the Deepwater Port Act which are the primary responsibility of the USCG and the Maritime Administration and regulated under the authority of 33 Code of Federal Regulations (CFR) Subchapter NN – Deepwater Ports.

This MOA updates Section 1 (Communications and Contacts) and replaces parts of Section 7 (Offshore Facilities System/Sub-system Responsibility Matrix) regarding floating offshore facilities of MMS/USCG MOA OCS-01: Agency Responsibilities, dated 30 September 2004. Implementation of this MOA will be in accordance with Section J (Memorandum of Agreements – Development and Implementation) of the Memorandum of Understanding (MOU) between the MMS and USCG, dated 30 September 2004. The participating agencies will review their internal procedures and, where appropriate, revise them to accommodate the provisions of this MOA.

B. STATUTORY AUTHORITIES

The USCG and MMS enter this agreement under authority of Title 14 United States Code (USC) §141 – Coast Guard Cooperation with other Agencies; 43 USC § 1331 et seq. - the Outer Continental Shelf Lands Act (OCSLA); 33 USC § 1321(j) – the Federal Water Pollution Control Act; and the Maritime Transportation Security Act of 2002 as codified in 46 USC, Chapter 701.

1

Applicable MMS regulations are found at 30 CFR, Subchapter B – Offshore, Part 250 – Oil and Gas and Sulphur Operations in the Outer Continental Shelf.

Applicable USCG regulations are found under 33 CFR, Subchapter N – Outer Continental Shelf Activities, Parts 140-147 and applicable parts of 46 CFR – Shipping and 33 CFR Chapter I, Subchapter H – Maritime Security.

C. Jurisdiction

The MMS, within the U.S. Department of the Interior (DOI), is responsible for managing the nation's natural gas, oil, and other mineral resources on the OCS in a safe and environmentally sound manner. Under the OCSLA and other authorities, the MMS regulates activities such as exploration, drilling, completion, development, production, pipeline transportation, storage, well servicing, and workover activities under its jurisdiction. MMS also grant rights-of-use and easements to construct and maintain facilities, and rights-of-ways for sub-sea pipelines, umbilicals, or other equipment.

The USCG, within the U.S. Department of Homeland Security (DHS), is responsible for protecting the marine environment, promoting the safety of life and property and ensuring security on the OCS. Under OCSLA, 33 CFR Subchapter N - Outer Continental Shelf Activities, and Title 46 USC – Shipping and Title 46 CFR, as well as other authorities, the USCG regulates OCS facilities, mobile offshore drilling units (MODUs) and vessels engaged in OCS activities, including, but not limited to, tank vessels, offshore supply vessels, and other vessels involved in OCS activities or transfers of certain cargoes.

D. AGENCY RESPONSIBILITIES

1. Communications and Contacts

The participating agencies will identify in writing appropriate representatives for the purposes of keeping each other timely informed of issues, relevant applications, routine policy determinations, and to coordinate joint activities. For the USCG, the Assistant Commandant for Marine Safety, Security and Stewardship is responsible for identifying that representative. For MMS, the Associate Director of Offshore Minerals Management is responsible for identifying that representative.

These representatives will maintain an accurate and updated list of contacts for their respective agency and will make notifications to their counterpart of any changes to agency representatives.

Designation of agency representatives by function:

	USCG	MMS
Headquarters	Chief, Vessel & Facility Operating Standards (CG-5222)	MMS Agency Liaison to the Coast Guard

	USCG	MMS
USCG Districts/MMS Regional Offices	**Gulf of Mexico (GOM):** D8 Chief of Prevention **Alaska:** D17 Chief of Prevention **California:** D11 Chief of Prevention	**GOM:** GOM Regional Supervisor for Field Operations **Alaska:** Alaska OCS Regional Supervisor for Field Operations **California:** Pacific OCS Region Chief, Office of Facilities, Safety, and Enforcement
USCG Sector/Marine Safety Units (MSUs)/ MMS Districts	Officer in Charge, Marine Inspection (OCMI) at: **GOM:** Sector Mobile Sector New Orleans MSU Morgan City MSU Port Arthur Sector Houston/Galveston Sector Corpus Christi **Alaska:** Sector Anchorage **California:** Sector Los Angeles/Long Beach	District Manager at: **GOM:** New Orleans District Houma District Lafayette District Lake Charles District Lake Jackson District **Alaska:** Alaska OCS Regional Supervisor for Field Operations **California:** California District

2. Floating Offshore Facility System/Sub-System Responsibility Matrix

The table provided in Annex 1 of this MOA lists the lead agency for systems and sub-systems associated with floating OCS facilities to include, but not limited to, floating production storage (FPS) and floating production storage and offloading (FPSO) units. Other agency roles are identified where applicable. The lead agency is responsible for coordinating with the other agency as appropriate.

E. General Provision

Nothing in this MOA alters, amends, or affects in any way, the statutory authority of the MMS or the USCG. This MOA cannot be used to obligate or commit funds or as the basis for the transfer of funds. All provisions in this MOA are subject to the availability of personnel and funds. The MOA is not intended to, nor does it, create any right, benefit, or trust responsibility, substantive or

procedural, enforceable at law or equity by any person or party against the United States, its agencies, its officers, or any other person. This MOA neither expands nor is in derogation of those powers and authorities vested in the participating agencies by applicable law. It is the intent of the parties that the MOA remain in force even if a portion of it is determined to be unlawful, provided the remaining portion can be read coherently and understood.

F. Amendments to the MOA

This MOA may be amended by mutual agreement of the participating agencies as described in Section J of the MMS/USCG MOU dated 30 September 2004.

G. Termination

The MOA may be terminated upon a 30-day advance written notification.

Chris C. Oynes
Associate Director
Offshore Minerals Management
Minerals Management Service
U.S. Department of the Interior

Rear Admiral Brian M. Salerno
Assistant Commandant for Marine
Safety, Security and Stewardship
U.S. Coast Guard
U.S. Department of Homeland Security

ANNEX 1

FLOATING OFFSHORE FACILITY SYSTEM/SUB-SYSTEM RESPONSIBILITY MATRIX

This table lists the lead agency for system and sub-systems associated with floating OCS facilities. Other agency roles are identified where applicable. The lead agency is responsible for coordinating with the other agency as appropriate.

Color Code
MMS is the responsible agency
USCG is the responsible agency
MMS/USCG or USCG/MMS have joint responsibilities (Note: Lead agency is stated first)

Item	System	Sub-System	Responsible Agency	Other Agency Role(s) and Comments
1	**Design & Operating Overview/Plan**			
1.a		Deepwater Operations Plans/New Technology Document where applicable	MMS	See applicable section on System Description/Components at end of table.
1.b		Design Basis Document	USCG	See applicable section on System Description/Components at end of table.
1.c		Platform Verification Program (PVP).	MMS	Includes the nomination of a Certified Verification Agent (CVA).See applicable section on System Description/Components at end of table.
2	**Unit Design, Fabrication, Installation, Modifications and Repairs**			
2.a		Non-ship shape hull	USCG/MMS	All design, fabrication, and installation activities of all non-ship-shape floating facilities will be reviewed by both agencies.
2.b		Ship-shape hull	USCG/MMS	USCG - All aspects of the design and fabrication of ship-shape floating facilities will receive review. MMS may require a CVA for the hulls of moored or dynamic positioned units.
2.c		Top side structures	USCG/MMS	USCG-Responsible for structures relating to marine systems, lifesaving equipment, accommodations, crane foundations, and other appurtenances. MMS-Responsible for all structural components related to drilling, production, completion, well servicing and workover operations.
2.d		Turret and turret/hull interface structure	MMS/USCG	USCG and MMS will each review the design of the turret and turret/hull interface structure for all floating facilities.
2.e		Design met-ocean conditions	MMS/USCG	MMS establishes site specific design met-ocean criteria. USCG establishes design met-ocean criteria for intact and damage stability.

2.f		Risers (drilling, production, and pipeline)	MMS	Pipeline risers may be subject to jurisdiction of the U.S. Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA) as defined in the 1996 DOT/DOI Pipeline Memorandum of Understanding (MOU) on Outer Continental Shelf (OCS) Pipelines.
3	**Floating Stability**			
3.a		Non-ship- shape floating facilities	USCG	USCG reviews and approves stability and sends copies to MMS.
3.b		Ship-shape floating facilities	USCG	USCG reviews and approves stability and sends copies to MMS.
4	**Station Keeping**			
4.a		Foundations	MMS	
4.b		Mooring and tethering systems	MMS/USCG	MMS is responsible for site specific mooring analyses. Both agencies will review synthetic mooring applications.
4.c		Design of dynamic positioning systems	USCG	
4.d		Operation of dynamic positioning systems	USCG/MMS	MMS is responsible for criteria for shut-in and disconnect when out of the watch circle. USCG mandates all other operational criteria.
5	**Drilling, Completion, Well Servicing & Workover Operations**			
5.a		See applicable section at end of table on System Descriptions/Components.	MMS	
6	**Production Systems**			
6.a		See applicable section at end of table on System Descriptions/Components.	MMS	
6.b		Produced hydrocarbons, fuel and flow assurance fluid tanks	MMS	All tanks outside of the hull of the unit
			USCG	All tanks inside of the hull of the unit
7	**Pipeline Operations and Components**			
7.a			MMS	Pipelines may be subject to jurisdiction of DOT, PHMSA as defined in the 1996 DOT/DOI MOU on OCS Pipelines.
8	**Offloading Equipment & Procedures**			
8.a			USCG	MMS – To first discharge manifold. USCG has lead on all other units. See diagram at applicable section at end of table for System Descriptions/Components
9	**Utility Systems**			
9.a		Boilers, pressure vessels, waste heat recovery systems (from any engine exhaust), water heaters and other piping or machinery	USCG	Listed equipment/systems associated with the unit's emergency and ship-service systems only.
			MMS	Listed equipment/systems supporting drilling, production, completion, well servicing and workover operations, such as waste heat or steam generation.

6

9.b		High pressure (HP) washdown	USCG	Listed equipment/systems associated with the unit's emergency and ship-service systems only.
			MMS	Listed equipment/system components and piping supporting drilling, production, completion, well servicing and workover operations.
9.c		Seawater supply	USCG	Includes sea chests and sea chest valves supplying water to such systems as ballast system, fire main system and engine cooling system.
9.d		Compressed air	USCG	Listed equipment/systems associated with the unit's emergency and ship-service systems only.
			MMS	Listed equipment/system components and piping supporting drilling, production, completion, well servicing and workover operations.
9.e		Potable wash and sanitary water	USCG	
9.f		Sewage unit & piping	USCG/MMS	USCG - All hardware and associated equipment
				MMS-NEPA and EPA; Discharge permits
9.g		Diesel fuel systems	USCG/MMS	USCG is responsible for diesel fuel systems related to marine systems, lifesaving equipment, accommodations, and cranes.
				MMS is responsible for all diesel fuel systems related to drilling, production, completion, well servicing and workover operations.
9.h		Bilge & ballast, including pumps, and related control systems	USCG	
9.i		Fuel gas from well	MMS	When powering drilling, production, completion, well servicing and workover operations.
			USCG	Down-stream of the prime movers emergency cutoff valve when powering emergency and ship-service systems only.
10	**Elevators for Personnel**			
10.a			USCG	
11	**Helicopter Landing and Refueling**			
11.a		Decks, fuel handling, and storage	USCG	
12	**Fire Safety Equipment and Systems**			
12.a		Fire protection, detection, and extinguishing	USCG	See applicable section on System Descriptions/Components at end of table.
12.b		Structural fire protection for accommodations	USCG	See applicable section on System Descriptions/Components at end of table.
13	**Safety Systems**			
13.a		Emergency shut-down (ESD) systems and components	MMS	For MMS required systems.
13.b		Remote shut-down devices	USCG	All remote stopping devices required for USCG-regulated systems.
13.c		Gas detection systems and components	MMS	

13.d		All safety systems and components associated with drilling, production, completion, well servicing and workover operations, including, but not limited to the control of the well.	MMS	
13.e		General alarm	USCG	Includes public address system when integrated with general alarm system
14	**Electrical Design & Equipment**			
14.a		Production	MMS	See item 6 on System Description/Components at end of table.
14.b		Systems solely dedicated to drilling, completion, well servicing and workover operations	MMS	See item 5 on System Description/Components at end of table. This includes both permanent equipment and equipment installed for a finite time and designed for removal (temporary equipment).
14.c		Systems sharing power with both ship-services and drilling, completion, well servicing and workover operations.	USCG/MMS	Systems dedicated solely to ship-services are the responsibility of USCG.
14.d		Emergency lighting power generation and distribution	USCG	
14.e		Hazardous areas classification	USCG/MMS	MMS and USCG will use industry standards, where applicable to minimize duplication of effort for industry.
15	**Aids to Navigation**			
15.a			USCG	
16	**Communications**			
16.a			USCG	
17	**Pollution Prevention**			
17.a		Pollution not associated with vessel transfers	USCG	Garbage, maintenance waste and plastics per the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)
17.b		Petroleum and other product transfers to and from a vessel (includes offloading of produced hydrocarbons)	USCG	
17.c		All floating facilities while in transit or off station	USCG	
17.d		All floating facilities on station or moored	MMS/USCG	MMS - All oil production related equipment (See item 5 – Drilling, Completion, Well Servicing and Well Workover; and Item 6 – Production Systems), but excluding oil storage tanks on FPSOs or similar units USCG - All other equipment and oil storage tanks on FPSOs or similar units
18	**Cranes and Material Handling Equipment**			
18.a		Crane design, certification, and operations	USCG	
18.b		Material handling equipment solely dedicated to drilling, completion, well servicing and workover operations	MMS	

18.c		Material handling equipment dedicated solely to ship-services, lifesaving, marine system maintenance etc.	USCG	
18.d		Lifting and hoisting equipment associated with the derrick.	MMS	
19	**Ventilation**			
19.a		Areas dedicated to drilling, completion, production, well servicing and workover operations.	MMS	
19.b		Drilling fluid handling areas.	MMS/USCG	
19.c		All other areas	USCG	
20	**Lifesaving Equipment**			
20.a			USCG	
21	**Workplace Safety and Health**			
21.a		Personnel protection equipment and operations.	USCG	
21.b		Hazardous material storage & handling (other than produced hydrocarbons)	USCG	
22	**Living Quarters and Accommodation Spaces**			
22.a			USCG	Includes permanent and portable units design & arrangement.
23	**General Arrangements**			
23.a		Physical location and type of all spaces including access/egress & means of escape.	USCG	
24	**Inspections, Drills and Operational Requirements**			Supplements list of above mentioned systems.
24.a		Structural inspection requirements	MMS	Inspects all structural components related to drilling, production, completion, well servicing and workover operations. This would include all required structural assessments after a severe weather event.
			USCG	Responsible for all inspections of the hull and structures relating to marine systems, lifesaving, accommodations, crane foundations, and other appurtenances.
24.b		Manning requirements for marine operations.	USCG	
24.c		Drills – fire and abandon	USCG	
24.d		Inspection and testing of drilling, production, completion, well servicing and workover operations.	MMS	
24.e		Well control, oil spill and hydrogen sulfide (H_2S) drills	MMS	Oil spill drills for drilling, completion, production, well servicing and well workover components.

24.f		Inspection and testing of marine and lifesaving equipment	USCG	
24.g		Well-head, template, associated equipment & facility and well removal (decommissioning)	MMS	
24.h		Diving operations & equipment	USCG	
25	Plans			
25.a		Emergency evacuation plans	USCG	
25.b		Safe welding, burning and hot tapping plans	MMS	
25.c		H_2S contingency plan (including equipment, control, personnel training and detection systems)	MMS	Includes H_2S personnel protection equipment
25.d		Security Plan if applicable	USCG	
25.e		Safety plan, fire control or fire equipment, and lifesaving equipment plans	USCG	
25.f		USCG required operations manual	USCG	
25.g		MMS Deepwater Operations Plans (DWOP)	MMS	
25.h		Oil Spill Response Plan	MMS	Covers all oil production related equipment (See Item 5 – Drilling, Completion, Well Servicing and Well Workover; and Item 6-Production Systems) pipelines, fuel sources supporting drilling, completion, production, well servicing and well workover, but excluding oil storage tanks on FPSOs or similar units. See 30 CFR 254 for specific plan requirements
25.i		Vessel Response Plan	USCG	Covers all other equipment, fuel sources, and oil storage tanks, whether above or below deck on FPSOs or similar units. To be submitted 60 days prior to planned operations as per 33 CFR 155.1065(a). See 33 CFR 155 subpart D for specific plan requirements
25.j		Mooring Inspection Maintenance Repair Replacement Plan	USCG/MMS	Must be submitted anytime a company wants to use synthetic moorings. It is submitted to both MMS and USCG and is a joint approval. The USCG writes the approval letter with MMS comments
25.k		Design Verification Plan	MMS	Applies to the MMS's Platform Verification Program to include nomination of a CVA
25.l		Fabrication Verification Plan	MMS	Applies to the MMS's Platform Verification Program to include nomination of a CVA
25.m		Installation Verification Plan	MMS	Applies to the MMS's Platform Verification Program to include nomination of a CVA

26	**Turret Operations**			
26.a		Quick-disconnectable turrets and associated buoys	MMS/USCG	
26.b		Non-readily disconnectable turrets and buoys associated with mooring and conventional risers	MMS/USCG	Buoys acting as part of the mooring system
26.c		Non-readily disconnectable turrets and buoys associated with conventional risers	MMS	No mooring associated with buoys, only with riser system
27	**Investigation - Lead Responsibility**			
27.a		Incidents involving systems the USCG has responsibility for under this MOA	USCG	See MMS/USCG MOA OCS-02 for Civil Penalties, MMS/USCG MOA OCS-03 for Oil Discharge Planning, Preparedness and Response and MMS/USCG MOA OCS-5 for Incident investigations.
27.b		Incidents involving systems MMS has responsibility under this MOA	MMS	See MMS/USCG MOA OCS-02: Civil Penalties, MMS/USCG MOA OCS-03: Oil Discharge Planning, Preparedness and Response and MMS/USCG MOA OCS-05: Incident investigation.
28	**Administer Shutdown or Resumption of Operation of a Facility**			
28.a			MMS	See Section D.10 – Abatement – MMS/USCG MOA OCS-3: Oil Discharge Planning, Preparedness and Response
29	**Safety Analysis**			
29.a		Safety analysis of industrial systems	MMS	

System Descriptions/Components

Item 1. Design and Operating Overview/Plan

1.a Deepwater Operations Plans – MMS

A. Conceptual Plan – General Design Basis and Philosophy
   1) An overview of the development concept(s),
   2) A well location plat.
   3) System control type – direct hydraulic or electro- hydraulic, and
   4) Distance from each well to the host platform.

B. Deepwater Operations Plans (DWOP)
   1) Description and schematic of typical wellbore, casing and completion,
   2) Structural design, fabrication and installation information for each surface system,
   3) Design, fabrication and installation information for the mooring systems,
   4) Information on any active station keeping systems,
   5) Information on the drilling and completion systems,
   6) Design and fabrication information for each riser system,

7) Pipeline information,
8) Information on the design, fabrication and operation of any offtake systems,
9) Information on subsea wells and associated systems,
10) Flow schematics and Safety Analysis Function Evaluation of the production system,
11) A description of the surface/subsea safety system and emergency support systems,
12) A general description of the operating procedures,
13) A description of the facility installation and commissioning procedures,
14) A discussion of any new technologies proposed, and
15) A list of any alternative compliance procedures or departures proposed.

C. New Technology Document
1) A discussion of any new technologies proposed, and
2) A list of any alternative compliance procedures or departures proposed.

1.b Design Basis Document - USCG
1) Description of the facility and its configuration,
2) Design methodology, including method of analysis, design codes and regulatory, requirements and environmental criteria and loading,
3) Design overview of primary structure and, if applicable, the tendons and mooring systems,
4) Design overview of electrical and control systems,
5) Design overview of marine and utility systems,
6) Design overview of fire-protection, lifesaving equipment and safety systems,
7) Design overview of the in-service inspection plan for the hull and tendons, including philosophy, methodology and drawings of areas to be inspected,
8) Intact and damage stability calculations and, for TLPs, include the tendon-attached mode,
9) Description of any unique design aspects that alleviate the negative consequences of damage stability scenarios, facilitate safe operations or enhance maintenance and inspection requirements, and
10) For converted facilities, a summary of previous service, certifications and classification status and an overview of any structural modifications proposed.

1.c Platform Verification Program – MMS

A. Design Verification Plan
1) Documentation of the design including location plat, site specific geotechnical report, contract design drawings and met-ocean data,
2) Abstract of computer programs used for analysis and a
3) Summary of major design considerations and approach needed for verification.

B. Fabrication Verification Plan
1) Approved for fabrication drawings and material specifications,
2) Material traceability procedures, and
3) A summary description of structural/fabrication specifications, tolerances, quality assurance, material quality controls/placement methods and methods/extent of NDE testing.

C. Installation Verification Plan
1) Summary description of planned marine operations,
2) Contingencies considerations,
3) Alternative course of action, and
4) An identification of areas to be inspected, specifying acceptance and rejection criteria.

Item 5. Drilling, Completion, Well Servicing and Workover Operations:

1) Drilling, production, and workover riser,

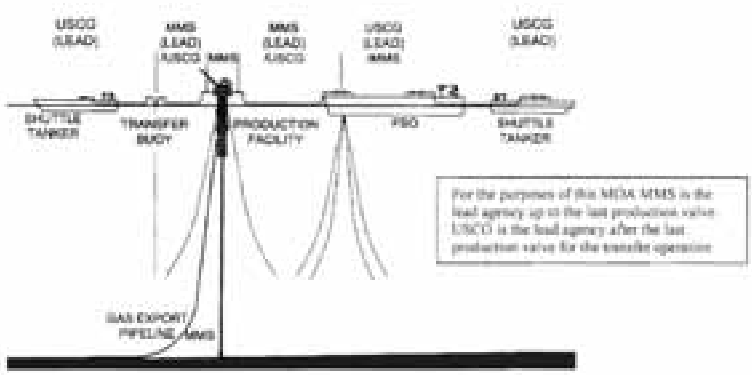
2) Blowout prevention equipment and control systems,
3) Drilling system and related relief valves, vent system, pressure vessels and pipeline, pumps, water systems, and safety systems,
4) Riser and guideline tensioning systems,
5) Motion compensating systems,
6) Instruments and controls,
7) Atmospheric vessels and piping,
8) Fitness of the drilling unit,
9) Lifting and hoisting equipment associated with the derrick,
10) Cementing systems and related equipment,
11) Circulating systems and related equipment, including: pipes and pumps for drilling fluids, workover and well servicing fluids, shale shakers, desanders, degassers and related equipment,
12) Structures including derrick and sub-structure,
13) Bulk material storage and handling systems, and
14) Other pressurized systems designed for industrial operations.

Item 6. Production Systems

1) Hydraulic and pneumatic systems,
2) Pipeline risers,
3) Production safety systems including subsurface and surface safety valves,
4) Relief valves, relief headers, vent and flare systems,
5) Production wells and wellhead,
6) Instrumentation, controls, and measurement (including oil and gas),
7) Gas compression,
8) Process system and related pumps,
9) Odorization for gas piped into enclosures,
10) Process system and related pressure vessels and piping,
11) Process system and related heat exchangers, including waste heat recovery units,
12) Chemical injection and treatment systems, and
13) Metering systems.

Item 8. Offloading Equipment and Procedures

1.a Lead Agency Diagram



Item 12. Fire Safety Equipment and Systems

1) Deluge systems in the well bay area,
2) Firewater pumps, piping, hose reel and monitor equipment,
3) Foam extinguishing equipment,
4) Fixed gaseous extinguishing equipment (carbon dioxide (CO_2) and halon alternatives),
5) Fixed water mist extinguishing equipment,
6) Portable and semi-portable extinguishers, and
7) Fire and smoke detection (excludes interfaces to MMS regulated safety systems).

ANNEX F: Letter from the USCG to the Republic of the Marshall Islands Regarding MODU Code Equivalence

U.S. Department of Transportation
United States Coast Guard

COMMANDANT
United States Coast Guard

2100 Second Street S.W.
Washington, DC 20593-0001
Staff Symbol: G-MOC
Phone: (202)-267-2978
FAX: (202)-267-0506

16703

AUG 0 9 2002

Republic of the Marshall Islands
Office of the Maritime Administrator
Attn: David L. Crede
11495 Commerce Park Drive
Reston, VA 20191-1507

Dear Mr. Crede:

Pursuant to your letter of August 23, 2000, my staff has compared "The Republic of the Marshall Islands' Mobile Offshore Drilling Unit (MODU) Standards", Publication MI-293 (Rev. 8/00), to the 1979 and 1989 editions of the International Maritime Organization (IMO) MODU Code. The MI-293 standards were also compared against U.S. requirements for existing MODUs (units constructed before December 31, 1981). These comparisons were for the purpose of determining whether the Marshall Islands' MODU Standards provide a level of safety that is generally equivalent to the applicable international and U.S. requirements to operate on the U.S. Outer Continental Shelf (OCS). I have determined that the provisions of Marshall Islands' publication MI-293 establishes a standard equivalent to that found in national and international instruments per Navigation and Vessel Inspection Circular (NVIC) 3-88, Change 1, as long as the requirements contained in the supplement for Marshall Islands' flagged MODUs (enclosure 1) is also complied with.

Therefore, a Marshall Islands' MODU Safety Certificate issued under the provisions of Publication MI-293 (Rev. 8/00) for units constructed on or after December 31, 1981, will be considered evidence of compliance with international and U.S. Coast Guard requirements under 33 CFR 143.207(c) and 33 CFR 146.205(c). Likewise, a Marshall Islands' MODU Document of Compliance issued under the provisions of Publication MI-293 (Rev. 8/00) for units constructed before December 31, 1981, will be considered evidence of compliance U.S. Coast Guard requirements under 33 CFR 143.207(b) and 33 CFR 146.205(b). Therefore, any unit in possession of a Marshall Islands' MODU Safety Certificate or Document of Compliance that also meets the requirements identified in the enclosure (1) supplement is eligible for a Coast Guard Certificate of Compliance (COC) to operate on the U.S. OCS.

Prior to COC issuance, a unit is subject to inspection by the Officer in Charge Marine Inspection (OCMI) to ensure compliance with all applicable standards as well as with the enclosed supplement. We recognize that there may be circumstances that require flexibility and the use of discretion in the application of certain inspection and equipment standards that are not specifically addressed in Publication MI-293. In these instances, the Marshall Islands shall notify G-MOC before deviating from the requirements outlined in MI-293 (Rev. 8/00).

16703

Subj: MOBILE OFFSHORE DRILLING UNIT STANDARDS

A copy of this letter with enclosures shall be aboard any MODU documented under the laws of the Marshall Islands while operating on the U.S. OCS. All Coast Guard Area, District and Marine Safety Offices have been notified via copy of this letter with enclosures. If you have any questions, please contact my G-MOC-2 staff at the phone number listed above.

Sincerely,

J. A. SERVIDIO
Commander, U.S. Coast Guard
Chief, Office of Compliance
By direction

Encl: (1) Supplement for Marshall Islands Flagged MODUs
(2) The Republic of the Marshall Islands' Publication MI-293 (Rev. 8/00)

Copy to: CG Districts
MSOs

Supplement for Marshall Islands Flagged MODUs

MODUs possessing a valid Marshall Islands' MODU Safety Certificate or Document of Compliance issued in accordance with the Republic of the Marshall Islands "Mobile Offshore Drilling Units Standards", Publication MI-293 (Rev. 8/00) must also meet the requirements identified below before a COC will be issued to engage in operations on the U.S. OCS. Compliance with these requirements will be verified at the discretion of the OCMI to which application for a COC has been made.

1. All units shall comply with the applicable provisions of Title 33 CFR Subchapter N – Outer Continental Shelf Activities. This includes but is not limited to inspections, investigations, citizenship requirements and restrictions on employment, workplace safety and health, operational requirements for foreign MODUs.

2. All units shall comply with the applicable provisions of Title 33 CFR Subchapter O – Pollution. This includes but is not limited to the Act to Prevent Pollution from Ships, MARPOL 73/78, IOPP, shipboard oil pollution emergency plans, operations and testing requirements, placards, records and logs, oil transfer procedures and marine sanitation devices (MSDs).

3. All units shall comply with the applicable provisions of Title 33 CFR Part 164 – Navigation Safety Regulations. This includes but is not limited to charts, publications, navigation equipment, and testing maintenance and reporting requirements.

4. Testing and Inspection of Pressure Vessels and Relief Valves – Pressure vessels shall be internally examined once every five years and relief valves shall be tested twice in five years with no interval more than three years in accordance with 46 CFR 61.10 and G-MOC Policy Letter 01-03.

5. Additional Lifesaving Equipment – All units shall comply with the additional lifesaving requirements of 46 CFR 108.503. Drillships not in possession of a valid MODU Safety Certificate (1989) shall comply with the requirements of 46 CFR Subchapter W.

6. Maintenance, Testing & Inspection of Lifesaving Equipment – All units shall comply with the maintenance, testing and inspection requirements of 46 CFR 109.301. All required maintenance, tests and inspections shall be documented.

7. Testing & Inspection of Fire Fighting Equipment – All units shall ensure that each hand and semi portable fire extinguisher, fixed fire-extinguishing system and gas detection system shall be tested and inspected annually in accordance with the requirements of 46 CFR 109.223. All required tests and inspections shall be documented.

8. Hospital Space, First Aid Kit & Litter – All units carrying 12 or more persons on a voyage more than three days shall have a dedicated hospital space on board that complies 46 CFR 108.209 or 46 CFR 108.210. All units shall have a first aid kit on board that complies with

ENCLOSURE(1)

46 CFR 108.707. All units shall have a litter on board capable of being used on the type of helicopter that service the unit in accordance with the requirements of 46 CFR 108.709

9. Hazardous Locations – All units shall comply with the electrical wiring materials and methods required by 46 CFR 111.60 for the hazardous locations listed in 46 CFR 111.105-33

10. The OCMI may require a unit to carry specialized or additional equipment if the conditions, arrangement or service of the unit present uniquely hazardous circumstances that are not adequately addressed by existing requirements or standards.

ANNEX G: List of Certificates and Expiration Dates

Certificate Name	Date of Issue	Date of Expiration
SOLAS Exemption Certificate	23-May-08	28-Feb-11
American Bureau of Shipping Certificate of Classification	19-Oct-09	28-Feb-11
Flag State Verification and Acceptance Document	2-Jan-06	28-Feb-11
International Oil Pollution Prevention Certificate (IOPPC)	4-Dec-07	28-Feb-11
Supplement to the International Oil Pollution Prevention Certificate (IOPPC)	4-Dec-01	28-Feb-11
International Sewage Pollution Prevention Certificate (ISPPC)	2-Jan-06	28-Feb-11
International Load Line Certificate (IL) 1966	11-Jun-06	28-Feb-11
Mobile Offshore Drilling Unit Safety Certificate (1989)	11-Jun-06	28-Feb-11
RMI Minimum Safe Manning Certificate (MSMC)	17-Sep-09	Not Applicable
Department of Homeland Security United States Coast Guard Certificate of Compliance (COC)	27-Jul-09	27-Jul-11
International Safety Management Certificate (SMC)	11-Jul-07	16-May-12
International Ship Security Certificate (ISSC)	16-May-07	16-May-12
RMI Ship Radio Station License	17-Dec-09	30-Jun-13
International Safety Management Code Document of Compliance	25-Apr-08	25-Jan-12
Certificate of Insurance or Other Financial Security in Respect of Civil Liability for Bunker Oil Pollution Damage	4-Nov-09	4-Nov-10
International Tonnage Certificate (1969)	1-Apr-05	Not Applicable
Republic of the Marshall Islands Office of the Maritime Administrator Continuous Synopsis Record (CSR) Document	24-Sep-09	Not Applicable

ANNEX H: General Arrangement Diagrams

Electronicallv published bv ABS Houston.
Reference 325950. dated 19-APR-2008.

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TRANSOCEAN OFFSHORE DEEPWATER DRILLING INC.		**Reference:**	**325950. 329658**/ABP
4 GREENWAY PLAZA. Houston. TX. 77046		**Proiect Number:**	**1818628**
		Class Number:	**0139290**

ATTN : Ms. Lauri L. Perrodin (lperrodin@mail.deepwater.com)

Vessel:	**Deepwater Horizon**	**19 April 2008**
Shipyard. Hull Numbers:	**HYUNDAI HEAVY INDUSTRIES CO LTD. O339**	
Review Activity:	**Offshore - Fire Control Plan –**	**325950**
	SOLAS – Structural Fire Protection	**329658**

We have received vour electronic submittal dated 02 April 2008 submitting copies of plans as listed therein on the above subiect and with regard thereto have to advise that provided the details and arrangements be adhered to. the work is to the satisfaction of the Survevors. and the Rules in all other respects are complied with. the same will be approved subiect to comments L-016.

.

The drawings have been reviewed in accordance with the following Rules and Regulations:

- ABS Rules for Building and Classing Mobile Offshore Drilling Units. 2001
- The IMO Code for the Construction and Equipment of Mobile Offshore Drilling Units. 1989. Resolution A.649 (16)

Comment P-001 has been closed as a result of this review; comments P-002 through P-004 are now survevor comments. Comments L-006 and L-015 were closed earlier. Comments L-016 has been created as a result of this review.

We note the following editorial comment:

> On sheet 2. the legend indicates 2 embarkation ladders are provided on the Second Deck and 2 more on the Third Deck. However. the plan indicates 2 embarkation ladders are provided on the Second Deck and 2 more on the Main deck.
>
> The relationship among CO2 protected spaces. storage locations and activation locations is unclear. Activation locations and storage location should be labeled as to which space they affect. Ref IMO resolution A.952(23).

For vour convenience. a copy of all comments associated with this plan is attached.

16855 Northchase Drive. Houston. TX. 77060. US
TEL: 1-281-877-5800

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ABSDWH004150

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One electronic copy of the drawing, appropriately stamped to indicate our review, is being returned.

An invoice to cover the cost of our review will be sent separately.

Please note that a copy of this plan is to be permanently exhibited on board the unit pursuant to the above noted Regulation.

If we may be of further assistance, please do not hesitate to contact Anne Price at (281) 877-5994 or the undersigned at (281) 877-6226.

Very Truly Yours

Carol Newell

Carol Newell
Managing Principal Engineer
Houston OED - Piping Systems

Cc: ABS Morgan City, LA – w/p
ABS Houston w/ invoice

16855 Northchase Drive, Houston, TX, 77060, US
TEL: 1-281-877-5800

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Drawing List

Engineering Office:	Houston OED - Systems	
Submitter:	TRANSOCEAN OFFSHORE DEEPWATER DRILLING INC.	
Drawing No	**Revision No**	**Drawing Title**
15 Oct 07	-	INCOMING EMAIL FROM CLIENT DTD
03 MAR 2008	-	INCOMING EMAIL SUBJ: RE-SUBMISSION OF 6087A-UN1000. REV. 3
6087aUN1000	3	Firefighting & Lifesaving Plan
6087aUN1000	4	Firefighting & Lifesaving Plan
6087aUN1000	5	Firefighting & Lifesaving Plan

Comments List

Thread No	Comment Text	Facilities	Action
L-001	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "A" rated bulkhead separating the Port Engine Room and the Transformer Room on the Second Deck. A Machinery space of category A adjacent to an Other machinery space requires a class "A-0" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment Closed per ABS Memo dated 18Jan08		
L-002	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "A" rated bulkhead separating the Starboard Engine Room and the Transformer Room on the Second Deck. A Machinery space of category A adjacent to an Other machinery space requires a class "A-0" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment Closed per ABS Memo dated 18Jan08		
L-003	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "A" rated bulkhead separating the Machine Shop and the Mechanics Shop on the Second Deck. An Other machinery space adjacent to a Service Space (high risk) requires a class "A-0" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment Closed per ABS Memo dated 18Jan08		
L-004	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "B" rated bulkheads and doors separating the Staterooms and the Corridor on the Second Deck. An accommodation Space adjacent to a Corridor requires a class "B" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment Closed per ABS Memo dated 18Jan08		
L-005	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "A" rated bulkhead separating the Transformer Room and the Corridor on the Second Deck. We note the plan indicates a class "B" rated bulkhead. An Other machinery space adjacent to a Corridor requires a class "A-0" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment Closed per ABS Memo dated 18Jan08		

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L-006	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "A" rated bulkhead separating the Electrical Room and the Corridor on the Second Deck. We note the plan indicates a class "B" rated bulkhead. An Other machinery space adjacent to a Corridor requires a class "A-0" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment remains open. Please revise plan to indicate that the bulkhead separating the Corridor from the Electrical Room port inboard of the Utility Trunks located on the 2nd deck has an A-0 level of fire integrity. A bulkhead separating a Corridor from an Other Machinery Space is required to have at least an A-0 level of fire integrity. We note that this bulkhead has a B-0 level of fire integrity. [IMO MODU Code 9.1.3/Table 9-1, ABS MODU Rules 3-4-1/Table 1]		
	Comment remains open. Please revise plan to indicate that the bulkhead separating the Corridor from the Electrical Room port inboard of the Utility Trunks located on the 2nd deck has an A-0 level of fire integrity. A bulkhead separating a Corridor from an Other Machinery Space is required to have at least an A-0 level of fire integrity. We note the drawing indicates part of this bulkhead has a B-0 level of fire integrity. [IMO MODU Code 9.1.3/Table 9-1, ABS MODU Rules 3-4-1/Table 1]		
	Comment Closed per ABS Memo dated 11Mar08		
L-007	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "A" rated bulkhead separating the A/C Unit and the adjacent Space on the Third Deck. An Other machinery space adjacent to an Other machinery space requires a class "A-0" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment Closed per ABS Memo dated 18Jan08		
L-008	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "A" rated bulkhead separating the Air Compressor Room (Stbd) and the adjacent Space on the Third Deck. An Other machinery space adjacent to an Other machinery space requires a class "A-0" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment Closed per ABS Memo dated 18Jan08		
L-009	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a class "A" rated bulkhead separating the Mud Pump Room and the F.O. Room on the Third Deck. A Hazardous area adjacent to a Service Space (high risk) requires a class "A-0" fire integrity rating. [IMO MODU Code 9.1.4.1 Table 9-1]		
	Comment remains open. Please revise plan to indicate that the bulkhead separating the Mud Pump Room from the F.O. Room located port side on the 3rd deck has an A-0 level of fire integrity. A bulkhead separating an Other Machinery Space from a High Risk Service Space is required to have an A-0 level of fire integrity. We note that the fire integrity of this bulkhead is not indicated. [IMO MODU Code 9.1.3/Table 9-1, ABS MODU Rules 3-4-1/Table 1]		
	Comment Closed per ABS Memo dated 04Mar08		
L-010	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate the bulkhead on the Forward – Starboard corner of the Third Deck is represented in red. We note the bulkhead is rated class "A" but is indicated in blue. A fire control plan complying with regulation II-2/15 of the 1974 SOLAS Convention should be permanently exhibited. [IMO MODU Code 9.13.1]		
	Comment remains open. Please revise plan to indicate that the bulkheads forming the Electrical Room and the space adjacent to the Utility Trunk located Starboard on the 3rd deck are represented by Red. A fire control plan complying with regulation 15.2.4.1 of the 1974 SOLAS Convention is to be permanently exhibited. We note these bulkheads are represented by Blue. [IMO MODU Code 9.13.1]		

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	Comment Closed per ABS Memo dated 04Mar08		
L-011	60008aUN1000-1 - POSTER	O339[Close]	Technical
	Please revise plan to indicate a two-way VHF radiotelephone apparatus for each lifeboats. All lifeboats should carry a two-way VHF radiotelephone apparatus. [IMO MODU Code 10.13.1]		
	Comment Closed per ABS Memo dated 18Jan08		
L-012	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Close]	Technical
	Please revise Sheet 2 to indicate that the bulkhead separating the Conference Room from the Corridor located on the 2nd Deck has a B-0 level of fire integrity. A bulkhead separating an Accommodation Space from a Corridor is required to have at least a B-0 level of fire integrity. We note that the fire integrity of this bulkhead is not indicated. [IMO MODU Code 9.1.3/Table 9-1. ABS MODU Rules 3-4-1/Table 1]		
	Comment Closed per ABS Memo dated 04Mar08		
L-013	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Close]	Technical
	Please revise Sheet 2 to indicate that the bulkheads separating the Subsea Office from the Corridor located on the 2nd Deck have a B-0 level of fire integrity. A bulkhead separating an Accommodation Space from a Corridor is required to have at least a B-0 level of fire integrity. We note that the fire integrity of these bulkheads is not indicated. [IMO MODU Code 9.1.3/Table 9-1. ABS MODU Rules 3-4-1/Table 1]		
	Comment Closed per ABS Memo dated 04Mar08		
L-014	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Close]	Technical
	Please revise plan to indicate that the bulkhead separating the Electrical Room from the Corridor located Starboard on the 3rd deck has an A-0 level of fire integrity. A bulkhead separating a Corridor from an Other Machinery Space is required to have at least an A-0 level of fire integrity. We note that this bulkhead has a B-0 level of fire integrity. [IMO MODU Code 9.1.3/Table 9-1. ABS MODU Rules 3-4-1/Table 1]		
	Comment Closed per ABS Memo dated 04Mar08		
L-015	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Close]	Technical
	Please revise plan to indicate that the bulkheads forming the space adjacent to the Utility Trunk located Starboard on the 2nd deck are represented by Red. A fire control plan complying with regulation 15.2.4.1 of the 1974 SOLAS Convention is to be permanently exhibited. We note these bulkheads are represented by Blue. [IMO MODU Code 9.13.1]		
	Comment Closed Per ABS Memo dated 11Mar08		
L-016	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Open]	Technical
	Please revise plan to indicate all deck ratings for all levels. The minimum fire integrity of decks should be as prescribed in table 9-2. [9.1.3/Table 9-2]		
P-001	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Close]	Technical
	Fire extinguishers are required for workshops and storage areas. Please add a type C-II for the subsea workshop on the third deck and a type A-II for the rubber goods room, also on the third deck. See ABS Rules for Building and Classing Mobile Offshore Drilling Units, 2001 4-4-1/Table 2		
	Revision 5 adds these extinguishers, this comment is closed.		
P-002	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Open]	Surveyor
	Surveyor is requested to verify fuel tank valve remote closure capability for any fuel tank having valves subject to a static head of pressure. See ABS MODU 4-4-1/31.5		
	This should be a Surveyor comment.		
P-003	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Open]	Surveyor
	The jet fuel storage area is required to have a Back-up firefighting system. The jet fuel unit on main deck has no portable fire extinguishers shown. Please add portable extinguishers to		

AMERICAS DIVISION

	the jet fuel unit. see ABS MODU 4-4-1/37.5.1.		
	Surveyor is requested to verify portable fire extinguisher is readily available for helifuel storage area.		
P-004	6087aUN1000 - Firefighting & Lifesaving Plan	O339[Open]	Surveyor
	Surveyor is requested to verify appropriate quantity of "Portable Extinguisher Spare/Fire Hose Spares" that are stored on the 28500 Flat (not second deck as shown on symbol legend).		

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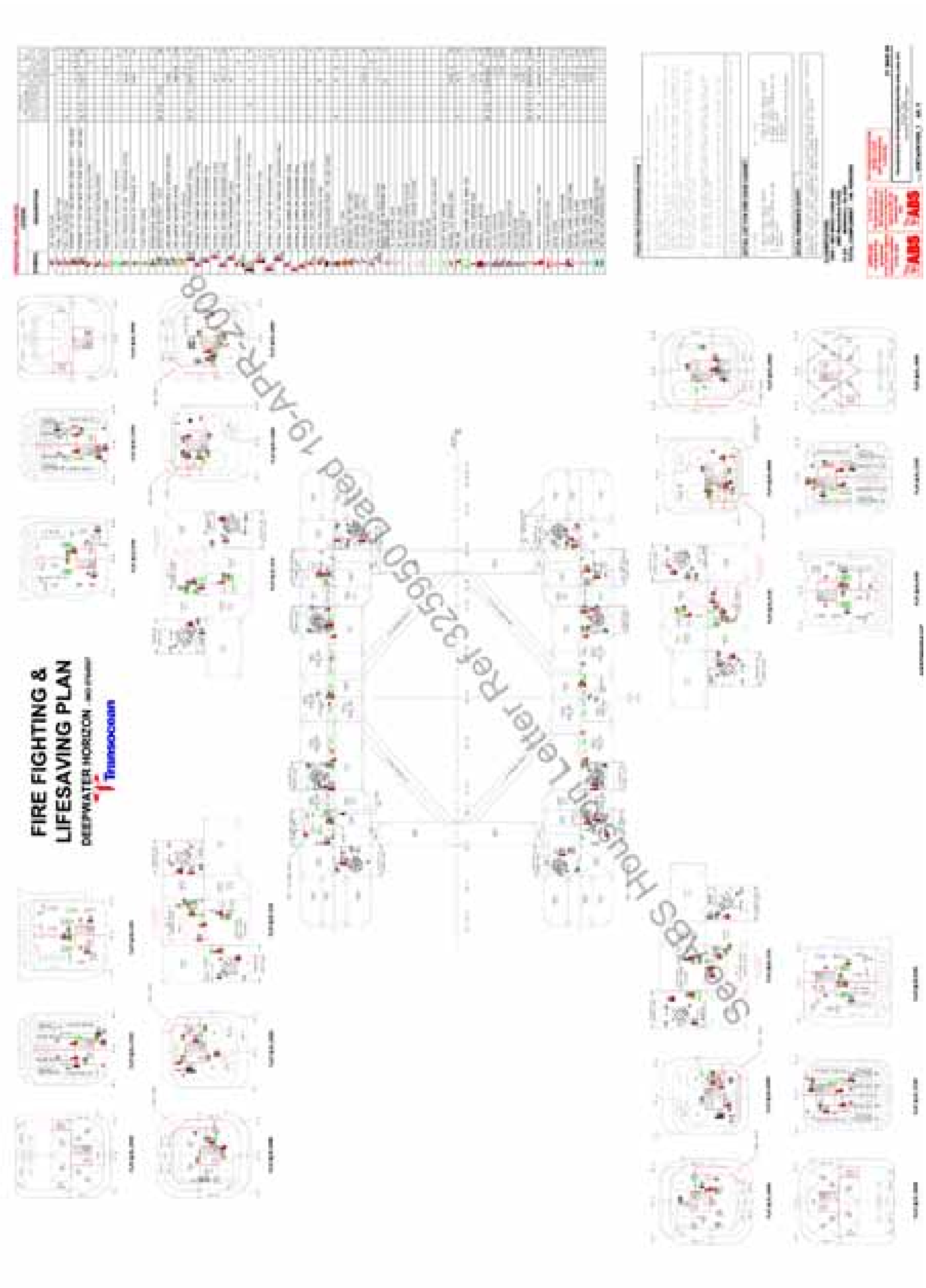
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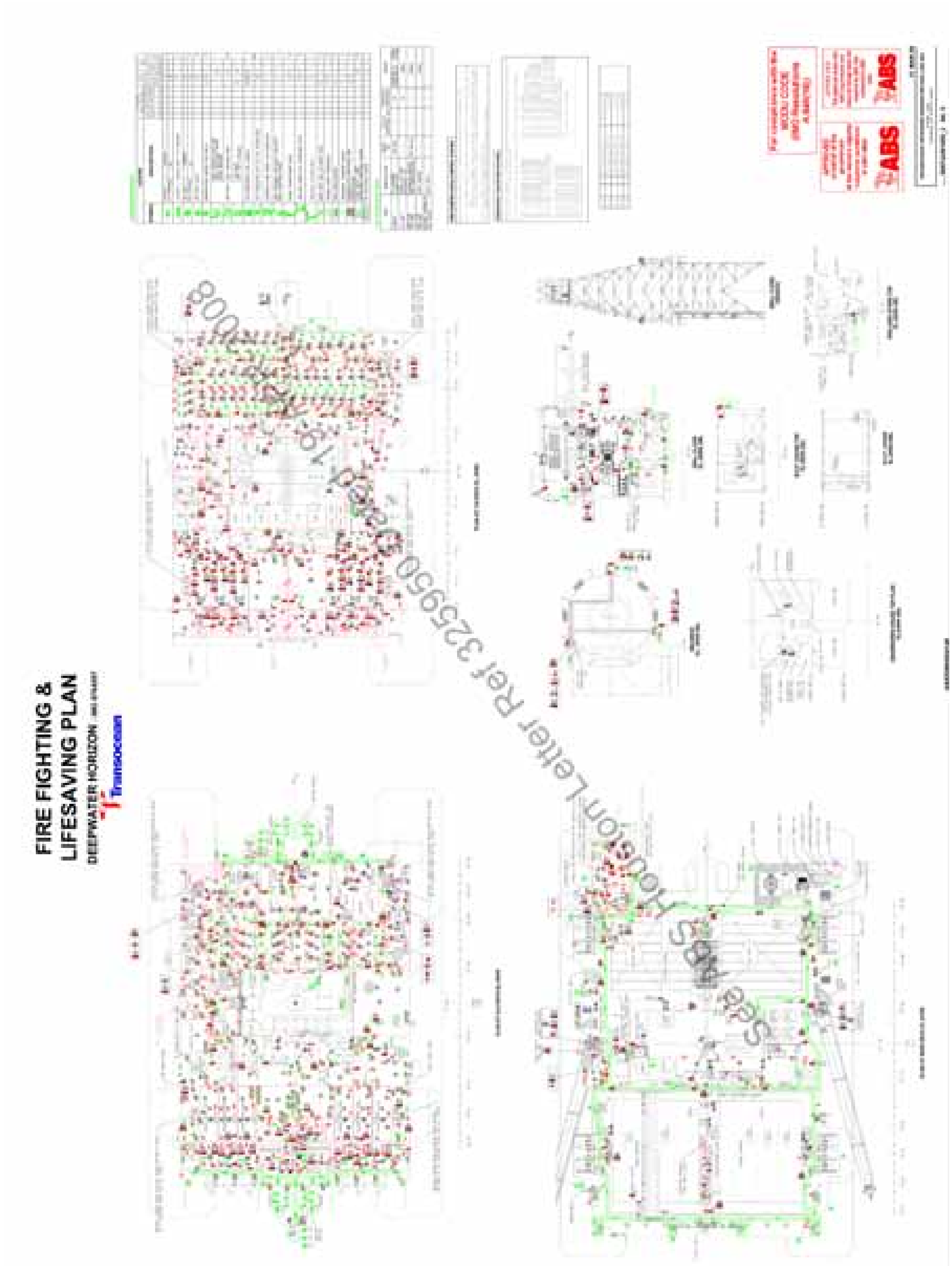
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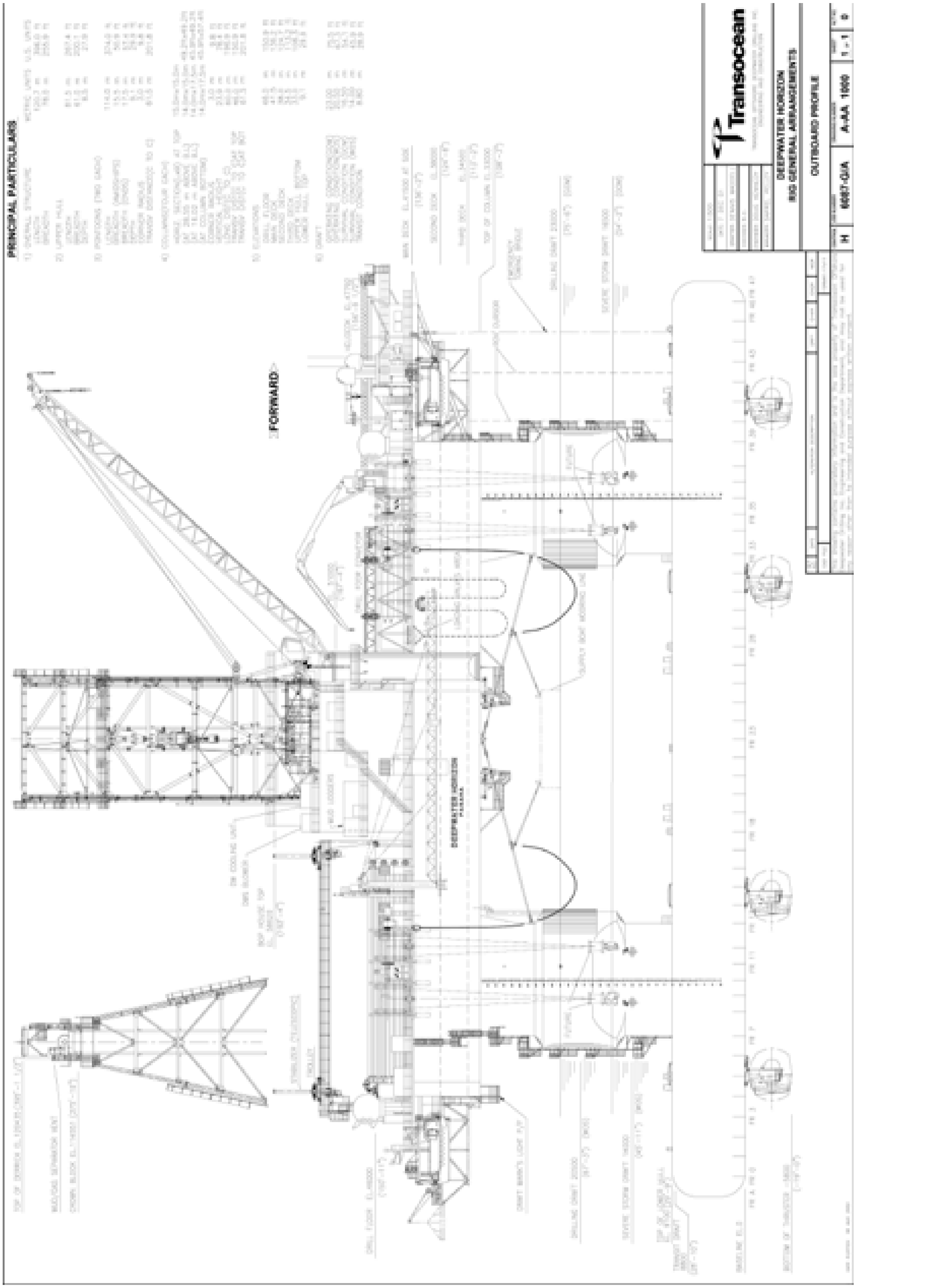
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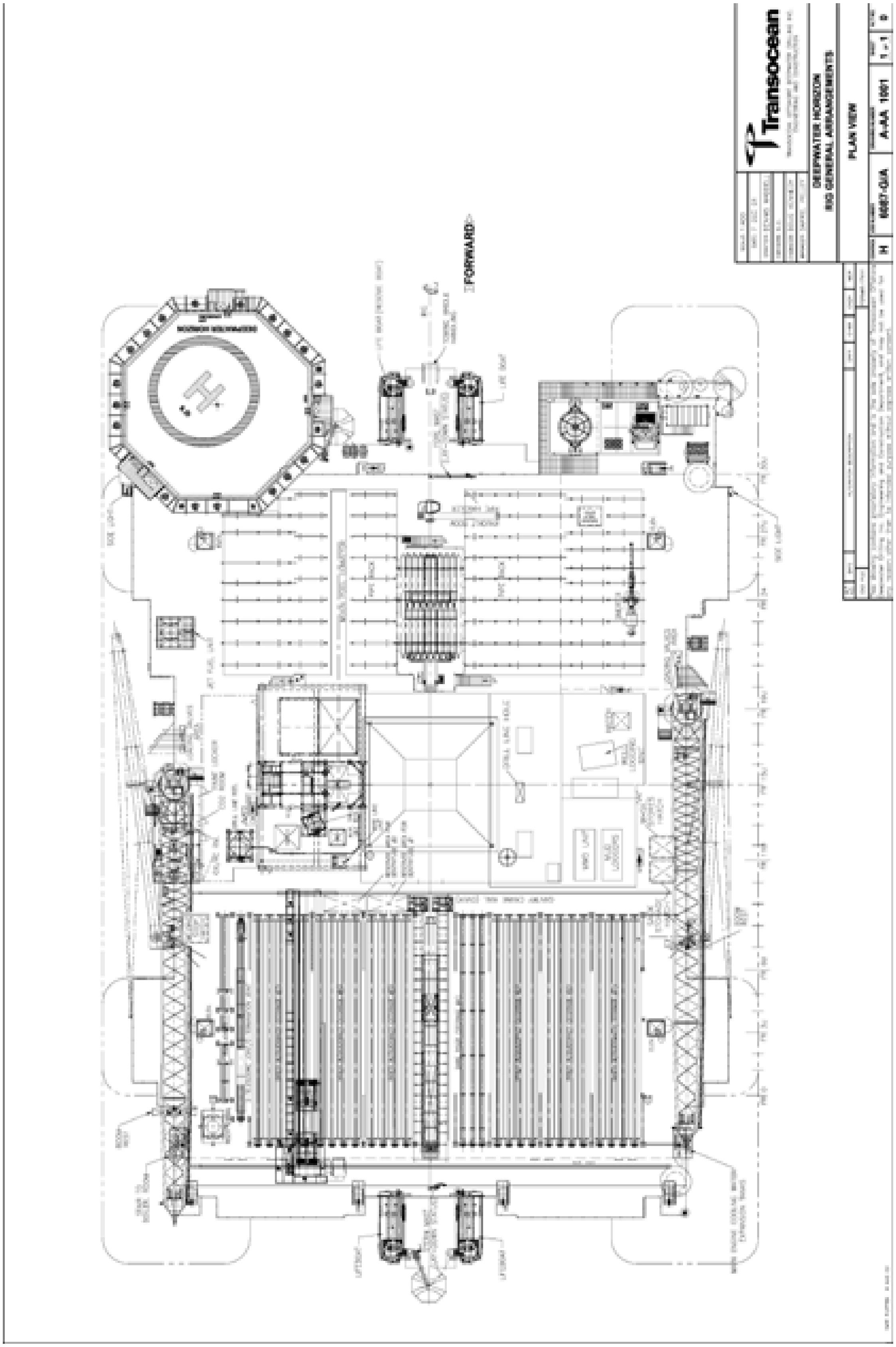
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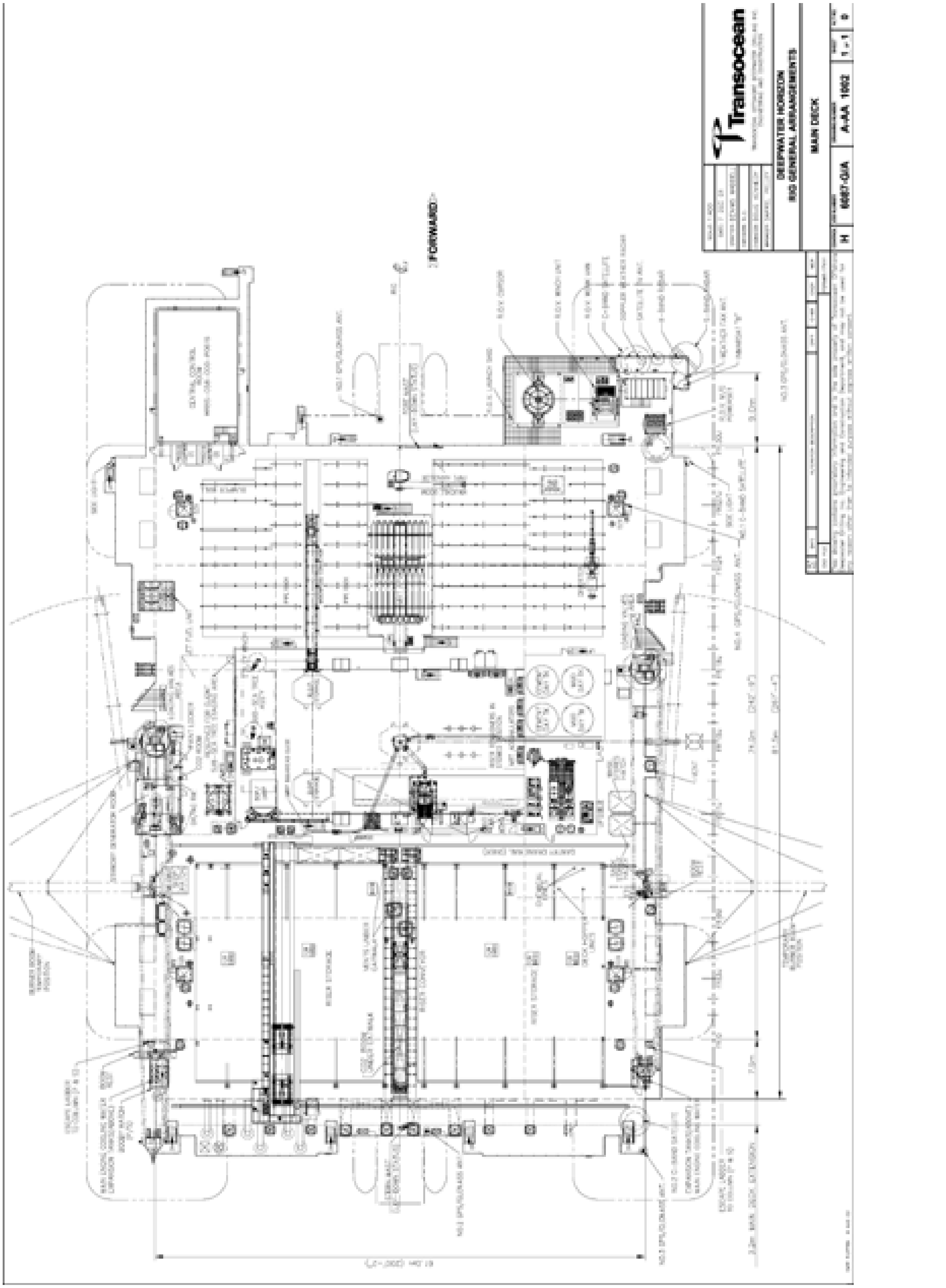
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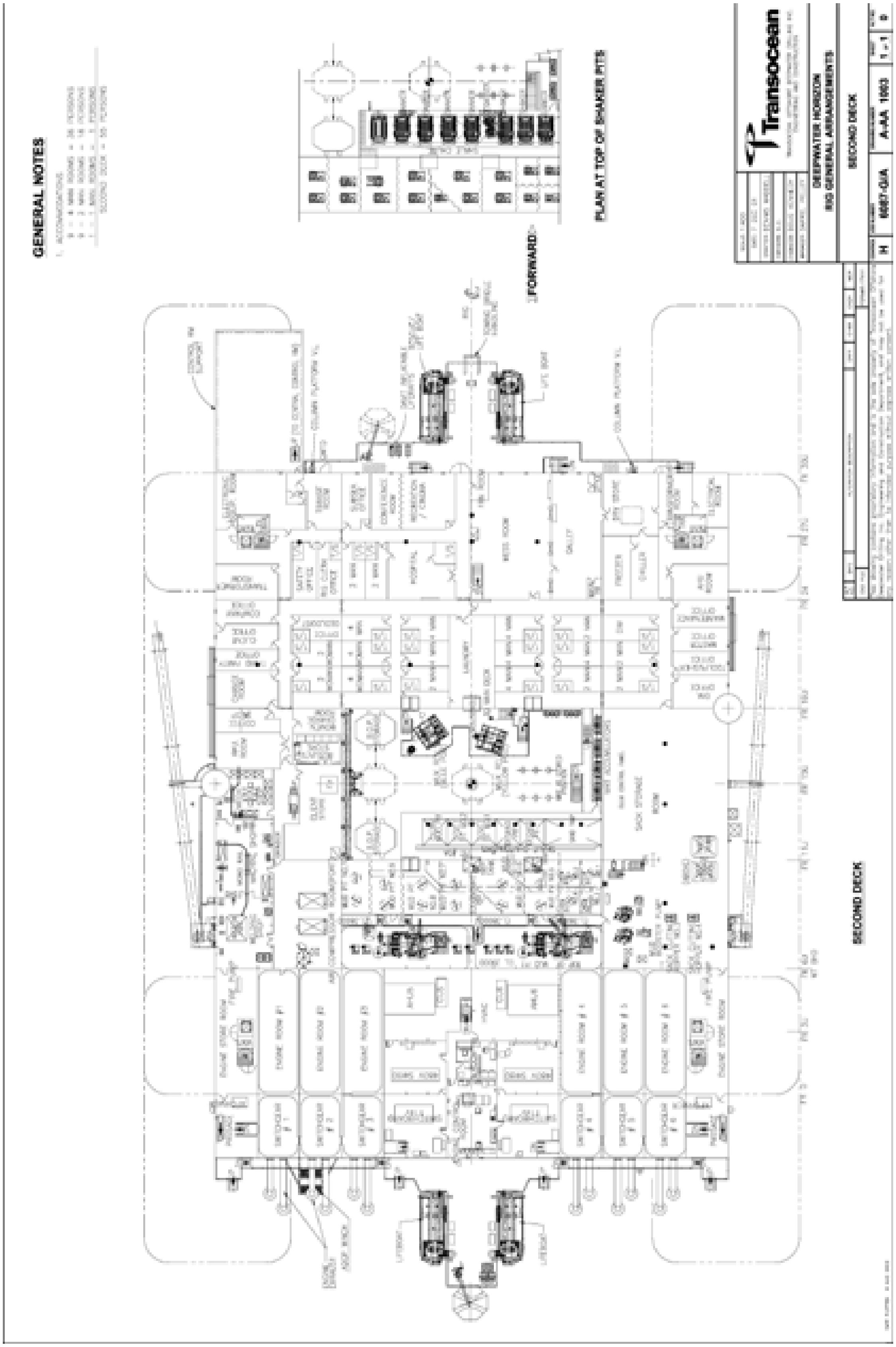
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FORWARD
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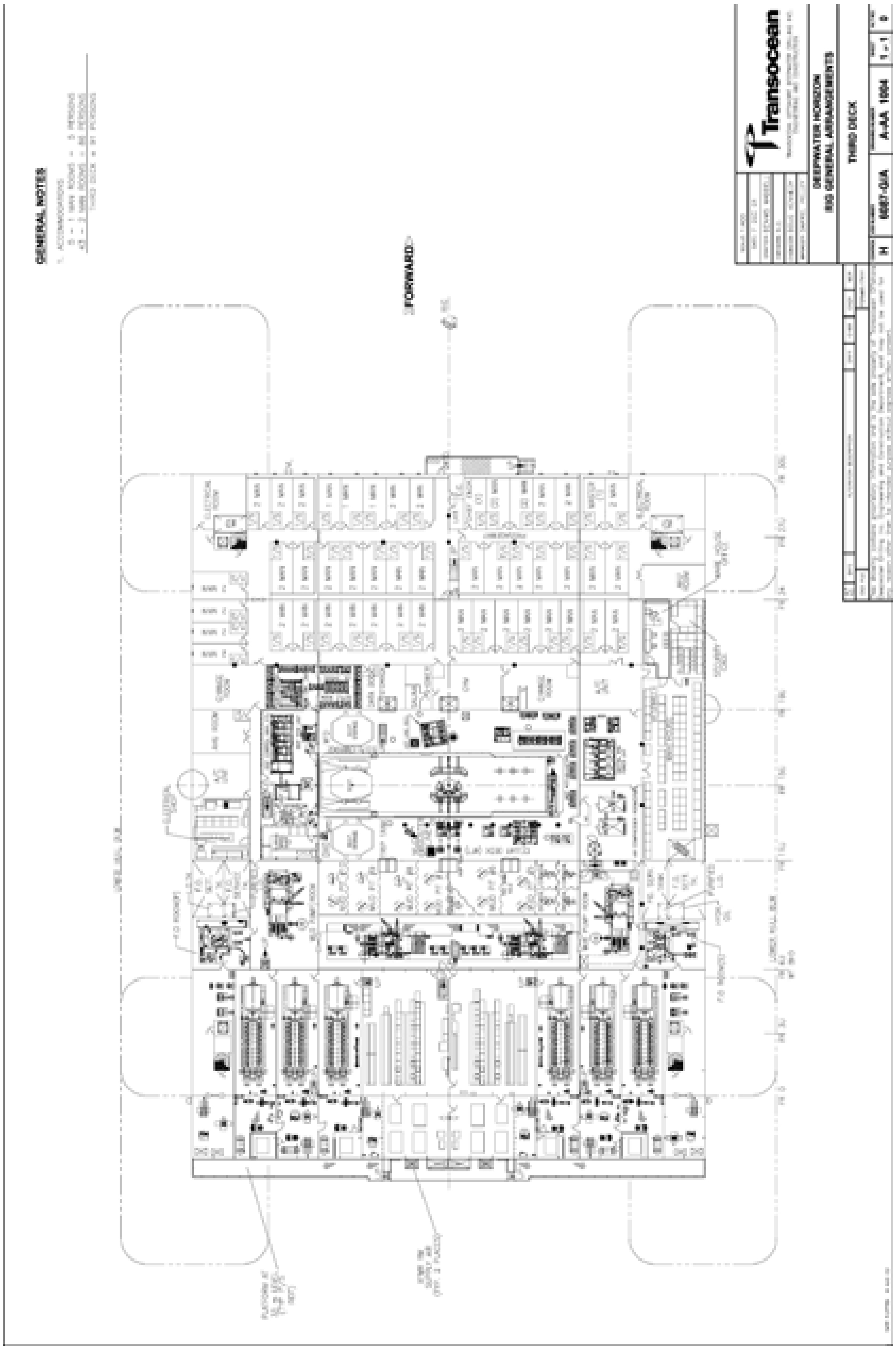
DEEPWATER HORIZON
SECOND DECK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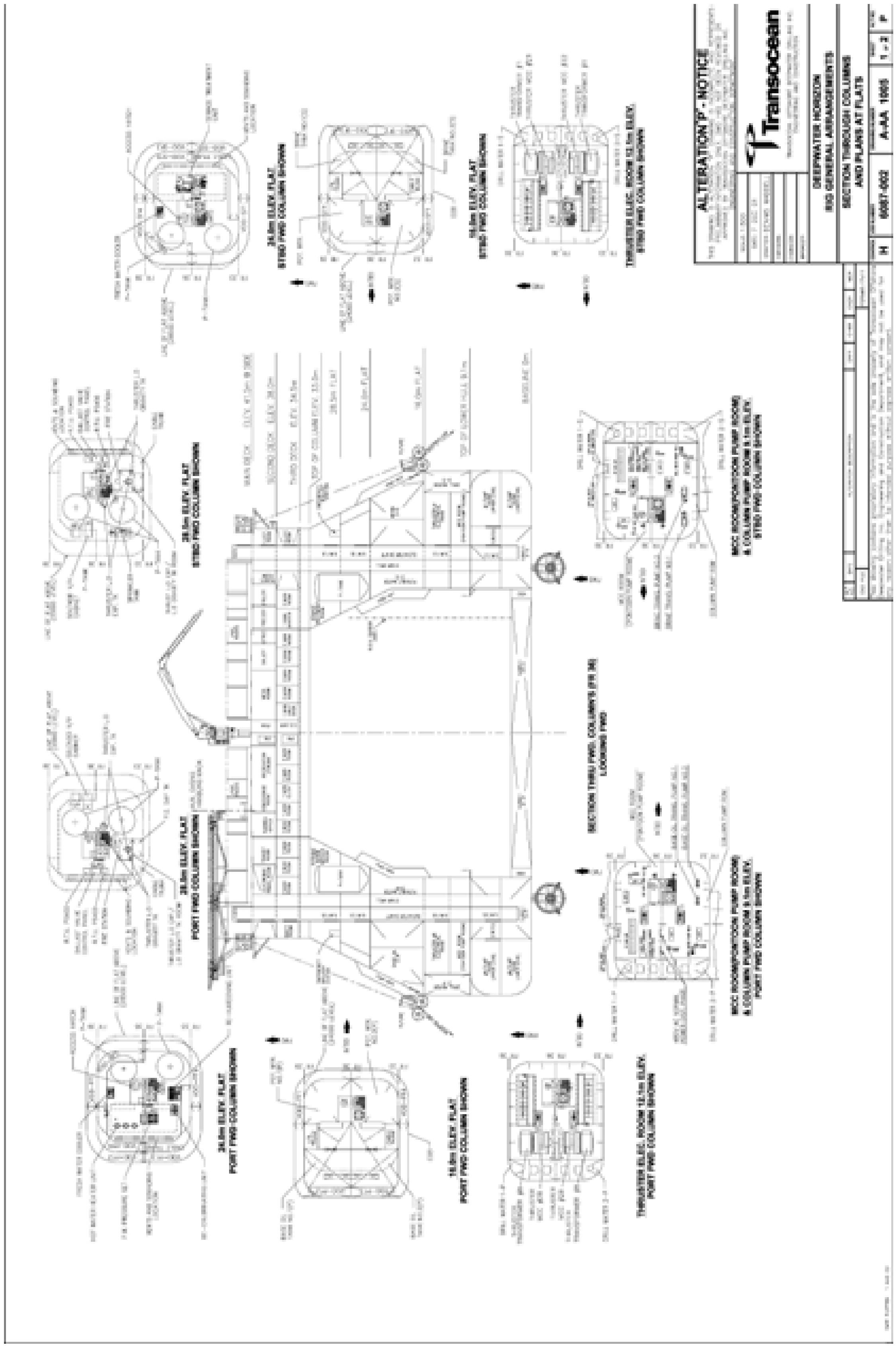
THIRD DECK
A-AA 1004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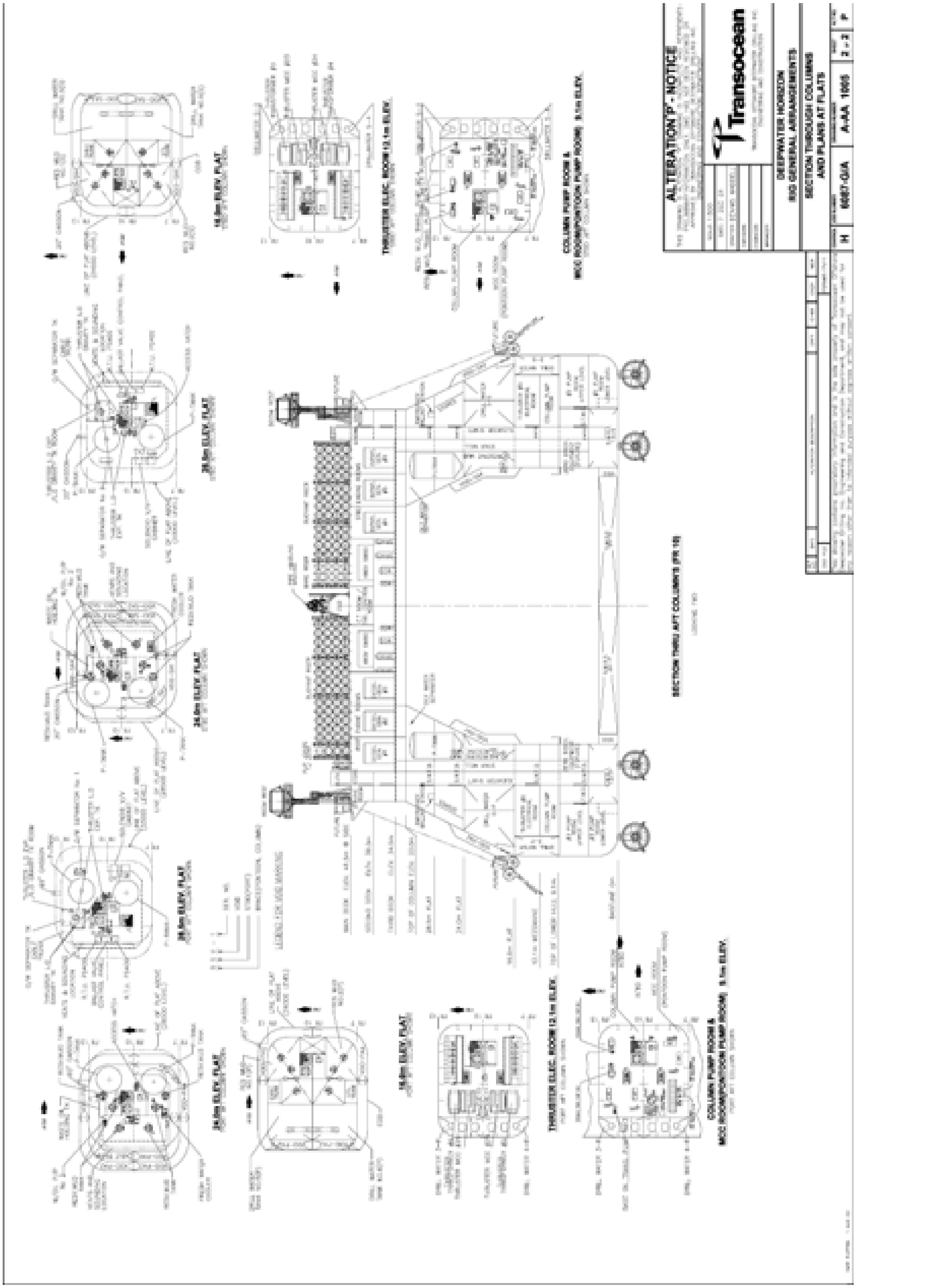
SECTION THRU FWD COLUMN'S (FR 36) LOOKING FWD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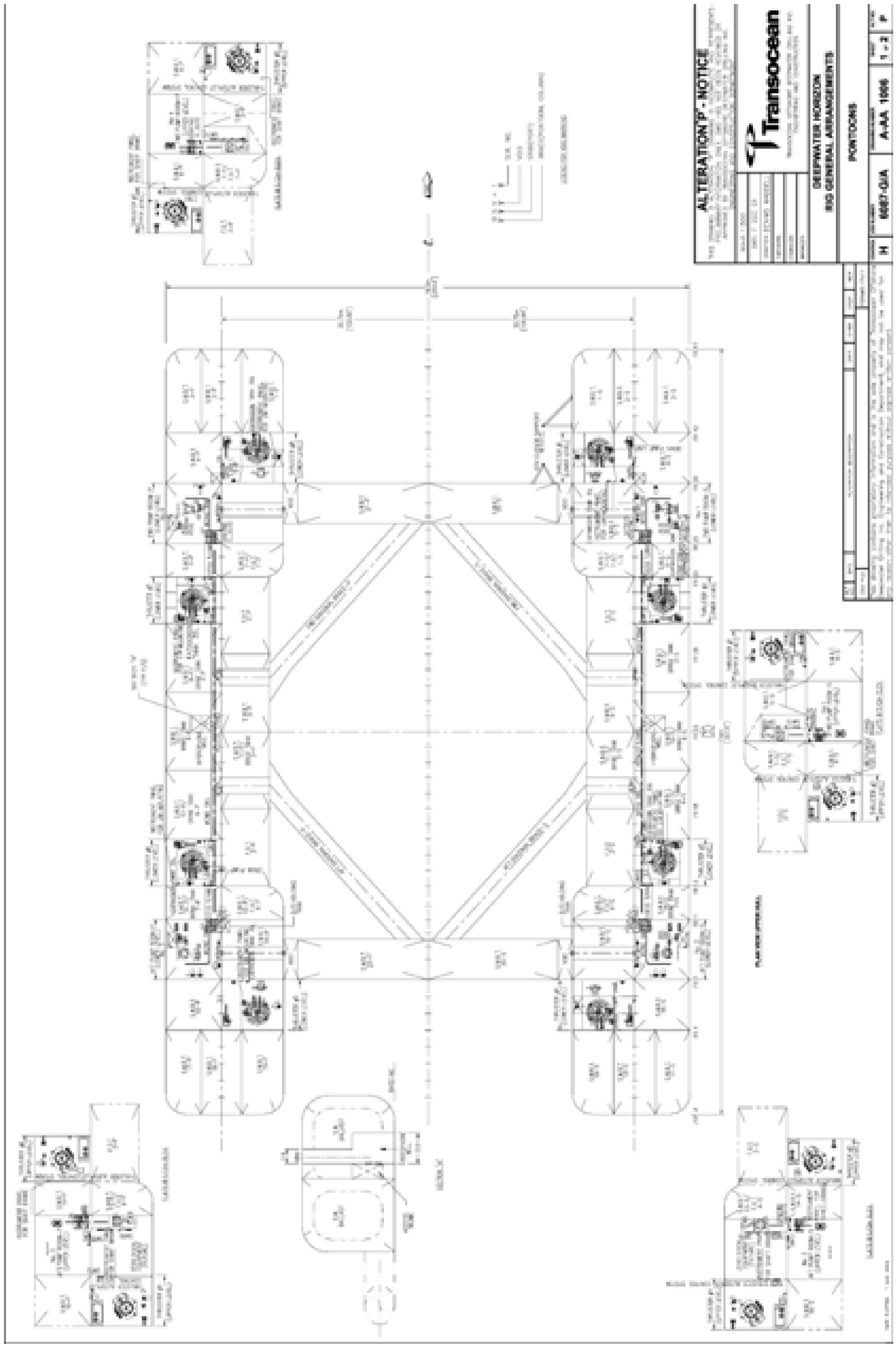
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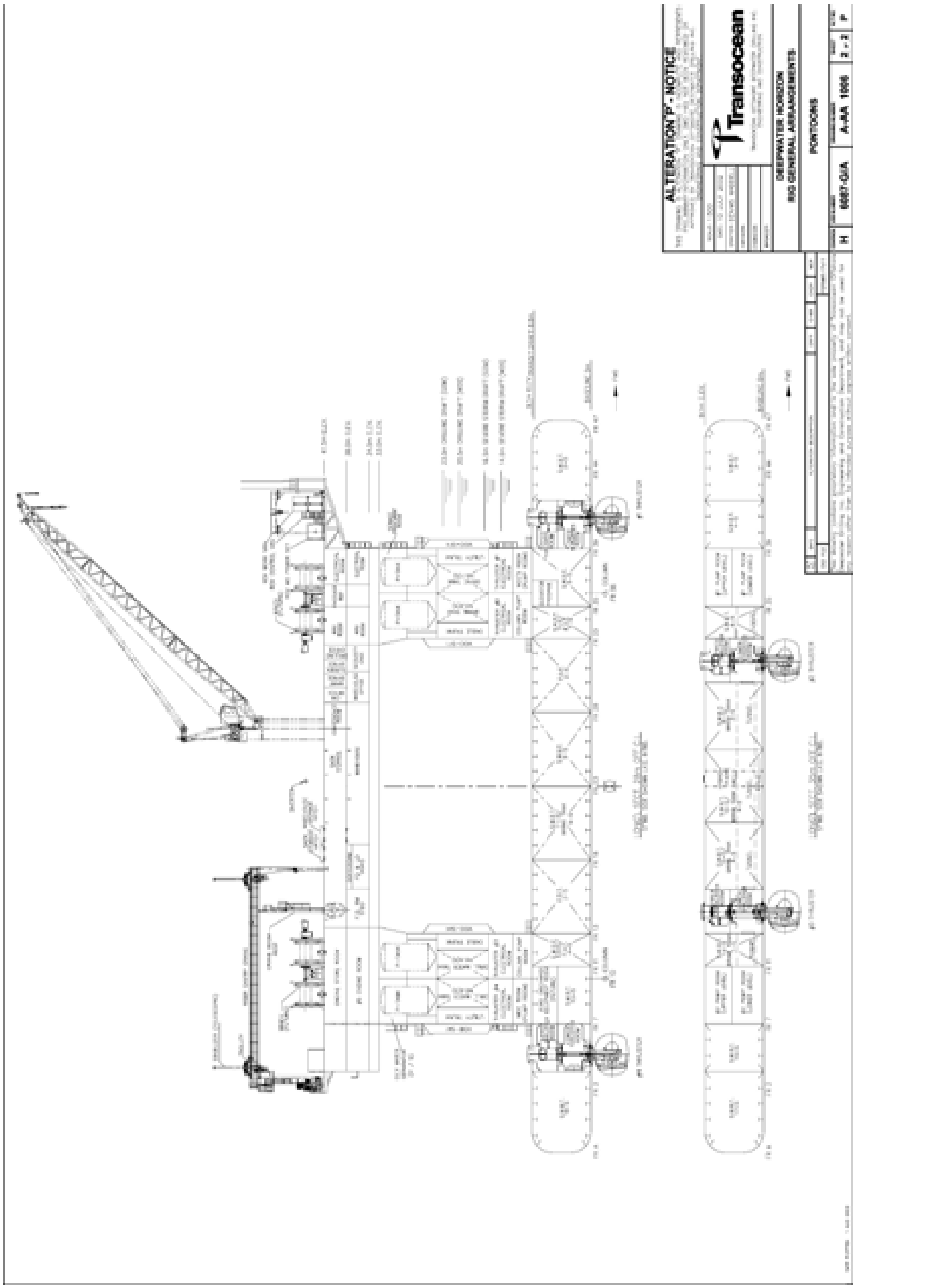
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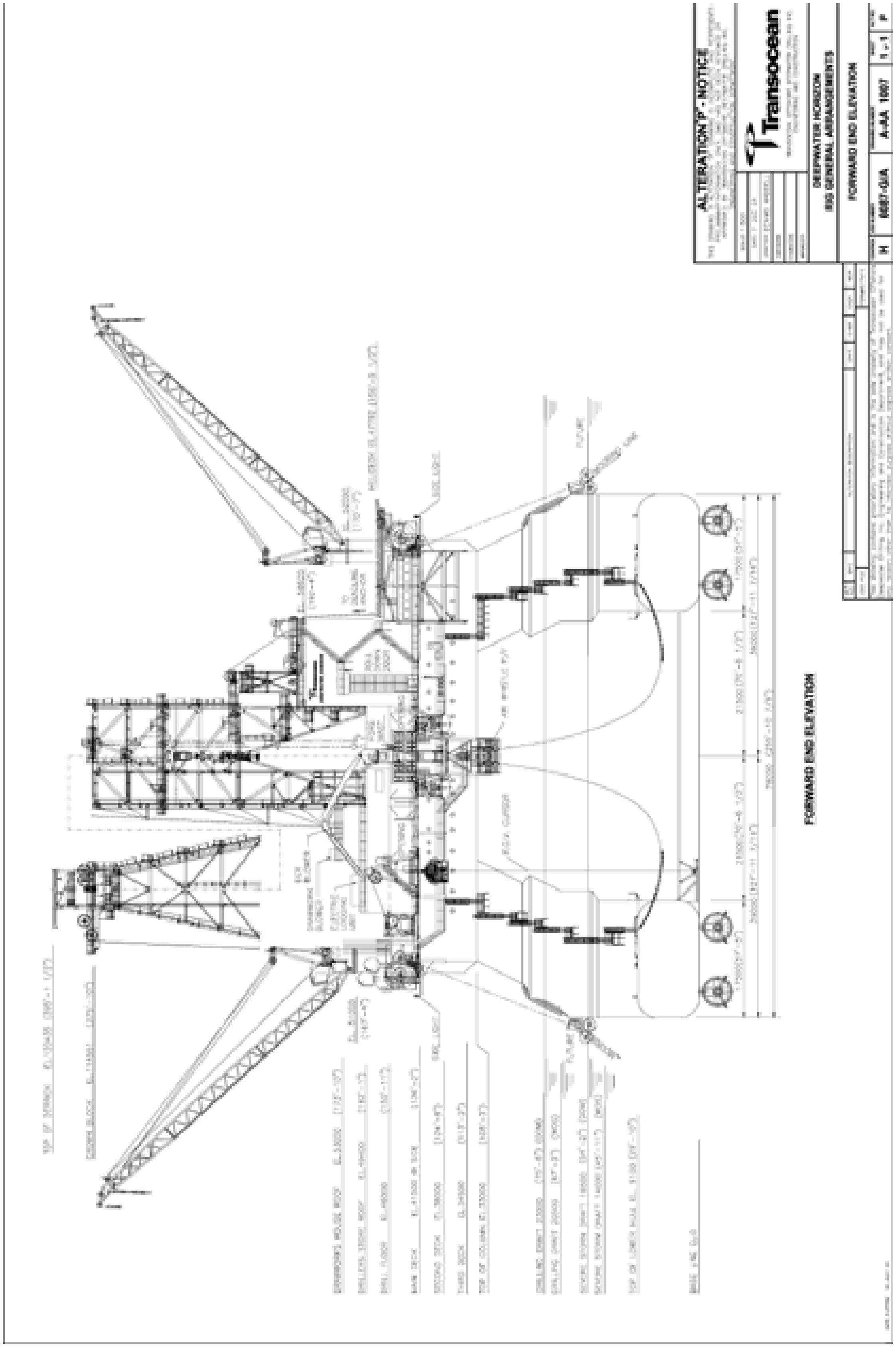
PONTOONS
6687-GA
A-AA 1006
2 of 2
P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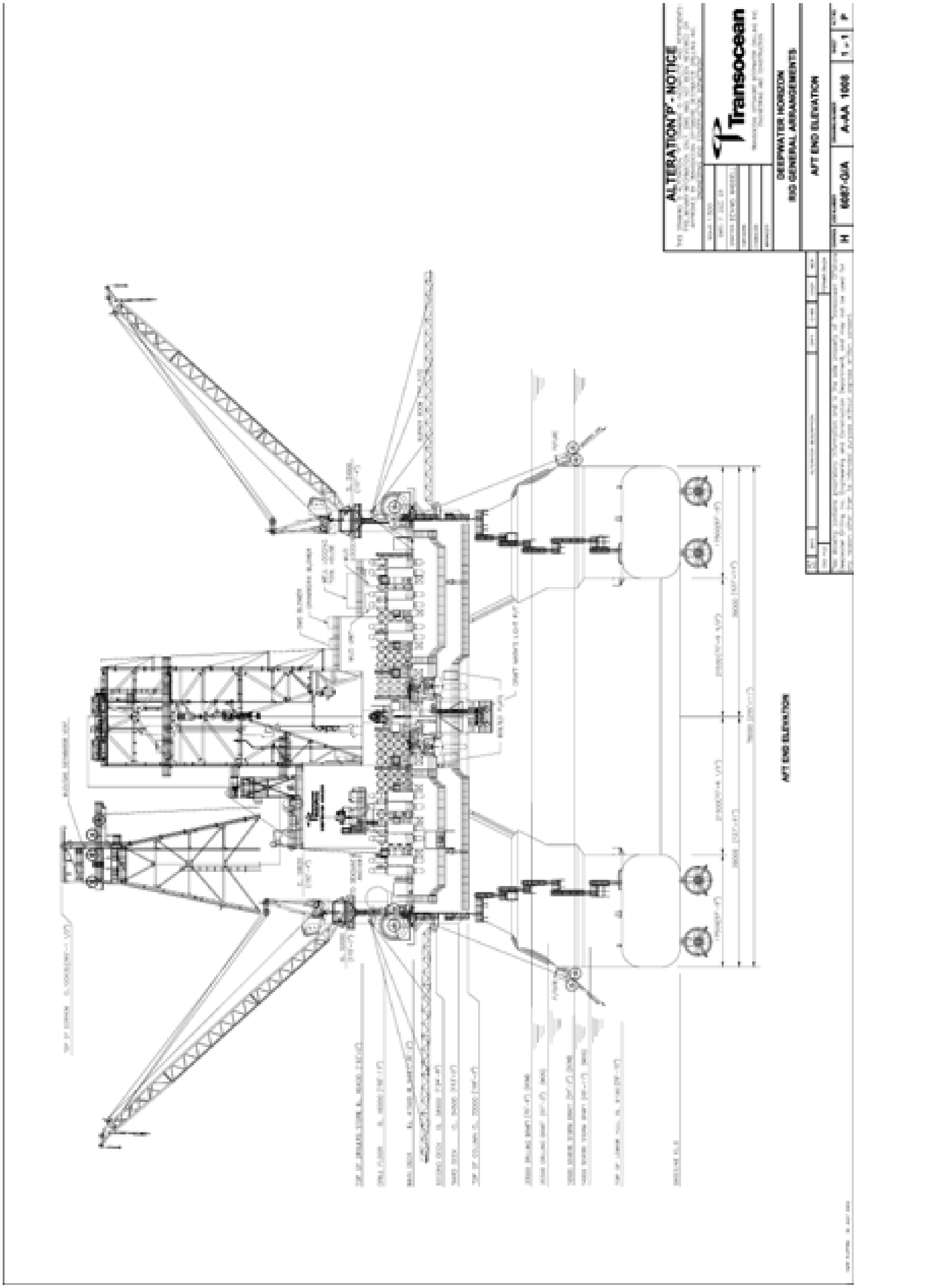
DEEPWATER HORIZON
RIG GENERAL ARRANGEMENTS
FORWARD END ELEVATION
FORWARD END ELEVATION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RIG GENERAL ARRANGEMENTS
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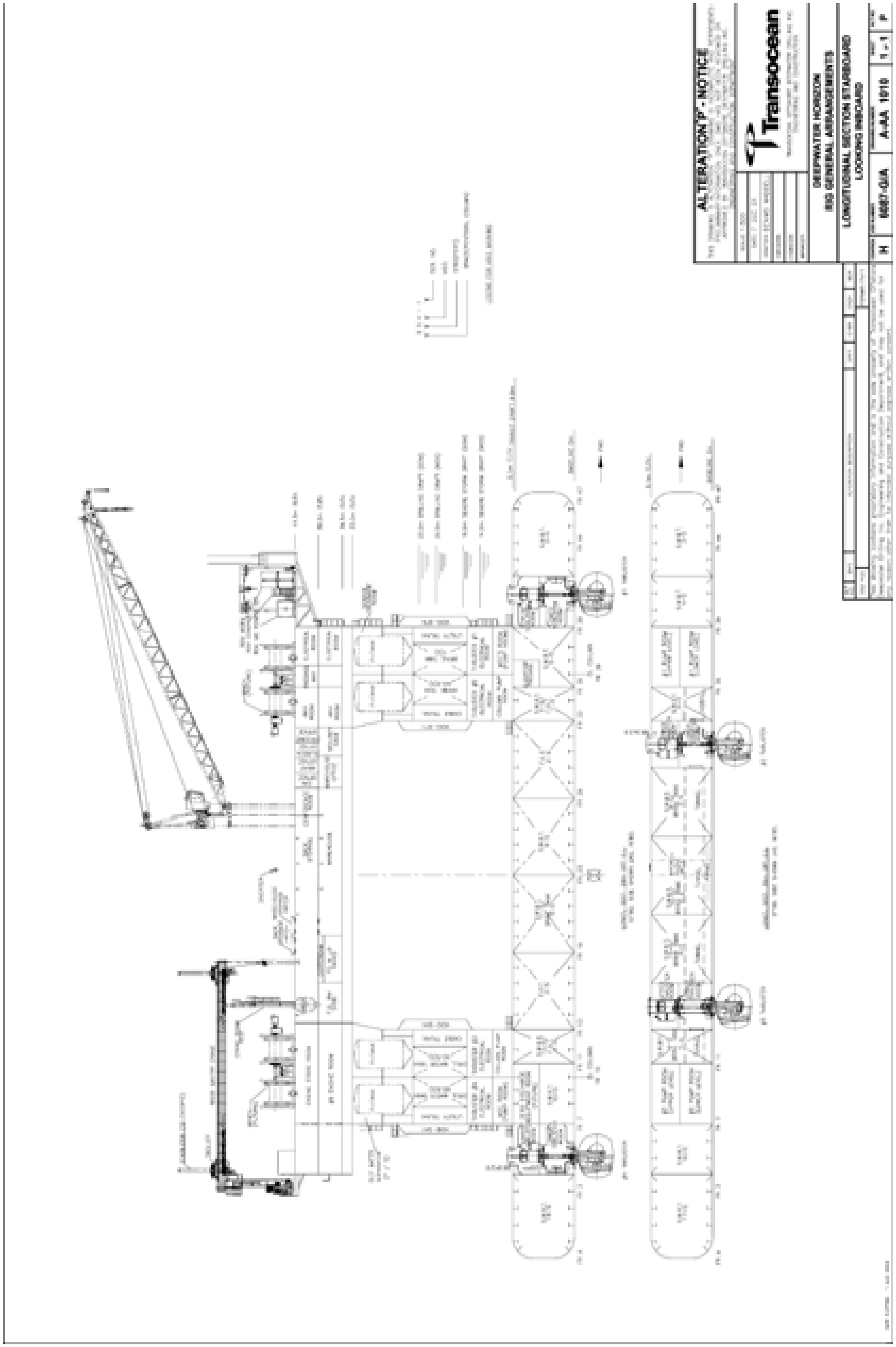
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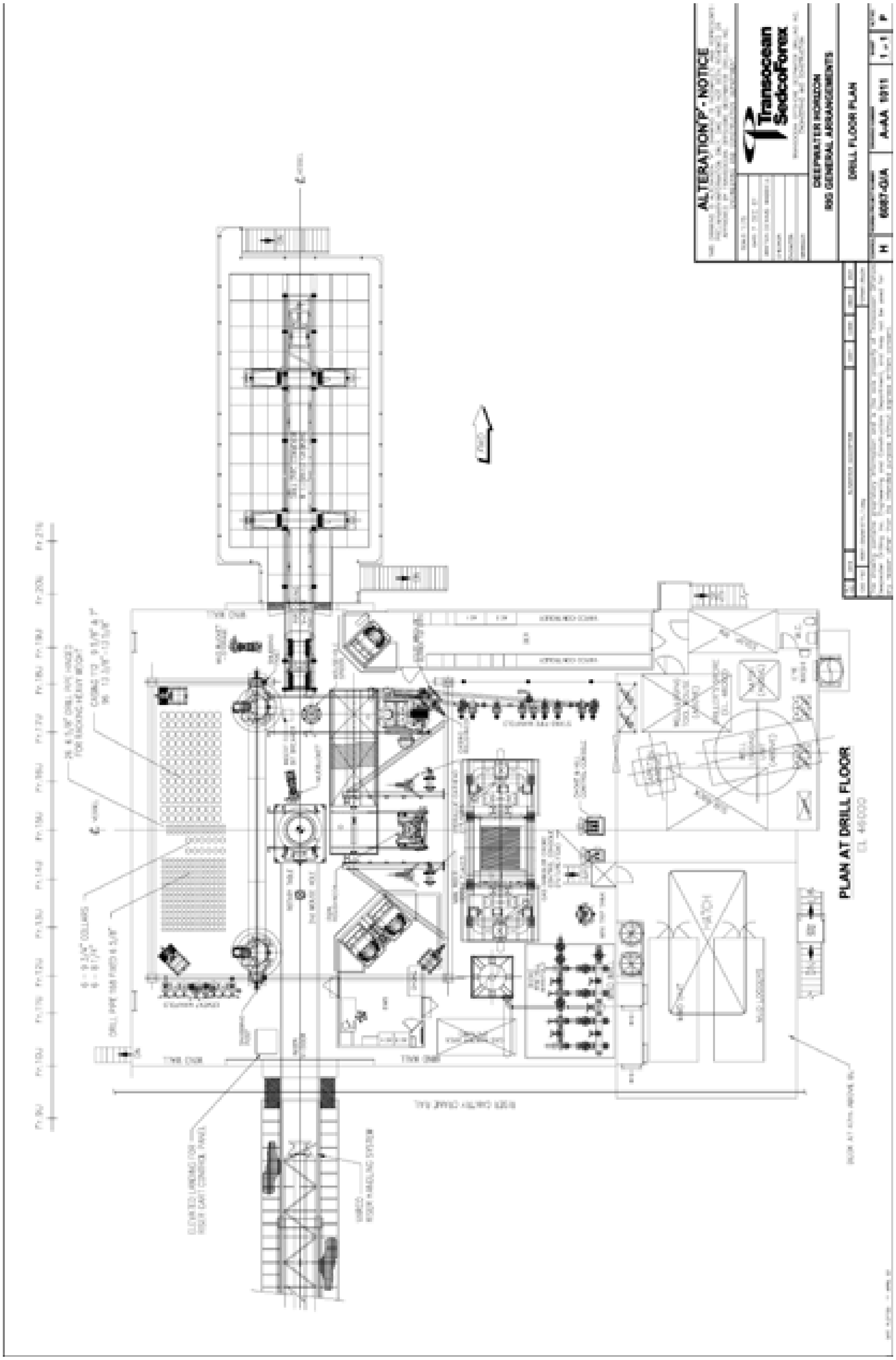
6687-GIA
A-AA 1010


ALTERATION 'P' - NOTICE
Transocean SedcoForex
DEEPWATER HORIZON
RIG GENERAL ARRANGEMENTS
DRILL FLOOR PLAN
PLAN AT DRILL FLOOR

ANNEX I: Crew List

Full Name	Position	Company
Benton, Oleander	Baker	Art Catering
Davis, Matthew	BR	Art Catering
Dolliole, Brian	Utility Hand	Art Catering
Eugene, Kevin	Steward	Art Catering
Hearn, Robert	Baker	Art Catering
Jones, Brad	Galley Hand	Art Catering
Lynch, Phillip (Bill)	Cook	Art Catering
Reed, Darrell	Galley Hand	Art Catering
Roberts, Kenneth	BR	Art Catering
Stevens, Virginia	Laundry	Art Catering
Ussin, Dominic	BR	Art Catering
Walker, Paula	Laundry - Days	Art Catering
Washington, Lonnie	Galley Hand	Art Catering
Young, Robert	Steward	Art Catering
Albers, Shane	Subsea Engineer	BP
Kaluza, Robert (Bob)	Well Site Leader	BP
Lambert, Lee	Well Site Trainee	BP
O'Bryan, Pat	Vice President Drilling and Completions Operations Manager, Gulf of Mexico, Deepwater	BP
Sims, David	Drilling and Completion Operations Manager	BP
Skidmore, Ross	Well Supervisor	BP
Tippetts, Brad	Field Engineer	BP
Vidrine, Donald	Company Man	BP
Credeur, Charles	Service Technician	Dril-Quip
Wilson, James	Dispatcher/Clerk	EPS
Haire, Christopher	Cementer	Halliburton
Tabler, Vincent	Cementer	Halliburton
Splawn, Robert	Coordinator	Hamilton Engineering
Jones, Gordon*	Mud Engineer	M-I Swaco
Lindner, Leo	Mud Engineer	M-I Swaco

Full Name	Position	Company
Manuel, Blair*	Mud Engineer	M-I Swaco
Meche, Greg	Mud Engineer	M-I Swaco
Quebedeaux, John T.	Mud Engineer	M-I Swaco
Benton, Tyrone	ROV Technician	Oceaneering
Costello, Darren A.	ROV Technician	Oceaneering
Ireland, Frank	ROV Technician	Oceaneering
Faulk, Shane D.	Technician	OCS
Guillory, Brett W.	Tank Cleaner	OCS
Kritzer, Joshua C. (Josh)	Tank Cleaner	OCS
LaCroix, Benjamin	Tank Cleaner	OCS
Lambert, Heath J.	Tank Cleaner	OCS
Lavergne, Carl	Supervisor	OCS
Richard, Coby J.	Tank Cleaner	OCS
Senegal, Kevin	Service Technician	OCS
Keith, Joseph	Mudlogger	Sperry Sun
Willis, Cathleenia M.	Mudlogger	Sperry Sun
Anderson, Jason Christopher*	Tool Pusher	Transocean
Anderson, Joseph Luke	Roustabout	Transocean
Barron III, Daniel Clark	Floorhand	Transocean
Bertone, Stephen Ray	Chief Engineer	Transocean
Breland, Craig Michael	Crane Operator	Transocean
Brown, Douglas Harold	Chief Mechanic	Transocean
Burgess, Micah Brandon	Driller	Transocean
Burkeen, Aaron Dale*	Crane Operator	Transocean
Burrell, Michael Wayne	Able Bodied Seaman	Transocean
Carden Jr., Stanley Neil	Electrical/Electronic	Transocean
Choy, Christopher Kegan	Roustabout	Transocean
Clark, Donald Neal*	Assistant Driller	Transocean
Cochran, Charles Harold	Chief Mechanic	Transocean
Cola, Kennedy	Roustabout	Transocean
Cole, Thomas	Roustabout	Transocean

Full Name	Position	Company
Cooley, Jason Eric	Chief Electrician	Transocean
Coon, Billy Ray	Able Bodied Seaman	Transocean
Crawford, Truitt Douglas	Roustabout	Transocean
Curtis, Stephen Ray*	Assistant Driller	Transocean
Davis, Stephen Todd	Welder	Transocean
Estrada, Eric R.	Subsea Trainee	Transocean
Evans III, Joseph B.	Materials Coordinator	Transocean
Ezell, Miles Randall	Senior Tool Pusher	Transocean
Fleytas, Andrea Anasette	Dynamic Positioning Officer	Transocean
Francis, Bill Scott	Medic	Transocean
Glendenning, Michael	Mechanic	Transocean
Graham, Anthony G.	Floorhand	Transocean
Hadaway, Troy James	Rig Safety & Training	Transocean
Harrell, Jimmy Wayne	Offshore Installation Manager	Transocean
Hay, Mark David	Senior Subsea Supervisor (Mux)	Transocean
Holloway, Caleb Chase	Floorhand	Transocean
Hughes, Matthew	Floorhand	Transocean
Ingram, James Guyton	Senior Materials Coordinator	Transocean
Isaac, Jerry Wayne	Mechanical Supervisor	Transocean
Jacobs, Matthew Seth	Roustabout	Transocean
Jernigan, William Harold	Chief Mechanic	Transocean
Johnson, Dustin Delane	Roustabout	Transocean
Johnson, William Patrick	Deckpusher	Transocean
Jones, Cole Tyler	Roustabout	Transocean
Kemp, Roy Wyatt*	Derrickhand	Transocean
Keplinger, Yancy J.	Senior Dynamic Positioning Officer	Transocean
Kersey, Jonathan Daniel	Floorhand	Transocean
Kleppinger, Karl Dale*	Floorhand	Transocean
Kuchta, Curt Robert	Master	Transocean
Mansfield, James Brent	1st Assistant Marine	Transocean
Martinez, Dennis	Deckpusher	Transocean

Full Name	Position	Company
Mayfield, Mike I.	Senior Dynamic Positioning Officer	Transocean
Meinhart, Paul James	Motor Operator	Transocean
Morales, Heber	Roustabout	Transocean
Morgan, Patrick Kevin	Assistant Driller	Transocean
Moss, Eugene D.	Crane Operator	Transocean
Murray, Chad Lee	Chief Electrician	Transocean
Nunley, Mark James	Floorhand	Transocean
Oldham, Jarod Richard	3rd Assistant Marine	Transocean
Petty, Alonzo	Derrickhand	Transocean
Pigg Jr, Samuel Wade	Roustabout	Transocean
Pitts, Jerry Matthew	Floorhand	Transocean
Pleasant, Christopher	Subsea Supervisor	Transocean
Ramos, Carlos Antonio	Roustabout	Transocean
Revette, Dewey*	Driller	Transocean
Rhodes, Karl Wesley	Pumphand	Transocean
Richards, Steven R.	Bosun	Transocean
Roark, Stenson Randal	Electronic Technician	Transocean
Roshto, Shane Michael*	Floorhand	Transocean
Rupinski, Darin Stanley	Dynamic Positioning Officer	Transocean
Sandell, Micah Joesph	Crane Operator	Transocean
Sellers, Terry Lee	Motor Operator	Transocean
Seraile, Allen J.	Assistant Driller	Transocean
Stone, Stephen L	Roustabout	Transocean
Stoner, William Wilton	Motor Operator	Transocean
Taylor, Carl Barrett	Radio Operator	Transocean
Terrell II, William Lewis	Chief Electronic Technician	Transocean
Trahan, Buddy Joseph	Division Manager Assets	Transocean
Watson, Nickalus	Roustabout	Transocean
Weise, Adam Taylor*	Floorhand	Transocean
Wheeler, Wyman W.	Tool Pusher	Transocean
Williams, Michael Keith	Chief Electronic Technician	Transocean

Full Name	Position	Company
Winslow, Daun C.	Division Manager	Transocean
Young, David William	Chief Mate	Transocean
Boullion, Brandon Keith	Technician	Weatherford
John, Lance M.	Rig System Specialist	Weatherford

* *Presumed deceased in the casualty*

ANNEX J: Table of Testimony Regarding Change of Command

Hearing Date	Name	Position	Transcript Citation	Key Testimony
5/27/10	Jimmy Harrell	Transocean, Offshore Installation Manager	148:13-149:5	"Well it didn't really matter. Like I say, the captain, he's in charge during an emergency. But that's something we always – I mean, we work together, but I do turn it over to him."
5/27/10	David Young	Transocean, Chief Mate	302:19-25	"The OIM is in charge while connected and the captain would be in charge of the emergency situation."
5/27/10	Captain Curt Kuchta	Transocean, Master	211:9-212:17	"Q: Now, you say that when Captain Wheatley asked you about a handoff between the OIM and the master . . . How do they [the mixed crew] know who is in charge at any time on the vessel? . . . A: It's pretty well understood amongst the crew who's in charge."
7/19/10	Stephen Bertone	Transocean, Chief Engineer	162:17-163:12; 167:815	"Q: When you went to the bridge – before you went to the bridge, who in your opinion, was in charge of the vessel? A: When the rig is not underway, the OIM is in charge. When the rig is underway, the Captain is in charge." "The Captain is second in charge in the event that the OIM is not present or is injured."
8/23/10	Daun Winslow	Transocean, Division Manager	478:7-14	"I think the first explosion or bang on the rig, it would be quite clear that the master would be in charge of the vessel during an emergency, fire."
8/24/10	Daun Winslow	Transocean, Division Manager	76:7-14	"Q: During any of your time on the DEEPWATER HORIZON on April 20th, did you see any confusion or uncertainty regarding who was in command of that vessel? A: No, sir."
8/26/10	David Sims	BP, Drilling and Completion Operations Manager	172:5-15;	"No I did not. That was – that's not something that I recall wondering or being concerned about whether the captain or the OIM was in charge."

Hearing Date	Name	Position	Transcript Citation	Key Testimony
8/26/10	David Sims	BP, Drilling and Completion Operations Manager	336:7-337:25	"My understanding and what I have always thought is that the OIM, Mr. Harrell, while the rig was attached to the bottom was THE lead Transocean employee. That was why I made the comment if Jimmy had been there we were still attached to the bottom and I just would have looked to him to be the lead Transocean person."
8/26/10	Patrick O'Bryan	BP, Vice President Drilling and Completions Operations Manager, Gulf of Mexico, Deepwater	393:12-394:8; 452:13-454:3	"The OIM was in charge of the operations going on. And my understanding was that the captain was in charge of the BP operations and what not going on on bridge" "I couldn't tell you if I noticed a shift. All I know is when everything was going on he [the captain] asked permission to EDS. It happened. And then about that time is when I was told that we needed to go 'cause everybody was going to the boats. And about the time that we walked out is when he said abandon ship, captain."
10/5/10	Andrea Fleytas	Transocean, Dynamic Positioning Officer	21:24-23:16; 34:4-16	"When the explosion happened, that's when I feel the captain was in charge . . . With my training I have been trained that my chain of command goes to the captain." "Q: So after the explosion the master of the vessel should be in command of the vessel; is that correct? A: Yes."
10/5/10	Yancy Keplinger	Transocean, Senior Dynamic Positioning Officer	164:4-167:4; 265:17-266:7	"Q: Was that transfer of authority logged or communicated to the crew in any way? A: No. It's understood. . . . The crew understood that in a emergency situation, the captain is in control." "Q: Everybody knew aboard that rig, sir, that the captain was in charge in the event of an emergency; is that right? A: Yes, it's understood."
12/7/10	Michael Wright	Transocean, CDO	194:14-23;	"No. There was no confusion from the response team as to who was in charge."

Hearing Date	Name	Position	Transcript Citation	Key Testimony
12/7/10	Michael Wright	Transocean, CDO	253:4-254:13	"Q: And based on the information you received through Mr. Winslow, did you have any doubt at that point . . . as to who was in charge . . . ? A: No. Once we knew the status of the people if they were injured, then we had no doubt. Q: Who was that? A: It was the captain."
12/9/10	Jerry Canducci	Transocean, ISM Manager	93:3-22;	"My opinion of the captain's demeanor is that he was very direct and organized and getting information from crew . . . It leads me to believe that the captain was in control and in charge. Q: All right. . . [D]o you have any impression or any doubts as to who was in charge out there that night? A: I do not."
			102:2-104:20	"The master's authority has never been in question . . .The master has overriding authority, especially with issues regarding the safety of the people, the vessel and the environment."