OCS Report
MMS 2006-058

Investigation of Riser Disconnect and Spill Green Canyon Block 652 OCS-G 21810 July 5, 2005

Gulf of Mexico
Off the Louisiana Coast

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U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Regional Office

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Glenn Woltman
Dr. Charles Smith

U.S. Department of the Interior
Minerals Management Service
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New Orleans
August 2006

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Investigation and Report

Authority

On July 5, 2005, at approximately 1200 hours, an unplanned riser disconnect occurred on the Ensco (hereinafter referred to as "Contractor" or "Ensco") semi-submersible drilling unit 7500 (hereinafter referred to as the "Rig"), resulting in the release of 710 barrels of synthetic-based mud. The incident occurred on Anadarko Petroleum's (hereinafter referred to as "Operator" or "Anadarko") Lease OCS-G 21810, Green Canyon Block 652, in the Gulf of Mexico (GOM), offshore the State of Louisiana.

Pursuant to Section 208, Subsection 22 (d), (e), and (f), of the Outer Continental Shelf (OCS) Lands Act, as amended in 1978, and Department of the Interior Regulations 30 CFR 250, Minerals Management Service (MMS) has investigated and prepared a public report of this accident. By memorandum dated July 12, 2005, the following personnel were named to the investigative panel:

Frank Pausina, Chairman – Office of Safety Management, GOM OCS Region
Glenn Woltman – Technical Assessment and Operations Support Section, GOM OCS Region
Charles Smith – Accident Investigation Board, Office of Offshore Regulatory Programs, MMS HQ

Because of an ongoing injury and his inability to participate in the investigative process, a memorandum dated June 29, 2006, released Frank Pausina from the panel.

Procedures

During the afternoon of July 5, 2005, District personnel from the Department of the Interior, Minerals Management Service (MMS) office in Houma, Louisiana, received preliminary statements on the incident from the Operator, along with the current status of recovery efforts. At that time, the rig was in a controlled drift at maximum thruster power with an easterly heading. The result of the incident was the loss of an estimated 710 barrels of synthetic mud when the riser was disconnected subsea. The well was secured with the blowout preventers closed, and all personnel on board were taken into account.

On July 6, 2005, members of the investigative panel received further information from the Operator, indicating that the rig was 3.3 miles from the well site, and that loop currents had subsided to 2.3 knots, thus allowing the rig to maintain position. On July 15, 2005, panel members requested various kinds of information and data from the Operator to prepare the panel investigation report. A second request for data was made to the Operator on August 16, 2005. Panel members attended a presentation by Anadarko to review the incident on August 22, 2005.

Interviews were scheduled with personnel from Anadarko and with the Ensco 7500 personnel during late August and September 2005 to collect information. However, because of the effects of Hurricane Katrina, the interviews were delayed, as most MMS regional personnel were placed on administrative leave until early October, and then re-located to a temporary office in Houston.

In December 2005, GOM Region, Office of Safety Management (OSM) personnel re-scheduled interviews with the Operator and various third parties. Personnel from Anadarko were interviewed on February 14, 2006, in Houston. Ensco 7500 Rig personnel were interviewed in Broussard, Louisiana, on February 23, 2006.

In addition to the interviews, other information was gathered at various times from a variety of sources. This information included the following reports, statements, and publications:

Daily Contractor Drilling Reports, May 26, 2005 – July 5, 2005;
Operator's Drilling Plan, OCS-G 21810 Well No. 2;
Operator's Application for Permit to Drill a New Well – Well No. 2;
Operator's Application for Revised New Well – Well No. 2;
Operator's written account of the incident, July 15, 2005;
United States Coast Guard Official Case Log of Incident dated July 5, 2005;
Operator's equipment and procedural changes to well plan after the incident;
MMS interviews with Operator drilling management and engineering, and operational personnel, Contractor drilling management, operational supervisors, and operational personnel;
Ensco 7500 Marine Riser Report dated January 14-24, 2004;
Ensco 7500 Marine Riser Report January 31, 2005;
Ensco 7500 Personnel Roster for May 25, 2005 – July 5, 2005;
NOAA Gulf of Mexico Buoy Data;

ABS Press Release December 6, 2000; “Delivery of Semi 'ENSCO 7500' Marks First Rig to Complete Alternate Compliance Program”; *ABS facilitates ACP on behalf of U.S. Coast Guard, creates 'one-stop shop' for rig certification.*

OTC Paper 17172, “Offshore Monitoring; Real World Data for Design, Engineering and Operation,” by Henk van den Boom, Jos Koning, Pieter Aalberts; MARIN

OTC Paper 10895, “Drilling Well Control Practices and Equipment Considerations for Deepwater Operations Plans,” by Michael E. Montgomery, WEST Hou, Inc. and Colin P. Leach, Well Control & Systems Design, Inc.

“DP Management Philosophy” – Reliability, Dynamic Positioning Conference, October 17-18, 2000, by Capt. Mike Easton, *R B Falcon,* and presented by Alan Adamson, Global Maritime

“Degraded Status” – Reliability, Dynamic Positioning Conference, October 17–18, 2000, by Chris Jenman, Global Maritime (London)

“Reliability and Risk Analysis of Station Keeping System of Mobile Offshore Drilling Units,” presented as a research project for Ph.D. thesis by Ph.D. candidate Zhen Gao

“Quantification of the Frequency of an Unsuccessful Disconnection because of a DP Problem” – Reliability, Dynamic Positioning Conference, October 13–14, 1998, by Chris Jenman**,** Global Maritime (London)

“Safe Disconnect During Drive-off/Drift-off when Drilling on DP,” IADC Drilling Northern Deepwater 2001, May 31–June 1, 2001, by Terje Olsen;

“Risk Associated with Drive-off/Drift-off when Drilling on DP,” Dynamic Positioning Conference, September 18–19, 2001, by Bjorn Inge Bakken with Scandpower A/S (Norway)

“What Happens in Water - The use of Hydrodynamics to Improve DP,” Dynamic Positioning Conference, September 18–19, 2001, by Radboud R. Th. Van Dijk and Albert B. Aalbers Maritime Research Institute, Netherlands (Wageningen)

“DP Design Studies” Dynamic Positioning Conference, September 17–18, 2002, by Arild Gonsholt and Bjørn Nygård, Kongsberg Simrad, Norway

MMS Technical Information Management System Well Data

Environmental Protection Agency (EPA) – “Statistical Analyses Supporting Final Effluent Limitations Guidelines and Standards for Synthetic-Based Drilling Fluids and other Non- Aqueous Drilling Fluids in the Oil and Gas Extraction Point Source Category.” EPA-821-B-00- 015.

Environmental Protection Agency (EPA) - Effluent Limitations Guidelines and New Source Performance Standards for discharges associated with the use of synthetic-based drilling fluids (SBF’s) and other non-aqueous drilling fluids in portions of the Offshore Subcategory and Cook Inlet portion of the Coastal Subcategory of the Oil and Gas Extraction Point Source Category under the authority of Sections 301, 304 (b), (c), and (e); 306; 307; 308; 402; and 501 of the Clean Water Act (the Federal Water Pollution Control Act); 33 U.S.C. 1311, 1314 (b), (c), and (e); 1316; 1317; 1318; 1342; and 1361.

The panel members met and discussed the evidence numerous times throughout the investigation and, after having considered all of the information available, produced the following report.

Introduction

Background

Lease OCS-G 21810 covers approximately 5,760 acres and is located in Green Canyon Block 652 (GC 652), Gulf of Mexico, off the Louisiana Coast. *For lease location, see Attachment 1.* The lease was issued effective June 1, 2000. Anadarko Petroleum Corporation is a 100-percent interest leaseholder and the Designated Operator.

Brief Description of Accident

On July 5, 2005, an unplanned riser disconnect was initiated on the *Ensco 7500* semi-submersible rig, which had been engaged in exploratory drilling activities, because of unfavorable sea and wind conditions associated with an approaching tropical depression. While the riser volume was being displaced with seawater in preparation for the disconnect operation, the rig was no longer able to maintain station adequately enough to complete the operation. As a result, the riser was disconnected from the Lower Marine Riser Package (LMRP), at which time 710 barrels of synthetic-based mud was released from the riser into the GOM. At the time of the disconnect, there were no open hole hydrocarbons exposed below the casing depth.

Findings

Preliminary Activities — Rig Utilization

On May 17, 2005, an Application for Permit to Drill (APD) an exploratory well for GC 652 was approved by the Minerals Management Service (MMS); this application was subsequently modified and again approved by MMS on May 24, 2005. Anadarko Petroleum Corporation initially contracted Transocean Inc. to conduct the drilling operations of the Green Canyon 652 (OCS-G 21810) Well No. 2 in a water depth of 4,331 feet. The dynamically positioned drillship *Deepwater Millennium*, owned and operated by Transocean Inc., was moved onto the well location on May 18, 2005. Exploratory drilling activities then commenced from the well's surface location at Lat 27 deg 20' 13.191" N and Long 90 deg 09' 17.835" W.

Within one week of spud of the GC 652 Well No. 2, sea state conditions at another Anadarko deepwater drill site (Desoto Canyon 621, Well No. 1 in the Atwater Valley Area) started to deteriorate as loop currents shifted to the east and increased to around 3 knots. Anadarko had contracted with the Ensco Offshore Company to drill the Atwater Valley exploratory well by using the dynamically positioned semi-submersible *Ensco 7500*; however, sea state conditions became too hostile to operate safely this semi-submersible in this environment. With the approval of the MMS, the Operator made the decision to finish drilling down and setting the 20-inch casing at their Atwater Valley location before securing the well and moving the rig off location. Transocean's *Deepwater Millennium* drillship, on location at the Green Canyon Block 652 drill site, was mobilized to the increasingly hostile Atwater Valley drill site, and the *Ensco 7500* semi-submersible drilling unit was mobilized onto the Green Canyon Block 652 well site, where sea state conditions appeared to be less hostile.

Drilling Activities — Mobilization of *Ensco 7500* to Time of Incident

Key events leading to the incident are detailed below (as obtained from drilling reports, interviews and written statements):

27 May – Rig under tow to Green Canyon Block 652.
28 May – Rig on location. Started running riser and blowout preventers.
29 May – Continuing to run riser. Picked up landing joint.
30 May – Rigged up choke and kill lines. Positioned rig and blowout preventers over wellhead. Latched wellhead. Closed blinds and installed diverter housing. Started picking up drill pipe.

31 May – Test blowout preventers. Picked up and started in hole with bottomhole assembly.

01 June – Washed and reamed to bottom, circulating synthetic-base mud in hole.

02–19 June – Drilling proceeded. Circulate mud to run casing. Started out of hole with drill pipe.

23 June – Finished pulling out of hole with drill pipe. Picked up cement head and 13-5/8 inch casing.

24 June – Finished running casing to bottom. Picked up casing hanger and landed casing in wellhead at 4,391 feet. Rigged up and pumped cement. Laid down cement head.

25–27 June – Laid down equalizer sub. Re-assembled equipment used to test for total dissolved solids. Tested blowout preventers. Picked up bottomhole assembly and ran in hole. Displaced hole with synthetic-base mud. Drilled cement and shoe. Circulated bottoms up.

28 Jun–03 July – Drilling hole to 21,130 feet. During this time period, winds remained relatively calm with seas 1-2 feet. Currents averaged around 2.1 knots.

04 July –

0600 hrs – Drilling while monitoring tropical developments**.**

***1800* hrs –** Suspended drilling operations at 21,715 feet because of approaching storm. Started circulating bottoms up to clean wellbore prior to pulling out of hole. Ensco personnel concerned about rig holding position. Held forward planning meeting to pull out of hole with drill pipe, run and set storm packer.

***2300* hrs –** Started tripping out of hole, laying down 6-5/8 inch drill pipe.

05 July –

0600 hrs – Continued laying down drill pipe.

0900 hrs - Rigged down 6-5/8 inch drill pipe handling tools, and rigged up 5-1/2 inch drill pipe handling tools. Thrusters running 70-80% with 5 engines (dedicated to thrusters) running 60%.

1000 hrs – Tripped out of hole 4 stands. Bit pulled up into 13-5/8 inch casing. Seven thrusters running 75% with 5 engines running at 70%. Current at 3 knots with winds at 23 knots. Operator aware of potential emergency disconnect. Rigged up 5-1/2 inch cross-over to top drive. Spaced out drill pipe in BOPE and hung off on upper variable bore rams within the BOP equipment.

1040 hrs – All 6 engines on line running 70% and 7 thrusters running at 84%.

1100 hrs – Started displacing 14.6 pound-per-gallon synthetic oil-base mud out of riser. Riser capacity about 1,538 barrels.

1130 hrs – Winds running 41 knots out of south with current at 3.2 knots while mud was being displaced. Rig position was slipping from its location.

1200 hrs – Rig struggling to hold position with 3.3-knot currents and 61-knot winds. Rig offset some 175 feet from well center. Contractor gives orders to function EDS. Waiting on Lower Marine Riser

Package to release. Running 5 degree angle in flex joint. Contractor gives second order to function EDS, and subsea engineer activates from different pod (see definition of pod below). Rig offset some 380 feet. Hard recoil.

1204 hrs – EDS function completed in 4 minutes. Slip joint pushed hard against moon pool BOPE guide, wedging the SDL tension ring. The rig rolled 5-7 degrees with 10-14 foot swells. The riser hanging below acted like pendulum, bending the inner barrel to the port side. Estimated 710 barrels spilled. Contractor directed vessel NNE away from the Marco Polo platform.

1300 hrs – Attempting to hold position some 12,474 feet from wellhead, but drifting.

1400 hrs – Rig holding position some 15,358 feet from wellhead.

1500 hrs – Rig location verified relative to Marco Polo and 14 inch-flowline. Closest distance between rig and flowline during drift was 4,700 feet.

Control pods are subsea distribution points for surface-generated power and surface controls to components positioned on the sub-sea template. They also serve as collection and transmission points for data collected by the various monitors on or below the seabed. The pods are mounted in accessible positions, are retrievable for repair, maintenance, or replacement as necessary. The pods are therefore functionally self-contained and retrievable units, typically housing solenoid operating valves, hydraulic control systems, and pressure-operated valves.

Developing Weather Conditions

The tropical wave that eventually developed into Hurricane Cindy moved westward off the coast of Africa on 24 June. By 3 July, thunderstorm activity had become concentrated over the Caribbean Sea, and the National Hurricane Center initiated satellite classifications. Nearby surface and buoy observations revealed a broad low pressure area had developed. Later that day, reconnaissance aircraft indicated a tropical depression had formed at 1200 hours approximately 70 nautical miles east of Chetumal, Mexico.

The depression continued on a slow west-northwestward track and moved across the east coast of the Yucatan peninsula early on 4 July. After moving inland, the cyclone turned northwestward and exited the northern coast of Yucatan just east of Merida at around 0900 hours on 4 July. The depression accelerated and became a tropical storm during the early morning hours of 5 July over the central Gulf of Mexico while moving northwestward at 15-17 knots. Cindy gradually turned northward and its forward speed decreased. Cindy steadily strengthened and became a hurricane at 1800 hours 6 July about 40 nautical miles south-southwest of Grand Isle, Louisiana. Landfall occurred later that day as a Category 1 hurricane.

On the day of the incident, the air temperature was about 82 degrees Fahrenheit. The barometric pressure was 29.90 inches. The wind direction was out of the south (approximately 104 degrees) at approximately 19 knots early in the morning, increasing to near 61 knots by noon. The seas were running about 4 to 6 feet, with swells increasing from 14 to 16 feet. Wave height is the measurement from mean sea level (MSL) to either the crest (top) of the wave or trough (bottom) of the wave. Under these weather conditions, the Rig was experiencing a pitch of 0.70 degrees increasing to almost 2.0 degrees by noon, and with a corresponding roll increasing from 1.0 degrees to nearly 4.0 degrees, and with a heave of 2.0 feet on a varying heading between 12 degrees and 40 degrees. Pitch is the pivotal movement up and down of the rig along the centerline axis from the bow to the stern. (When the bow goes up, the stern goes down). Roll is the pivotal movement up and down of the rig along the centerline axis from port to starboard sides. (When the port side is up, the starboard side is down). Heave is the vertical movement up or down of the rig along the surface of the water. Doppler water current speed data varied, but generally was measured at less than 1.2 knots near surface.

Unplanned Disconnect

Although the system was not yet a tropical storm, the Operator and Drilling Contractor had elected to suspend drilling activities at 21,715 feet at 1800 hours on July 4. Suspension of drilling activities occurred some 18 hours in advance of the incident. Personnel commenced circulating bottoms up to clean the well bore, and by 2300 hours started pulling the 6-5/8-inch drill pipe. All of the 6-5/8-inch drill pipe was out of the hole the next morning by 0830 hours (July 5, 2005). Personnel started to pulling the 5-1/2-inch drill pipe at 0930 hours; however, with the rig having difficulty holding position, orders were given at around 1000 hours to space out the 5-1/2-inch drill pipe in BOPE and hang off the pipe with 260,000 pounds on the upper variable bore rams (VBR) on the BOP stack. At 1100 hours orders, were given to displace the choke and kill lines, boost lines, and riser with seawater. At that time, the Rig heading was 12 degrees with seven thrusters working and six engines operating against winds out of the south at 61 knots and seas running 14 to 16 feet. According to the Contractor’s on-duty DP Operator during the morning shift prior to disconnect, the thrusters were operating at about 75-85 percent capacity with the engines running at 60-70 percent. Testimony from the DP Operator indicated that sufficient power to the thrusters was not the problem. The rig did not have enough thruster capability to hold location. He further indicated that one thruster was down for planned maintenance.

According to testimony from the Contractor’s maintenance supervisor, Thruster No. 5 to the starboard aft outboard side had been down for some 3-4 months prior to this incident, awaiting replacement of seals, and was not operational at the time of the incident. To complete this maintenance work, environmental conditions are critical, normally requiring currents not to exceed 1 knot. He indicated that to replace the seals, personnel would have to disconnect the brake assembly from the shaft and, further, that this could not be accomplished if any current was moving past the thruster propeller.

The Contractor’s Offshore Installation Manager (OIM) confirmed what the DP Operator had indicated, that appropriate engine power was available. However, he mentioned that the combination of the environmental forces (wind and wave) with the currents exceeded the Ensco’s thruster power. When questioned about the reason for the reports of the engines over-heating, the OIM indicated that no engines were shut down. He stated that under “phase-back” operations, the engines cater to the thrusters, shedding load from the drill floor to propulsion. As more power is required to maintain location, the power available to perform drilling functions decreases, and pumps and peripheral equipment slow down. According to testimony from the Operator’s drilling consultant, with the currents and wind directions off of the rig’s beam, and with the rig experiencing a heave of 6 feet, orders were given at 1200 hours to shut down the pump and to direct all power on the rig to the thrusters, and to immediately engage the auto disconnect sequence.

As the OIM was waiting for the LMRP to release and the tension ring to lift the slip joint, he reportedly witnessed a 5-degree angle on the flex joint without corresponding slip joint release. The OIM again gave orders to function the Emergency Disconnect Sequence (EDS). The subsea engineer activated the EDS from a different POD. At 1202 hours, according to Ensco reports (2 minutes after initiation of auto disconnect), the riser tension ring recoiled hard out of the water, causing the slip joint to push hard against the moon pool, wedging the SDL tension ring and bending the inner barrel to the port side and causing the tension line to jump sheave. The LMRP was disconnected. Interviews revealed that the subsea engineer had added closing pressure to each side of the open/close valve to ensure closure of rams, not realizing that this action could delay the LMRP function during disconnect sequence, should an EDS be necessary. The EDS sequence was completed at 1204 hours according to Anadarko records (4 minutes after initiation of EDS).

There was some contention as to how long the EDS took to complete. According to the OIM, the operating pressure on the rams was from 0 psig to 3,000 psig. When they hung off on the top rams, they had increased the closing pressure to 3,000 psig to secure the upper rams and left this pressure on the rams until the disconnect. The OIM stated that some experts would suggest that the pressure should then be backed down to 1,500 psig to secure the well. On the other hand, the operator stated that, had pressure been backed down, the EDS would have executed within the normal time frame. The contractor disagreed and stated that, in their opinion, failure to reduce the pressure did not delay the riser disconnect. The equipment manufacturer does not recommend one procedure over the other.

According to API Spec 16D 1st Edition Section 2.2.2.5, Norsok Section 5.10.3.7 and IADC documents, the control system for a subsea blowout preventer (BOP) stack should be capable of closing each ram blowout preventer in 45 seconds or less. Closing response time should not exceed 60 seconds for annular BOP's. Operating response time for choke and kill valves (either open or close) should not exceed the minimum observed ram response time. Time to unlatch the LMRP should not exceed 45 seconds. Measurement of response time begins at pushing the button or turning the control valve handle to operate the function and ends when the BOP or choke or kill valve is actually closed, effecting a seal, or when the hydraulic connector(s) is fully unlatched.

Post-Incident Review

Immediately after the incident, the Operator contracted an ROV boat to assess any damage to the wellhead and BOP's prior to returning to location. Visual data indicated no structural damage or variance from the pre-disconnect condition. The ROV also performed a 300-foot site survey to note any synthetic-base mud residue on the seafloor. Videotapes were sent to MMS. No damage occurred to any other structure in the immediate area during float off. The rig ROV did an initial inspection of the riser and LMRP prior to pulling; there was no visible sign of damage; the riser and LMRP were pulled and inspected and no damage was found. The slip joint was bent and recovered and then replaced with a backup. The riser tensioner ring cable was pinched and was replaced. The Operator maintained dialogue with MMS until operations were back to "normal."

The Operator had estimated that they would need about two hours to displace the surface lines and riser pipe totally with seawater. Because of the rapid intensification of storm conditions, partial displacement was achieved, thus the loss of an estimated 710 barrels of synthetic base mud. The rig commenced controlled drifting with riser hanging below.

Loop current information leading up to and including the time frame over which the incident occurred, measured via the acoustic doppler current profiler (ADCP) monitoring system on the Rig, was indicating currents to be at 1.2 knot. At the same time, crews onboard the DP vessel were struggling to maintain position and direction, relying solely on the basis of the DP system computers, which suggested actual loading conditions near the ocean's surface of nearly 3 knots. These forces are derived from computer models on the vessel, and are forces impacting the rig's ability to maintain station.

The most immediate subsea obstruction was the previously drilled and then temporarily abandoned Well No. 1 in the block (surface location 125 feet away from the well being drilled). No other subsea structures were nearby. The largest surface structure nearby was the Anadarko Petroleum Corporation-operated Marco Polo TLP, a block to the north with its associated flow lines.

The Rig

Ensco 7500 is classed as an A.B.S. Maltese Cross A1 column-stabilized drilling unit with a Dual Redundant ASK Dynamic Positioning System. *For a description of the rig, s*ee *Attachment 2*. The vessel was commissioned in 2000 and is equipped with six (6) EMD 20L710G7B/EMDEC-5000 HP each engines with 6 Baylor 8855YNB generators (generating 3,580 kW/5114 kVa @ 4,160V with 0.7 pf). There are eight 3000-hp Schottel SRP2020 Thrusters, a four-bay, twelve-drive SCR System for Drilling Systems. The unit is designed to operate in 8,000 feet water and drill to 30,000 feet with a Varco TDS-4H (750 ton) top drive and a Maritime hydraulic, 1000k CMC drill string compensator. Published operating parameters list the transit speed of the vessel at 3.5 knots at a 45-foot draft. Transit speed is generally defined over relatively calm waters.

There are two engines rooms, each containing three engine/generator sets. Each engine room has separate systems for auxiliary support.

The Dynamic Positioning (DP) system is a dual redundant Nautronix ASK 4002 unit. The two main operator control consoles (ASK1 & ASK2) contain the control processors, operator keyboard, and display units. The DP system can control up to eight 3,000-hp thrusters. The maximum thruster load would be 17.9 MW at full power on all eight units. DP commands azimuth and power to each online thruster, which keeps the rig on location. Normally, the system would be using four thrusters.

The rig complies with ABS Guidelines for Thrusters and Dynamic Positioning Systems DPS-2 Classification. Section 3.7 of the document applies to power systems. The DPS–2 classification requires that the power system have the capability of withstanding a single fault bus failure so that sufficient power remains for positioning and auxiliary systems within the specified operating envelope. The failure of an engine room would reduce the power generating capacity by half and reduce the operating envelope.

Rig-Specific Station-Keeping Guidelines

Station-keeping guidelines for operating *Ensco 7500* in high-current areas of the Gulf of Mexico have been revised by the contractor as a result of this incident. Rig-specific information dated August 2005 now reflects loop currents and associated eddies in the Gulf of Mexico. The revised criteria confirm that the *Ensco 7500* is limited in its station-keeping ability to approximately 2.5 knots of current at a 60-foot drilling draft in calm weather (wind and seas). Operations are limited by both the riser angle at the BOP stack and the ability to maintain station at a drilling draft. Watch areas have been extended and tightened, and now include action items to be taken under possible operating condition combinations, reflecting on a published chart plotting wind speed versus surface current speed.

Normal, continuous operating conditions (**green area**) would typically entail maximums of up to four engine/generator sets on line, six thrusters utilized, and no more than 50-percent thruster loading. With no equipment outages, these numbers provide for one engine/generator set and one thruster to be down for maintenance with an additional engine/generator set and thruster held in reserve. Periodic maintenance is considered part of normal operations. Normal environmental operating conditions are considered to be those allowing for normal vessel maneuverability, such as full freedom to change heading for enhanced operations, i.e., giving lee protection to supply boats alongside. Additionally, normal operations would imply no adverse weather forecasts within the next 24 hours that could require drilling operations to be suspended.

Guarded operations (**blue area**) are defined as continuing for six hours or more with a maximum of four engine/generator sets on line, thruster utilization at six maximum, thruster loading at 50 percent or less, with the rig limited in heading change capability, and no adverse weather forecasts within the next 24 hours that would require drilling operations to be suspended.

The “Suspend Drilling Operations” condition or **yellow area** of the chart is reached when, in “Normal” or “Guarded” operating conditions, the weather or eddy current forecasts for the area or the actual environment and/or current in the area are likely to produce, or are actually producing, conditions exceeding the “Normal” or “Guarded” operations area of the graph. Such conditions are expected to continue for six hours or more, with thruster utilization at six maximum, and thruster loading within a range of 50-70 percent. The vessel can operate in this range of the graph long enough to secure drilling operations and to prepare the well for a planned disconnect if environmental conditions continue to deteriorate.

The **orange area** on the chart is defined as requiring 70-80 percent power on six thrusters to hold position. Preparations to perform an orderly disconnect should be completed by this time. The vessel can continue to operate in this range, but any redundancy has been compromised.

The **red area** on the chart is defined as requiring 80 percent or more power on six thrusters. All available resources will be online by this point and riser/LMRP disconnect can be called for at any time if required.

Prior to this incident, the rig-specific operating windows for the *Ensco 7500* dated back to when the rig was placed in service in September 2000. Only two criteria were identified as a precursor to disconnecting; namely, the limits of “Normal” operations and the “Yellow Alert” circle. The Normal position consisted of the day-to-day working arena where there were small flex joint angles, insignificant stroke out of the telescoping joint, no chance of collision between the riser and the moon pool, and small upper flex joint angle. It was bounded by a radius from the wellhead to approximately one-quarter of the disconnect radius. When this boundary was exceeded, the alarms triggered. The Yellow Alert was caused by a significant deviation from the Normal criteria. A stroke-out of plus or minus ten feet from the norm (not necessarily the center) was half the allowable limit, thus Yellow. When within one degree of collision with the moon pool, conditions would be Yellow, as would the situation remain when the upper flex joint read 2.5 degrees.

Deepwater Drilling Guidelines Revised by Operator

In February 2006, the Operator informed the panel members that, with the revised EDS Action Plan developed after this incident, they have contracted three drillships more capable of holding position during weather or loop current events. The Operator indicated that not only do these drillships have more thruster capacity, but they also have the ability to position the bow of the ship into the current to reduce contact area, thus making it easier to maintain position.

The Operator has incorporated several important steps in plans to improve operations in the event of another emergency disconnect.

- In the short term, the Operator plans to prepare, collect, and review a detailed infrastructure map to ensure that each working rig has the most up-to-date, as-built maps of any nearby facilities, to include locations of tendons, flow lines, subsea architecture, and/or an area identified by complex subsea equipment, umbilicals, pipelines, wellheads, other equipment known as a “no fly-by” area.

- Simulated Operations (SIMOPS) plans will be updated to reflect daily projections of the rig path in the event of disconnect, based on current weather and loop current readings.

- A prioritized call list (internal/external) will be compiled in the event of a disconnect, detailing timing and personnel to notify of potential events, and notifications to both the production personnel and shore-base personnel when a rig is having trouble.

- Safe operating windows (rig specific) will be determined and documented in line with contractor’s operating guidelines, and tied into the direction of drift off and existing infrastructure in the area. This safe operating window will be based on maximum current, wind, wave conditions, and thruster power requirements.

- A work boat will be on standby in the event the operating window becomes elevated.

- Determine the cause of radar misreadings at the Marco Polo TLP and correct; more training to be incorporated by company.

- In the long term, station-keeping ability to be heavily weighted in rig selection process to limit downtime and associated costs and to limit exposure to damaging events with other subsea facilities.

- Anchoring options will be more thoroughly evaluated to assess DP/moored combinations and to evaluate enhanced mooring systems in place or under design.

Drilling Unit Classifications and Certifications

There are a number of international classification societies. The three major ones involved with the offshore exploration and production industry are Det Norske Veritas (DNV), American Bureau of Shipping (ABS), and Lloyd's Register of Shipping (LRS).

Most vessels are today classed with a notation +1A1, indicating that the vessel is built and maintained to the highest standards of the particular classification society. When the word classification is used today, it references a set of standards established and maintained by a specific classification society. For example, classification based on DNV rules and the related certification imply fitness for purpose in the sense that DNV approves the completed "object" and certifies (reviews, inspects and tests) all the systems. Thus, all power, safety, control, drilling, or other systems will be certified as safe and fit for purpose. DNV is not a designer or operator, thus would not influence operational factors such as reliability and efficiency.

Certification may be defined as steps taken to confirm that an "object" satisfies specific standards. The "object" can be a complete platform, ship, or drilling semi-submersible; it can also be a system within these vessels or one component of a system. The “object” also can be "the most basic" part of a component, i.e., the steel, the electrical cable, etc. Certification may or may not ensure fitness for purpose, depending on a number of factors. Because of this, *it is the responsibility of those designing or using an object to understand what is implied by its certification.*

According to a work presented at the September 17-18, 2002, Dynamic Positioning Conference, in a paper entitled “DP Integration and Technology Growth on Workboats” by U.H. (Jack) Rowley with Engine Monitor, Inc., each of the three primary classification societies, ABS, DNV, Lloyds, as well as IMO, offers rules for various levels of dynamic positioning certifications. References for the basic DP requirements are as follows:

- ABS Steel Rules 2002 Part 4, Chapter 3, Sec 5, and Paragraph 15
- Lloyds Rules for Class of Ships, Jul 2001 Part 7, Chapter 4, Section 1-7
- DNV Rules for Class of Steel Ships, Jan 1990 Part 6, Chapter 7, Section 1-7
- IMO Maritime Safety Committee (MSC) Circular 645 dated 6 Jun 1994

Although all are members of the International Association of Class Societies (IACS), significant differences remain evident in the requirements for the varying DP levels to achieve class notation. The paper presents an expanded table originally provided in DNV Part 6, Chapter 7, Section 2, Table E1, and notes the different classification designations for each of the agencies, highlighting some of the key differences. *For rig classification designation table, see Attachment 3.*

Drilling Unit DP Systems

A paper presented at the Dynamic Positioning Committee Conference in Houston October 17 and 18, 2000, entitled "Reliability-Degraded Status" by Chris Jenman, is referenced in this report. The paper indicates that, typically, all DP vessels are degraded to some extent most of the time because of planned maintenance, testing, breakdown, or repair; i.e., DP vessels are not strictly in DP class 2 or 3 as certified. The effects of degradation commercially and in terms of risk are matters that depend on (a) the view of the client and the contract, (b) the level of initial redundancy, (c) the weather conditions, (d) the work being done, (e) the water depth, and (f) the acceptable risk.

The normal operating condition for a DP vessel is the setup of systems and equipment whereby any design failure mode relevant to her DP equipment class or any other reasonable failure mode found by past operational experience will not cause an unacceptable loss of position or excursion in the existing circumstances and environmental conditions. A degraded operating condition for a DP vessel is a setup of systems and equipment whereby any design failure modes relevant to her DP equipment class or any other reasonable failure mode found by past operational experience is likely to cause an unacceptable loss of position in the existing or reasonably anticipated circumstances and environmental conditions.

The management of safety regardless of the system used should always include the management of nonconformance. A degradation of the DP system so that it no longer has all the equipment required for her DP class 2 or 3 is a nonconformance, and should be addressed according to the Safety Management Systems in place.

Emergency Disconnect Procedures

The ability to close a well automatically and then disconnect the lower marine riser package plays an extremely important role in offshore drilling operations, for safety and environmental reasons. *For a schematic of the LMRP, see Attachment 4.*

In any emergency situation, the primary objective of the EDS is to make the rig safe and secure the well as quickly as possible. The secondary objective is to disconnect in such a manner as not to damage the equipment for future rapid re-entry in the well. Failure of the EDS is considered to be a low risk event. However, if a failure were to occur, the consequences could be extremely high.

Initiating the disconnect sequence must be done when the vessel reaches the predefined red zone. If this action is delayed, either by operators evaluating or hesitating to push the button, it may be crucial for the situation. To control all the effects discussed above better, a computer program has been developed. The program will advise where the red zone should be set, based on (a) vessel characteristics, (b) environmental conditions, (c) footprint of rig showing initial position and excursions, (d) drive-off scenarios, (e) recovery, and (f) maximum allowable riser angle. A footprint is the outline of the vessel's movement in a particular sea state, which is a function of the control system, the position references, the thruster respond times, and environmental conditions.

Government Regulations and Criteria for Suspension of Well

So that the MMS can monitor compliance with the provisions of NTL 2005-G05 and ensure that all lease holders have specific operational plans to deal with current events, each lease holder must provide (pursuant to 30 CFR 250.417(e)) certain information in his APD to drill a well using a floating MODU in water depths greater than 400 meters (1,312 feet). The information included on the APD contains a (1) description of the criteria that will cause the operator to implement rig shutdown and/or move off procedures; and (2) discussion of the specific measures each operator will take to curtail rig operations and move off location when such currents are encountered as defined by the operator's met ocean criteria and the Operator's specific outer parameter(s) in which they plan to operate as they sequentially discontinue operations and prepare for disconnect. Furthermore, the Operator must detail his plans to (a) suspend drilling operations if well conditions permit, (b) pull out of hole if well conditions permit (well control, lost circulation, etc.), (c) set storm packer or other means of isolating the well, such as cement retainer, cement plug, or drill pipe hang-off tool, (d) displace riser and prepare for disconnect (hang off drill pipe if required) and to disconnect, and (e) pull LMRP to surface as opposed to suspending riser beneath rig and to remain on location (DP operations).

International Pre-Hire Requirements for DP Vessels

The HSE (Health and Safety Executive) in the United Kingdom utilizes a combination of safety case and verification schemes to ensure the safety of drilling operations in their regulatory area. The safety case requires "suitable and sufficient quantitative risk assessment" to be carried out and the identified mitigation undertaken and documented to "reduce risks to the health and safety of persons to the lowest level that is reasonably practicable," alternately called ALARP. Other safety case requirements include a statement of performance standards, limits of environmental conditions beyond which the installation cannot be safely operated, and a demonstration that "the risks from a major accident are at the lowest level that is reasonably practicable."

The PSA (Petroleum Safety Authority) regulations require the operator to define acceptance criteria for risk, "taking into account the possibility for as well as the consequences of identified accidental events." In risk mitigation, priority should be given to reducing the probability of occurrence over reduction of consequence. Finally, a list of analyses that were done shall be documented. Although it recognizes that risk cannot be eliminated, risk shall be reduced, ALARP.

Australia's Submerged Lands Act has many similarities to the United Kingdom’s HSE regulations. They also require safety cases with risk assessments and utilize the ALARP phraseology.

Although jurisdiction of the standards governing DP vessels falls under the United States Coast Guard, when operators hire contractors to undertake drilling activities on the Outer Continental Shelf of the Gulf of Mexico, much of the work done by Norway’s Statoil to pre-qualify contractors may be applicable. According to the paper presented at the Dynamic Positioning Conference in September 2002, “Worldwide DP Requirements Implementation and Operational Experience” by Bjørn Abrahamsen with Statoil and Alan Adamson of Global Maritime, a document was developed for Statoil valid for using dynamically positioned units or vessels. Tender documentation requirements for pre-hire review include:

- Complete vessel Failure Mode & Effect Analysis (FMEA) to highlight known failure modes.
- Complete and inclusive proving trials and evidence of systematic yearly trial procedures based on the vessel’s FMEA.
- FMEA updates when revisions or equipment upgrades take place.
- Procedures
- Evidence of systematic and effective check-listing

- Full review of reference systems suitability
- Full review of alert lights/sounds for DP/drilling alerting against specific Statoil requirements
- Training and experience of crew, DP certification, and log books
- Flag State Verification documentation as required under (IMO MSC Circ. 645).

Review of Pre-Job Safety Analysis – Safety Meeting

Daily pre-tour safety meetings were held and reported on the IADC forms. On the day before the disconnect, the crew reviewed pit gain procedures, storm preparation procedures, functioning of all rig floor safety valves, and water tight doors.

Conclusions

The Accident

On July 5, 2005, at approximately 1200 hours, an unplanned riser disconnect occurred on the *Ensco 7500*, while it was performing drilling activities on Green Canyon Block 652 Well No. 2 for Anadarko Petroleum Corporation. The unplanned disconnection of the LMRP from the subsea blowout preventer resulted in the release of pollutants into the Gulf of Mexico.

Cause of Incident

The pollution event was a result of the unplanned disconnect of the LMRP from the subsea blowout preventer equipment during a time of shifting loop currents coupled with quickly deteriorating met-ocean conditions from tropical storm developments, the sum of which pushed the rig's DP system capability to the limits, leading to an unacceptable loss of rig position, prior to displacing the riser and surface lines of the drilling mud with seawater.

Probable Contributing Cause

Contributing to the loss of position for this DP vessel, leading to the decision to initiate the disconnect sequence prematurely and release the LMRP, which ultimately resulted in the release of pollutants into open waters, were inadequate rig-specific station-keeping criteria, including site-specific met-ocean data over a wide range of sea states and loop currents. The following points are made:

1. Correspondence provided the panel members suggested that the station-keeping criteria in effect at the time of the incident provided for no rig directives until such time as either the (a) currents reach 2.7 knots and there is a weather pattern that could produce 50 MPH winds within 200 miles of the rig or (b) currents reach 3 knots or higher. This pre-existing, rig-specific, station-keeping criteria did not reflect loop currents and associated eddies in the Gulf of Mexico.

2. Information provided the panel members acknowledges the rapidly deteriorating met-ocean conditions over an 18-hour period prior to the incident. However, according to Ensco Weather Logs and Eddy Watch Reports over the 7–day period prior to the incident, with relatively calm seas and winds, currents had run as high as 2.7 knots and had averaged over 2 knots throughout the

period. Preparations to disconnect the riser with impending tropical development close to entering the Central Gulf of Mexico should have been considered very likely.

3. Revised criteria, based on the incident failure analysis, confirmed that the *Ensco 7500* is limited in its station-keeping ability to approximately 2.5 knots of current at a 60-foot drilling draft, in calm weather (wind and seas).

4. On the basis of the panel's findings from this investigation, it appears that the Operator did not fully verify by prescribed methods the operational functionality of the vessel over a wide range of sea states, such as those expected or anticipated during the drilling campaign. Management of non-conformance issues regarding the likelihood of a failure mode to cause an unacceptable loss of position given existing or reasonably anticipated circumstances and environmental conditions should have been completely addressed by the Operator to conduct the well program safely and in a manner that would reduce risk to a level as low as reasonably practicable.

Recommendations

A. It is recommended that MMS issue a Safety Alert to lessees and operators containing the following:

1. A brief description of the accident
2. A summary of the causes
3. The following recommendations with respect to *dynamically positioned drilling rigs*:
    a) Lessees and operators should review the adequacy of their policies/plan regarding planned and unplanned riser disconnects.
    b) Riser disconnect policies/plans should address at a minimum the following:
        i) A site-specific riser disconnect/policy plan per location as a complement to a general plan
        ii) Development of site-specific environmental/oceanographic data for the purpose of position holding and riser angle minimization considerations.
        iii) Development of criteria for the initiation of riser disconnect operations as a function of impending tropical storm conditions.
        iv) A routine review of T-time estimates during storm seasons**.**

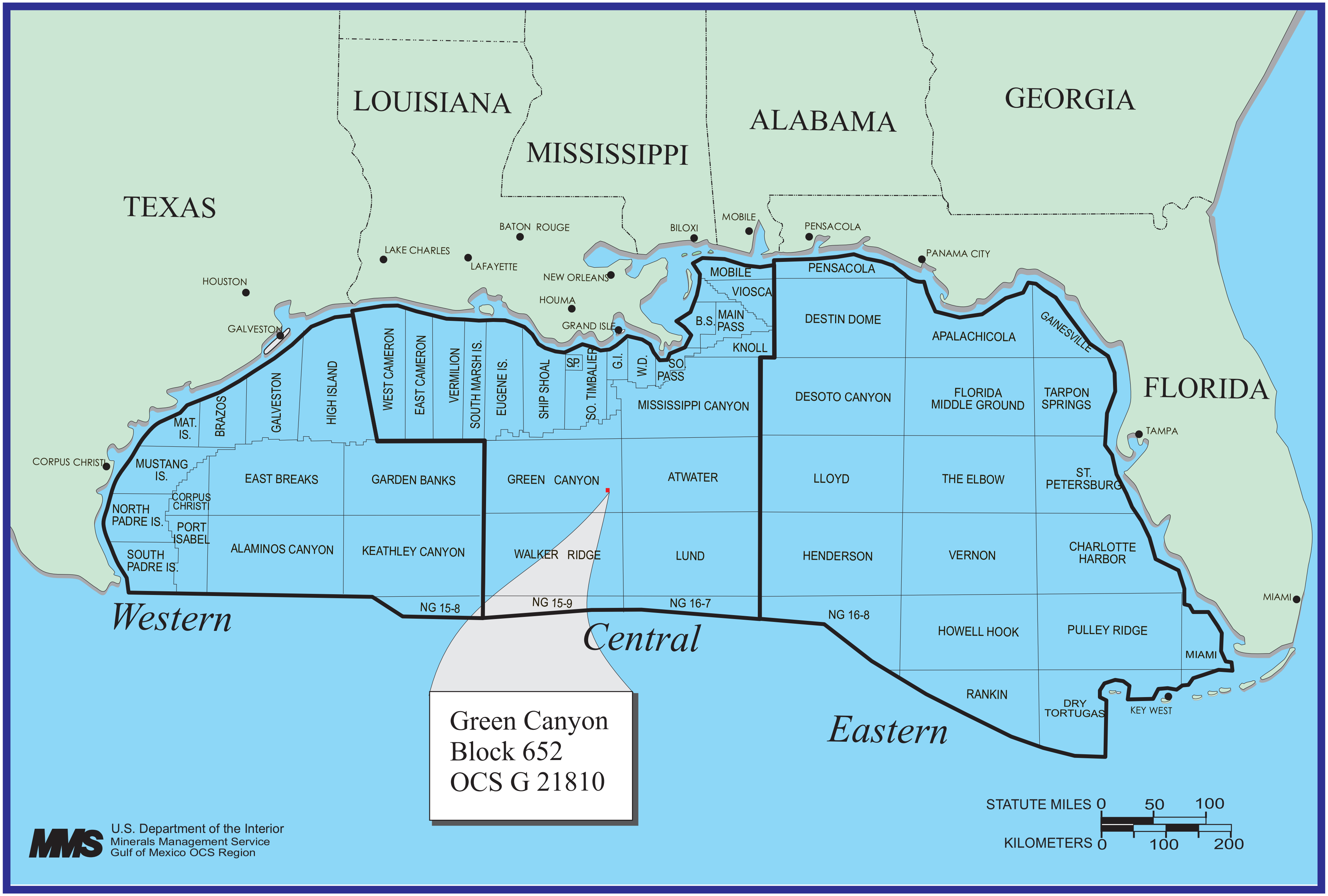
B. It is recommended that MMS modify the regulations at 30 CFR 250.417 for APD's for dynamically positioned drilling rigs to include the following:

1. Criteria/guidelines for suspending and securing the well in high currents and bad weather conditions. The operator should specify when he plans sequentially to discontinue operations in a tabulated format dependent on optimal rig positioning and heading as follows:

	Sea state (feet)	Surface current (knots)	Wind load (knots)	Upper Flex joint angle	Lower Flex joint angle	Available % Rig power
Drilling ahead						
Set storm packer						
Displace riser. Prepare for disconnect.						
Disconnect						
Station keeping ability						

2. A description as to how the rig heading will be optimized for expected seasonal weather conditions to minimize the forces on the rig and the riser
3. A discussion of any sea bottom conditions (such as escarpments or cliffs or subsea equipment) and surface obstructions (such as nearby platforms) that would limit the direction the rig could move when disconnecting the riser.
4. A description of how currents, sea states and weather will be monitored and all equipment and/or services are to be used.
5. A description by the Operator of the station-keeping equipment and/or systems on board that support the rig classification and certification. Pre-qualifications of DP vessels should include in the Pre-hire verification a complete vessel Failure Mode & Effect Analysis (FMEA) to highlight known failure modes, complete and inclusive proving trials, and evidence of systematic yearly trials procedures based on the vessel's FMEA.

Attachment 1



Location of Lease OCS G 21810, Green Canyon Block 652

ENSCO 7500 Dynamically Positioned Semisubmersible

ENSCO 7500 Design (Non Harsh Environment), Built: December 2000.

ENSCO

Rig Specifications:

Rated Drill Depth	30,000 ft.
Nominal Water Depth	200-8000 ft.
Draft	Operating 60 ft.
Survival Draft	45 ft. / Survive 90 ft. wave
Overall Length	240 ft.
Overall Width	228 ft.
Columns	50 x35 ft.
Pontoons	50 x 24 x 290 ft.
Variable Load	Transit 5,000 ST
	Survival 6,500 ST
	Drilling 8,500 ST
Cranes	1-Dreco 72DNS 140 1-Dreco 72DNS 160
Gantry Crane	1- x 106'-3" ft. span, 32 ton

Storage Capacities:

Drill Water	8,334 bbls
Potable Water	1,066 bbls
Fuel Oil	16,414 bbls
Liquid Mud (Deck)	3,625 bbls.
(Lower Hull)	8,550 bbls
Bulk Mud & Cement	20,118 cu. ft.
Sack Storage	8,000 sacks
Sewage Treatment	2 - Omnipure: (1) Model 12MX
	(1) Model 15 MX
Desalination Units	6-Alfa Laval JWP-26-C80
	3000 GPD each.
Heliport	Sikorsky S-61
	20,500 gross lbs
Quarters	Bunks for 122 people
Personnel Survival	(4) 73-person covered lifeboats
	(6) 25-person life rafts

Tubulars:

Drill Pipe	5 ½", 24.70#, S-135, HT-55, Range 2
HWDP	5 ½", 60.10#, S-135, HT-55, Range 2
Landing String	5 ½", 38.01#, S-135, HT-55, Range 2
Drill Collars	9-1/2", 8-1/4", and 6-3/4"

Special Features:

Built: TDI-Halter, Orange, TX. – December 2000
DP: API RP 2SK & Deepstar II criteria
Mooring / DP: API RP 2SK & Deepstar II criteria
Winches: 8 x Skagit 3 ¼" – K4 chain – 1000ft chain
Engines: 6 x EMD 20-710GB7 / MDEC – 5000 Hp/ea
SCR: Thrusters, 8 x DW3000-6, 3400ADC, 750 VDC
SCR: Drilling, 12 x DW1400-6, 1500ADC, 750 v
Emerg Gen: 1 x Caterpillar 3512B, 1476 Hp

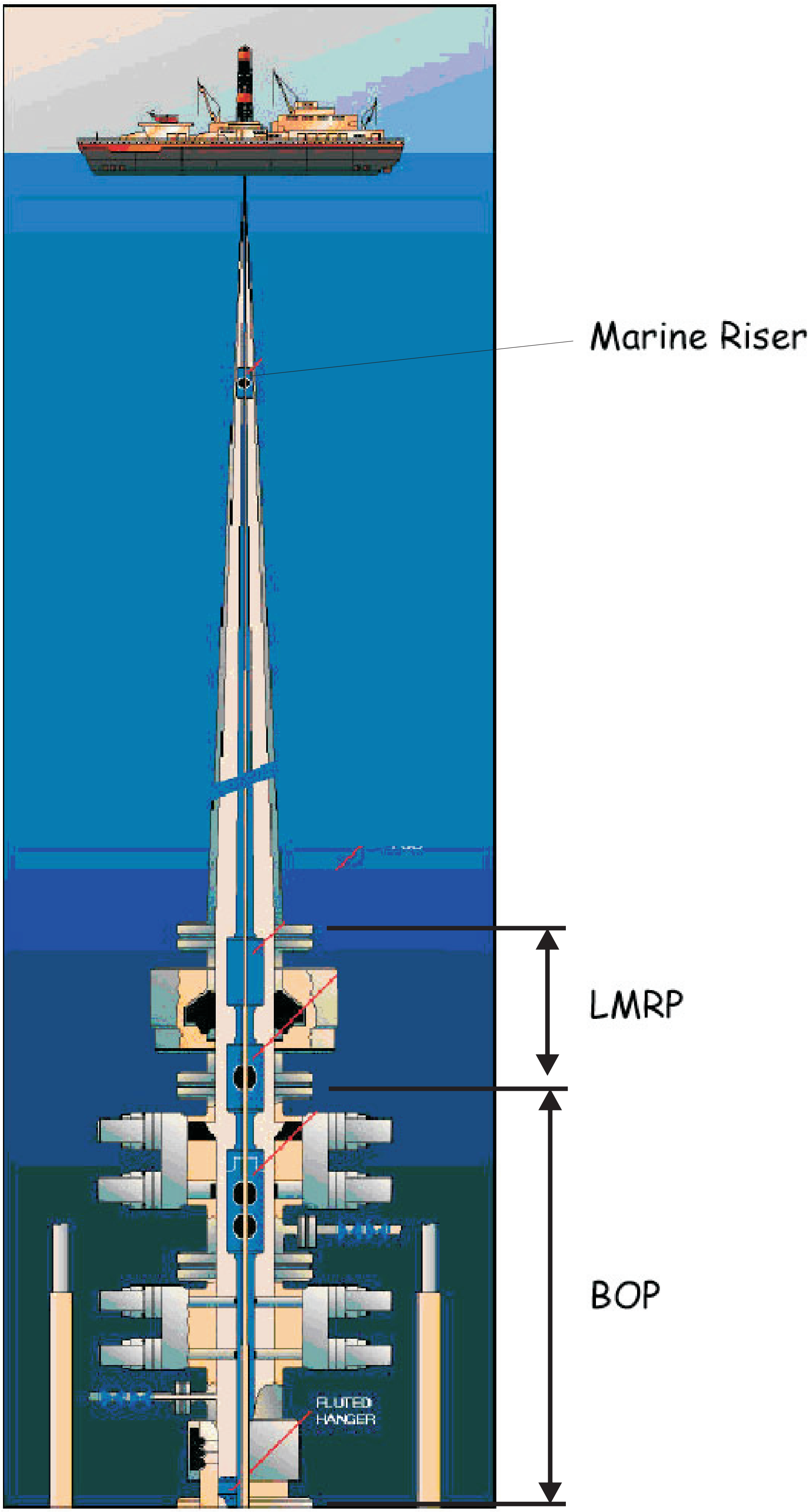
Drilling Equipment Specifications:

Drawworks	National 1625-DE (3,000 Hp) Dretech Model 15050 Brake
Classification	A. B. S.
Pumps	3-National 14-P-220 Triplex w/GE752
Riser Pump	Lewco W446 w/OEM 320 Hp AC drive
Rotary Table	Varco RST 605 Hydraulic, 1000 Ton
Top Drive	Varco TDS-4H, 750T, 7.5Kpsi, GE752
BOP Equipment	5 Ram Hydril 18-3/4" 15M.
	Dual Hydril Annular 18-3/4" 10M GX
BOP Connectors	1 Cameron HC 18-3/4" 10M LMRP
	1 Vetco HD 18-3/4" 15M BOP Connect
Choke Manifold	3 1/16" x 15,000 psi. WOM with Power Choke Dual Hyd. Chokes
Derrick	Dreco 170' x 46' x 40' GNC 1,928,000#, SHL 1,500,000#
Pipe Handling	Fully automated Varco PRS3I racker
	Varco AR4000 iron roughneck
	Varco PS30 slips & BX 4+5 elevators
Compensator	Maritime Hydraulic 1000K CMC
Riser	Dril-Quip 21" 2.5M Flanged -85% buoyant
	4-1/2" ID C/K lines – 4" ID booster line
	Dual 2-7/8" ID hydraulic conduit lines
Control BOP	Hydril Multiplex
Tensioning	Retsco 8 x 250 Kip
Shale Shakers	5-Brandt LCM-3D Cascade, 5.9 G's
Mud Cleaner	1-Brandt ATL-16/3 Stainless dual
Degassers	2-Brandt DG-10 Vacuum type.

Subsystem or Component		*Minimum Requirements in Group Designation*			
	ABS	***DPS-0***	***DPS-1***	***DPS-2***	***DPS-3***
	DNV	***AUTS***	***AUT***	***AUTR***	***AUTRO***
	Lloyds	***DP(CM)***	***DP(AM)***	***DP(AA)***	***DP(AAA)***
	IMO MSC/Cr645	***Not Recognized***	***Class 1***	***Class 2***	***Class 3***
Power Systems	Gen and Prime Movers	Non-Redundant	Non-Redundant	Redundant	Redundant separate compts
	Main Switchboard	1	1	1 with bustie	2 with n/o bustie in separate compts
	Bus-Tie Breaker	0	0	1	2
	Distribution System	Non-Redundant	Non-Redundant	Redundant	Redundant through separate compts
	Power Management	No	No Optional - IMO	Yes Optional - IMO	Yes Optional - IMO
Thrusters	Arrangement of Thrusters	Non-Redundant	Non-Redundant	Redundant	Redundant in separate compts
	Hold station with single thruster failure	No	No for ABS, IMO and DNV; Yes for Lloyds	Yes	Yes
Control	Auto Control – No. of Computer Sys	1	1	2	2 + 1 in alternate control station
	Manual Control – Joystick with auto heading	No	Yes	Yes	Yes
	Single Levers for each Thruster	Yes	Yes	Yes	Yes
Sensors	Pos. Reference Sys.	1	1 for IMO, 2 for others	3	3 with 1 in alt control station

Rig Classification Designation

Attachment 4



Schematic of LMRP

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.