Blowout Preventer - Appendices

7536

Exhibit No.

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Appendix A: Abbreviations and Acronyms

ACS	Acoustic Control System
AMF	Automatic Mode Function
APD	Authorization for Permission to Drill
API	American Petroleum Institute
Autoshear	An Emergency BOP system on the HORIZON, activated when
BAST	Best Available and Safest Technology
Beach	On shore
BHA	Bottom Hole Assembly
BHPM	Bottom Hole Assembly Pressure Method
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement, formerly MMS
BSR	Blind Shear Ram
BOP	Blowout Preventer
Casing	Pipe used to line the hole
CCU	Central Control Unit
CFR	Code of Federal Regulations
Deadman	An alternative term for the AMF System.
DP	Drill Pipe
DS	Drill String
DVS	Double V Shear (Ram)
DWOP	BP's Drilling and Well Operations Practices
Dynamic Event	Flow
EB	Engineering Bulletins
EDS	Emergency Disconnect System
EP	Initial Exploration Plan
EPI	Engineering Partners International, L.L.C.
ER	Emergency Response
FAT	Factory Acceptance Test
Fishing	Pulling disconnected material out of the wellbore
FMECA	Failure Mode, Effect and Criticality Analysis
ft	Foot or feet
gpm	gallons per minute
GoM	Gulf of Mexico
Hot Stab	ROV Connection

HORIZON	DEEPWATER HORIZON
HP	High Pressure
HPU	Hydraulic Power Unit
Hydrocarbons	Deposits beneath the earth's surface such as oil and gas
IADC	International Association of Drilling Contractors
In	Inch or inches
ID	Inside diameter
Joints	Individual sections of drill pipe
Kick	Unexpected flow of hydrocarbons into the wellbore
LDS	Lock Down Sleeve
LIT	Lead Impression Tool
LMRP	Lower Marine Riser Package
Long String	Long String of Production Casing
MASP	Maximum Anticipated Surface Pressure
MAWP	Maximum Allowable Working Pressure
MC252	Mississippi Canyon Block #252 – location of the Macondo well
MD	Measured depth
MGS	Mud-gas separator
MMS	Minerals Management Service, now BOEMRE
MODU	Mobile Offshore Drilling Unit
Mud	Drilling mud
MUX	Multiplex
MW	Mud Weight
NDT	Non-Destructive Testing
NPT	Non-Productive Time
OCS	Outer Continental Shelf
OD	Outside diameter
OEM	Original Equipment Manufacturer
OIM	Offshore Installation Manager
PLC	Programmable Logic Controller
ppf	Pounds per foot
ppg	pounds per gallon
psi	Pounds per square inch
Riser	Marine Riser System
RMS	Rig Maintenance System
ROV	Remotely operated vehicle
RP	Recommended Practice

SEM	Subsea Electronic Module
SPOF	Single Point of Failure
ST Lock	Hydro-mechanical ram locking mechanism
TA	Temporary Abandon
TD	Total Depth
TVD	Total Vertical depth
UMRP	Upper Marine Riser Package
UWILD	Underwater Inspection in Lieu of Dry-Dock
V	Volt
VBR	Variable Bore Ram

Appendix B: Deepwater Drilling
[1]

Deepwater drilling has been commonly known historically as the process of conducting oil & gas exploration and production operations in seawater depths of more than 500 feet ("ft"). Using this definition, there have been approximately 600 Deepwater wells drilled in the GoM.[2]

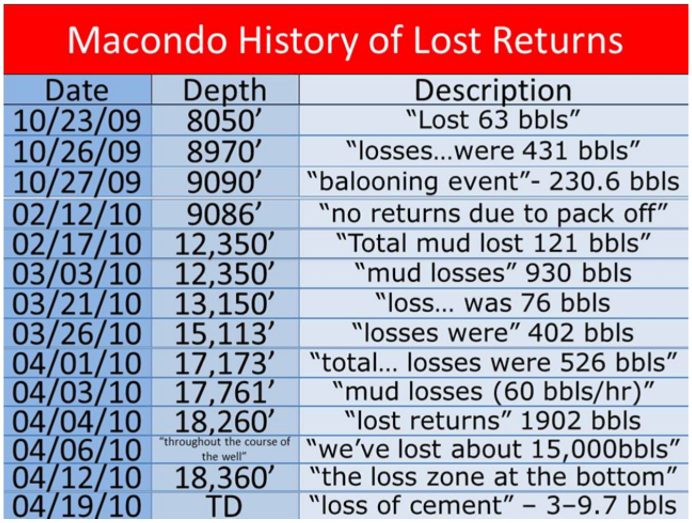
Oil production in water depths exceeding 6,000 ft is currently taking place in different parts of the world.[3] New explorations in ultra-Deepwater drilling operations are being performed in water depths exceeding 9,000 ft.[4]

Deepwater drilling presents unique technical and safety challenges, especially for the BOP. At these depths, the BOP equipment, hoses, and connections cannot be reached, except by Remote Operated Vehicle ("ROV"). ROV operations are difficult due to water pressure, lack of visibility, depth perception and color (everything is monochromatic), lack of appropriate tools and the limitations of remote control. In addition, the BOP cannot easily be brought to the surface even when the well is shut in, especially when the well is flowing. When the BOP malfunctions, repair or replacement becomes difficult, if not impossible. Accordingly, planning for Deepwater drilling BOP strategies must be undertaken with the utmost care and prudence.

SINTEF published a reliability study on behalf of the MMS, to review subsea BOP performance, entitled *Deepwater Kicks and BOP Performance* dated July 24, 2001.[5] The study reported a total of 117 BOP failures and 48 well kicks were recorded in the 83 wells observed between 1997 and 1998.[6] Of the 83 wells, 58 wells were deemed "exploratory drilling", defined as drilling in less well known formations. Macondo was an exploratory well.[7]

The report indicated that many of the GoM Deepwater wells were high pressure/high temperature wells.[8] The frequency of Deepwater kicks where a BOP was necessary to control the event was high when there was a low limit between the pore pressure and fracture pressure, such as on the Macondo.[9] During the kick control operations, BOP failures were observed that were probably caused by the kick killing operations.[10]

Macondo experienced numerous lost circulation events, and three kicks between February and April 2010, including one which resulted in reducing the total depth of the well.[11] The kicks were circulated out while the annular was engaged. Refer to Figure B.1 on the following page.



Macondo History of Lost Returns

Date	Depth	Description
10/23/09	8050'	"Lost 63 bbls"
10/26/09	8970'	"losses…were 431 bbls"
10/27/09	9090'	"balooning event"- 230.6 bbls
02/12/10	9086'	"no returns due to pack off"
02/17/10	12,350'	"Total mud lost 121 bbls"
03/03/10	12,350'	"mud losses" 930 bbls
03/21/10	13,150'	"loss… was 76 bbls
03/26/10	15,113'	"losses were" 402 bbls
04/01/10	17,173'	"total… losses were 526 bbls"
04/03/10	17,761'	"mud losses (60 bbls/hr)"
04/04/10	18,260'	"lost returns" 1902 bbls
04/06/10	"throughout the course of the well"	"we've lost about 15,000bbls"
04/12/10	18,360'	"the loss zone at the bottom"
04/19/10	TD	"loss of cement" – 3–9.7 bbls

Figure B.1. Macondo's History of Lost Returns or Lost Circulation Source: Skripnikova[12]

In BP's risk assessment for the Macondo well, it was identified that offset wells (wells drilled in the vicinity to access the same reservoir) had experienced multiple kicks and lost circulation events which presented a risk to time and costs.[13] Risk to safety was never mentioned.

The SINTEF report concluded that BOP configuration should include two (2) BSRs to increase safety availability in Deepwater drilling.[14] Replacing the upper pipe ram with a BSR would improve the ability to shear and seal the well during an emergency well control situation.[15]

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Figure C.3. Well Control

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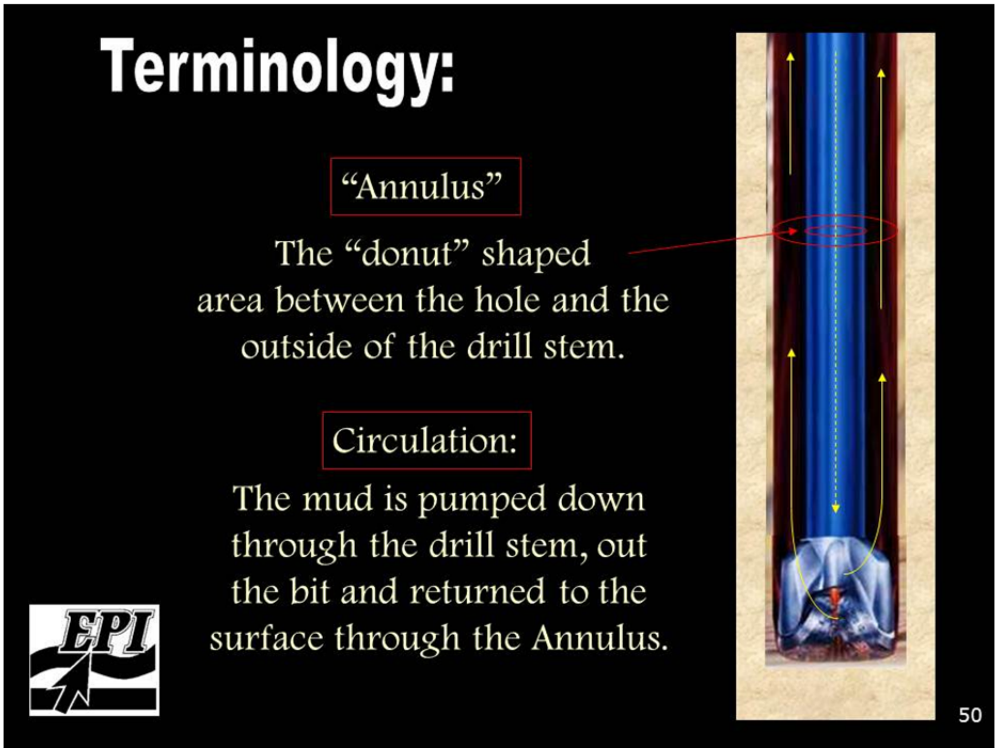
Appendix D: Blowout Preventers & Systems

A BOP is basically a pressure vessel. It can have multiple configurations based upon the drilling and completion operations being conducted.

A BOP is also a valve. When actuated, a BOP is intended to seal-off (1) the annular space or (2) the wellbore from below in order to contain formation pressures, i.e., the kick, downhole. The annulus or annular space is the area which surrounds a cylindrical object within a larger cylinder. In the oilfield, it is the donut-shaped space between the outside diameter ("OD") of the pipe in the wellbore and the inside diameter ("ID") of either the wellbore or casing. Refer to Figure D.1.

The BOP provides a means of containing wellbore flows and pressures during a kick. The design of the BOP permits drilling mud to be circulated into and out of the wellbore so that the kick can be circulated out and the well can be returned to its controlled, i.e., non-flowing condition. The BOP is also capable of suspending the drill string.



Terminology:

"Annulus"

The "donut" shaped area between the hole and the outside of the drill stem.

Circulation:

The mud is pumped down through the drill stem, out the bit and returned to the surface through the Annulus.

Figure D.1. The Wellbore Annulus

Once a BOP is actuated and seals, it contains the wellbore fluids and the wellbore pressures beneath it.

BOP original equipment manufacturers ("OEM") provide their BOPs with maximum allowable working pressure ("MAWP") ratings such as 2,000 psi, 3,000 psi, 5,000 psi, 10,000 psi and 15,000 psi. MAWP is provided for static and not dynamic flow conditions. Regardless of the BOP stack's overall pressure rating, the MAWP of the downhole casing which lines the wellbore ("Casing") limits the well's MAWP.

There are 2 types of BOPs; annular and ram-type. Refer to Figures D.2 and D.3 below.

Figure D.2. Exemplar: Hydril Annular BOP

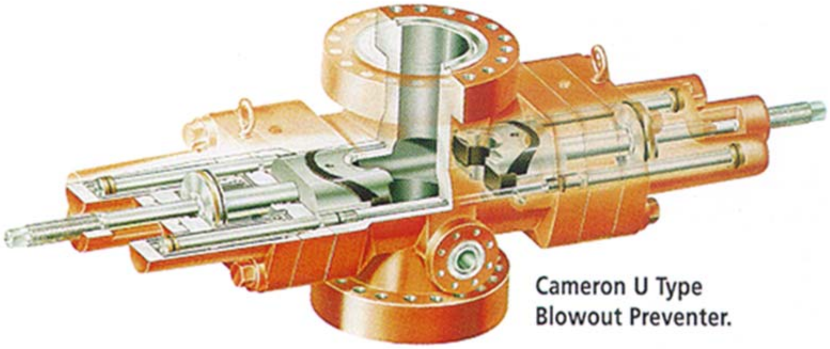


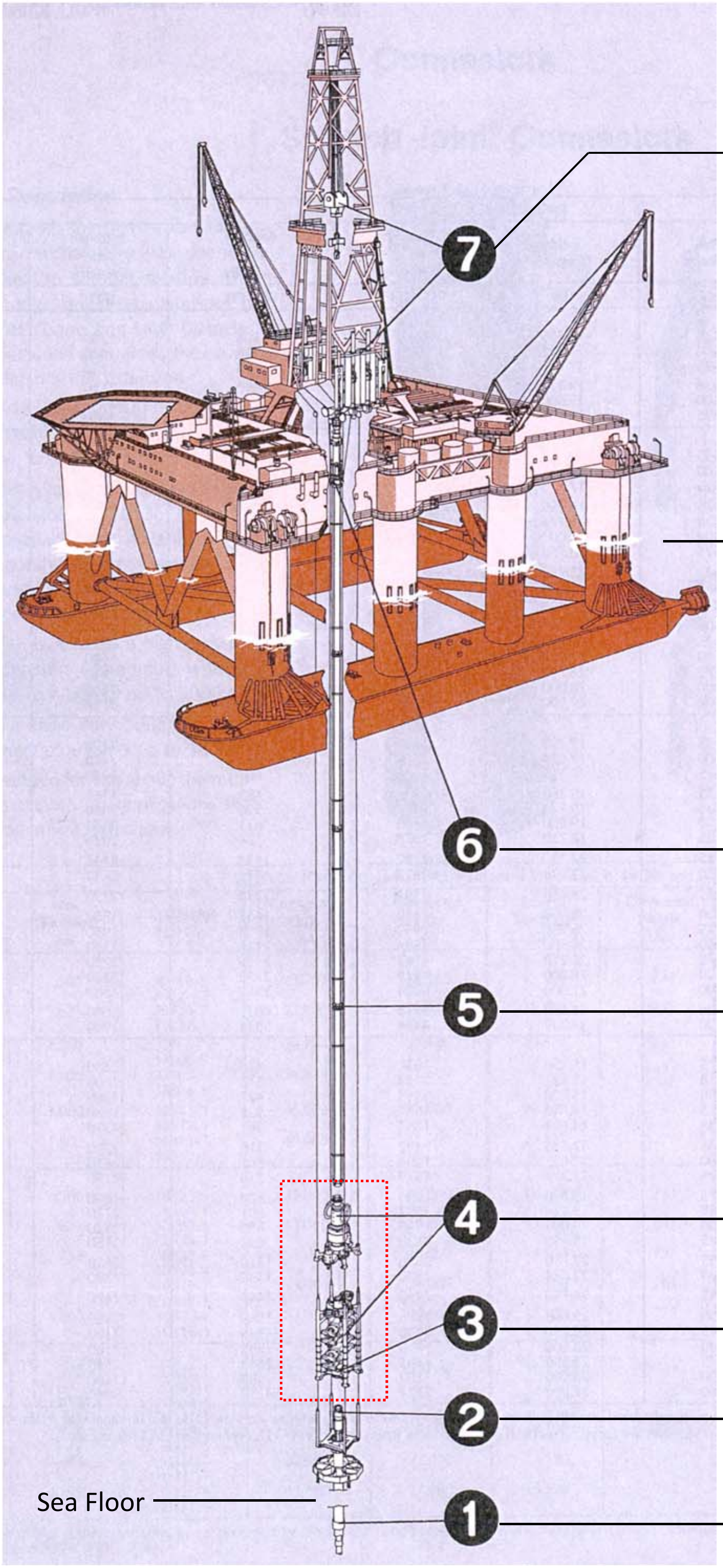
Figure D.3. Exemplar: Cameron Ram-Type BOP

When the drill string is in the wellbore, a subsea BOP must have the capability of shearing the drill string, shutting-in the wellbore and sealing it off from the surface. Shearing the drill string is accomplished by installing Shear rams into the body of a ram-type BOP.

All subsea BOPs are required to have a shearing/sealing ram (a "BSR"). A blind ram seals, a shearing ram shears, a blind-shear ram does both. When the BSR was developed, it was the first time there was the ability to shear and seal simultaneously with one (1) movement of the rams through the opening of the wellbore. Prior, all rams had to seal around the pipe and then attempt to shear with another stroke. Because of dynamic flow conditions, this was often a failure.

After the drill string is severed by the Shear rams, the LMRP should be capable of being disconnected from the lower BOP stack.

Refer to Figure D.4 on the following page of a subsea BOP connected to its MODU .



Motion Compensation System to include:

- Drill String Motion Compensator
- Riser and Guideline Tension Systems
- Upper Marine Riser Package ("UMRP")

(6) Telescopic Joint Assembly

(5) Marine Riser System

(4) BOP (LMRP and Lower BOP Stack) & Flex Joint

(3) BOP Connector

(2) Wellhead and Casing Hanger Systems

(1) Conductor Pipe and Subsurface Casing

Figure D.4. Subsea BOPs hooked-up to a Mobile Offshore Drilling Unit ("MODU") (from the 1896-1987 Oilfield Composite Catalogue, Vetco Gray)

Because the BOP is placed on the ocean's floor, it must be operated from the surface. Electrical and hydraulic lines, control pods, hydraulic accumulators, valves, "choke and kill" lines, a riser connector, a wellhead connector and a support frame are connected to, and are part of, a BOP. Acoustic devices were available that would allow for the remote actuation of subsea BOPs.

The BOP on the HORIZON was a five (5) cavity stack which attached to the wellhead. The lower BOP stack sits on the wellhead. The Lower BOP Stack is connected to the Lower Marine Riser Package ("LMRP"). The LMRP contained the annular BOPs. The LMRP had two (2) control pods, designated blue and yellow. A Multiplex Electronic Control ("MUX") cable connected the pods to the HORIZON. Electronic signals were transmitted from the rig through the MUX cables to the electronic packages within the pods. Then the signals were decoded to deliver certain commands to solenoid valves using battery power.

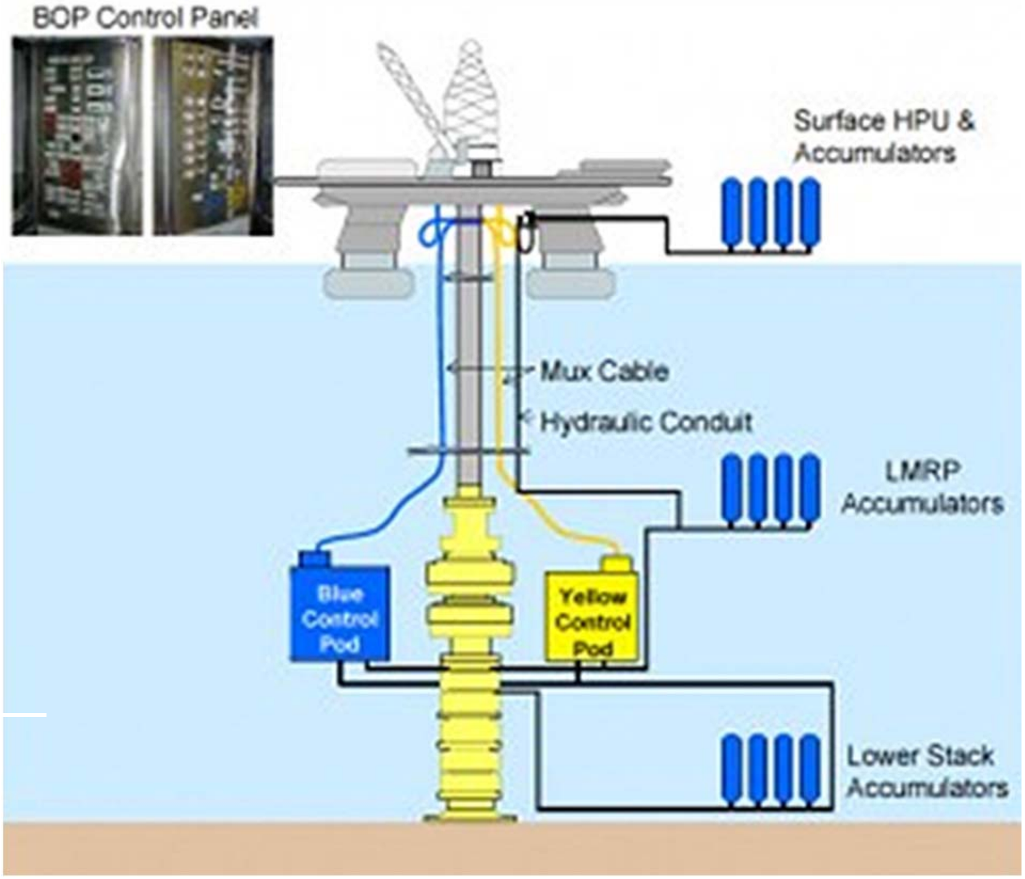


Figure D.7. MUX Cables & Hydraulic Conduits connected to the Blue & Yellow Pods

Solenoid valves are flow control devices in each pod. When energized by an electronic signal, a solenoid valve generates a hydraulic signal to operate a hydraulic component on the BOP.

At the bottom of the HORIZON LMRP was a hydraulically actuated connector. This connector attached the LMRP to the top of the lower BOP stack. This connector was similar to the wellhead connector which locked the lower BOP stack onto the wellhead.

The LMRP could be disconnected from the lower BOP stack, remotely by operator controls on the rig. Then, the HORIZON could move-off, if necessary, while the Lower BOP stack remained on the subsea wellhead. Refer to Figure D.6.

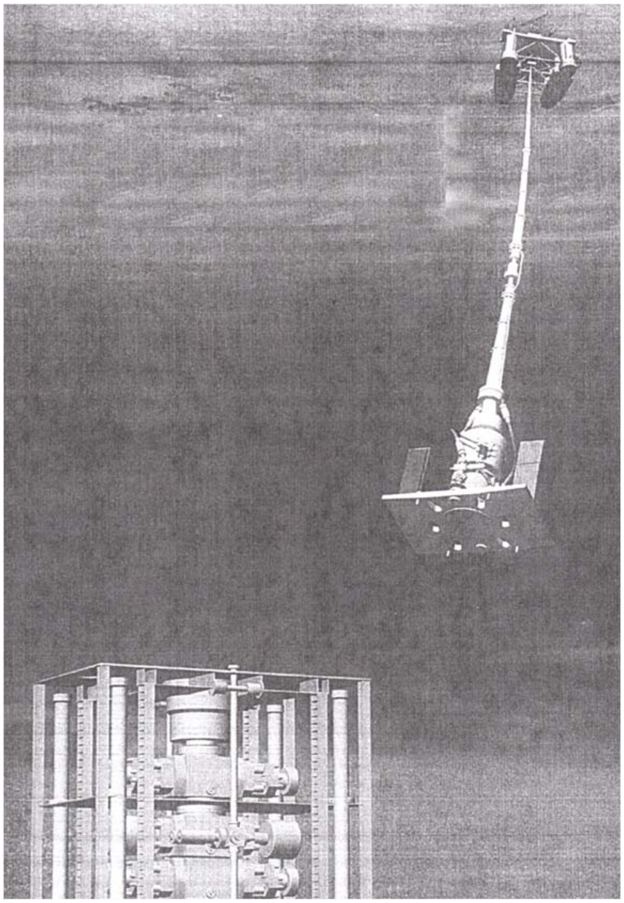


Figure D.6. Example of Disconnect LMRP from Lower BOP Stack with HORIZON moving-off (from the cover of Cameron's __Emergency, Back-up and Deepwater Safety Systems__)

Auxiliary lines include (a) "choke and kill" lines (b) mud booster lines and (c) hydraulic conduit lines. They are normally spaced asymmetrically around the Riser.

(a) "choke and kill" lines extend from the wellbore at the seafloor up to the MODU when the BOP has been shut-in and the wellbore sealed. Mud can be pumped down the kill line into the wellbore. Mud and wellbore fluids are circulated out of the wellbore through the choke Line. A Drilling choke, i.e., variable opening valve, is connected at the end of the choke Line in order to control the flow and pressure of the displaced wellbore fluids and mud.

The BOP and its control systems ("CS") must also have emergency closure systems available to the MODU on the surface.

Failures of BOPs have been well documented throughout the industry. Several reports studying BOP failures and several reviews show a long history of BOP failure upon emergency activation. Well control policies that rely solely on the BOP as the only barrier are reckless and below the minimum standard of care. BP's own policy requires a minimum of two (2) barriers and the BOP is not considered one of those barriers.

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Appendix F: Responsibility for BOP Configuration

Information reviewed showed that BP was responsible for, and exercised control over, the configuration, management, monitoring, testing and usage of this BOP.[32] Between 2001 and 2010, even though the BOP is part of the rig and owned by Transocean, BP was the dominant force in its configuration.[33]

Vastar, and its successor, BP, specified the configuration of the BOP, participated in its design, and chose its components and control systems.[34]

Vastar, BP's predecessor:

- Configured a 5-cavity BOP;
- Specified a 30 second disconnect in connection with the Deadman system; [35]
- Decided against equipping the HORIZON with an acoustic trigger, i.e., a remote control;[36]
- Required certain adjustments be made by Cameron before accepting the BOP into service after the Factory Acceptance Test[37];
- Specified the location of the MUX cables;[38]
- Selected EDS-1 (activation of the BSRs only) instead of EDS-2 (activation of the CSR first, followed by the BSR) as the primary emergency disconnect mode.[39]

The original contract with Transocean, specified the configuration of the BOP; ten (10) years later, in September 2009, Amendment #38 to the contract, BP again specified the BOP configuration.[40] By Federal regulations and industry standards, BP was responsible for the BOP. Under the CFRs, BP was obligated to ensure proper configuration, testing, training and use of the Subsea BOP equipment. See 30 CFR 250 400 *et seq.,* cited; American Petroleum Institute ("API") Recommended Practices ("RP") No. 53 or API RP 53.[41] BP knew the importance of the BOP. BP repeatedly, post-blowout, said that their well control plan was to rely on the BOP.[42]

With only one BSR, BP's Management knew that it was difficult to remove all of the single points of failure ("SPOF"). In a Risk Assessment performed on the HORIZON's BOP CS, in 2001, there was an indication that the final shuttle valve, supplying the BSR with pressurized hydraulics, as well as the BSR itself, represented a single point failure that accounted for 56% of the likelihood of the system to fail to perform an EDS.[43] Studies had shown that with the addition of a second BSR in the upper pipe ram cavity, the probability of a blowout would be reduced in comparison to the three VBRs present in most BOP configurations. Even knowing that, and knowing that other rigs in the GoM had 2 BSRs,[44] BP left only one BSR in HORIZON's BOP configuration.

BP was responsible for calculating the Maximum Anticipated (Allowable) Surface Pressure (MASP), a regulatory requirement relating to the BOP (*30 CFR 250.446)*[45]*.* Inexplicably, BP never properly utilized MASP in setting well control policy or to determine safety risks (MASP is discussed in more detail below).[46]

BP's Management did not adequately address the safety aspects of the BOP configuration for the inherent risks associated with the Macondo well design.[47] In fact, according to BP's Risk Register for Macondo, non-productive time (NPT) was the only risk associated with Macondo's BOP.[48]

In addition, BP's Management spent considerable time/money to invent, install, test and patent a digital BOP testing system.[49] This proprietary system had no effect on safety, but was designed solely to save money by reducing non-productive time.[50]

In 2004, BP's Management decided to convert the BOP lower VBR to a Test ram.[51] A test ram will sustain pressures from above, i.e., during BOP pressure testing, but not from the wellbore below the test ram. BP spearheaded the decision and paid for the test ram conversion.[52]

"…we (BP) drove the decision to install test rams"

BP's Management also talked about the savings that this test ram conversion would bring[53], while simultaneously admitting that the decision "*reduces the safety margin*" of the BOP.[54] The test ram reduced redundancy, i.e., the lower BOP stack went from three VBRs to two. By making the lower ram a test ram, BP violated its own well control policy which stated the "*the lowermost ram be preserved as a master component and only used to close in the well when no other ram is available for this purpose*."[55] On the test ram decision, BP analyzed the risks and concluded that lowering safety was justified because of the monetary savings.[56] Again, in 2008, BP recognized that the "test ram" conversion would lower the safety profile.

BP's Management modified the lower annular from a 10,000 psi rated component to a 5,000 psi stripping annular.[57] Cameron specifically warned that this particular BOP component should not be put into a situation where it was exposed to greater than 5,000 psi[58]. There was no evidence that BP went through any risk assessment prior to the change order[59].

> *"BP wants [stripper packer] on DEEPWATER HORIZON at all times."*

While on location in 2007, the HORIZON's VBRs failed while attempting to shut-in and seal-off the wellbore annulus. BP's Management, independent of Transocean, decided to retain Wild Well Control, a third party vendor, to perform a risk assessment of the HORIZON's BOP.[60] BP was considering whether to upgrade the BOP. If BP were not the entity making the decisions, the assessment would have been superfluous.

BP also had actual control over the HORIZON's BOP. BP's own policy manuals required a certain BOP configuration,[61] required industry best practices,[62] and required bridging documents between BP and Transocean.[63] BP manuals specified that BP personnel must ensure that BP's well control policies were implemented and followed by Transocean[64] Well control included many areas (for example, using a fluid column as the primary barrier), one of which was the proper and appropriate use of the BOP.[65]

On Macondo, BP's Management consistently made decisions regarding the BOP. For example, a leak was discovered in a shuttle valve on the yellow pod, it was placed in vent, i.e., inactive.[66] BP's Management decided not to pull the LMRP to fix the yellow pod,[67] despite MMS requirements to do so.[68]

During drilling, someone accidentally hit the Joystick and stripped DP through the upper annular, a non-stripping annular.[69] Stripping is moving DP and its Tool Joints, located on the ends of the DP, through the annular while closed. On April 5, 2010, a stripping operation occurred through the upper annular[70]. Later, pieces of rubber were found in the shaker, from Macondo's flow returns.[71] On April 20, 2010, an actuation pressure of 1,900 psi was required to affect a seal on the upper annular, when the normal setting was 1,500 psi.[72]

BP's Management knew that the annular had been subjected to repeated activation, and knew frequent use of either or both annulars would cause accelerated element wear.[73] Even after all of this, BP decided not to pull the BOP to inspect and/or repair it.

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Appendix G: DEEPWATER HORIZON'S Subsea BOP

The BOP is a "safety critical" piece of equipment, i.e., its failure endangers life, property, and/or the environment.[76]

For BP's Macondo, the HORIZON's BOP was outfitted top to bottom with:

- Blind Shear Ram ("BSR") in the upper cavity and;
- Casing Shear Ram ("CSR") in the second cavity;
- Variable Bore Rams ("VBR") in the third and fourth cavities and;
- VBR in the lower cavity. Note: this VBR was modified in 2004 to be a test ram.
- One (1) Vetco Gray Super HD H-4 wellhead connector[77]

In accordance with the API 16D, Section 5.2.1, the control system for a BOP shall be designed to deliver power fluid at sufficient volume and pressure to operate each individual ram-type BOP within 45 seconds. Refer to Figure G.1 below and G.2 on the following page of the entire BOP used on BP's Macondo.

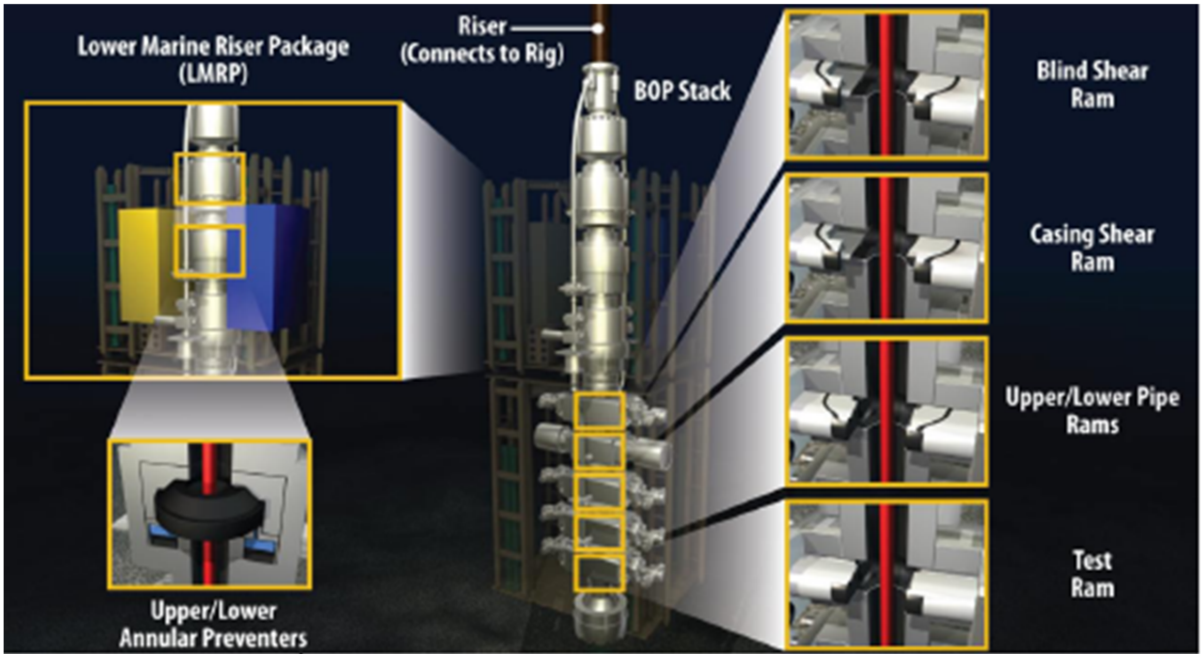
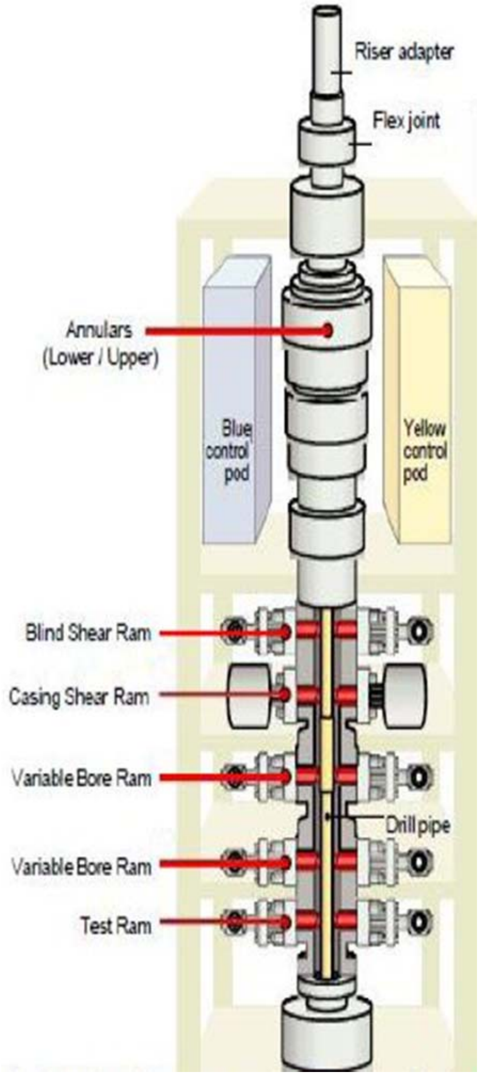


Figure G.1 The BOP on the DEEPWATER HORIZON
Source: TrialGraphix



BP's MACONDO BOP DESIGN & RATINGS

- **UAP:** Upper Annular Preventer rated at 10,000 psi.

- **LAP:** Lower Annular Preventer rated at 5,000 psi due to modification for stripping. (reduced from 10,000 psi at BP's request)

- **BSR:** Blind Shear Rams to cut DP in two then shut-in and seal-off the wellbore. This BSR was rated at 15,000 psi static rating. (Performance in dynamic conditions unknown.) (The wellbore is 18 ¾" wide, but cutting blades are only 17 7/8" (lower blade) and 15 ¼" upper blade.) Pipe outside the blades will not be sheared.

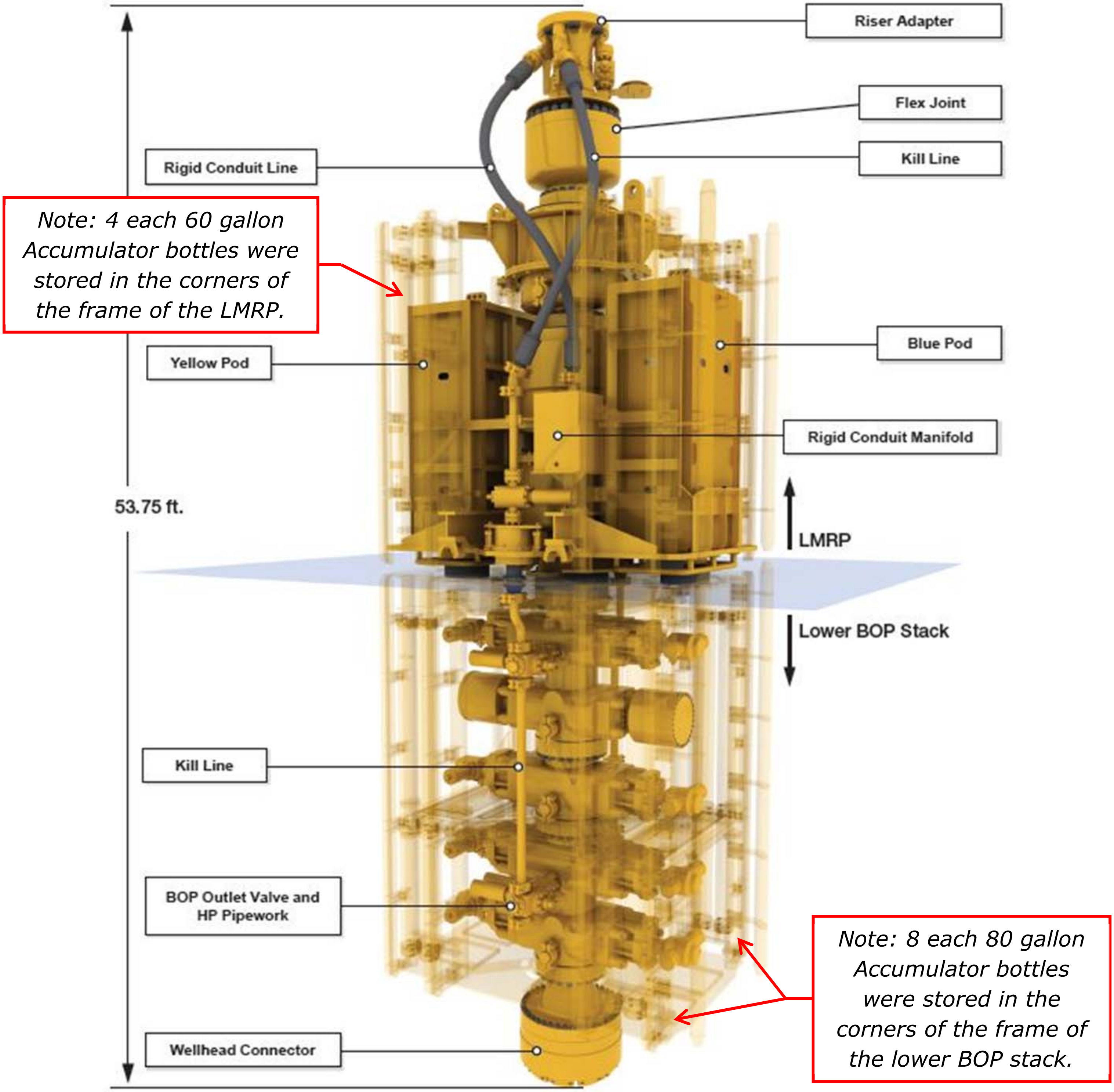
- **CSR:** CSRs cut pipe and casing into two but are not designed to shut-in the well and seal-off the wellbore.

- **VBR:** Upper and Middle Variable Pipe Rams. Its packers can close on a range of DP from 3½" to 6⅝" OD and seal up to 15,000 psi static.

-**Test Ram:** This was originally a VBR but converted to a test ram on BP's request. Test rams can seal up to 15,000 psi static from above (e.g., for tests), but cannot seal pressure from below (i.e., the wellbore).

Figure G.2 BP's Macondo well's BOP
Image Source: Aconawellpro

The LMRP was comprised primarily of two control pods, blue and yellow, and two annular BOPs. Also refer to figure G.3 on the following page.



Note: 4 each 60 gallon Accumulator bottles were stored in the corners of the frame of the LMRP.

Note: 8 each 80 gallon Accumulator bottles were stored in the corners of the frame of the lower BOP stack.

Figure G.3 LMRP & Lower BOP Stack
Source: Transocean's Investigation Report June, 2011

The Cameron Model DL annular had a rubber seal in the shape of a doughnut, also known as an elastomeric packing element, reinforced with steel ribs.[78] When actuated, the upward movement of the annular BOP piston forced the packing element to squeeze inward to seal around the drill string's OD and shut-in and seal-off the annulus. The API required that this packing element shut-in and seal-off the wellbore within 60 seconds as part of its certification process. Refer to Figure G.4 below.

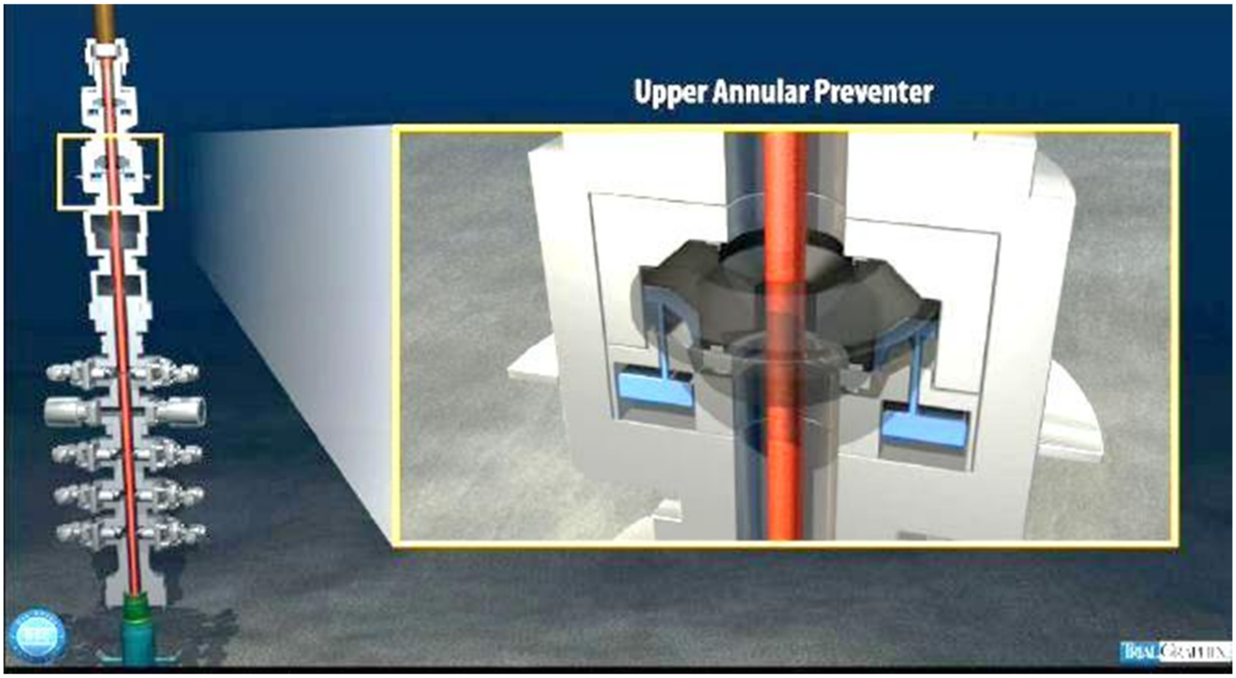


Figure G.4 Annular BOP Source: TrialGraphix

The HORIZON upper annular BOP was rated for 10,000 psi (static flow, not dynamic).[79]

In 2006, BP modified the lower annular BOP to allow for the stripping of 6⅝" DP.[80] After the modification, the pressure limit for the lower annular BOP was dropped to 5,000 psi.[81] Stripping is the process of raising or lowering the drill string through a closed annular BOP.

BP's Macondo well plan called for 6⅝" and 5½" DP to be used during the drilling process.[82] BP told the MMS that 6⅝" DP would not be used below the BOP except when setting the 16" OD casing and for no more than 12 hours.[83] BP later told MMS that 5½" DP would not be run into the well except to set the 16" casing.[84] The two apparently contradictory statements were made when the Marianas was going to be drilling Macondo, but BP never corrected the MMS filings. The Macondo was actually drilled primarily using 6⅝", 32 ppf, S135 DP. [85]

Studies have shown that when stripping is required as part of well control operations, there is a greater chance for the annular BOP's packing element to fail. Macondo experienced at least three (3) kicks which were recognized and circulated out between February 11 and April 20, 2010. Some are listed in Figure G.5 below.

Macondo History of Well Control Events

Date	Depth	Description
10/26/09	8970'	"well appearing to be flowing"
10/27/09	9071'	"well not static" "we took the kick"
2/17-23/10	12,350'	"Total mud lost 121 bbl."
3/2-5/10	12.350'	"Mud losses" 930 bbl.
3/8-14/10	13,250'	"Took a kick at 13,250"
4/4-7/10	18,260'	"lost returns" 1902 bbl. we've lost about 15,000 bbl.
4/20/10	18,360'	Kick leads to blowout and explosion

Figure G.5 Well Control Chronology on Macondo [86]

These kicks, from February of 2010 forward, resulted in annular activities, some for many days.

Pipe was stripped through the upper annular on April 5, 2010, making it suspect for sealing purposes. This increased risk was revealed during the negative pressure test performed on April 20, 2010. The annular would not seal at 1,500 psi and required additional pressure above 1,900 psi to complete the seal.

> *"A leaking annular packer will manifest itself by requiring steadily higher pressures to effect the seal during BOP test, and is the first indication that it is worn or damaged and should be changed at the earliest opportunity…"* [87]

The elastomeric annular element, which is the primary closing element, was subjected to a great deal of wear and erosion. Rubber pieces were reported to have been found in the particulate matter removed from the drilling mud,[88] indicating elastomeric wear on the annular.

Thus, by April 20, 2010, all parties knew that the annular BOPs had an increased risk of failure due to the stripping activities and prior actuations as a result of multiple kicks.[89]

Ram-Type BOP

A ram-type BOP should be capable of quickly shutting-in and sealing-off the wellbore during a well control event. A ram-type BOP consists of two ram hlocks diametrically opposed. Each Ram Block contains packing and/or seal elements. Hydraulic actuators, normally retracted, force the two ram blocks together to shut-in and seal-off the wellbore. An example of a ram-type BOP is the BSR. Refer to G.6 below.

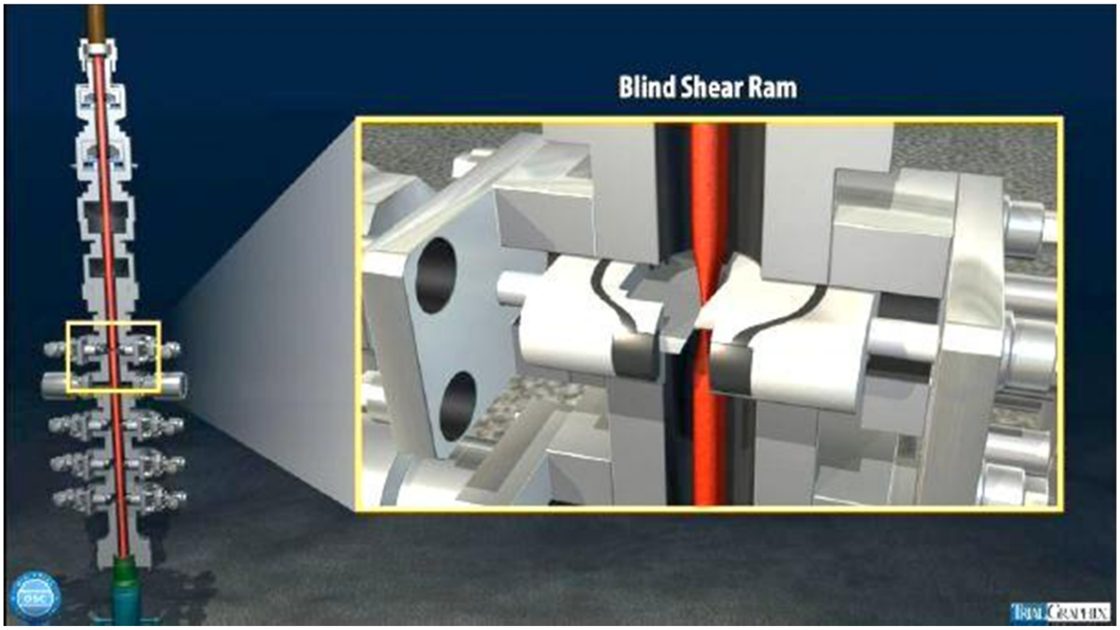


Figure G.6 BSR used on Macondo Source: Trial Graphix

The pressure regulator (for the lower BOP accumulator stack) used to supply energized hydraulic fluid to the BSR was set to 4,000 psi. Post incident testing indicated that the BSR's regulator might have been set between 3,800 and 4,000 psi.

After the BSR is activated during a well control event, i.e., the well is flowing, its ram blocks move into the path of the well's flow thus exposing their elastomeric sealing elements to the flow. Should the BSR take too long to close, the elastomers could become eroded and fail to seal-off the wellbore.

The BSR on the Macondo should have been designed so that it could shear the pipe and seal its wellbore with any DP in use.

The BSR could be activated from control panels on the HORIZON, i.e., the low pressure BSR function, high pressure BSR function and the EDS function. The BSR could also be activated by the Automatic Mode Function ("AMF"), also known as the "Deadman", the Autoshear function, or by ROV hot stab.

Every emergency BSR system (EDS-1, EDS-2, high pressure BSR function, Autoshear AMF, and ROV hot stab) relied upon the BSR ram blocks to shear the pipe and seal the well. From inception, BP, Transocean, and Cameron knew that the BSR was a single point failure designed into the BOP.

BOP Control Systems

There were primary and secondary means available to activate Macondo's BOP.

Primary (MUX Cables)

When operating in deepwater, rapid signal transmission on the HORIZON was accomplished electronically. These primary systems use Programmable Logic Controllers ("PLCs") to translate the operator's action from a control panel to an electronic signal which is transmitted subsea. The operator-controlled function of the BOP was a primary control. The high-pressure BSR function, and the EDS function, were both operated by this primary system.

The primary system of operating Macondo's BOP when on the ocean floor was the use of a multiplex electronic control ("MUX") system. Commands from a surface panel were sent to a junction box, on to the MUX cable reels, and then through the MUX cables to the yellow and blue pods. These signals were to be processed by the PLCs located in the pods and converted to hydraulic signals that would actuate certain control valves and direct operating fluid to/from the BOP.[90] Each control pod had two subsea electronic modules ("SEM"), two subsea transducer modules ("STM"), pressure regulators, solenoid valves, subsea hydraulic accumulators, and operating valves.[91] The STM's function was to monitor the hydraulic control system pressures and the hydrostatic pressure acting on the BOP.

The BOP could be energized from three different control stations on the HORIZON; the rig floor, the HORIZON's Bridge and the Central Control Unit's ("CCU") panel. All BOP elements of the BOP could be engaged from any of these three locations.

The MUX BOP control systems were located in two different areas; one is considered safe and the other hazardous. Both areas were interconnected with two independent data bus and power supply systems. The hazardous area is connected to the safe area via data line and is supplied by two independent power sources. The hazardous area had explosion proof HPU and control boxes located on the diverter unit.

However, the blue and yellow MUX cable reels, which were integral to all three control panels, were located in the HORIZON's moon pool. The moon pool is considered a hazardous area,[92] since it is the area at the top of the Riser and a direct conduit to the wellbore.

Should an explosion in the Moon Pool area compromise the MUX cables, that event would eliminate all BOP control functions from the three operator control units. There was no acoustic trigger on Macondo's BOP which could activate the pods remotely. When BP specified the placement of the MUX cables, they should have considered the location to be a SPOF.

This SPOF could have been avoided in three ways:

- An acoustic trigger, providing an alternate means of operator activation (available in 2001);
- [redacted]
- [redacted]

Had any of those actions been taken by BP, the operator would have been able to activate EDS after the explosions. Then, the LMRP would have been disconnected from the lower BOP[93] and the HORIZON would have been saved. Intervention after April 20, 2010, would also have been made easier.

EDS

The Emergency Disconnect System (EDS) was activated by the primary controls, i.e., through the MUX cables. The EDS was designed to execute a series of BOP functions in a timed sequence when energized by the surface MUX control system. Buttons (you push and hold one while depressing a second button for the desired function) on a control panel activated a pre-defined sequence of functions in the BOP to secure the well by first closing the BSR and then disconnecting the LMRP, i.e., EDS-1.

At Macondo, the active EDS sequence was EDS-1. EDS-1 was programmed to close the BSR in approximately 46 seconds and then unlatch the LMRP. EDS-1 functioned only the BSR while Cameron's EDS-2 closed the CSR first then closed the BSR approximately 45 seconds later. Neither EDS sequence actuated the VBRs.

EDS-2 would have improved the chances of successfully shearing the DP and sealing Macondo.[94] The CSRs, if activated first, would have provided a temporary reduction in flow, which would have had the effect of shielding the BSR elastomers from erosion damage while the BSR was closing, improving the chances of a successful seal. Given the DP strings in use on the HORIZON, BP's Management should have programmed EDS-2 as the active emergency mode.

Secondary

After the primary controls were rendered inoperable by the explosion, three (3) secondary means were available to control the BOP on Macondo:

- The Autoshear function;
- The Automatic Mode Function ("AMF") or "Deadman" and;
- Remotely Operated Vehicle ("ROV") intervention

Autoshear

The Autoshear function was a stand-alone, passive system which automatically shuts-in the wellbore upon an unplanned disconnect of the LMRP. The Autoshear function has a valve which is connected to a rod welded between the LMRP and the Lower BOP stack. It has two modes: disarmed and armed.

If armed and the LMRP unexpectedly disconnected from the lower BOP stack, the spring loaded mechanism would energize certain hydraulics and activate the high pressure shear circuit to close the BSR.

AMF

The AMF, sometimes called the "Deadman", was an automatic emergency backup control system located in the yellow and blue pods. It was a secondary system used to activate the hydraulic circuit to close the BSRs upon a catastrophic failure which resulted in the loss of both hydraulic pressure and electric power to the BOP from the surface.[95] This function was developed in the event the Riser failed, i.e., collapsed or parted.

The AMF, supplied by Cameron, utilized some of the components used in the primary control system operations, including the SEMs. The major components associated with the system are:

- Two subsea electronic modules (SEM A and SEM B) located in each of the pods;
- AMF cards (one per SEM - four total in the BOP system);
- Dedicated 9-volt (V) DC battery pack per AMF card (one per SEM- four per BOP system);
- 27V DC battery pack shared for both SEM A and B (one per pod);
- Solenoid 103 located in each pod. When energized the high-pressure blind shear circuit is activated for 30 seconds, then the AMF is activated. And;
- Dedicated subsea hydraulic accumulators stack.

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Conclusion: Primary and Secondary Intervention Systems

The ability of the primary systems (high-pressure BSR and EDS) to operate the BOP is destroyed when the MUX cables are destroyed. The secondary systems are for limited conditions. The prerequisites for Autoshear, were never satisfied, because it depended upon a disconnect of the LMRP.[103] It was unknown when the conditions for AMF were satisfied, i.e., it is unknown when the hydraulic power was lost.[104]

The design of the BOP system left a very real scenario, therefore, whereby, the HORIZON would not have emergency BOP activation: namely, where the

MUX cables were destroyed, hydraulic power was still intact, and the LMRP was still connected. That "hole" in design was what happened on April 20, 2010.

The primary system should have had an alternate means of activation.

Accumulators

The Hydraulic Power Unit provided hydraulic power fluid, which operated the subsea lower BOP and LMRP system functions. The BOP was fitted with two (2) accumulator banks. The LMRP bank included 4 each, 60 gallon accumulator bottles. The Shear Circuit Bank located on the lower BOP stack included 8 each, 80 gallon accumulator bottles.

There is a flexible bladder or bag inside the accumulator bottle charged with nitrogen. As hydraulic fluid is pumped into the accumulator bottle, it surrounds the outside of the Bag. As more fluid is pumped into the accumulator bottle, the Bag compresses the nitrogen to its pre-charged pressure. The accumulator bottles are all pre-charged with nitrogen and hydraulic fluid at the surface before splashing the BOP and setting it atop the wellhead on the ocean floor.

The banks of the BOP's accumulator bottles were connected together in series. The accumulator was rated at 5,000 psi. The 5,000 psi flows to a regulator, which governs how much fluid pressure will be delivered to the ram-type BOP pistons. On the HORIZON, the BSR and CSR accumulators were regulated to 4,000 psi. There were indications that the accumulator's BSR and CSR regulator was set lower to 3,800 psi.

Refer to Figure G.7 below of the 80 gallon accumulator bottles on the lower BOP stack:

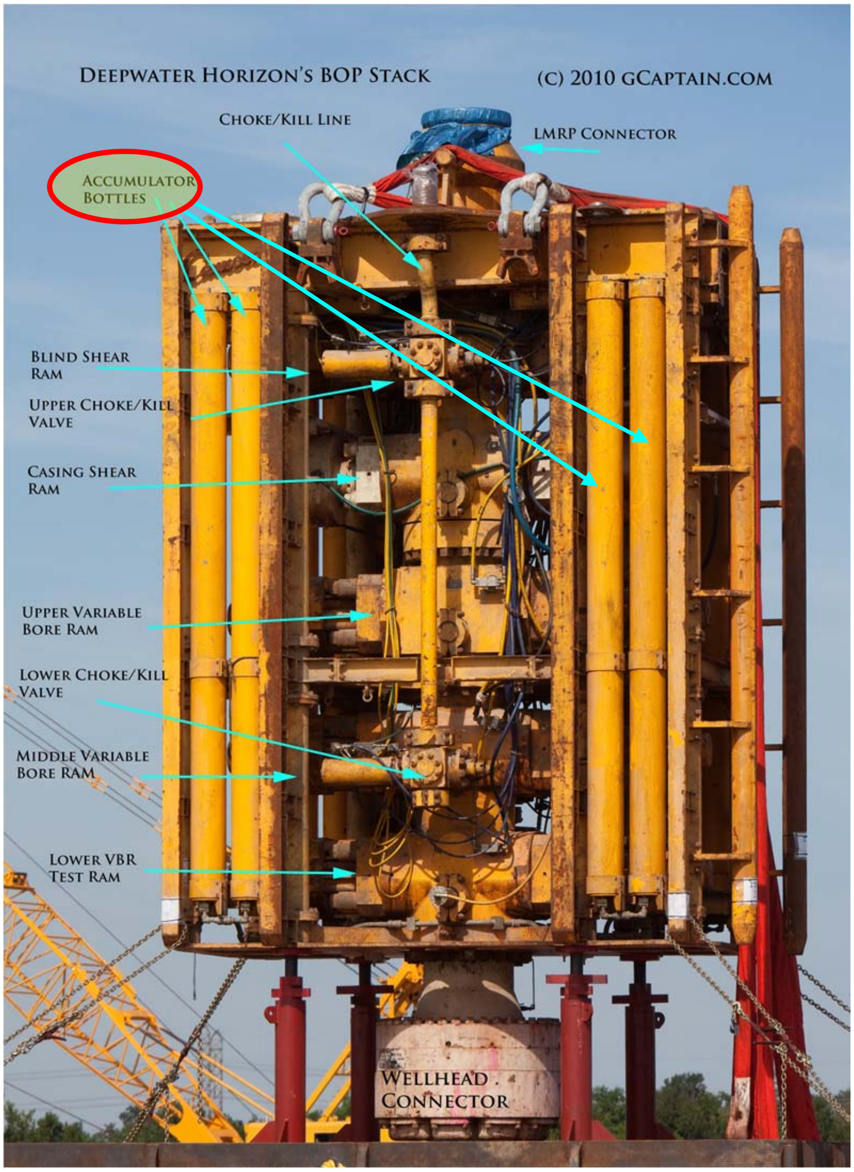

Figure G.7 Accumulator Bottles on the lower BOP stack. (from DNV's Report)

Once the BOP was atop the subsea wellhead, there was only one (1) way to measure how much nitrogen pressure and hydraulic fluid were in the accumulator bottles; bleeding-off the pressure in the accumulator bottles and then pre-charging them back up to their regulated pressures from the surface. The accumulator bottles would be pre-charged to their regulated pressures via electric pumps on the HORIZON.

The accumulators should be capable of:

- Closing all ram-type BOPs (maximum of 4);

- Locking all ram-type BOPs locking devices and close one annular BOP;
- Unlock all ram-type BOPs locking devices and open one annular BOP; and;
- Retain 50% of the required volume in reserve

Per API RP 53 Section; 13.3.2:

> *"BOP systems should have sufficient usable hydraulic fluid volume (with pumps inoperative) to close and open one-type preventer and all ram-type preventers from a full-open position against zero wellbore pressure. After closing and opening one annular preventer and all ram-type preventers, the remaining pressure shall be 200 psi or more above the minimum recommended pre-charge pressure."*

Post incident, a leak was discovered in the HP casing shear regulator. At the time of discovery, pressure in the accumulators was 3500 psi. Seveal other leaks were found after the explosion.

The subsea BOP accumulator was a single point of failure for the emergency systems on the HORIZON BOP. Even if the subsea BOP accumulator stack was working perfectly, it was limited in the force (psi) that it could deliver. Subsea accumulator systems that would deliver 5,000 psi were available from Cameron, but they were not on the HORIZON. Even after BP upgraded the HORIZON drill pipe from 5½" to 6⅝", BP did not upgrade the accumulator. BP and Transocean knew that the BOP stack could not shear 6⅝"".

The accumulator stack delivered hydraulic force to the BSR of 4,000 psi. The force available would be limited by regulator settings (i.e., the regulator could be set to less than 4,000 psi). If any leaks existed, the force would be further reduced.

The accumulator force available affects the ability to shear. Namely, could the drill pipe strings in use on the Macondo be sheared with only 4,000 psi? With respect to the 6⅝" drill pipe that was primarily used to drill Macondo, the answer is no.

Even with respect to the 5½" drill pipe across the BOP at the time of the explosion, there is a question. With elevated wellbore pressures, it would take approximately 4,000 psi to shear the 5½" pipe and this is only true if you:

a. Assume no safety margin;

b. Assume no individual variation in the pipe, which Cameron expressly says you should not assume;

c. Ignore the effects of any off-center pipe; and

d. Ignore the effects of dynamic flow.

For the drill pipe strings in use on the Macondo, the limitation of the accumulator system available pressure was significant.

G.1 Modifications

Several modifications were made to the BOP and its control system between the commissioning of the HORIZON and April 20, 2010. Nine of those modifications were documented by a Transocean Management of Change document. At least two of those nine modifications were specifically requested by BP. According to Transocean, the Management of Change documents for the remaining eleven modifications were lost after the HORIZON sank.

Notable modifications were:

- MOC SS-005 - Performed by Cameron on January 1, 2003 when the retrievable pods was changed to non-retrievable pods which reduced the number of possible failure points, but did not allow for the pods to be brought to the surface for repairs while the LMRP was connected to the wellhead.
- MOC SS-010 - Performed by Cameron and completed on December 13, 2004. Per BP's request, the lower pipe rams were converted to test rams which allowed for the testing of the BOP without the requirement of running a test plug into the well. Notably, the ROV hot stab was not changed at this time. The ROV hot stab should have been changed at this time to the middle VBR, which was now the lowermost effective BOP component. From 2004 to 2010, the ROV hot stab was apparently never tested, since tests would have immediately disclosed the problem. Later, after the disaster, several days were spent trying to use the ROV hot stab to close the

middle VBRs. On May 3, 2010, it was discovered that the ROV hot stab was still connected to the lowermost ram, making these efforts futile. There was no correct schematic of the BOP to show this. Cameron had made the change to test rams, but denied responsibility.

- MOC SS-016 - Performed by the HORIZON Crew on June 5, 2006. BP requested an 18-3/4" annular stripping element be installed in the lower annular to allow for the stripping of 6⅝" DP through the closed annular. The pressure rating for the lower annular dropped to 5,000 psi ,as opposed to the original 10,000, as a result of this change

G.2 Testing

The CFR Title 30: Part 250 **Oil Gas and Sulphur Operations in the OCS** specified the purpose of BOP testing is to ensure the BOP system and its system components are pressure tight and fit-for-purpose

On the Macondo, the testing protocol was set by BP[105] through its request for dispensation from MMS directed testing requirements; i.e., testing frequency and pressures.

BP's Management recognized the importance of clarity as well as execution of BOP testing procedures:

> *"I rewrote it [the BOP checklist] to take out some of the ambiguity and standardized the process. Not only do you need a good checklist, but it comes down on how you execute it. When the check list is interrupted it is started over from the beginning. This eliminates distractions being the root cause."*

[redacted]

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> [redacted]

On Macondo, BP sought, and obtained, exceptions from testing required by the Code of Federal Regulations (23-Feb-03 Edition) for the BOP and its control system. The APD, as approved, stated: (emphasis added)

> **250.447(b) The 14-day BOP pressure test is not required for BSRs**. The BSRs and the wellhead connector will be tested to the casing pressure tests as specified in the APD during casing tests such that code requirement of 250.449(e) is met. 250.449(e) calls for the interval between any blind or BSR BOP pressure test may not exceed thirty (30) days.)
>
> **250.447(c)** The BOP's well be pressure tested every 14 days. **The BOP test before drilling out each casing string and/or liner shall not be expressly required,** except that the 14-day pressure test must be valid. This applied to the following casing strings:
>
> - 18" Liner;
> - 16";
> - 13 5/8" Liner and;
> - Contingency liners.
>
> **250.448 (b & c) Subsea BOPs will <u>not</u> be pressure tested to 15,000 psi rating working pressure, and the annular will <u>not</u> be tested to 70% of its rated working pressure,** on the test stump, or after installation. We propose that single ram-type BOPs shall be stump-tested to 10,000 psi and the annular BOPs shall be stump-tested to 5,000 psi. Thereafter, test pressures will be per the APD.
>
> **The BSRs will not be pressure tested to their MAWP** upon installation or during subsequent tests. The BSRs will be tested to the casing test pressures as specified in the APD.
>
> **The upper inner and outer annular bleed valves will <u>not</u> be pressure tested to their MAWP**. A pressure test of the upper inner and outer bleed valves will be performed against the annular BOP to the annular test pressure specified in the APD.
>
> **250.449(f) BP requests not to test on 6⅝" Casing landing string during BOP tests. During drilling operations 6⅝" DP will be used above the BOP stack (it will never go into or below the BOP)**. The remainder of the string will be made up of 5½" DP from the BOP down. However, to land the heavy 22" and 16" casing strings, a 6⅝" DP landing string will be used. Once the Casing is landed and cemented, the 6⅝" DP will be across the BOP for

> approximately 12 hours. There will be no drilling ahead with the 6⅝" DP in or below the BOP. Both 5½" and 6⅝" DP will be tested during the stump test, prior to running the BOP.
>
> **250.449(f)** VBRs will be pressure tested against largest and smallest sizes of DP that will be across the stack, excluding drill collars, HWDP, and bottom-hole tools.
>
> The annular BOP will only be tested to the smallest OD DP when a tapered string is in use.
>
> **250.449(h)** Request to delay or omit 7-day function test of BSRs and CSRs, when function test is due and the drill string is across the stack. The maximum time between function tests shall not exceed 14 days, unless authorized by the MMS district office on a case by case basis.

The testing of the BOP was determined by BP, not Transocean. The BP WSL was required to sign-off on all BOP testing done on the rig. In its Authorization for Permission to Drill ("APD") on Macondo, BP was the one who requested MMS permission to exempt the HORIZON BOP from required testing. Basically, BP wanted to test less often[106] and at lower pressures.[107] BP set the parameters and MMS, in deference to BP's expertise, agreed.

BP never tested to any maximum pressures that might actually be encountered on Macondo.[108]

Even though BP was granted dispensation from specific testing parameters, they were obligated to have a BOP that ensured well control, and that each component of the BOP met or exceeded the BP's calculated MASP for the Macondo Well.

Pre-Macondo Testing

A complete function test was performed on the BOP from both control pods prior to the BOP being placed on top of the wellhead to ensure the system was fully operational. After the BOP was in operation, weekly and bi-weekly function and pressure tests were performed while the BOP was attached to the wellhead. Testing procedures addressed static rather than dynamic conditions.

In addition to the weekly/bi-weekly tests, records indicate these additional tests were conducted:

- March of 2001 - DEEEPWATER HORIZON BOPs underwent a Failure Mode, Effect and Criticality Analysis ("FMECA"). Excluded from the FMECA were the control panels and buttons.
- In 2001, Cameron performed a Factory Acceptance Test on the BOP. At that time, Vastar/BP requested changes prior to the acceptance of the BOP into service.
- April 2001 - A qualification test of the HORIZON BOPs was conducted at the surface. A joint of 5½", 21.9 lbs/ft, S-135 DP was successfully sheared at a shearing pressure of 2,900 psi which was slightly greater than the pressure predicted by Cameron's shearing formula. Only one shear test was performed and only under static conditions at ambient (sea level) pressure.

  As was Cameron's practice, no pressure testing or dynamic testing was performed. Neither BP, nor Transocean requested1 any further shear test on the HORIZON.
- June 2003 - EDS activation occurred, including DP shear, when the HORIZON evacuated the well site due to approaching Hurricane Bill.

Per a Cameron Engineering Bulletin dated May 23, 2003, a preventative maintenance-complete overhaul of Cameron BOPs should be completed at least once a year and tested to MAWP. No documentation has been provided to substantiate that these tests were actually performed by BP.

Prior to deployment on Macondo, there was no record of any tests being performed on the EDS, Autoshear, AMF and ROV intervention systems.

Macondo Testing

After the HORIZON arrived at Macondo, certain maintenance was performed on the BOP prior to it being deployed. During that period of time, all the rubber components, the upper annular's packer element, lower annular packer element, the ram packers, top seals, bonnet seals and various gaskets were replaced.

Pre-charge pressures on the accumulator bottles were checked. After the completion of this maintenance, the BOPs were subjected to function testing. The BSR, VBRs and associated valves were stump tested to 250 psi low, 15,000 psi high (the VBRs with 6⅝" DP).

The upper annular BOP was tested to 250 psi and 10,000 psi for 5 minutes. The lower annular BOP was tested to 250 psi and 5,000 for 5 minutes.

Both pods were subjected to a surface pre-run function test with charged accumulator bottles. During this testing, all of the hoses were also tested for leaks.

The EDS-1 and EDS-2 functions were dry fired and the data logger checked for proper functions. A low pressure unlock test was performed on the LMRP connector. And surface pre-run pressure tests were run on the BOPs to 3,000 psi on all ram-type BOP Bonnets.

All of these tests were performed prior to splashing the BOP. After the BOP was attached to the wellhead, the wellhead connection was tested against the BSR at 250 psi and 2,600 psi.

Subsea static pressure testing of the BSR was conducted to 7,500 psi. The BSR was closed and the BSR and wellhead connector were tested to 250 psi and 6,500 psi for 5 minutes. A pressure test was performed of the lower annular on 6⅝" DP at 250 psi and 3,500 psi for 5 minutes. The same test was conducted on the upper annular BOP at pressures of 250 psi and 5,000 psi for 5 minutes.

All ram-type BOPs and fail safe valves were pressure tested to 250 psi and 6,500 psi. The BSR, BOPs, choke manifold and the kill Line were function tested from the Toolpusher's control panel using the yellow pod.

The BOP was tested on 6⅝" DP using the blue pod as per BP and MMS requirements. The yellow pod, the Diverter and the VBRs were function tested from the Toolpusher's control panel. After the initial testing of the BOP subsea, weekly and bi-weekly prescribed function and pressure tests were conducted.

BP supplied the test pressure parameters to Transocean. These pressures were based on the pressures BP believed would not adversely affect the formations being drilled. BP did not request, or do, testing subsea to maximum wellbore pressures that could be present on Macondo.

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The 2001 Risk Assessment performed on the HORIZON BOP, revealed that a dominant likelihood of failure of the critical functions for well control was the reluctance of operators to initiate BOP functions. The Assessment stated:

> *"… the failure of the indication to identify need to initiate EDS or operator failure to initiate EDS."*

[redacted]

[redacted] In this case, regarding the BOP, BP engaged in minimal BOP training for its employees.

Mr. Martin Breazeale was employed by BP to train its WSL candidates. Mr. Breazeale testified that he did not provide any BOP training with respect how the BOP was used. He did not provide any training to WSLs on how to calculate MASP. He testified that the WSLs were to obtain the MASP calculation from BP engineering. Conversely, BP engineering staff denied knowledge of when and how a BOP was to be operated

Mr. Breazeale had certain BP materials which were used to train WSLs. Those materials included a module pertaining to a BOP. Upon examination, there is no training on how to use the BOP, nor how to use the BOP in an emergency well control situation.

Mr. Breazeale stated that WSL candidates attend well control school with Wild Well Control ("WWC"). Mr. Pat Campbell, the CEO of WWC admitted that WWC provided certain well control training to BP personnel. However, WWC did not spend any time instructing BP on how to utilize the BOP in an emergency well control situation. Nor did WWC spend any time discussing regulatory requirements, i.e. testing requirements or the calculation or use of MASP.

WWC's only training was to inform the WSL participants that these regulations existed. There was no WWC training given on how to generate such regulations to set specific well control policies on a well. BP's Management provided no instruction on the proper design, assembly, application, testing, maintenance and utilization of the BOPs on their wells.

BP's WSLs recognized that they had not received competent BOP training.
For example, a BP WSL in Alaska stated:

> *"There is little or no formal education in BOP do's and don'ts."*

That email chain also said:

> *"We have a long history of closing the wrong preventer on the wrong tool…will the [HORIZON] rams shear…asked a few folks here at BP, but no one was definite in their response"*

Several of BP's employees have professed complete ignorance in connection with the BOP. Examples include:

1. Mr. David Sims, BP's Head of Engineering, who was involved in the well, both before and after his promotion of April 2, 2010, said that he

   "*knew as much about the BOP as a galley hand*";

2. Mr. John Guide, both by his emails and his testimony, indicated that he was not aware of issues regarding the BOP's safety or its correct usage or shearability;
3. Mr. Martin Breazeale, the person who trains the WSLs for BP, and who was training Mr. Lee Lambert, a WSL trainee on the HORIZON at the time, said that there is nothing in the training materials that discussed how a BOP was to be used;
4. Mr. Ian Little, who was Mr. Guide's and Mr. Sims' superior up until early April 2010, professed no knowledge of BOPs;
5. Mr. Morel and Mr. Hafle, two other BP Macondo engineers, both invoked the 5th Amendment refusing to testify. But no emails have surfaced from either dealing with BOP well control/safety issues or MASP;
6. Mr. Breazeale, BP's WSL trainer, also testified that the WSL would not be responsible for calculating MASP, even though it is a regulatory requirement;
7. Mr. Wong, BP's auditor, said that they did not audit the BOP's safety regulations for compliance;
8. Mr. Byrd, BP's 30(b)(6) witness stated that he did not know anything about how the BOP was to be used and knew nothing about regulatory compliance requirements;
9. Mr. Keeton, a Transocean Rig Manager on the HORIZON until September 2009, stated that Mr. Cocales, with BP, was inexperienced;
10. Mr. Jonathan Sprague, with BP, stated: "Granted our engineers are inexperienced".;

11. Mr. Bellows with BP, noted that BP had little experience with narrow margin wells, like Macondo;
12. There was no showing that WSLs were aware of ROV functionality, including the time required to activate an ROV, the need for emergency ROVs, the time required to close a BSR using an ROV, the ineffectiveness of ROVs with a flowing well, etc.;
13. Mr. Breazeale testified that the potential WSLs received additional well control training from a company called Wild Well Control. Upon deposing Wild Well Control's 30(b)(6) witness, Mr. PatCampbell, he said that

> *"…any BOP training, in terms of regulatory compliance, or regulatory requirements, and how to use the BOP under specific well control conditions was limited".*

BP employees are trained to always close the annulars first; they are not trained to consider other options, such as closing the VBR's first, nor or they trained to evaluate response options based upon individual well conditions. BP's Well Control Manual says the annulars should be closed first. BP's manuals also say that BP should ensure that contractors follow BP well control policy.

Mr. Breazeale said that BP's policies require that the annular be closed first and then wait until the wellbore pressure stabilized. On being asked what would happen if the wellbore pressure did not stabilize, i.e., the annulars failed to seal the well, Mr. Breazeale had no answer.

Also, there was apparently no training in connection with BP's Well Site Leaders as to how to utilize the MASP in terms of actual well control policy, or effective usage of the BOP.

In other words, if MASP shows that well pressures have the potential to exceed the ratings of the annulars, there was no training provided by BP's Management as to how that situation should be handled or developed. There was no training requiring that BP's WSLs or the Well Team Leader, such as Mr. Guide, calculate DP shearability. BP's 30(b)(6) Corporate Representative, Mr. Mike Byrd, said that he was relying upon an obsolete shearing chart to determine the shearability of any DP strings. According to Cameron, the chart was obsolete in 2008. Mr. Byrd, BP's 30(b)(6) witness,

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BSR

The West Engineering Services Shear Ram Capabilities Study Final Report dated September 2004 stated:

> *"…this well control function of last resort is to shear pipe and secure the well with the sealing shear ram. As a result, failure to shear when executing this final option would be expected to result in a major safety and/or environmental event. Improved strength in drill pipe, combined with larger and heavier sizes resulting from deeper drilling, adversely affects the ability of a given ram BOP to successfully shear and seal the pipe in use."*

Macondo's BSR was fitted with a single shearing blade including a single straight edge shearing blade.

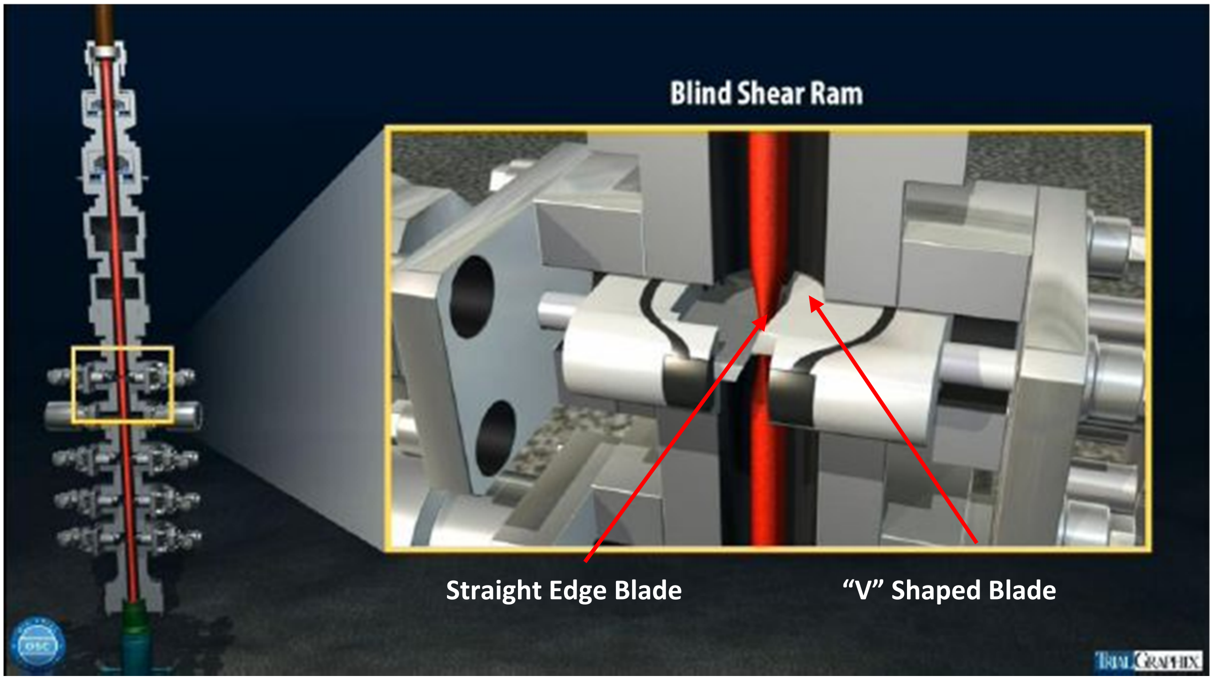

Figure G.8 BSR Shearing DP Source: TrialGraphix

This West Engineering Report stated that single "V" shaped BSRs, i.e., like HORIZON's, were:

> *"…about 20% less efficient than their newer Double V Shear ("DVS") ram, DVS, which has both blades V shaped." Refer to Figure G.9 below.*

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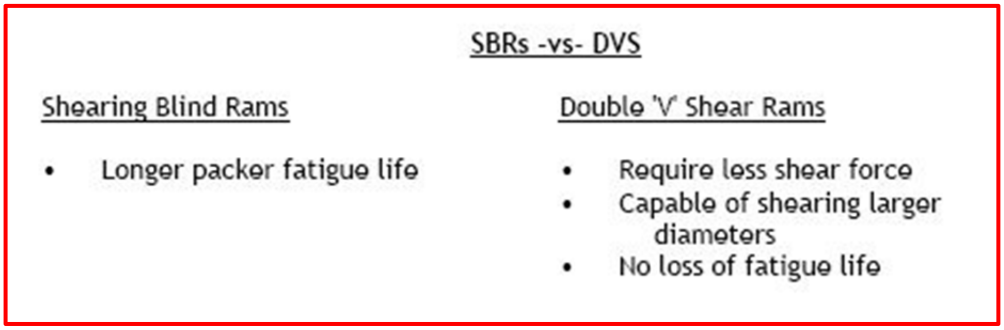
Refer to Figure G.11 below:



SBRs -vs- DVS

Shearing Blind Rams	Double 'V' Shear Rams
• Longer packer fatigue life	• Require less shear force • Capable of shearing larger diameters • No loss of fatigue life

Figure G.11: Comparison SBR vs. DVS Source: Cameron EB 852D

Tandem Boosters

To increase the shearing force for Macondo's BSR, BP's Management could have used a set of Tandem Boosters. Tandem Boosters have two pistons, instead of one, to provide closing force. Cameron stated that:

> *"...a tandem booster features a two-part piston designed to disengage after shearing, but prior to energizing the packers.*

> *This allows for increased shear forces without additional wear on the packers".*

Cameron also stated that:

> *"Tandem boosters approximately double the force available to shear pipe".*

The tail rod of the Tandem Booster has the same stroke as the BOP's piston so the Tandem Booster can be installed and the ST Locks can still be utilized. Refer to Figure G.12 below.

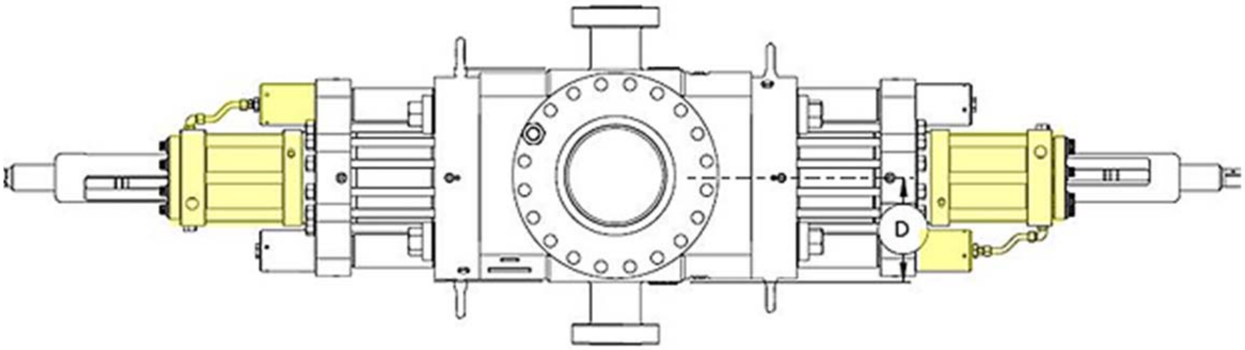


Figure G.12: Tandem Boosters (in yellow) Source:

Subsea BOP Acoustic Control Systems:

There were four (4) ways to activate the BSR in an emergency: 1) EDS which can be activated from the rig, 2) AMF which activates on loss of hydraulic and electrical supply from the rig, 3) The auto-shear function, and 4) ROV intervention.

An Acoustic Control System ("ACS") could have been a secondary and automatic control system for Macondo's BOP. An ACS is a BOP control system that is intended to be a backup to the BOP's primary CS. In the event that the primary CS for Macondo's BOP was lost, Macondo's BOP functions could be completed by utilizing the HORIZON's ACS.

Sonardyne, a manufacturer of ACS, stated that acoustic signals are fundamentally more robust then analogue signals and are, therefore, better suited to real time monitoring applications.

According to Cameron, it has been providing Subsea BOP ACS in both the GoM and North Sea since 1975. Completely self-contained and independent of the primary BOP's control system, the Cameron Acoustic System maintains BOP functions in emergency situations. Cameron employees testified that they have had no complaints with the reliability of their acoustic systems. The system surface control unit is portable and can be safely used to send acoustic signals to the BOP from a distance of up to one (1) mile.

Key Features of an ACS are:

- Wireless activation; no reliance on MUX cables;
- Designed for ROV deployment and retrieval;
- Easily moved between wells and;
- Water depths to over 10,000 feet.

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BP, as the owner of the Thunderhorse production platform, had DVS ram blocks and tandem boosters configured in its BOP. Other rigs within the Transocean fleet had double BSRs and improved ram blocks and tandem boosters. None of those improvements were made to the HORIZON'S BOP.

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Appendix H: BP's Macondo Well

"BP is committed to conducting its operations in a manner which ensures that wells are designed, drilled, completed and maintained to a high and consistent standard. Sound engineering judgment and governmental regulations may require that operations be carried out to standards exceeding these policy statements." [110]

H.1 Application for Permit to Drill

A well must be designed to keep oil and gas contained in the proper well physical structure.[111] The wellbore is essentially a vessel that is designed to control and contain the fluids or gases which are to be extracted. Containment is vital at all times, and that starts with a good well design.

The design of an offshore oil and gas well such as Macondo is the responsibility of the Operator based on the available seismic and geological data[112]. BP's geologists and engineers analyzed certain data to determine the proper casing sizes, weights, grades, strengths, the casing's cementing program, the mud program, the well control equipment and other various materials and equipment used to ensure well integrity throughout the drilling process.[113]

BP had initially planned to drill Macondo as a vertical well to a Total Depth (TD) of 20,200 feet to learn more about the geology of the area and to potentially locate a profitable reservoir.[114] The well was estimated to cost $96M and take 51 days to drill.[115]

The Macondo Peer Review Feedback noted four overall impressions, one of which was that the:

> *"Well location was conducive to a fast track schedule….with a low risk of No Drilling Surprises and a manageable PPFG, i.e., Pore Pressure Frac gradient window."* [116]

The well plan was written-up by BP's Engineering Team and subsequently, BP's Operations Team signed-off on the plan[117]. In mid-April, just a few days prior to the blowout, BP admitted that planning lagged behind operations[118]. According to BP emails, there were so many last minute changes to the well plan prior to the blowout that BP's, WSLs had "…come to their wits end"[119] And personnel were

> "…*flying by the seat of our pants! Everybody wants to do the right thing, but this huge level of paranoia from engineering leadership is driving chaos*."[120]

Many documents show that by April 20, 2010, BP was in a hurry to finish the well.[121]

The original APD was filed with the MMS on May 13, 2009, and was approved on May 22, 2009.[122] By filing an APD, the operator agreed to follow MMS 30 CFR Part 250 which required the use of BAST as standard operation procedures.[123] In the Initial Exploration Plan ("EP"), BP attested to their abilities to respond to a worst case spill scenario estimated to be 162,000 barrels per day, but the likelihood of a spill associated with a blowout was determined to be unlikely and a scenario for a potential blowout was deemed "not required."[124]

Plans filed with MMS were seriously deficient in critical areas of flow rate, total volume and maximum duration of a potential blowout.[125] BP did not adequately prepare for a spill in the Deepwaters of its Macondo well.

The APD was modified several times, once specifically to designate the HORIZON rather than the MARIANAS as the drilling rig.[126] With an exploration well where limited knowledge was available about the environment, it is typical for well plans and well designs to change. However, BP's policies stated design changes shall be documented and subjected to formal Management of Change processes and risks reassessed and mitigated.[127]

For the APD, BP was to specify including but not limited to:

- Geological Information;
- Rig Information;
- Proposed well location;
- Drilling Prognosis and summary of drilling, cementing and mud processes;
- Pore pressure, mud weight, and fracture gradient plots;
- Well Design Information;
- Wellbore schematics;
- Engineering calculations;
- BOP & Diverter Schematics with Operating Procedures, and;
- Preventer Information and test information including pressures.[128]

Prior to HORIZON's selection, BP's policies required assurance that the operating capability of the HORIZON was suitable for the environmental conditions that would prevail at the wellsite; and that all equipment materials and services were fit for the purpose intended and in compliance with local legislative, BP, and industry standards and specifications, as required.[129]

The drilling engineers on BP's Wells Team were required to calculate the Maximum Allowable (Anticipated) Surface Pressure ("MASP") with input from the surface and reservoir engineers.[130] The MASP was calculated from the pressure and temperature measurements from the logs made during the drilling operations.[131] The bottom hole temperatures and pressures were recorded and a gradient was calculated back to the mud line, i.e., seafloor so that the pressure and temperature of the mud column at the mud line (ocean floor) could be established.[132]

HORIZON's BOP had to be rated at or greater than the absolute temperatures and pressures expected at its wellhead.[133] Further, MMS required the addition of a safety factor (BP used 500 psi).[134] Macondo's MASP would be listed as part of the APD along with BOP's ratings and their test pressures.[135]

BP stated in their APD that Macondo's MASP would be 8,404 psi using the Bottom Hole Pressure Method ("BHP") calculation at the mudline.[136] Macondo's TVD bottom hole pressure at 20,200 ft was expected to reach 15,126 psi based on this BHP Method used to calculate MASP.[137] Refer to Figure H.3.

All of these pressures were above the MAWP of the HORIZON's lower annular BOP and many were above the MAWP of the upper annular.[138]

BP also supplied the specifications for the various types and sizes of casing and DP to be used on the Well.[139] The requirements derived from the expected temperatures and pressures would be reviewed with Transocean against the capability of the each BOP to ensure the BOP was suitable for the water depths, pressures, temperatures and sizes and weights of the DP to be used in the well.[140]

Drilling deepwater wells in the GoM typically means that the operator would probably have to contend with high-porosity, high-permeability formations.[141] These formations are known to have a very narrow margin between the rock's pore pressure and the rock's fracture gradient.[142] BP was apparently convinced that they could achieve good zonal isolation in Macondo.[143]

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H.2 Maximum Allowable Surface Pressure ("MASP"):

What is MASP?

Onshore Wells:

After a section of a well has been drilled, it normally would be lined with a string of casing ("casing string") and cemented in place.[168] As drilling operations continue, a bit will be run on the end of the drill string that will drill out of the bottom of the casing string and deeper into the formation.[169] The bit will drill a predetermined distance below the bottom of the casing string and stop.[170]

Absent any other formation testing and presuming the wellbore was balanced there would be no flow from (or into) the formation and, therefore, no change in the fluid height in the wellbore.[171] Under those conditions, the total vertical depth ("TVD") can be determined and the bottom hole pressure ("BHP") can be calculated.[172] For example, if the well had a total vertical depth of 10,000 ft at the bottom of the Casing string and the hole was filled with mud that weighed 10 pounds per gallon ("lbs/gal"), the BHP would be 10 lbs/gal x 0.052 x 10,000 ft = 5,200 psi.[173]

A leak-off or formation fracture test would determine the static pressure, or fracture pressure at which the formation just drilled would fail.[174] This pressure is also referred to as Frac-at-Shoe Pressure.[175] Frac-at-Shoe pressure can be higher than BHP. For this discussion, presume that Frac-at-Shoe pressure was 6,000 psi.

Considering that natural gas exists in the formation, the gas gradient in psi per foot of vertical depth ("psi/ft") should be calculated based upon methane at the highest BHP, in the deepest open hole section below the current shoe. A common rule of thumb is 0.1 psi/ft for hole depths above 10,000 ft and 0.15 psi/ft for deeper wells.[176]

Gas entering the wellbore at the bottom of the hole exerts a BHP upward on the column of mud in the well. Refer to Figure G.1 below.

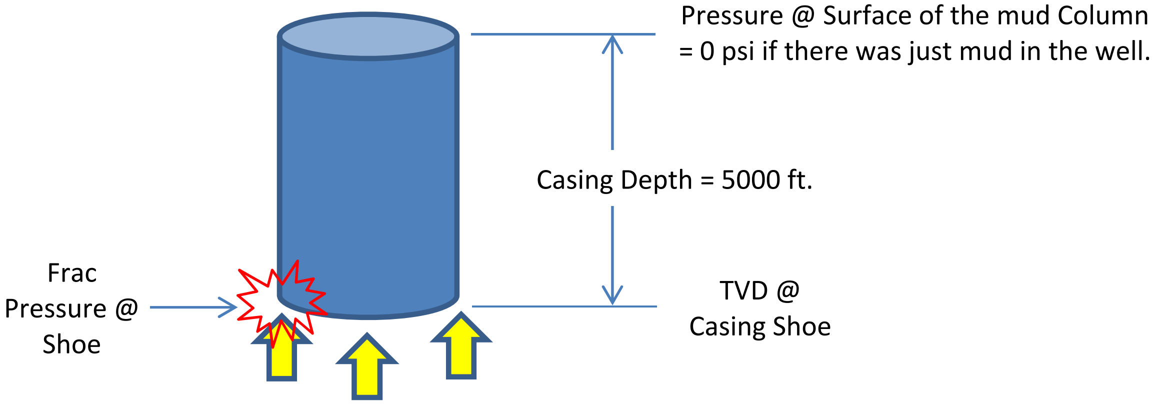


Figure G.1 Frac-at-Shoe Calculation Method

In this example, the maximum expected pressure at the surface using the Frac-at-Shoe method would be:

$$6{,}000 \text{ psi} - (5{,}000 \text{ ft} \times 0.1 \text{ psi/ft}) = 5{,}500 \text{ psi}$$

For gas to enter the wellbore, it would have to have a greater pressure than the pressure the mud would exert from the bottom of the well.[177] With gas pushing against the bottom of the mud column, there would be pressure at the surface.[178] Therefore, in our example and with no safety factor, the gas could push the column of mud out of the wellbore. As more gas enters the wellbore, the mud column becomes shorter resulting in a reduced hydrostatic head to hold it back.

To shut-in and seal-off this well at the surface before this happened, the wellhead and blowout preventer equipment should be capable of withstanding at least 5,500 psi using the Frac-at-Shoe method.

There are two industry acceptable methods to calculate MASP: Frac-at-Shoe and Gas-to-Surface.[179] Both calculations assume that the casing is (1) fully evacuated of mud and then (2) is displaced with gas.[180]

The Gas-to-Surface method uses data from the next section of hole to be drilled.[181] For example, assume that we drill from 10,000 ft to 11,000 ft, 1,000 ft deeper. We predict that our mud weight at 11,000 ft will be 11.0 lbs/gal. The BHP would be calculated as 11.0 lbs/gal x 0.052 x 11,000 ft = 6,292 psi. Refer to Figure G.2 below.

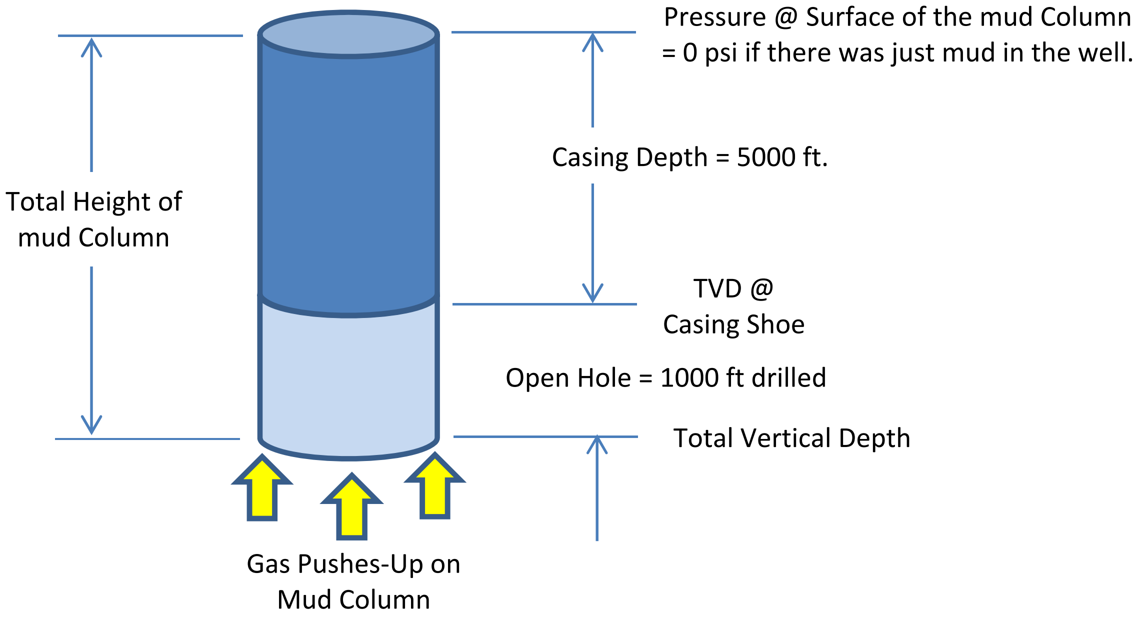


Figure G.2 Gas-to-Surface Calculation Method

The hole is now deeper than 10,000 ft. If a gas gradient of 0.15 is used, the Gas-to-Surface pressure would be:

$$6,292 \text{ psi} - (11,000 \text{ ft} \times 0.15 \text{ psi/ft}) = 4,642 \text{ psi}$$

Therefore, the wellhead and BOP equipment should be capable of withstanding at least 4,642 psi using the Gas-to-Surface method. If a gas gradient of 0.1 psi/ft were used, then this Gas-to-Surface method would have yielded 5,192 psi.

The minimum of Frac-at-Shoe **MASP** or Gas-to-Surface **MASP** becomes the well's **MASP**. In this example, our well's **MASP** for this section of hole would be either 4,642 psi or 5,192 psi. There is no need to design for a **MASP** that is not physically possible.

Macondo:

Macondo's mud line was at approximately 5,054 ft below sea level.[182] In some of their calculations, BP used a mud weight of 14.4 lbs/gal and a mud line depth of 5,067 ft.[183] Macondo's final measured depth was supposed to be 20,200 ft from a reference point aboard the HORIZON.[184] Macondo's BHP at this depth would be:

$$20{,}200 \text{ ft} \times 14.4 \text{ lbs/gal} \times 0.052 = 15{,}126 \text{ psi}$$

Again, at the top of the static mud column, the Pressure @ Surface of the Mud Column = 0 psi if there was just mud in the well

Similarly, hydrostatic pressure at the mud line, or inside the BOP, would be:

$$5{,}067 \text{ ft} \times 14.4 \text{ lbs/gal} \times 0.052 = 3{,}794 \text{ psi}$$

BP used 0.15 as Macondo's gas gradient.[185] Using the Gas-to-Surface or Bottom Hole Pressure Method to calculate MASP at the surface would be:

$$\mathbf{MASP}_{\text{surface}} = 15{,}126 \text{ psi} - (20{,}200 \text{ ft} \times 0.15 \text{ psi/ft}) = 12{,}096 \text{ psi.}$$

$$\boxed{\mathbf{MASP}_{\text{mud line}} = 15{,}126 - [(20{,}200 \text{ ft} - 5{,}067 \text{ ft}) \times 0.15 \text{ psi/ft}] = 12{,}856 \text{ psi}}$$

BP utilized a 500 psi Safety Factor ("SF"). Therefore:

$$\boxed{\mathbf{MASP}_{\text{mud line with SF}} = 12{,}856 \text{ psi} + 500 \text{ psi} = 13{,}356 \text{ psi}}$$

Rounding 13,356 psi up to the nearest 100 would be

MASPmud line with SF = **13,400 psi**

If BP used a gas gradient of 0.10, then:

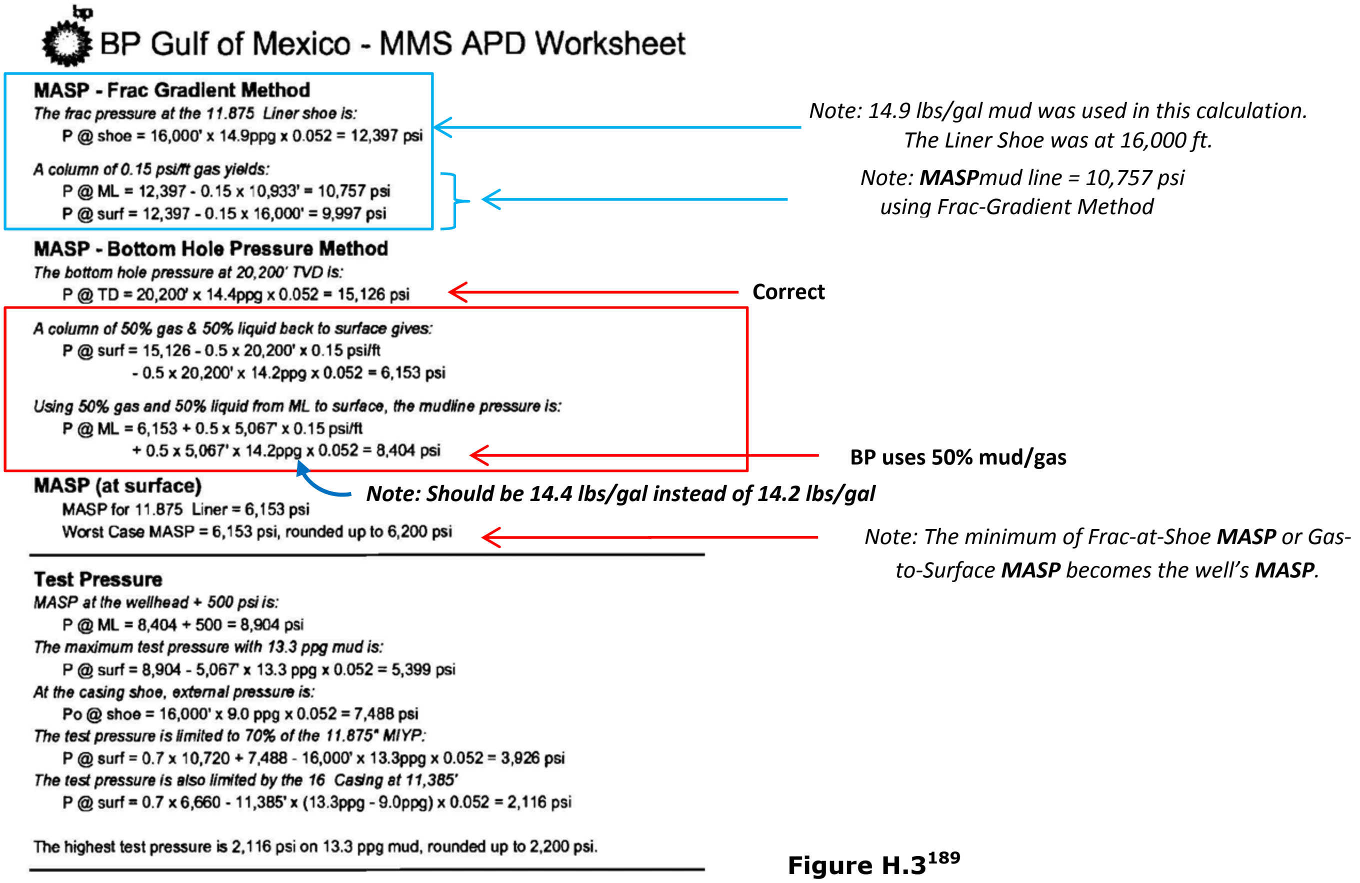
MASPmud line = 15,126 psi – [(20,200 ft – 5067 ft) x 0.10 psi/ft] = 13,613 psi
+ 500 psi (safety factor) = 14,113 psi or 14,100 psi

Either the Gas-to-Surface or Bottom Hole Pressure Method used above considers the fact that the Casing would be fully evacuated of mud by gas entering the wellbore.[186] Further, that the wellhead and BOP equipment on the mud line should be capable of withstanding **MASP**mud line using this particular method.[187]

For Macondo, BP calculated **MASP** with a column 50% gas and 50% mud.[188] Using BP's formula:

MASP = FPmax – HPgas
Where FP = maximum static head pressure of the fluid column
where HP = static head pressure of the gas column

MASPmud line @ 50% = 15,126 psi - [**0.5** x (20,200 ft – 5,067 ft) x 14.4 lbs/gal x 0.052] – [**0.5** x (20,200 ft – 5,067 ft) x 0.15 psi/ft] =
15,126 psi - 5666 psi – 1,135 psi = 8,325 psi



BP Gulf of Mexico - MMS APD Worksheet

MASP - Frac Gradient Method

The frac pressure at the 11.875 Liner shoe is:
P @ shoe = 16,000' x 14.9ppg x 0.052 = 12,397 psi

A column of 0.15 psi/ft gas yields:
P @ ML = 12,397 - 0.15 x 10,933' = 10,757 psi
P @ surf = 12,397 - 0.15 x 16,000' = 9,997 psi

MASP - Bottom Hole Pressure Method

The bottom hole pressure at 20,200' TVD is:
P @ TD = 20,200' x 14.4ppg x 0.052 = 15,126 psi

A column of 50% gas & 50% liquid back to surface gives:
P @ surf = 15,126 - 0.5 x 20,200' x 0.15 psi/ft
- 0.5 x 20,200' x 14.2ppg x 0.052 = 6,153 psi

Using 50% gas and 50% liquid from ML to surface, the mudline pressure is:
P @ ML = 6,153 + 0.5 x 5,067' x 0.15 psi/ft
+ 0.5 x 5,067' x 14.2ppg x 0.052 = 8,404 psi

MASP (at surface)

MASP for 11.875 Liner = 6,153 psi
Worst Case MASP = 6,153 psi, rounded up to 6,200 psi

Test Pressure

MASP at the wellhead + 500 psi is:
P @ ML = 8,404 + 500 = 8,904 psi
The maximum test pressure with 13.3 ppg mud is:
P @ surf = 8,904 - 5,067' x 13.3 ppg x 0.052 = 5,399 psi
At the casing shoe, external pressure is:
Po @ shoe = 16,000' x 9.0 ppg x 0.052 = 7,488 psi
The test pressure is limited to 70% of the 11.875" MIYP:
P @ surf = 0.7 x 10,720 + 7,488 - 16,000' x 13.3ppg x 0.052 = 3,926 psi
The test pressure is also limited by the 16 Casing at 11,385'
P @ surf = 0.7 x 6,660 - 11,385' x (13.3ppg - 9.0ppg) x 0.052 = 2,116 psi

The highest test pressure is 2,116 psi on 13.3 ppg mud, rounded up to 2,200 psi.

Note: 14.9 lbs/gal mud was used in this calculation. The Liner Shoe was at 16,000 ft.

*Note: **MASP**mud line = 10,757 psi using Frac-Gradient Method*

Correct

BP uses 50% mud/gas

Note: Should be 14.4 lbs/gal instead of 14.2 lbs/gal

*Note: The minimum of Frac-at-Shoe **MASP** or Gas-to-Surface **MASP** becomes the well's **MASP**.*

Figure H.3[189]

Using BP's Frac-at Shoe calculation resulting in a **MASP**mud line pressure of 10,757 psi was a correct calculation based upon the information provided. However, using a 100% fluid column resulted in a **MASP**mud line of 12,856 psi. If BP's 500 psi factor of safety was added to both results, **MASP**mud line would be 11,257 psi and 13,356, respectively.

BP's calculation using a 50% gas and 50% mud column significantly lowered the results of their **MASP**mud line making it appear that BP had a greater safety margin in Macondo's BOP than actually existed.[190] Their lower value resulted by their using the Bottom Hole Pressure method yielding a **MASP**mud line of 8,404 psi. Adding BP's 500 psi factor of safety would yield 8,904 psi. Instead, **MASP**mud line is 10,757 psi, plus a 500 psi safety factor, which produces an **MASP**mud line of 11,257 psi.

Shearability

One of the crucial functions for a blowout preventer is having the ability for the BSR, in an emergency situation, to shear, shut-in and seal the well. It is imperative for the operator to understand the shearing pressures required for the shear rams to shear/seal the DP and the ability to deliver that pressure at that specific depth. This should also include the effects of the existing pressure in the wellbore.

The MMS regulation 30 CFR Part 250.416(e) requires the lessee to provide information that shows the BSR installed in the BOP stack (both surface and subsea stacks) are capable of shearing the DP in the hole under maximum anticipated surface pressures.

BP underestimated **MASP**mud line not only with regard to sizing Macondo's BOP sealing components, such as its annulars and VBRs, but also with regard to the ability of the BSR to reliably shear the pipe sizes expected to be in its cavity.[191]

With regard to shearing pipe in the BSR, the **MASP**mud line calculation using Cameron's formulas become critical. WWC's Mr. Campbell testified that a minimum 20% safety margin is preferred. Effectively, with 4,000 psi actuation pressure available BP's Management should have known that at Macondo's mud line, that pipe could only be reliably sheared with a minimum of 3,200 psi.

BP, having never looked at shearability of DP in general, also never addressed any need for margin of safety.

The gas gradient selected is another matter. BP should have had deepwater data which would have helped them better decide upon which gas gradients at given depths, pressures and temperatures, would be applicable.

Refer to the table below. Note that BP's Management calculated a Maximum Allowable (or Anticipated) wellbore pressure ("**MASP**mud line") at the mud line where the BOP was located. **MASP**mud line was also value which BP's management used to determine the maximum allowable working pressure ("MAWP") ratings for Macondo's BOP.

There are two ways for BP's Management to calculate **MASP**mud line *with the lower value being used*. The **MASP**mud line pressure that BP's Management chose to use, including BP's 500 psi safety factor, was 8,904 psi which was substantially lower than the other calculated value, including BP's 500 psi safety factor, which was 11,257 psi.

With no factor of safety for shearing the DP, and using Cameron's Shearing Capabilities of shear rams for HORIZON's BSR (as explained and applied by Cameron witnesses in their depositions) the minimum BSR shearing pressures are:

BP's Pressure to shear @ **MASP**$_{\text{mud line}}$ with 50% gas	5½"-21.9 lbs/ft Grade S-135 DP	5½"-24.7 lbs/ft Grade S-135 DP	6⅝"-25.2 lbs/ft Grade S-135 DP	6⅝"-27.7 lbs/ft Grade S-135 DP
8,904 psi	3,840 psi	4,205 psi	4,270 psi	4,596 psi

BP's Pressure to shear @ **MASP**mud line with 100% gas/frac gradient	5½"-21.9 lbs/ft Grade S-135 DP	5½"-24.7 lbs/ft Grade S-135 DP	6⅝"-25.2 lbs/ft Grade S-135 DP	6⅝"-27.7 lbs/ft Grade S-135 DP
11,257 psi	4,196 psi	4,562 psi	4,623 psi	4,953 psi

The lowest pressure reflected in the above table is the pressure that BP concedes could be present on Macondo. The highest pressure is what BP claimed **MASP**$_{\text{mud line}}$ would produce on Macondo with 100% gas.

The regulated accumulator pressure available for the BSR was 4,000 psi or less. However, if the pressure in the BSR Cavity was as stated in the table, the DP in Macondo on April 20, 2010 could not be reliably cut such that Macondo could be shut-in and sealed-off.

Any reasonably prudent operator would absolutely require a margin of safety between the operational limits of the system and the pressure needed to shear. Also keep in mind that Cameron does not guarantee that the pressures that are stated will shear the drill pipe, but recommends instead that the operator perform actual shearing tests. Neither BP, nor Transocean, did any actual shearing tests on the HORIZON (other than the original 2001 test done at Cameron's facility).

In order to know whether the BOP will shear, the shearability of the drill pipe string, or tubular, that is across the BOP must be calculated. In 2008, Cameron provided a formula to calculate this. Prior to 2008, Cameron had used a chart. If one was to use the chart correctly, one would have to extrapolate from the findings on the chart in order to determine shearability. Some people at BP and Transocean sporadically and intermittently referred to such chart. For example, there was an email in 2005 recognizing that 6⅝" drill pipe could not be sheared.

Even for the wellbore pressures anticipated by BP, there was no margin of safety on shearing force. BP's own well control blowout expert was Pat Campbell, founder of Wild Well Control, a blowout specialist. Mr. Campbell has handled over 1,000 blowouts, including these in Kuwait. BP called him in to assist on the March 8, 2010, kick on Macondo (that resulted in stuck pipe and the need to sidetrack the hole) and also, on April 21, 2010, after the disaster. Mr. Campbell testified that you would want, at a minimum a 20% margin of safety. Effectively, with 4,000 psi available, you would want to plan to shear pipe needing only 3,200 psi or less. This would give you a margin of safety for individual variations. BP, having never looked at shearability of DP in general, also never addressed any need for margin of safety.

Likewise, there is a BP email chain in approximately 2007 regarding shearability of drill pipe strings in connection with the HORIZON that state:

"I can't seem to find any shearability numbers for the Horizon."

"Does anyone have this information."

The email chain goes on to state:

"This is interesting.

Does personnel on the rig have knowledge of this information?"

After the incident, the HORIZON WTL, John Guide, asked for information regarding the shearability of the drill pipe strings that were located on the HORIZON. Even though he was the WTL for the HORIZON, and had been for some time, he did not know whether the drill pipe being carried on the HORIZON was BSR shearable or not.

All of this demonstrates that there was no training given by BP to its WTLs or its WSLs, regarding the calculation of shearability of a tubular that was across the BOP.

Nor is there any evidence that BP relied upon, discussed, analyzed or reviewed this issue with Transocean. No evidence exists that Transocean addressed this issue meaningfully before the incident. For example, after the explosion, one of Transocean's subsea engineers noted that it would take 4,700 to 4,800 psi to shear the 6⅝" tubular, if that tubular was located within the BOP. Of course, as has been noted, there was only 4,000 psi available, under the best of circumstances, to be used in an emergency, to shear.

In other words, with regard to shearability, BP did not calculate it, or train on it, nor did they check to see if Transocean had done so. As in other areas of BOP use, BP had no systems review, or safety process review to ensure compliance.

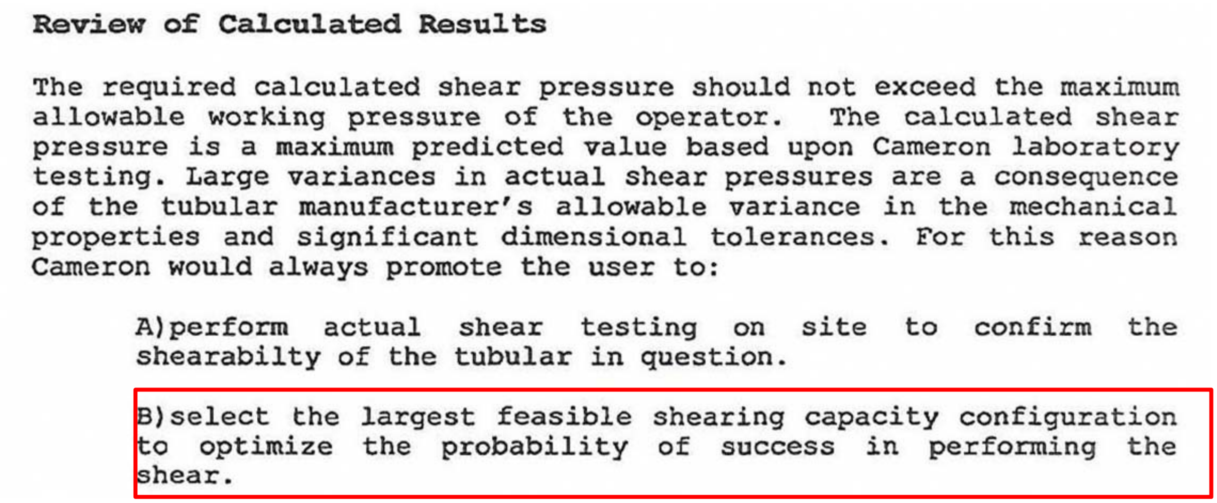
BP was below the standard of care when running DP sizes through the BSRs which could not reliably be sheared at **MASP**mud line. The DP sizes used by BP included:

- 5½"-21.9 lbs/ft Grade S-135 DP;
- 5½"-24.7 lbs/ft Grade S-135 DP;
- 6⅝"-25.2 lbs/ft Grade S-135 DP;
- 6⅝"-27.7 lbs/ft Grade S-135 DP;
- 6⅝"-25.2 lbs/ft Grade V-150 DP; and
- 6⅝"-27.7 lbs/ft Grade V-150 DP

Using BP's factor of Safety of 500 psi, **MASP**mud line, by BP's frac gradient, should have been approximately 11,257 psi.

The regulated accumulator pressure for the BSR was 4,000 psi. If the pressure in the BSR Cavity was higher than MASP, the 5½" DP that was to be cut in two on April 20, 2010 could not be reliably cut such that Macondo could be shut-in and sealed-off.

Cameron stated:



Review of Calculated Results

The required calculated shear pressure should not exceed the maximum allowable working pressure of the operator. The calculated shear pressure is a maximum predicted value based upon Cameron laboratory testing. Large variances in actual shear pressures are a consequence of the tubular manufacturer's allowable variance in the mechanical properties and significant dimensional tolerances. For this reason Cameron would always promote the user to:

A) perform actual shear testing on site to confirm the shearabilty of the tubular in question.

B) select the largest feasible shearing capacity configuration to optimize the probability of success in performing the shear.

No reasonably prudent operator would rely upon this blowout preventer to shear under any of the above pressures. And no reasonably prudent operator would plan for the lowest possible pressure. A reasonably prudent operator would plan for the highest realistic pressure when evaluating the capability of the blowout preventer in an actual well control situation.

BP, and Transocean, fell below the standard of care in failing to conduct actual shear tests, and in failing to provide for an adequate margin of safety, and in failing to anticipate that this blowout preventer would fail if faced with wellbore pressures that Macondo was capable of producing.

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BP's Risk Register, with regard to the BOP, does not list a blowout, or uncontrolled well flow, as a perceived risk.[205] The only risk associated with the BOP mentioned is NPT (i.e., downtime on the rig).[206]

No documents from Macondo specifically deal with emergency BOP activation. No one analyzed well containment or blowout risk. On the rare occasions where BP policy does indicate a safety problem (for example, when BP audit recommends the HORIZON be pulled out of service for overdue maintenance), BP employees overrule the decision unilaterally. BP management does not question the BP employees on why they have overruled the BP audit. On many facets of well control safety, BP ignored the BOP. No safety process system existed with regard to reviewing BOP issues.

Transocean's Responsibilities

As the HORIZON owner, Transocean was responsible for the following:[207]

- Provide the equipment and competent personnel for drilling operations to be carried out per the specified contract provisions;

- Manage, maintain, repair and test all equipment, including well control equipment in accordance with all of BP’s requirements and guidelines;
- Use reasonable means to control and prevent fire and blowouts and to protect BP’s well;

According to BP's Well Control Manual, Transocean had the following responsibilities during a Macondo well control event:

- Implementation of BP’s well control operation;
- Ensure that HORIZON’s Driller and the Rig Crew had correctly responded;
- Shutting-in and sealing-off Macondo using the HORIZON’s BOP CS and Responsibility to oversee the activities of their Rig Crews under BP’s direction and control.

Appendix I: Events Leading-Up to BP's Macondo Blowout

On or about January 31, 2010, Transocean's HORIZON replaced the MARIANAS on Macondo.[208]

From February 1st through the 4th, the BOP was tested before being run subsea and placed atop Macondo's Wellhead.[209] Prior to the BOP being splashed, a leak was found in the hydraulic system which controlled the BOPs yellow pod.[210] The BOP was subsequently splashed on Macondo on February 6, 2010.[211]

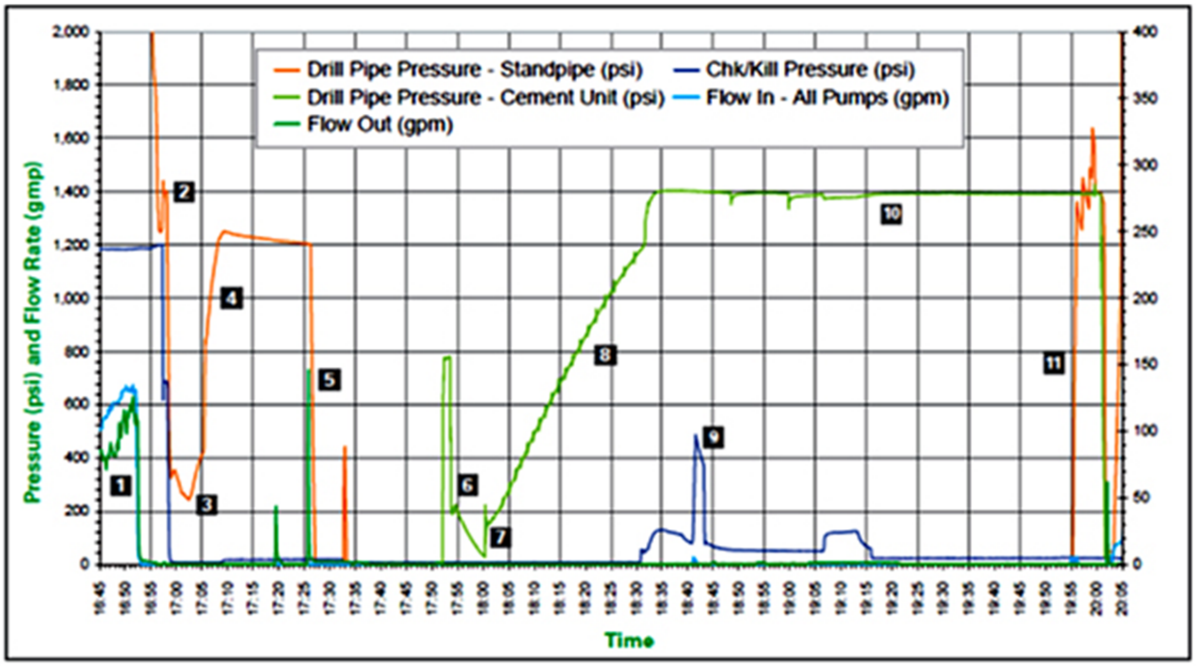
A well control event on March 8, 2010 caused the drill string in Macondo to become stuck.[212] Macondo was then sidetracked and a new casing profile was submitted by BP to the MMS, which was approved.[213] As previously discussed, Macondo's new casing profile included a Long String.[214] The Long String was comprised of two (2) sizes and weights of Casing; 9⅞" OD, 62.8 pounds per foot ("lbs/ft") and 7" OD, 32 lbs/ft.[215] After the Long String had been hung from Macondo's Wellhead, it was to be cemented in-place.[216]

Another loss circulation event occurred on April 4, 2010.[217] After the insertion of a lost circulation pill, the mud weight was reduced in the well and drilling continued five days later.[218]

The Long String was ultimately run into Macondo on April 18, 2010 and was completed approximately thirty five (35) hours later.[219]

The crew performed two negative-pressure tests on April 20th.[220] With the mud pumps turned-off, the Crew opened the top of the tapered string to atmosphere to bleed-down the DP pressure to zero, if possible, and to watch for any flow.[221] The annular preventer was leaking and closing pressure had to be increased from 1500 to approximately 1,900 psi to form an effective seal with the DP.[222]

After the negative-pressure test was complete, the annular regulator was reset to 1500 psi.[223] Since the crew knew that at least 1900 psi was required to affect a seal, the annular regulator should have been set at 1900 psi at a minimum.



1. Spacer displacement complete; mud pumps stopped.
2. Annular preventer closed; attempt to bleed drill pipe pressure to zero.
3. Drill pipe pressure decreases to only 273 psi; annular preventer leaking.
4. Drill pipe pressure increases as annular preventer leaks; hydraulic closing pressure increased to seal annulus.
5. Drill pipe pressure bled to zero for negative-pressure test.
6. Decision made to conduct negative-pressure test via kill line; kill line opened; 3 bbls to 15 bbls bled to cement unit.
7. Shut in kill line at cement unit, drill pipe pressure starts to increase.
8. Drill pipe pressure slowly increases to 1,400 psi.
9. Fluid pumped into kill line to confirm full; kill line opened to mini trip tank for monitoring.
10. Discussion ongoing about 'annular compression' and 'bladder effect' while monitoring kill line; drill pipe pressure static at 1,400 psi.
11. Negative-pressure test concluded, declared a success; preparation made to continue displacement.

Figure I.1 Source: Bly Report, Page 88 from Sperry-Sun Logs

When the DP was shut-in, the DP pressure climbed from 266 psi to 1,262 psi.[224] Three (3) more attempts were made to bleed-down the DP pressure to 0 psi.[225] On the second test, BP used a reading from the kill line and ignored readings from the DP.[226] At 8:00 PM, BP's WSL in consultation with Transocean's Crew, declared the second negative-pressure test a success supposedly confirming the Well's integrity.[227] BP then moved onto the next step in its abandonment procedure.

BP's final displacement procedure called for pumping seawater through the DP to displace the remaining mud from inside the Riser into the mud pits, along with the Spacer, to the surface.[228] BP's plan was for the Crew to subsequently discharge the Spacer overboard into the GoM.[229]

After the mud was displaced, BP's Well had become underbalanced to one (1) or more of the shoe track barriers.[230]

The BOP Failed

Individuals who were watching for kicks on the HORIZON included the driller, assistant drillers, and the mudloggers.[231] Means of detecting kicks at the surface included monitoring the levels and volumes of mud in the active pits, which were empty or being emptied.[232] During mud transfers to the M/V DB, the active pit volumes could not be adequately monitored.[233]

An increase in mud volume in the pits can be an indicator of a kick.[234] Visual checks can also be performed by observing whether fluids are flowing from the well when the pumps are off.[235] After the pumps are shut off, flow from the well should cease. Monitoring DP pressure is another indicator.[236]

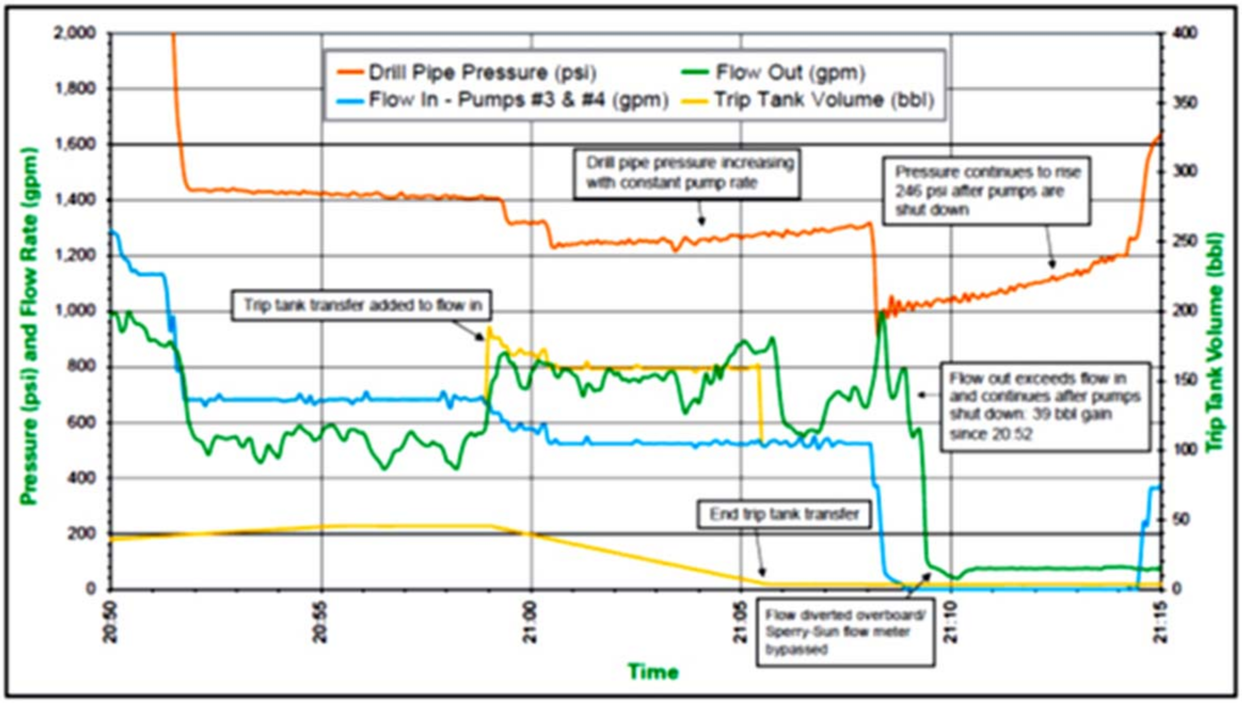


Figure I.2 Source: Bly Report, Page 93 from Sperry-Sun Logs

DP pressure began to slowly increase at approximately 9:01 PM, even though seawater pumping rates remained constant.[237] DP pressure crept-up from 1,250 psi to 1,350 psi in seven (7) minutes.[238] This trend should have been a signal of a kick. The BP WSL should have been on the rig floor during the displacement.[239] One (1) reason for this phenomenon would be the influx of hydrocarbons into the well, i.e., kick pushing fluids into the ID of the DP. Meanwhile, mud from the ID of the Riser continued to flow up to the HORIZON.[240]

According to various reports,[241] the following events show the approximate time line for the evening of April 20, 2010.

The Crew also awaited the return of the Spacer to the surface. At 9:08 PM, the Rig Crew shut down the pumps to test and look for the Spacer.[242] A valve on the discharge flow line, which carried mud to the active pits, was closed.[243] The pumps were shut down from approximately 9:08PM to 9:13 PM while fluid samples were tested and results confirmed.[244] The test results were ultimately approved and the Crew turned the pumps back on.[245] DP pressure increased from 1,017 psi to 1,266 psi while the pumps were turned-off. [246]

At ~ 9:14 PM, the Crew put the pumps back on-line.[247] Seawater was pumped down the DP while the Spacer and any seawater below it was being displaced and directed overboard.[248] Evidently, the pump's flow rate increased along with DP pressure.[249]

At ~ 9:18 PM as a pump was brought online to pump down the kill Line. A pressure relief valve opened on one of the pumps.[250] A group of crewmembers went down to the pump room to fix the relief valve.[251] The Crew shut down all of the mud pumps immediately to determine which pump was affected.[252] Two (2) of the three (3) Pumps came back online within twenty (20) seconds after relief valve 2 was identified and isolated.[253]

The Driller increased pumping flow rates down the DP and the kill Line over the next 10 minutes to displace the Spacer.[254] However, DP pressure continued to increase.[255]

Just before 9:30 PM, the Driller noticed an odd and unexpected pressure difference between the DP and the kill Line.[256] The pumps were shut down to investigate.[257]

DP pressure decreased after the pumps were turned off but then rose by approximately 550 psi over the next 5.5 minute period.[258] The pressure in the kill Line remained significantly lower than the DP's.[259] During discussions about the pressure difference between the DP and the kill Line, DP pressure continued to rise.[260]

At ~ 9:31PM, there is some evidence that one of the annulars was closed.[261] If it was closed at this time, it failed to seal the wellbore.[262]

At ~ 9:36 PM, the Driller had one (1) of his Crew bleed the pressure from the DP to eliminate the pressure differential between the DP and kill Line.[263] DP pressure initially dropped off but then rose again.[264] No visual flow check was made in the mud pits and the well was not shut in.[265]

At ~ 9:39 PM, DP pressure decreased.[266] The Crew changed the discharge flow to the Trip Tank and checked for flow[267]. At 9:42 PM, the Trip Tank filled rapidly.[268]

Between 9:40 and 9:43 PM, mud began spewing from the Rotary Table.[269] The flow was immediately routed from the Riser into the MGS.[270]

At ~ 9:43 PM, there is evidence that the Crew closed the upper annular BOP in an attempt to shut-in the Well.[271] In setting up for the negative-pressure test, the Driller had positioned the DP so that only the pipe portion of the DP was adjacent to the ram-type BOPs.[272] Flow from the well apparently lifted the drill string upwards such that it forced a tool joint into the upper annular BOP before it fully closed.[273] In any event, the annular failed to shut-in the well.

A VBR was probably activated.[274] Flow rates from Macondo were such that neither the upper annular BOP nor the VBR could seal the wellbore's annulus.[275] It was believed that it closed, but did not seal.[276] The DNV Report indicates the middle VBR was closed when the BOP was retrieved; since the middle VBR had no ROV hot stab, this would indicate that the rig crew may have closed the middle VBR.[277]

This release of mud, formation fluids, gas and solids from the Riser overcame the MGS's capacity. [278] It overflowed onto the rig floor. Macondo's discharge blew these materials up to the Crown Block at the top of the HORIZON's Derrick. The mud Gas Separator (MGS) was overwhelmed. Discharged gas spread across the aft deck and into the internal spaces of the HORIZON setting off gas alarms.[279]

At ~ 9:47 PM, the DP pressure increased from 1,200 psi to 5,730 psi.[280] The Crew closed the second VBR in an attempt to seal the wellbore. Pressure increased on the ID of the DP and the elastomers as the VBR's closed.[281] The VBRs closed, but probably failed to seal the well.[282] Even if the VBRs effected some seal, it was probably partial, and temporary.[283] Hydrocarbons flowed up and expanded within the Riser and were vented and exhausted onto the rig floor of the HORIZON.[284]

At ~ 9:49 PM, two (2) sequential hydrocarbon ignitions, one ignition followed by another, occurred on the HORIZON.[285] The HORIZON lost power. Data transmission to the shore was ceased.[286]

Seven (7) minutes later, at approximately 9:56 PM, the EDS was noted to have been activated from the bridge.[287] This was the final recorded well control attempt from the surface.[288]

The HORIZON was abandoned at approximately 10:28 PM.[289]

Macondo had noticeably kicked at about 9:00 PM on April 20, 2010.[290] The wellbore remained open, i.e., not shut-in under the Diverter's packing element and DP pressure began to rise.[291] A U-Tube effect was occurring between the ID of the DP and the wellbore annulus. Refer to Figure I.6 below.

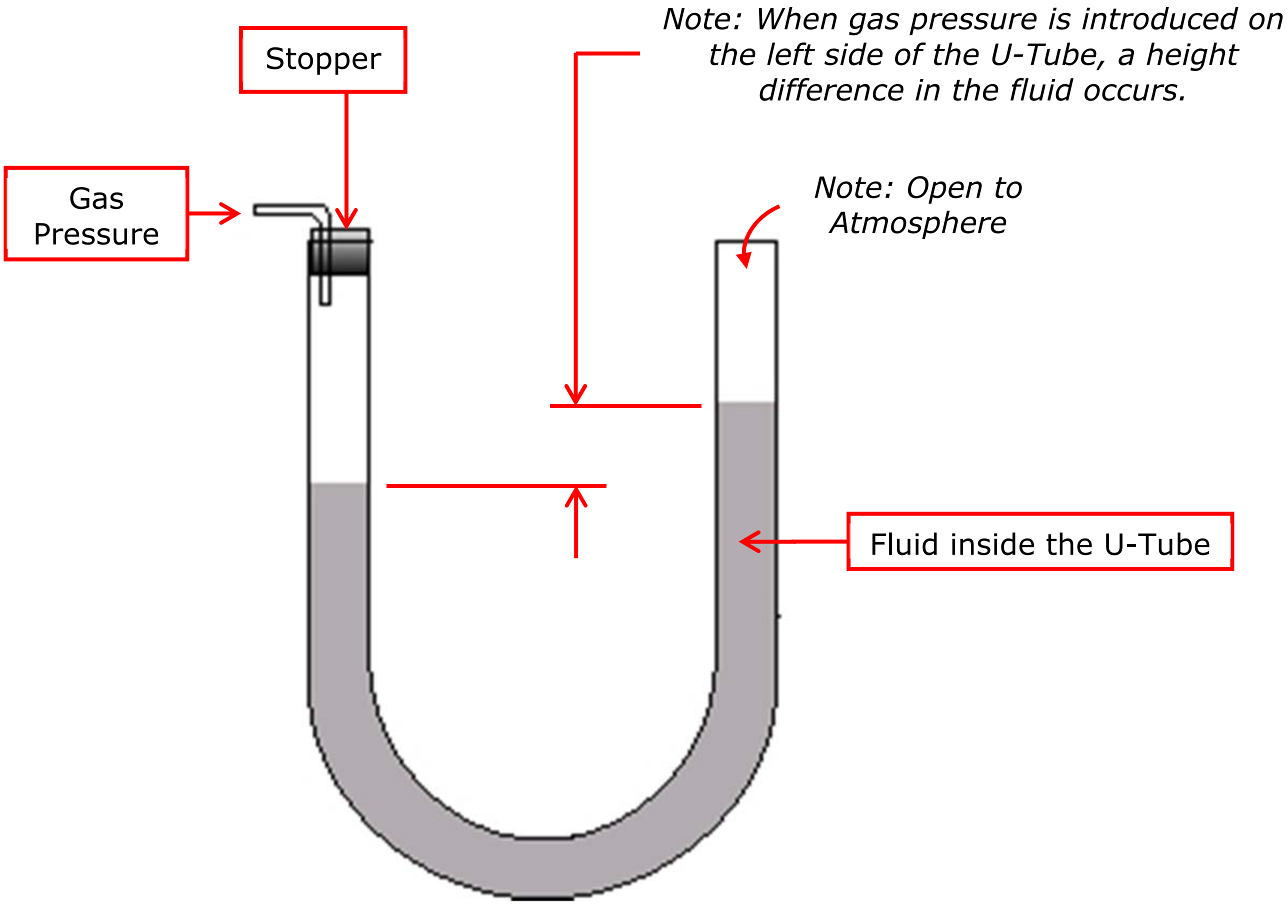


Figure I.6 U-Tube

Refer to Figure below

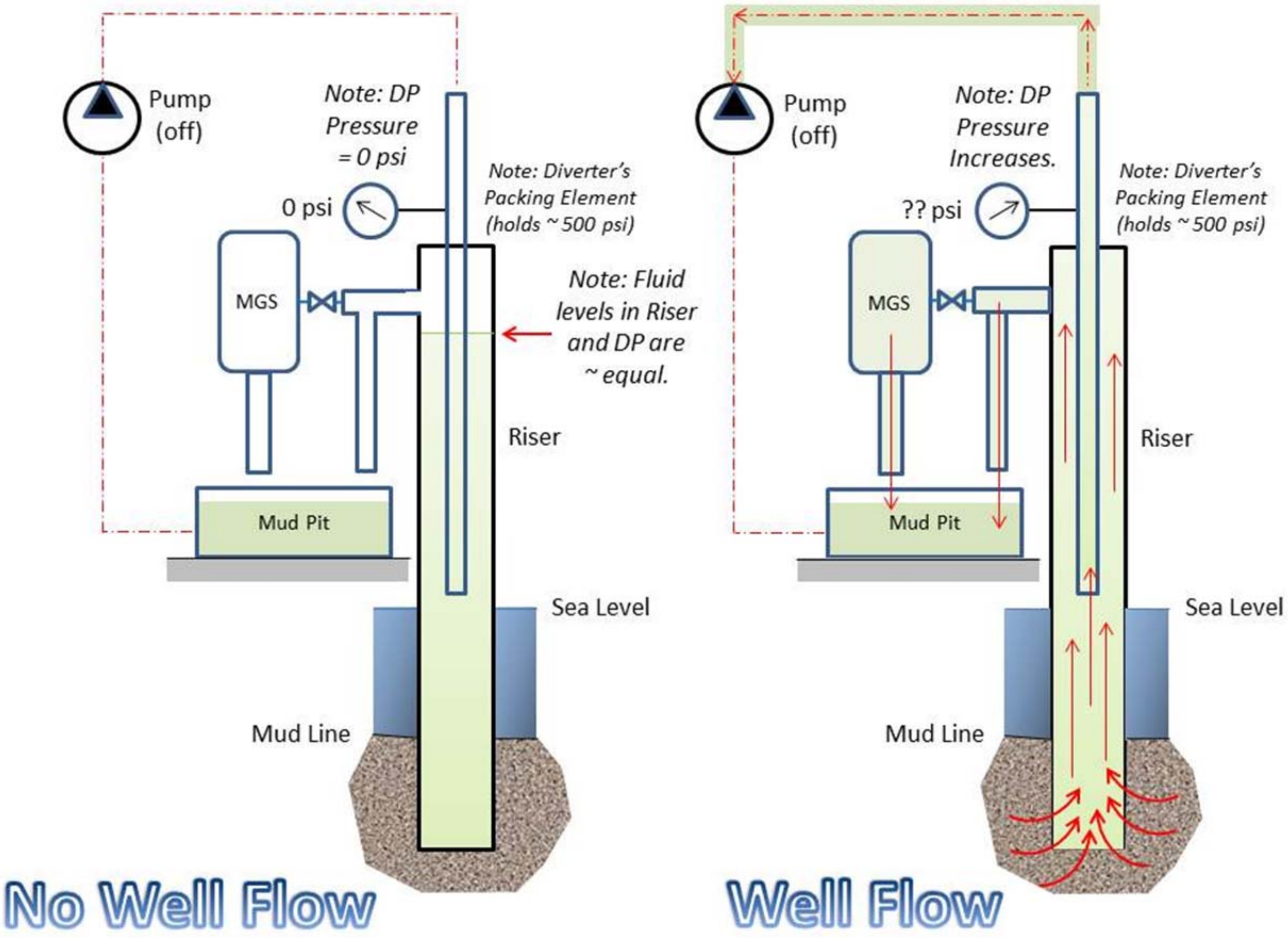


Figure I.7 Simplified Diagram of Macondo as a U-Tube

The rise in DP pressure was a positive indicator on the surface that Macondo was exerting fluid pressure against the column of fluid in the DP. If a rise in DP pressure was occurring the fluid level in the Riser should increase.

If Macondo was not flowing, then the DP pressure should have been 0 psi. Refer to Figure I.7 above pertaining to "No Well Flow."

But Macondo was flowing.

Then, pumping commenced to displace mud in the wellbore and the Riser and also to pump the Spacer to the surface.[292]

With the mud pumps on and the well flowing, the DP pressure has to increase. Conceivably, the mud column in the Riser would be getting very close to or right under the packing element in the Diverter.

If the kill Line's valve was closed, then DP pressure should be approximately equal to kill Line pressure.

Macondo was producing more returns than was being pumped into it.[293] BP and Transocean and the mudlogger should have realized that this was occurring.

Once the kill Valve on the kill Line was opened, the mud pumps were now working against wellbore pressures in both the DP and kill Line. Between 9:40 and 9:43 PM, mud began spewing from the Rotary Table.[294]

As Macondo continued to flow and pressures increased, flow was diverted to the MGS.[295] Flow rates from Macondo were such that neither the upper annular BOP nor the VBR could seal the wellbore's annulus.[296]

This release of mud, formation fluids, gas and solids from the Riser overcame the MGS. It overflowed onto the rig floor. [297] Macondo's discharge blew these materials up to the Crown Block at the top of the HORIZON's Derrick.[298] Once hydrocarbons were on the rig in this quantity, ignition was only a matter of time.

Had BP shut-in and sealed Macondo earlier, this disaster would not have happened.

Appendix J: Post Blow-out

The eventual outcome, along with photographic evidence indicates the flow to the surface did not stop after the closing of the annular and VBRs[299]. Hydrocarbons and well debris flowed with increasing velocity between the packing elements and the drill string inside of both the annular and the VBRs.[300] Erosion occurred which created a flow path for hydrocarbons to continue feeding the fires as the Rig continued to burn and eventually sink.[301]

Testimony indicates that one or more attempts were made to activate the rig's EDS function.[302] The EDS was initiated from the bridge following the initial explosion, the lights indicated it had begun the sequence, but it failed to complete the function and activate the BSR.[303]

The AMF had to be manually armed by the Crew from the control panel and required at least one operational control pod and sufficient hydraulic power to activate.[304] Testimony states that the Crew was able to arm the AMF but that both control pods may not have been operational as evidence would later verify.[305]

There is no evidence that the BSRs were successfully activated from the rig's control panel. This was likely due to the loss of the MUX cables from the explosions and resulting fires.[306]

A ROV attempted to cut the MUX and hydraulic lines on the BOP but was unsuccessful in actuating the BOP's BSR.[307]

The BSR can be activated by an ROV hot stab connection with the BOP hydraulic lines. The pump on the ROV supplies the power to close the BSR. Several unsuccessful hot stab interventions were attempted prior to the DEEPWATER HORIZON sinking.

During ROV hot stab intervention, a leaking fitting was revealed in the ST Lock's close hydraulic circuit.[308] After the leak was repaired, another attempt was made to close the BSRs through the activation of the autoshear function.[309] This was accomplished by severing the activation rod that connected the LMRP to the lower BOP stack.[310] It was believed that it pressured up suddenly at that time.[311] Members of the Incident Management team who were monitoring the ROV operations when the Autoshear was activated, reported that movement was observed on the BOP Stack[312]. This movement was consistent with the BOP's stack accumulators discharging.

During the next 83 days multiple attempts were made to stop the flow of oil and gas and kill or cap the Well. Eventually, the riser was cut, and, on July 15, 2010, a capping stack stopped the flow. The well was later bullheaded, and the relief finally killed the well in September 2010. The BOP was recovered on September 5, 2010.[313] The LMRP was separated and both sections transported to NASA Michoud West Dock Test Site, Louisiana. They were offloaded on October 3, 2010.

Valves and devices were moved prior to the forensic evaluation, both during the attempts at ROV intervention and when the BOP was brought to the surface. Assumptions have been made in different reports as to the conditions and positions of the various BOP components during the blowout.

The internal photographic evidence revealed severe erosion of the DP and rams as well as the total absence of elastomeric seals.[314] Much of the critical evidence had been destroyed by the extreme velocity of the fluids, drilling debris and reservoir materials that flowed through the wellbore.[315]

The aggressive erosion lasted from the time of the blowout until the Well stopped flowing through the BOP when the well was plugged in September 2010. Evidence of compacted mineral debris found in the rams, cavities and DP confirmed the intensity of the blowout as it blasted away at the BOP.[316]

"Wellbore pressure simulation using Olga well flow modeling indicates a differential pressure across the annular preventer of over 8,000 psi after the annular was sealed. Given that the lower annular preventer was rated at 5,000 psi working pressure, it might not have held a differential pressure of over 8,000 psi." [Bly Report]

Appendix K: Macondo Design and Implementation Failures

Below is a table regarding some of the issues that have been discovered in this investigation.

Macondo Design and Implementation Failures:

Flaws, Defects &Inadequacies	Comments
Critical Inherent flaws and deficiencies in well design	BP's well design specifically regarding the displacement and temporary well abandonment plan was inadequately conceived and risk assessed and allowed for the well and BOP to be placed in a vulnerable position.
Inadequate assessment and management of perceived operational risks	BP performed a risk matrix which _______ They were either unaware or misunderstood the risk intrinsic to the well design and other testing and abandonment procedures.
Failure to follow required or accepted operational guidelines	Inadequate procedures and expected responses were developed for critical procedures: maintaining hydrostatic pressure, removal of fluids prior to setting a cement plug, failure to verify the cement barrier, failure to run a cement bond log, failure to maintain adequate supplies of mud for a well control event.
Failure to adequately identify and anticipate change to risks based on late changes to well design and procedures	Changes in procedures in the weeks, days, and hours prior to the blowout were not often subject to peer review, MoC process or regulatory oversight.
Poor communication	BP failed to adequately communicate between themselves and operational groups leaving key personnel with inadequate information to properly assess and mitigate the Well's condition prior to and after the influx of gases. Individuals were left to make critical decisions without all the necessary information of the complexity or criticalness of the issues (complex nature of cement job, fragility of well, etc.) WSL's failed to consult personnel on shore regarding pressure anomalies observed during removal of mud and the negative-pressure test.

Flaws, Defects &Inadequacies	Comments
Insufficient planning for blowout scenario	BP had not fully assessed the risk of a potential blowout in their initial exploration plan: flow rate, total volume and maximum duration. Stated blowout scenario "not required."
Inadequate review of Well program with contractors	No evidence of review of the well program with BP and the HORIZON OIM prior to resumption of drilling to ensure well control needs and issues were addressed: including blowout and contingency plans.
Incomplete and inadequate procedures	BP failed to develop or adopt clear procedures for the well abandonment process. Information was minimal and did not include the expected results. The procedures were in direct opposition to regulatory requirements which would increase the possibility of the BOP seeing greater pressures.
Failure to adequately identify and mitigate anomalies	If expected responses are not returned, the operation should be stopped and the reason for the discrepancy determined and remediated. Pressure responses deviated from the expected results and they were either not understood or explained away.
Muddled lines of authority	BP's change in structure had created confusion within BP and between BP and its contractors in regards to the lines of authority as was evidenced by emails from BP employees.
Failure to identify subtle changes in the environment	Data available showed a number of subtle changes to the environment that should have alerted personnel to anticipate a possible change in risk, which should have provoked an action. Increasing pressures after the pumps were shut in, pressure differential between the DP and kill lines, should have prompted visual flow checks and the immediate shut in of the well.
Inadequate design of the BOP	BAST was not used. All well control events, including the worst well control events, should have been identified on Macondo and its BOP Stack and CS designed, assembled and tested, accordingly.
Installation of one BSR	Should have used 2 BSRs; the lower BSRs would protect the upper BSRs if operated in that order.

Flaws, Defects &Inadequacies	Comments
Non-inclusion of Tandem Boosters on the BSR.	BAST was not used. Tandem Boosters would have provided additional hydraulic energy for the BSRs to shear 5½" S-135 DP. Absent Tandem Boosters, there was no additional hydraulic energy available to close the one (1) set of BSRs
[redacted]	[redacted]
Conversion of Bottom VBR to Test Ram.	Eliminated bottom VBR as a BOP and reduced VBR redundancy. Did not comply with BP's policy requiring the bottom most VBR be capable of sealing the wellbore.
Insufficient Regulator Pressure on High Pressure Shear Circuit to activate BSR to cut 5½"-21.9 lbs/ft, S-135 DP at mud line	Shear calculations for 5½" S135 DP were either not performed or were calculated improperly for determining required pressure to shear at depth.
Use of 50% mud & 50% Gas for Maximum Allowable Surface Pressure ("MASP") substantially reduce MASP.	Realistic calculations for MASP at the mud line would be 100% gas. BP violated its well control policies by not using 100% gas column to surface in calculating MASP
LMRP: Lower Annular BOP de-rated to 5,000 psi.	MASP was close to 10,000 psi @ mud line which eliminated this BOP from sealing MASP at mud line
Emergency Disconnect System ("EDS"): EDS-1 was used; EDS-2 was not used.	BAST not used. EDS-2 activated CSRs first; BSRs second to shut-in and seal-off well. Closed CSRs protect elastomers on BSRs during closure. Since the annulars and VBRs are not a part of the EDS sequences, the EDS sequence used on the HORIZON should be the most reliable to shear the DP and seal the well (EDS-2).
[redacted]	[redacted]

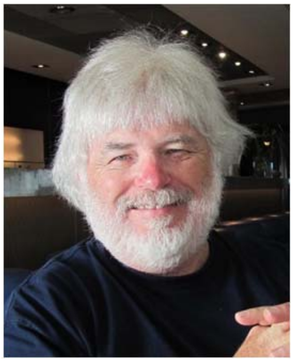
Flaws, Defects &Inadequacies	**Comments**
[redacted]	[redacted]
[redacted]	[redacted]
Shuttle Valve on each BOPs was a SPOF.	As a SPOF; shuttle valves needed to be protected from damage. Their functionality would be determined during subsea BOP testing. If the BSR shuttle valve was inoperable, hydraulic fluid could not reach the BSRs.
[redacted]	[redacted]
[redacted]	[redacted]
No dynamic flow testing of BOP Components	The effects of dynamic control needed to be tested and identified and properly risk assessed and mitigated prior to the configuration of the BOP. If the effect of dynamic flow could not be overcome, Well control events need to be recognized early enough to reduce the effect on the BOPs ability to shut/seal. Redundant BOPs should have been used on Macondo such that closing the lower BOP would isolate dynamic flow from its upper BOP so that it can more reliably seal-off the well.
[redacted]	[redacted]

Flaws, Defects &Inadequacies	Comments
No Acoustic Trigger System	BAST was not utilized. Acoustic Trigger would have provided redundancy in BOP emergency functions and systems.
No BSR Shear Testing of off-center DP	BAST was not utilized. BSR shearing blades utilized did not extend across the entire wellbore. Other blades were available which would cover the entire cavity.
No ability to monitor accumulator charge levels	
No BP enforcement mechanism for internal and/or 3rd Party audit findings.	
[redacted]	[redacted]
Upper Annular BOP sealing ability compromised	Drill String was stripped through the non-strippable Upper annular during operations. Rubber pieces appeared in return flow from well. Multiple kicks required the annular be used to shut-in and circulate out the well on numerous occasions.
[redacted]	[redacted]
Failure to activate BOP Emergency Control Systems with loss of MUX Cables.	Use of an Acoustic Trigger would have backed-up the ability to close the BSRs in an emergency. In the event that the primary control system was lost, the BOP Stack's emergency functions could be completed through a signal. Acoustic Triggers have been in use since 1975.

Flaws, Defects &Inadequacies	Comments
Hydraulic leaks in certain BOP components not repaired or monitored	Leaks in hydraulic equipment reduce pressures and volumes required to reliably activate BOP components.
Lack of BP review and analysis on Event Logger data.	Event logger data was not being sent to BP for contemporaneous analytical review. All BOP functions would be recorded on Event Logger stored in the CCU.
[redacted]	[redacted]
Incorrect utilization of MASP in Well Control policies.	MASP showed the BOP to be insufficient to deal with maximum anticipated wellbore pressures. BP should have used higher rated components.
Drilling mud removed from HORIZON at critical time	Mud was the primary well control. By removing the mud from the HORIZON, it eliminated a barrier. BP relied upon a good cement job as the only remaining barrier to control the well.
Deficient well control procedures	After the negative pressure test, a well control event occurred; i.e., DP pressure increased. Macondo should have been shut-in and the anomaly investigated.
Policy to Close Annular first	The annular psi ratings had been reduced to below the expected pressures. The policy to shut in the annular first should have been changed to use a ram which fell within expected pressures.
VBRs closed second after upper Annular BOP closed.	VBRs had a greater psi rating then the annular BOPs and BP's policy should have been changed to activate the VBRs first in lieu of the reduced annular ratings.

Flaws, Defects &Inadequacies	Comments
Insufficient charge/Volume in the accumulator bank for activation of BSRs.	Calculations for necessary psi to shear the DP at depth were either not performed or incorrect.
Macondo had been an unstable well	Previous kicks and loss circulation events were significant warnings which should have alerted BP as to the instability of the well and made them more vigilant and quicker to respond to possible well flow.
No Predetermined Blowout Scenario on the evening of April 20, 2010.	There was no well control procedure in-place whereby the observation of positive DP pressure after a negative pressure test would dictate that the well should be shut-in and sealed-off. Further, that drilling mud should be available at all times in order to kill the well.
On April 20, 2010, hydrocarbons in the Riser were discharged to MSG instead of being discharged through the two 14" Diverter Lines.	The MGS did not have the capability to contain this uncontrolled well flow. BP's policy stated that the when hydrocarbons were above the BOP and into the riser, the diverter was to be closed and flow directed through the MSG.
The MSG became overwhelmed causing the packer element in the Diverter to rupture.	Explosion! All BOP functions lost as MUX cables were destroyed. Autoshear does not fire because LMRP does not separate.
BSRs were incapable of shearing 5½" & 6⅝ DP at MASP	

Appendix L: Mr. Gregg S. Perkin, C.V. and related information



Mr. Gregg Perkin became a registered Professional Engineer by examination in the State of California in 1978. He is currently registered as a Professional Engineer in good standing by examination, experience & comity in thirteen (13) states: California, Texas, Hawaii, North Carolina, Oklahoma, Wyoming, New Mexico, Arkansas, Alabama, Montana, Mississippi, Colorado and Louisiana. Mr. Perking graduated in 1973 from with a Bachelor of Science in Mechanical Engineering from California State University at Long Beach ("CSULB").

Mr. Perkin was directly employed in the oil & gas industry from 1968 through 1986. His Oilfield Service Industry experience included working for companies such as: Regan Forge and Engineering, Smith International, Incorporated, Newpark Resources and The Oilpatch Group, holding positions of Draftsman, Design Engineer, Engineering Manager, Manager of Technical Services, Chief Engineer, Vice President of Engineering and Director of Manufacturing. During his adult life, Mr. Perkin worked as an oilfield Roughneck or Floorman, Derrickman, Serviceman and Field Engineer in both offshore and onshore drilling and completion operations.

In mid-1986, Mr. Perkin began his work as an independent professional mechanical engineering consultant. In 1995, Mr. Perkin co-founded Engineering Partners International, L.L.C. (“EPI”). He is presently employed by EPI as an independent consultant and Professional Engineer in the areas of domestic and international onshore and offshore Oil & Gas Drilling and Production operations including the design, use and application of much of the equipment and systems used in this field.

As one (1) of EPI’s Principal Engineers, Mr. Perkin has often been independently retained to conduct product design analysis, design equipment, failure analysis, review claim elements of intellectual property and provide other independent engineering consulting services related to mechanical equipment including, specifically, Blowout Preventers (“BOP”).

Since 1996, Mr. Perkin has been a part time Instructor at the University of Texas’ Petroleum Extension Service (“PETEX”).

Mr. Perkin has also served as a Lecturer and Instructor for FMC Corporation, Baker-Hughes, Incorporated and National Oilwell Varco. He has also authored and co-authored energy related technical papers and articles for the International Association of Drilling Contractors (“IADC”), the Society of Petroleum Engineers (“SPE”) and PetroSafe.

He is an inventor and co-inventor on thirteen (13) U.S. patents.

Mr. Perkin is presently affiliated with, and has memberships in the following professional organizations: American Petroleum Institute (“API”), Society of

Petroleum Engineers (“SPE”), International Association of Drilling Contractors (“IADC”), American Society of Mechanical Engineers (“ASME”), National & Texas Societies of Professional Engineers (“NSPE & TSPE”), National Fire Protection Association (“NFPA”), Instrument Society of America (“ISA”) and the American Welding Society (“AWS”).

Gregg S. Perkin, P.E.

CEO/Principal Mechanical Engineer,
EngineeringPartners@msn.com

PROFESSIONAL SUMMARY:

- Mechanical Engineer with over forty (40) years of domestic and international experience in energy-related and other industries.
- Registered Professional Engineer by examination & comity in thirteen (13) states; California, Hawaii, Texas, North Carolina, Oklahoma, Wyoming, Montana, New Mexico, Arkansas, Alabama, Mississippi, Colorado and Louisiana.
- Expert witness in litigation and insurance matters; over twenty one (21) years experience in giving legal testimony as a forensic engineer relative to:
  - ☐ Oil & Gas Well Drilling, Drilling & Well Servicing Rigs, Completion, Production and Well Servicing.
  - ☐ Onshore & Offshore Safety Systems Blow Out Prevention Equipment, Pressure Control, Top Drive Design & Systems, Coiled Tubing, Artificial Lift, Subsurface Safety Valves, Thread Design, Connections, Directional Drilling, Boring & Surveying, MWD equipment, Downhole Tools and Equipment and Instrumentation.
  - ☐ Pipeline design, installation & construction; equipment use, drilling techniques and applications including DOT Pipeline Safety Regulations.
  - ☐ Mechanical Systems Design, Machinery, Equipment & Tools.
  - ☐ Onshore and Offshore Cranes; rigging and other heavy lift equipment.
  - ☐ Power Generation, Power Transmission and Power Utilization.
  - ☐ Atmospheric Tanks and Pressure Vessels.
  - ☐ Worked as an Oilfield Roughneck, Derrickman and Serviceman in both offshore and onshore operations.
  - ☐ Production, Refining & Process Safety Management.
- Experienced in various mechanical fields relative to conducting product liability, personal injury and accident reconstruction analysis.
- Author of technical manuals, computer programs and industry related papers.
- Safety expertise re: oil & gas facilities, refining and construction operations worldwide. Completed thirty two (32) hour Certified Safety Professional (“CSP”) Review Course.
- Inventor & co-inventor; presently hold thirteen (13) US patents pertaining to downhole equipment and other mechanical systems.
- Instructor; University of Texas at Austin; Petroleum Extension Service (“PETEX”). Drilling & Production, Well Deepening Operations, Directional Drilling & Sidetracking, Pipeline Materials of Construction and Offshore Catastrophes; Lessons Learned.
- Board of Advisors; University of Texas at Austin (2004).

PROFESSIONAL EXPERIENCE:

1996 to Present **Engineering Partners International**
Kingwood, (Houston), Texas
CEO, Principal Engineer

Conduct product liability, personal injury and accident reconstruction investigations relative to mechanical equipment, oil & gas well drilling, well servicing, completion and production systems, surface and downhole operations. Expert in the design, use and evaluation of tools & equipment, tanks, pressure vessels, rotating & dynamic machinery, pipelines and pipeline operations. Expert in the use of finite element analysis for complex stress analysis problems (both elastic and plastic), heat transfer, dynamics and vibrations. Note: merged previous employer PVA, Inc. into EPI.

1995 to 1996: PVA, Incorporated
Kingwood, (Houston), Texas
Principal Engineer

Development and evaluation of the design, use and application of mechanical engineering systems relative to offshore and onshore drilling, to include production and refining operations and other mechanical systems including tools & equipment, atmospheric tanks and pressure vessels and rotating & dynamic machinery. Expertise relative to matters involving natural gas and liquid propane (LP) storage, transportation/distribution systems and the evaluation, use and installation of associated products and services.

1987 to 1994 CH&A Corporation
Kingwood (Houston), Texas
Senior Consulting Engineer, Principal Engineer

Consultant to PEMEX (Petroleous Mexicanos), 1993-1994 relative to offshore safety systems. Co-author of three (3) technical papers published by the Society of Petroleum Engineers

1986 to 1987 Cougar Tool, Incorporated, Division of the Oil Patch Group
Houston, Texas and Edmonton, Alberta, Canada
Engineering Manager

Guided the development of new and improved products in the area of downhole drilling equipment used on a worldwide basis. Also, guided the development of downhole drilling tool projects including directional and straight hole drilling systems

1985 to 1986 Lone Star Grinding, Incorporated
Houston, Texas
Vice President of Engineering

Responsible for the design of very accurate hardened and ground working and master thread gages conforming to the specifications of the American Petroleum Institute (API) and the American Society of Mechanical Engineers (ASME) specifications. Also, responsible for the creation of new gauging systems and quantifying them for the National Bureau of Standards. Past chairman of American Petroleum Institute (API) work groups relative to Non-Magnetic Drill Collars in Directional Drilling and Rotary Shouldered Connections

1980 to 1985 LOR, Incorporated
Houston, Texas
Chief Engineer, Director of Manufacturing

Responsible for overseeing the engineering, quality control and manufacturing departments. Personally designed, developed, field tested and supervised the development of numerous mechanical devices for oilfield drilling and completion purposes; some of which were patented. Author of LOR's Practical Product Guide and Functional Downhole Drilling Series. Directly responsible for plant manufacturing operations, safety and the installation of a fully operational metallurgical laboratory

1969 to 1980 Servco, Division of Smith International, Incorporated
Los Angeles, California, and Houston, Texas

Draftsman, Engineer Trainee, Design Engineer, Engineering Manager

Personally designed, developed, field tested and supervised the development of numerous mechanical devices for oilfield drilling and completion purposes; some of which were patented. Co-author of Servco's Handbook of Downhole Drilling & Completion Systems. Designed a series of products relative to enhanced recovery (EOR) in the areas of reverse circulation drilling and production.

1968 to 1969 Regan Forge & Engineering
San Pedro, California
Draftsman, Engineer Trainee

Responsibilities included working in the product design group relative to the design, use and application of offshore and onshore blow out prevention equipment, to include subsea production equipment.

EDUCATION:

- Bachelor of Science in Mechanical Engineering from California State University at Long Beach, (1973)
- Attended graduate courses in Business Administration after graduation.
- Petroleum Extension Service (PETEX), University of Texas at Austin.
- Paul Munroe School of Hydraulic Equipment.
- American Management Association; Engineering Management & Fundamentals of Management
- Algor™; Finite Element Analysis techniques pertaining to linear and non-linear materials and mechanical event simulation

REGISTRATIONS:

Registered as a Professional Mechanical Engineer by examination and comity in California, Hawaii, Texas, North Carolina, Wyoming, Montana, Ne Mexico, Arkansas, Alabama, Mississippi and Louisiana.

AFFILIATIONS & MEMBERSHIPS:

- American Petroleum Institute (API)
- Society of Petroleum Engineers (SPE)
- International Association of Drilling Contractors (IADC)
- American Society of Mechanical Engineers (ASME)
- National & Texas Societies of Professional Engineers (NSPE, TSPE).
- National Fire Protection Association (NFPA)
- Instrument Society of America (ISA)
- American Welding Society (AWS)
- Association of Energy Servicing Companies (AESC)
- American Society of Civil Engineers (ASCE)

DEPOSITION AND TRIAL APPEARANCES BY GREGG S. PERKIN, P.E. SINCE 2001

Plaintiff	Defendant	State	County/Parish/Other	Cause/Docket No.	Year My Depo Taken	Appear @ Trial (Y)?
Muriel Sanders	**Mobile Drilling**	Texas	162nd Judicial District Court, Dallas, Texas	DV99-3268	2001	
Thomas	NGO, City of San Jose	California	San Jose	CV774842	2001	
Seth Becker	Baker-Hughes; Tidewater, Hydra Rig, et al	Louisiana	USDC, Western District of Louisiana	99-1198	(no depo	Y (did not testify)
Newfield Exploration Inc	OSCA	Texas	USDC for the Southern Dist of TX, Houston Div.	H-00-3442	2001, 2002	Y (did not testify)
Joseph Deley	**Diamond Offshore Company**	Louisiana	USDC, Eastern District of Louisiana	00-3775	2001	
Seagull Energy	**BakerMO**	Texas	USDC, Southern District of Texas, Houston Div.	99-E-14719-mc	2001	Arbitration
Wesley Witz	**Parker Drilling Offshore USA, LLC**	Louisiana	USDC, Western District of Louisiana	CV00-2530	2002	
Dianne Prassas, et al	National Propane, et al	Arizona	Superior Court, State of AZ, Maricopa County	CV99-00461	2002	
James Griggs	**Texas Department of Criminal Justice**	Texas	District of Harris County, TX; 3rd Judicial Dist.	No.99-119	2002	Y
Edward Sandoval	California Department of Water & Power	California	Superior Court, State of CA, County of LA	PC024924Z	2002	
Frank Bonner	**Consolidated Pipe & Supply**	Texas	151st Judicial District Court, Harris County	1999-40617	2002	
Michael August	**Shell Exploration & Production Company**	Louisiana	USDC, Eastern District of Louisiana	00-3593; Section "C"	2002	
Victor Barkley	Pride Offshore, Inc.	Texas	USDC, Southern District of Texas, Galveston Div.	G-P01 211	2002	
Mildred Davis	Conveyor-Matic Incorporated, et al	Texas	DC, Tarrant County, TX 236th Judicial District	236-182360-00	2002	
Brute Sootblowers, Inc.	Peerless-Winsmith, Incorporated	Texas	USDC, Southern District of Texas, Houston Div.	H-01-3761	2002	
Daniel Easterday	**Leeward Auto Recycling**	Hawaii	District Court of the First Circuit, State of Hawaii	02-1-0614-03	2003	
Richard Kelly, et al	**Forcenergy, Waters Equipment, et al**	Louisiana	USDC, Eastern District of Louisiana	Jan-48	2003	
Ronald Bourque	Compression Coat, Inc., Caterpillar, Inc., et al	Louisiana	16th Judicial Distruct Court, Parish of Iberia	Docket No. 87079. 87229	2003	
Armando Lopez, et al	**Cox & Perkins Exploration, Inc.**	Texas	234th Judicial District Court, Harris County	2002-19434	2003	
Randy Spouse	**Dunhill Resources, Incorporated**	Texas	Pusuant to the American Arbitration Rules	70 116 0082102	2003	
Janet Weber	**Eco-Adventures (M/V MAKAI)**	Hawaii	US District Court, State of Hawaii	CV02-00596ACK/BMK	2003	
Billy Bob Bridges	**Hydra Rig, Varco, et al**	Texas	342nd District Court of Tarrant County, TX	342-191154-02	2003	
Blance Estella Dotson	George E. Failing Company, et al	Hawaii	US District Court, State of Hawaii	01-1-0628 (3)	2003	Y
Avondale Industries, Inc.	Tyco Valves & Controls	Louisiana	US District Court, Eastern District of Louisiana	01-2923	2003	Y
Anna Brown	**Lattimore Materials Co., et al**	Oklahoma	USDC, Eastern District of OK	CIV 02-350-P	2003	
Christopher Taylor	**Barnett Wireline Service & Rental Tools, Inc.**	Louisiana	USDC, Western District Louisiana; Lafayette-Opelousas Division	CV02-1823 "L-O"	2004	
Larry Purviance	Zeneca AG Products, et al	Texas	USDC, Southern District, Houston Division	H-01-2581	2004	
Sterling Chemicals	PraxAir, Incorporated	Texas	District Court of Galveston County, TX; 405th Judicial District	00-CV-0060	2004	Y
Anthony White	The Offshore Drilling Company ("TODCO")	Texas	USDC, Southern District, Galveston Division	CA G-03-462	2004	
Michael Rostie	Kerr McGee Rocky Mountain Corporation, Bravo Services, et al	Colorado	District Court, Denver County, State of Colorado	03-CV-6022 Ctrm. 7	2004	
Roy Seger & Shirley Faye Hoskins	**Diatom Drilling Company**	Texas	District Court, Hutchinson County, TX, 84th Judicial District	30,110	2004	
Harvey Montoya	**Helmerich & Payne International Drilling Co., Shell Exploration and Production Co., et al**	Wyoming	USDC of Wyoming	Civil No. 03-CV-16 4D	2004	
The Hasha Family Limited Partnership IV, LT & the Hasha Family Limited Partnership III, LTD	**Varco International, Incorporated**	Texas	American Arbitration Association; Houston Office	70 Y 189 00371 03	2005	
Gryphon Exploration Co.	**JFE Steel America, Inc., et al**	Texas	Southern District of Texas, Galveston Division,	G-03-266	2005	
Tommy Dicks	**The Natcher Corporation, Inc. and Rowan Drilling Company, Inc.**	Louisiana	USDC Western District of Louisiana; Opelousas Division	CV 03-1004	2005	
Rhonda Currington, et al	**TEG/Sefton**	California	Superior Court of the State of California for the County of Los Angeles; North Valley District	PC033424	2005	
Louisiana Safety Systems	**Gator Valve Incorporated & Gator Valve LLC**	Louisiana	USDC, Western District of Louisiana	04-0346	2005	
Ronald Deschwanden	Pool Well Servicing Company, Plains Resources, et al	California	Superior Court of the State of California, for the County of Los Angeles, Central District	BC270120	2005	
Perla Rubio, et al	Kerns Oil & Gas, Inc., Diamondback Drilling Inc., et al	Texas	49th Judicial Court of Webb County, TX	2003CVQ0011323-DI	2005	
Henry Poirier	**Diamond Offshore Drilling, Incorporated**	Louisiana	USDC, Eastern District of Louisiana	03-3200	2005	Y
Jason Peppers	Aries marine Corporation, Hydril Company, LP et al	Texas	USDC, for the Western District of Texas; Monroe Division	C.A. No. CV04-2356-M	2005	
Ruth Stensaker	Flying J Oil & Gas, Incorporated, et al	Montana	USDC; for the District of Montana	CV04-168-BLG-RWA	2006	Y
Oscar Jones	Fowler Transportation, Ltd	Texas	71st Judicial District, Harrison County, TX	04-0844	2006	
Wilbros Group, Incorporated	**MasTec Pipeline Company**	Oklahoma	USDC for the Northern District of Oklahoma	CIV-03-1561-R	2x in 2006	
MasTec North America, Inc.	El Paso Field Services, LP	Texas	District Court of Harris Co, TX; 334th Judicial District	2004-39579	2x in 2006	Y
Cressman Tubular Products Corporation	**Southwest Stainless, Incorporated**	Texas	(Dallas) County Court at Law No. 5	05-02373-E	2006	
Varco, L.P.	Pason Systems, Incorporated	Colorado	USDC for the District of Colorado	03-M-2579 (BNB)	2006	

BOLD TYPE INDICATES THE SIDE MR. PERKIN REPRESENTED

DEPOSITION AND TRIAL APPEARANCES BY GREGG S. PERKIN, P.E. SINCE 2001

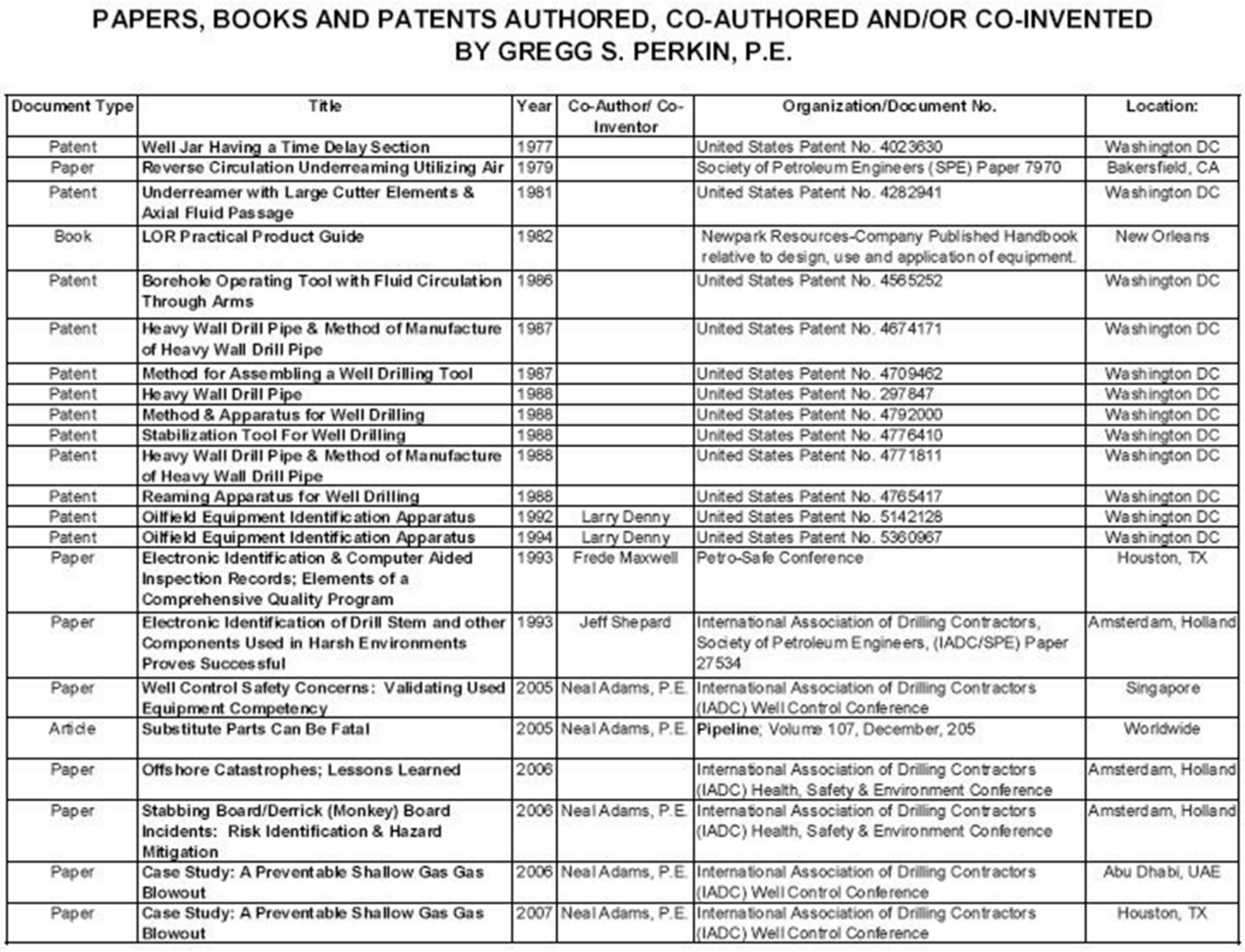
Plaintiff	Defendant	State	County/Parrish/Other	Cause/Docket No.	Year My Depo Taken	Appear @ Trial (Y)?
Roger Curd	**AOP Industries, Incorporated**	Louisiana	USDC, Eastern District of Louisiana	03-CV-3126	2006	
Mike Melton, et al	Encana Oil & Gas (USA), Inc., et al	Utah	USDC for the District of Utah	05-CV-842-PGC	2006	Y
Equilon Pipeline Company, LLC (Shell Pipeline)	IDEX Corporation and DKP Enterprises	Louisiana	29th Judicial District Court, Parish of St. Charles, State of Louisiana	56,461-C	2007	Y
Michael Shane Reed	Parker USA Drilling Company, et al	Louisiana	USDC, Western District of Louisiana, Lafayette-Opelousas Division	CV05-1950	2007	
Christopher Morgan	The Offshore Drilling Company ("TODCO")	Louisiana	USDC, Eastern District of Louisiana	05-1361	2007	Y
Lyondell-Citgo Refining LP	World Car Carriers, Inc. and the M/V COSMO SPIRIT	Texas	USDC for the Southern District of Texas, Houston Division	H-06-1152	2007	Y
Roy & Sandy Deroche	**Supreme Contractors, LLC, et al**	Louisiana	16th Judicial District Court, Parish of St. Mary, State of Louisiana	115404-A	2007	
Kentucky Oil Technology, N.V.	**Schlumberger Technology Corporation**	California	USDC, Northern District of California, San Jose Division	04-CV-03843-RMW	2007	
Pride Offshore, Incorporated	Weatherford, U.S., L.P.	Louisiana	USDC; Eastern District of Louisiana	05-2424	2007	
Wood Group Pressure Control, L.P.	**B&B Oilfield Services, Inc.**	Louisiana	USDC; Eastern District of Louisiana	06-3002, Sect. "N", Mag. 4	2007	
Bidina Florence, et al	Energen Resources Corporation	New Mexico	2nd Judicial District Court, County of Rio Arriba, State of New Mexico	D-117-CV-2005-00090	2007	
James Ayo	**Wilcrest Field Services, El Paso Corporation, et al**	Texas	District Court of Harris County, TX; 129th Judicial District	06-515	2007	
Jessie L. Thomas	Maersk Line, Ltd.	Louisiana	USDC, Eastern District of Louisiana	06-0005	2007	Y
Jason E. Waites	V.A. Sauls, Incorporated	Mississippi	Circuit Court of Jasper County, Mississippi 1st Judicial District	15-0062	2007	
Perforaciones Exploracion y Produccion, et al	**Seacor Holdings, Inc. Grupo TMM, S.A. and Maritimas Mexicanos, S.A. de C.V.**	Texas	United States District Court for the Southern District of Texas, Galveston Division	C.A. No. G-05-419	2007	Y (2X)
The Offshore Drilling Company ("TODCO")	**Michael Palmer**	Texas	United States District Court for the Southern District of Texas, Corpus Christi Division	C-06-515	2008	Y
E.J. LeFort, Jr., et al	T-3 Energy Services, et al	Louisiana	32nd Judicial District Court for the Parish of Terrebonne, State of Louisiana	No. 145144, Division C	2008	
Greenhunter Energy, Inc.	Womble Company	Texas	215th Judicial District Court, Harris County	Unknown	2008	Y
Ronnie Thornton	Diamond Offshore Drilling, Inc	Louisiana	United States District Court, Eastern District of Louisiana	Civil Action No. 07-1839	2008	Y
Timothy Thomas	Razor Sharp Edgemaking System, et al	Louisiana	Western District Court of Louisiana	Docket No. 6:07-CV-0826	2008	
Wells Fargo, et al	**Greka Oil & Gas Incorporated**	California	Superior Court for the State of California for the County of Santa Barbara, Santa Maria (Cook Division)	Case No. 1155864	2008	
Larry Taylor	Diamond Offshore Drilling, Inc	Louisiana	USDC, Eastern District of Louisiana	Civil Action No. 06-6318	2008	
Mid-Continent Casualty Company	Bay Rock Operating Company, et al	Texas	District Court for the Western District of Texas, San Antonio Division	Cause No. SA 07 CA 0274 OG	2008	
Fall Protection Systems, Inc	**Azteca Milling, LP and Flexible Lifeline systems (formerly known as SEAFLEX, INC.)**	Missouri	United Sates District Court, Eastern District of Missouri	Case No. 4:07-cv-01303-JCH	2008	
Carl Rollins	Tulsa Tubular, Inc., et al	Texas	DC, Harris County, Texas, 11th Judicial District	Docket No. 2005-52503	2008	
Rodney Andrade	Cooper/T. Smith, et al	Louisiana	U.S. District Court, Middle District of Louisiana	Civil Action No. 06-907	2008	
Billy Denson	Diamond Offshore Drilling, Inc	Louisiana	Civil District Court, Parish of Orleans, State of Louisiana	Civil Action No. 01-10856, Division "D"	2008	
Brenda Slate, et al	**Shell Oil Company, et al**	Alabama	In the Circuit Court of Mobile County, Alabama	CV-2006-406-JSJ	2008	
Ray Whittemore	Bois D'Arc Energy, Inc	Louisiana	United States District Court, Eastern District of Louisiana Division of New Orleans	Civil Action No. 06-8997	2009	Y
M&N Equipment	Eric Smith	Wyoming	Ninth Judicial District Court, Sublette County, Wyoming	Docket No. 2007-7084	2009	
William Cooley	Densbury Onshore, LLC	Mississippi	USDC, Southern District of Mississippi, Eastern Division	4:08-CV-00035-TSL-LRA	2009	
Thomas M. Henson	Pioneer Drilling Company, et al	Texas	In the District Court, Johnson County, TX	C200800525	2009	
John Pierce	**Tommy's Mobile Boat & Motor Service, Incorporated D/B/A Rockwall Marine and Teleflex, Incorporated D/B/A Teleflex Marine**	Texas	In the District Court of Rockwall County, TX, 382nd Judicial District	Cause No. 1-08-551	2009	Y
MacLean-Fogg Company	**Eaton Corporation**	Texas	USDC for the Eastern District of Texas, Marshall Division	Civil Action No. 2:07cv472	2009	
BLR Construction Companies, LLC	**White Oak Operating Company, LLC**	Texas	55th Judicial District/Harris County, TX	Cause No. 2007-60434	2009	
Daniel Paul Kibodeaux, et al	**Soloco, LLC, et al**	Louisiana	14th Judicial District Court, Calcasieu Parish, State of Louisiana	2006-00468-JSJ	2009	
Larry E. Mullins, Jr.	Fowler Transportation, Ltd.	Texas	District Court of Wise County, Texas, 271st Judicial District	Cause No. 08-08-578	2009	
Jeffrey Hunkin	Cooper/T. Smith, et al	Louisiana	USDC, Western District of Louisiana	Docket No. 08-0046	2009	
Bobbie Smith	Ideal Industries	Louisiana	USDC, Eastern District of Louisiana	Civil Action 08-5169	2009	
Mark Hudson	Schlumberger Technology Corporation & Alpha Marine Services, Inc	Louisiana	USDC, Eastern District of Louisiana	Civil Action No. 08-4754 Section N, Magistrate 2	2010	

BOLD TYPE INDICATES THE SIDE MR. PERKIN REPRESENTED

DEPOSITION AND TRIAL APPEARANCES BY GREGG S. PERKIN, P.E. SINCE 2001

Plaintiff	Defendant	State	County/Parish/Other	Cause/Docket No.	Year My Depo Taken	Appear @ Trial (Y)?
China Star Oil Company, LLC	MAC Oilfield Company, John Widcott & Worth Hooper, D&L Oil Tools	Texas	In the 42nd Judicial District, Taylor County, Texas, Cause No. 46457-A	Cause No. 46457-A	2010	
Warren Dupre	TODCO, Offshore Equipment Services, et al	Texas	In the District Court of Galveston County, TX, 405th Judicial District	Cause No. 07-CV-1304	2010	Y (did not testify)
Renee Trahan & Patricia Landry	**The State of Louisiana through the DOT and Development**	Louisiana	In the Vermilion Parish Court	Docket No. 2003-0280L	2010	Y (2X)
Michael Fruge, et al	Ulterra Drilling Technologies, L.P, et al	Louisiana	USDC, Western District of Louisiana, Lafayette-Opelousas Division	Docket No. 6:07-CV-00789	2010	
William Stanley	Diamond Offshore Drilling, Inc	Texas	In the 11th Judicial District Court of Harris County, TX	Cause No. 2009-50114	2010	Y
John Delcambre	Apache Corporation, Waukesha-Pearce Industries, Inc. & Exterran, Inc.	Louisiana	USDC, Western District of Louisiana	Suit No. 6:08-cv-0707	2010	
Vickie Lynn Nault, et al	Basic Energy Services, Inc., et al	Texas	259th Judicial District Court of Jones County, TX	Case No. 21,164	2x in 2010	Y
Jason Clark	Pan Southern Petroleum Corporation	Mississippi	USDC Southern District of Mississippi, Jackson Division	Civil Action No. 3:08cv472	2010	
James E. Holliday	**Southern Energy Homes, Inc., et al**	Alabama	Circuit Court of Winston County, Alabama	Civil Action No. 2008-900064	2010	
Highmount Exploration & Production Holdings Corporation	**Helmerich & Payne International Drilling Company**	Texas	In the District of Harris County, 269th Judicial District	Cause No. 2009-22173	2010	
Southern Oaks Water Systems, Incorporated	Devon Energy Corporation, et al	Texas	DC of Montgomery County, 359th Judicial District	Cause No. 08-04-04127-CV	2010	
Linda Graves, et al	BP PLC	Texas	405th Judicial District Court of Galveston County, TX	Case No. 06-CV-0852	2010	
Joshua Alan Williams	M.D. Cowan, Inc., Tesco Services, Inc., Jeffrey Anderson and RigTechnology	Arkansas	USDC for the Eastern District of Arkansas, Western Division	Civil Action No. 4:09-cv-459	2010	
OCS Midstream Services, LLC	Hamilton Metals, Inc., Nippon Steel Corporation, Tube-Tech Services, Inc., et al	Texas	151st Judicial District Court of Harris County, TX	Cause No. 2009-46502	2010	
Petroplex Energy, Incorporated	Nabors Well Service, Ltd and Smith International, Inc., et al	Texas	In the 143rd Judicial District Court for the State of Texas, County of Reeves	No. 08-10-19210-CVR	2010	
I.G. Petroleum, LLC	Gary Wooley, Individually	Texas	In the District Court, Harris County, Texas, 189th Judicial District	Cause No. 2009-2115	2010	
Davenport Drilling & Pump Service	Franks Casing Crew & Rental Tools, Inc., et al	Texas	In the District Court, 45th Judicial District, Bexar County, TX	Cause No. 2009 CI 05146	2011	
Jonathon Fender	Delta Petroleum Corp, Baroid Drilling Fluids, Inc., Sheldon Van Voast, William Sauer and Harold Hastings	Wyoming	In the District Court for Fremont County, Wyoming, 9th Judicial District	Civil No. 37243	2011	
Jamie Raynes	McMoRan Exploration Co., Newfield Exploration Company, Petro Construction Management, Production Services Network, et al	Louisiana	In the United States District Court, Eastern District of Louisiana;	Civil Action No. 08- 5018; C4	2011	
Louis Kimich	Aquadrill, Inc., **Millenium Petrochemicals**, Inc. and Spir-Star Ltd, et al	Texas	In the District Court, Harris County, TX, 125th Judicial District	Case No. 2008-36752	2011	
Ultra Pure Twater echnologies, Inc. dba Ice Island Systems ("ICEX")	Standex International Corporation, et al dba Master Bit	Louisiana	15th Judicial District Court, State of Louisiana	Docket No. C-20084587"J"	2011	

BOLD TYPE INDICATES THE SIDE MR. PERKIN REPRESENTED



PAPERS, BOOKS AND PATENTS AUTHORED, CO-AUTHORED AND/OR CO-INVENTED BY GREGG S. PERKIN, P.E.

Document Type	Title	Year	Co-Author/ Co-Inventor	Organization/Document No.	Location:
Patent	**Well Jar Having a Time Delay Section**	1977		United States Patent No. 4023630	Washington DC
Paper	**Reverse Circulation Underreaming Utilizing Air**	1979		Society of Petroleum Engineers (SPE) Paper 7970	Bakersfield, CA
Patent	**Underreamer with Large Cutter Elements & Axial Fluid Passage**	1981		United States Patent No. 4282941	Washington DC
Book	**LOR Practical Product Guide**	1982		Newpark Resources-Company Published Handbook relative to design, use and application of equipment.	New Orleans
Patent	**Borehole Operating Tool with Fluid Circulation Through Arms**	1986		United States Patent No. 4565252	Washington DC
Patent	**Heavy Wall Drill Pipe & Method of Manufacture of Heavy Wall Drill Pipe**	1987		United States Patent No. 4674171	Washington DC
Patent	**Method for Assembling a Well Drilling Tool**	1987		United States Patent No. 4709462	Washington DC
Patent	**Heavy Wall Drill Pipe**	1988		United States Patent No. 297847	Washington DC
Patent	**Method & Apparatus for Well Drilling**	1988		United States Patent No. 4792000	Washington DC
Patent	**Stabilization Tool For Well Drilling**	1988		United States Patent No. 4776410	Washington DC
Patent	**Heavy Wall Drill Pipe & Method of Manufacture of Heavy Wall Drill Pipe**	1988		United States Patent No. 4771811	Washington DC
Patent	**Reaming Apparatus for Well Drilling**	1988		United States Patent No. 4765417	Washington DC
Patent	**Oilfield Equipment Identification Apparatus**	1992	Larry Denny	United States Patent No. 5142128	Washington DC
Patent	**Oilfield Equipment Identification Apparatus**	1994	Larry Denny	United States Patent No. 5360967	Washington DC
Paper	**Electronic Identification & Computer Aided Inspection Records; Elements of a Comprehensive Quality Program**	1993	Frede Maxwell	Petro-Safe Conference	Houston, TX
Paper	**Electronic Identification of Drill Stem and other Components Used in Harsh Environments Proves Successful**	1993	Jeff Shepard	International Association of Drilling Contractors, Society of Petroleum Engineers, (IADC/SPE) Paper 27534	Amsterdam, Holland
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Article	**Substitute Parts Can Be Fatal**	2005	Neal Adams, P.E.	**Pipeline**; Volume 107, December, 205	Worldwide
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Paper	**Stabbing Board/Derrick (Monkey) Board Incidents: Risk Identification & Hazard Mitigation**	2006	Neal Adams, P.E.	International Association of Drilling Contractors (IADC) Health, Safety & Environment Conference	Amsterdam, Holland
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Article	**Case Study: Critical Well Data go Unanalyzed, Leading to Fatal Shallow Gas Blowout**	2007	Neal Adams, P.E.	**Drilling Contractor**; Vol 63, No. 4, July/August 2007, Published by the International Association of Drilling Contractors (IADC)	Worldwide
Book	**Fundamentals of Petroleum; 5th Edition, Oilfield Metallurgy**	2010	John Hadjioannou, P.E., Adam Cook, E.I.T	The University of Texas, Petroleum Extension Srvice ("PETEX")	Worldwide
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Appendix M: Sources and Information

Documents / Transcripts / Exhibits - provided via FTP site

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I have attempted to include in the endnotes and appendices all documents and transcripts that I have considered.

In addition to the documents cited, deposition transcripts and exhibits were made available to me through the use of an FTP site. I have attached a list of these documents, since some may not be included or identified specifically in my report or its appendices.

I reviewed some video footage and still images provided from the following ROVs:

- C-Express – C-Innovations
- Boa Sub C – Millennium 36
- Boa Sub C – Millennium 37
- Skandi Neptune- Hercules 6
- Skandi Neptune – Hercules 14

I have also reviewed additional media, including possibly some media from the following sources:

- Figure 109: ROV-C Innovation video footage of the failed attempt to cut the autoshear hydraulic plunger at 23:30 on April 21, 2010 [141]
- Figure 110: ROV-C Innovation video footage of the failed attempt to raise pressure during hot stab of the blind shear ram at 01:15 on April 22, 2010 [141]
- Figure 111: ROV-C Innovation video footage of the successful attempt to sever the PBOF cables (highlighted with a yellow dashed circle) at 02:45 on April 22, 2010 [142]
- Figure 112: ROV Millennium 37 video footage of the successful attempt to cut the autoshear hydraulic plunger at 07:30 on April 20, 2010 [142]
- Figure 113: ROV Millennium 37 video footage of the LMRP/BOP stack connection shortly after cutting the autoshear hydraulic plunger at 07:30 on April 22, 2010 [143]
- Figure 114: ROV Millennium 37 video footage of the LMRP "LATCH/UNLATCH" indicator shortly after cutting the autoshear hydraulic plunger at 07:30 on April 22, 2010 [143]
- Figure 115: ROV Millennium 36 video footage of the failed attempt to raise pressure during hot stab of the blind shear ram at 08:00 on April 22, 2010 [144]

- Figure 116: ROV Millennium 36 video footage of the LMRP flex joint before and after the kinking of the riser at 10:22 on April 22, 2010 [144]
- Figure 117: ROV Millennium 37 video footage of a successful attempt to raise pressure during hot stab of the blind shear ram at 10:45 on April 26, 2010 [145]
- Figure 118: ROV Millennium 37 video footage of a successful attempt to raise pressure during hot stab of the blind shear ram at 21:45 on April 26, 2010 [145]
- Figure 119: ROV Millennium 37 video footage of a successful attempt to maintain pressure during hot stab of the blind shear ram at 03:15 on April 27, 2010 [146]
- Figure 120: ROV Millennium 36 video footage of a successful attempt to maintain pressure during hot stab of the blind shear ram at 21:30 on April 29, 2010 [146]
- Figure 121: ROV Millennium 37 video footage of an inspection of a fitting on the blind shear ram at 08:15 on April 22, 2010 [147]
- Figure 122 ROV Millennium 37 video footage of a repair to a fitting on the blind shear ram at 08:20 on April 22, 2010 [147]
- Figure 123 ROV Millennium 37 video footage of an inspection of the ST lock shuttle valve on the blind shear ram at 22:20 on April 25, 2010 [148]
- Figure 124 ROV Millennium 37 video footage of an inspection of a repair of the ST lock shuttle valve on the blind shear ram at 05:45 on April 26, 2010 [148]
- Figure 125 ROV Millennium 36 video footage of a leak in the fittings behind the right side ST lock on the blind shear rams [149]

I made two trips to the NASA Michoud facility and personally inspected the BOP and other components in connection with the Deepwater Horizon incident. I also inspected various components associated with the relief effort. During these visits I took photographs of the items I reviewed.

Also, since April 20, 2010 I have seen various new media reports, pictures, videos, and miscellaneous articles related to the incident. I did not consider these in my professional capacity.

Furthermore, all exhibits marked though the date of this report were made available to me. It is possible that I may have briefly reviewed some documents not listed in this appendix. I have tried to list those things that I have considered as noted in my report and its appendices.

EPI Materials

I may have also relied upon the EPI materials listed below:

Title	Author(s)	Publisher/Copyright
Applied Drilling Engineering	Bourgoyne-Millheim-Chevrolet Young	Society of Petroleum Engineers/First Printing 1986
Casing & Liners for Drilling & Completion	Ted G. Byrom	Gulf Publishing Company/Copyright 2007
Composition & Properties of Drilling & Completion Fluids	Darley-Gray	Originally Published by Gulf Publishing Company/Copyright 1988
Decision Analysis-Petro Exploration	Newendorp-Schuyler	Planning Press/Copyright 2000
Deepwater (Petro Explor.& Prod)	Leffler-Pattarozzi-Sterling	Penn Well Corporation/Copyright 2003
Deepwater Horizon Accident Investigation Report	British Petroleum	9/8/2010 (Exhibit 1)
Drilling	Nguyen, J.P.	Editions TECHNIP/Copyright 1996
Drilling & Casing Operations	Short, J.A.	PennWell Books/Copyright 1982
Drilling Engineering	J.J. Azar and G. Robello Samuel	Penn Well Corporation/Copyright 2007
Drilling Mud & Cement Slurry Rheology Manual	Gulf Publishing	Gulf Publishing Company/Copyright 1982
Environmentally Safe Drilling Practices	Navarro, Armanda	PennWell Books/Copyright 1995
Five Minute Rig Safety Meeting Topics for Drilling Contractors	IADC	IADC/Copyright 1982
Formulas & Calculations-Drilling	Lapeyrouse, Norton	Gulf Professional Publishing/Copyright 2002 (Exhibit 2098)

Title	Author(s)	Publisher/Copyright
Introduction to Well Control (Second Edition)	The University of Texas; Petroleum Extension Service (2nd Edition)	The University of Texas at Austin - Petroleum Extension Service/Copyright 1999
Offshore Well Construction (First Edition)	PETEX	The University of Texas, Continuing Education Petroleum Extension Service/Copyright 2005
Oilwell Drilling Tech	McCray & Cole	University of Oklahoma Press/Copyright 1979
Practical Underbalanced Drilling and Workover	The University of Texas; Petroleum Extension Service/Bill Rehm	The University of Texas, Continuing Education Petroleum Extension Service/Copyright 2002
Practical Well Control	The University of Texas; Petroleum Extension Service (4th Edition)/Ron Baker	The University of Texas, Continuing Education Petroleum Extension Service/Copyright 1998
Primer in Drilling & Production Equipment, A	Lynch, Philip	Gulf Publishing Company/Copyright 1980
Rules-of-Thumb for the Man on the Rig	Murchison, William	?
Underbalanced Drilling Manual	Gas Research Institute	Gas Research Institute/Copyright 1997
Well Completion and Servicing	D. Perrin	Editions TECHNIP/Copyright 1999
Well Control for Completion and Workover (Second Edition)	Well Control School	The University of Texas at Austin - Petroleum Extension Service/Copyright 1992
Wind Waves & Weather (Rotary Drilling Series)	The University of Texas; Petroleum Extension Service (Third Edition)	Petroleum Extension Service The University of Texas/Copyright 2004
Dictionary for the Oil and Gas Industry, A	The University of Texas; Petroleum Extension Service (First Edition)	Petroleum Extension Service The University of Texas/Copyright 2005
Scientific & Technical Terms	McGraw-Hill	McGraw-Hill Book Company/Copyright 2002

Title	Author(s)	Publisher/Copyright
Design of Machine Elements	Spotts, M.F.	Prentice Hall/Copyright 2003
Engineering Mechanics: Dynamics	Fanger, Carleton	Charles E. Merrill Publishing Company/Copyright 1970
Engineering Mechanics: Statics	Fanger, Carleton	Charles E. Merrill Publishing Company/Copyright 1970
Fundamentals of Fluid Mechanics (Fifth Edition)	Munson, Bruce R.	John Wiley & Sons/ Copyright 2005
Mechanical Engineering Design (Second Edition)	Shigley, Joseph	McGraw-Hill Book Company
Rules of Thumb for Mechanical Engineers	Pope, Edward (Editor)	Gulf Professional Publishing/Copyright 1996
Series in Mechanical Engineering	McGraw-Hill	McGraw-Hill/Copyright 1988
The Practice of Reservoir Engineering	Dake, L.P.	Elsevier/1994
Theory of Machines and Mechanisms	Shigley, Joseph/Uicker, John	McGraw-Hill Book Company/Copyright 2003
A Primer of Oilwell Drilling 7th Edition	The University of Texas; Petroleum Extension Service/Paul Bommer	The University of Texas, Continuing Education Petroleum Extension Service/Copyright 2008
A Primer of Oilwell Service, Workover, and Completion (First Edition)	The University of Texas; Petroleum Extension Service/Kate Van Dyke	Petroleum Extension Service The University of Texas/Copyright 1997
Casing and Cementing 2nd Edition	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1982
Casing and Cementing 3rd Edition	The University of Texas; Petroleum Extension Service	The University of Texas; Petroleum Extension Service/Copyright 2001
Drill String and Drill Collars	The University of Texas; Petroleum Extension Service	The University of Texas; Petroleum Extension Service/Copyright 1995

Title	Author(s)	Publisher/Copyright
Fundamentals of Petroleum 4th Edition	The University of Texas; Petroleum Extension Service/Kate Van Dyke	Petroleum Extension Service The University of Texas/Copyright 1997
Safety on The Rig	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1999
The Rotary Rig and Its Components (Fourth Edition)	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1995
Well Cementing	The University of Texas; Petroleum Extension Service	The University of Texas; Petroleum Extension Service/Copyright 1983
Buoyancy, Stability, and Trim (Unit V - Lesson 3)	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1976
Circulating Systems (Third Edition)	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1981
Drilling Mud (Third Edition)	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1984
Man Management and Rig Management (Unit IV)	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1987
Subsea Blowout Preventers & Marine Riser Systems	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1976
Testing and Completing (Second Edition)	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 1983
Oil & Gas Equipment & Controls	Genuine Kimray, Inc.	Genuine Kimray, Inc./Copyright 1948
Webster's Unabridged Dictionary (Second Edition)	Random House	Random House Reference/Copyright 2005
Oxford Advanced Learner's Dictionary (Seventh Edition)	Sally Wehmeier	Oxford University Press/Copyright 2005

Title	Author(s)	Publisher/Copyright
A Dictionary for the Oil and Gas Industry, 1st edition	The University of Texas; Petroleum Extension Service	Petroleum Extension Service The University of Texas/Copyright 2005
Guide to Blowout Prevention	Well Control School	WCS - Well Control School/Copyright 2004
Well Control for The Man on The Rig	Murchison, William J.	Murchison Drilling Schools/First Printing 1978, Reprinted 2007
Stress and accidents in the Offshore Oil and Gas Industry	Sutherland, Valerie	Gulf Publishing Company/Copyright 1991
The Properties of Gases and Liquids	Poling, Bruce - Prausnitz, John - O'Connell, John	McGraw-Hill/Copyright 2001
Composite Catalog of Oil Field Equipment & Services, 1986-87; Volume 1, A thru D; 37th Revision	World Oil	Gulf Publishing Company/Copyright 1986
Composite Catalog of Oil Field Equipment & Services, 1986-87; Volume 2, E thru H; 37th Revision	World Oil	Gulf Publishing Company/Copyright 1986
Composite Catalog of Oil Field Equipment & Services, 1986-87; Volume 3, I thru N; 37th Revision	World Oil	Gulf Publishing Company/Copyright 1986
Composite Catalog of Oil Field Equipment & Services, 1986-87; Volume 4, O thru Z; 37th Revision	World Oil	Gulf Publishing Company/Copyright 1986
Health, Safety and Environmental Reference Guide	International Association of Drilling Contractors	International Association of Drilling Contractors/Copyright 2004
Standard for Safety Steel Aboveground Tanks for Flammable and Combustible Liquids (Seventh Edition)	Underwriters Laboratories Inc.	Underwriters Laboratories Inc./Copyright 1981, Seventh Edition 1993
Maritime Accidents What went Wrong?	Edward T. Gates	Gulf Publishing Company/?
Product Safety Management and Engineering (Second Edition)	Willie Hammer	American Society of Safety Engineers/Copyright 1993

Title	Author(s)	Publisher/Copyright
Safety and Health for Engineers (Second Edition)	Roger L. Brauer	John Wiley & Sons, Inc. Publication/Copyright 2005

End Notes

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[1] DISCLAIMER: Many parties involved with the incident have conducted and published their own investigations. EPI may cite those investigations on background information or undisputed facts. This should not be taken to mean that EPI accepts the conclusions of any particular investigation.

[2] Tankersley, Jim (2010-06-19). "A closer look at deep-water drilling". Los Angeles Times. http://articles.latimes.com/2010/jun/10/nation/la-na-oil-spill-qa-20100610

[3] Deep Water: The Gulf Oil Disaster and the Future of Offshore Drilling, Report to the President, January 2011, Page 33

[4] *Ibid*

[5] Deepwater Kicks and BOP Performance, SINTEF Industrial Management, Report No. STF38 A01419, July 24, 2001

[6] *Ibid*

[7] Deepwater Kicks and BOP Performance, SINTEF Industrial Management, Report No. STF38 A01419, July 24, 2001

[8] Deepwater Kicks and BOP Performance, SINTEF Industrial Management, Report No. STF38 A01419, July 24, 2001

[9] Deposition Testimony of Billy Dean Ambrose, July 18-19, 2011, 495:15 – 495:25

[10] Deepwater Kicks and BOP Performance, SINTEF Industrial Management, Report No. STF38 A01419, July 24, 2001

[11] Macondo History of Lost Returns, Skripnikova, (Ex. 3497)

[12] *Ibid*

[13] Risk Register for the Macondo Project, June 20, 2009, BP-HZN-2179MDL00670193, (Exhibit 757)

[14] Deepwater Kicks and BOP Performance, SINTEF Industrial Management, Report No. STF38 A01419, July 24, 2001

[15] *Ibid*

[16] BP Wells Engineer OJT Module #7, BP-HZN-2179MDL01342044-01342052, (Exhibit 2096)

[17] Deposition Testimony of Patrick Joseph Campbell, July 12-13, 2011, 341:9 – 341:14

[18] BP Well Control Manual, Volume 2: *Fundamentals of Well Control*, BPA-D-002, December 2000, Issue 3, BP-HZN-2179MDL00336410-00336757, (Exhibit 2390); Deposition Testimony of Daun Winslow, April 20-21, 2011, 598:6 – 598:12; MACONDO, *The Gulf Oil Disaster, Chief Counsel's Report: National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling*, 2011, Page 20, (Exhibit 986)

[19] *Guide to Blowout Prevention,* WCS- Well Control School, April, 2004, 1-1 – 1-3

[20] *Macondo Well Incident*, Transocean Investigation Report, Volume II, Appendix G, June 2011, Pages 20-21

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[21] *Guide to Blowout Prevention,* WCS- Well Control School, April, 2004,2-1

[22] BP Well Control, GP 10-10, Section 6: *Well Control Practice*, 6.1.3, November 18, 2008, BP-HPZ-2179MDL00408005-00408026, (Exhibit 215); Maersk Well Control Manual, BP-HZN-2179MDL02250970

[23] Deposition testimony of Martin Breazeale, May 16-17, 2011, 138:19-24

[24] *Macondo Well Incident*, Transocean Investigation Report, Volume 1, June 2011, Pages 99

[25] Deposition Testimony of Billy Dean Ambrose taken on July 18-19, 2011, 355:17 – 356:1

[26] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, Pages 136

[27] *Ibid*

[28] *Ibid*

[29] Deposition Testimony of Patrick Joseph Campbell, July 12-13, 2011, 344:7 – 344:20; Deposition Testimony of Mark David Hay, June 29-30, 2011, 21:17 – 22:14

[30] BP Well Control Manual, Volume 1: *Procedures and Guidelines*, BPA-D-002, December 2000, Issue 3, BP-HZN-2179MDL00335948-00336409, (Exhibit 2389)

[31] BP Drilling and Well Operations Practice, E&P Defined Operating Practice, GP10-00, October 2008, Issue 1, Section 1: Introduction, 1.2 General page A-2, BP-HZN-2179MDL00057263 00057372, (Exhibit 93)

[32] Deposition Testimony of Michael Byrd, July 13-14, 2011, 367:18 – 367:23; Deposition Testimony of David McWhorter, July 7-8, 2011, 590:20 – 591:11; Deposition Testimony of Melvin Whitby, July 18-19, 2011, 243:25 – 244:8

[33] Deposition Testimony of Tony Hayward taken, June 6, 2011, June 8, 2011, 573:1 – 573:10

[34] Deposition Testimony of Michael Byrd taken on July 13-14, 2011, 367:18 – 367:23; Deposition Testimony of David McWhorter, , July 7-8, 2011, 590:20 – 591:11; Deposition Testimony of Melvin Whitby, July 18-19, 2011, 243:25 – 244:8; Deepwater Horizon Weekly Ope3rations/Engineering Meeting, May 29, 2001, TRN-INV-0184295, (Exhibit 4620)

[35] Minutes of meeting dated August 2, 1999, CAM-CIV-0018779; Drilling Contract, RBS-8D Semisubmersible Drilling Unit, between Vastar Resources, Incorporated and R&B Falcon Drilling Company, Contract No. 980249, December 9, 1998, BP-HZN-MBI00021461-00021464, BP-HZN-MBI00021479-00021480, BP-HZN-MBI00021507 -00021509, BP-HZN-MBI00021537-00021547, Exhibit 4112); Vastar Resources Incorporated, Deepwater Horizon Technical Paper, Revision 5, Issue EDS/DMS Disconnect Philosophy, September 13, 1999, TRN-HCJ-00026742 -0026748, (Exhibit 4114); Vastar General Purpose Worksheet, BP-HZN-2179MDL00088346, (Exhibit 4115); Vastar Resources Incorporated, Technical Position Papers – Deepwater Horizon, TRN-HCJ-00026738J-00026738, (Exhibit 4116)

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[36] Deposition Testimony of Michael Byrd taken, July 13-14, 2011, 595:4 – 595:18

[37] Deposition Testimony of William LeNormand, June 20-21, 2011, 246:23 – 249:4

[38] Drilling Contract, RBS-8D Semisubmersible Drilling Unit, between Vastar Resources, Incorporated and R&B Falcon Drilling Company, Contract No. 980249, December 9, 1998, BP-HZN-MBI00021461 - BP-HZN-MBI00021464, BP-HZN-MBI00021479-00021480, BP-HZN-MBI00021507 0021509, BP-HZN-MBI00021537-00021547, (Exhibit 4112)

[39] Technical Position Paper, EDS/DMS Disconnect Philosophy, BP-HZNBLY00058860

[40] Amendment #38 to Contract No. 980249, September 28, 2009, BP-HZN-CEC041476 – BP-HZN-CEC041596, (Exhibit 1488)

[41] Code of Federal Regulations Title 30 Part 250 Oil and Gas and Sulphur Operations in the Outer Continental Shelf, Subpart D, Section 250.400, et seq ; American Petroleum Institution Recommended Practice 53: Recommended Practices for Blowout Prevention Equipment Systems for Drilling Wells

[42] Deposition Testimony of Tony Hayward taken on June 6, 2011, June 8, 2011, 235:1 – 235:19, 277:7 – 277:10, 301:7 – 301:10

[43] Risk Assessment of the Deepwater Horizon Blowout Preventer (BOP) Control System, Final Report, April 2000, CAM-CIV-0019032 – CAM-CIV-0019076, Exhibit 4120

[44] Deposition of Jack Carter Erwin taken on June 6-7, 2011, 62:2 – 62:7, 73:19 – 73:22, 134:23 – 135:5, 494:12 – 494:20

[45] Code of Federal Regulations Title 30 Part 250 Oil and Gas and Sulphur Operations in the Outer Continental Shelf, Subpart D, Section 250.446, What are the BOP maintenance and inspection requirements? [68 FR 8423, Feb. 20, 2003, as amended at 75 FR 63374, Oct. 14, 2010]

[46] Deposition Testimony of Michael Byrd taken on July 13-14, 2011, 33:21 – 45:8

[47] Deposition Testimony of Michael Byrd taken on July 13-14, 2011, 381:17 – 383:17

[48] Risk Register for the Macondo Project, June 20, 2009, Exhibit 757

[49] Winters et al. United States Patent, Patent No. US 7,706,980 B2, April 27, 2010, Exhibit 227

[50] Deposition Testimony of Warren Winters taken on February 14-15, 2010, 136:18 – 137:5, 314:8, 312:24

[51] Letter from Transocean to BP America Production Company, Subject: Letter Agreement from Conversion of VBR to a Test Ram, CONTRACTOR-5121-2002-011, October 11, 2004, TRN-HCEC-00064131 - TRN-HCEC-00064132, Exhibit 6120

[52] Email string, David Sims, Ian Little, et al, Subject: Re: Update on TO performance, July 17, 2007, BP-HZN-MBI00037507 – BP-HZN-MBI00037508, Exhibit 274

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[53] Email string, Chris Young, Curtis Jackson, et al, Subject: Deepwater Horizon – Test Ram, September 15, 2004, BP-HZN-BLY00056043 – BP-HZN-BLY00056046, Exhibit 7045

[54] Letter from Transocean to BP America Production Company, Subject: Letter Agreement from Conversion of VBR to a Test Ram, CONTRACTOR-5121-2002-011, October 11, 2004, TRN-HCEC-00064131 - TRN-HCEC-00064132, Exhibit 6120

[55] Stones WR 508 #1, Technical File Note, Issue: Test Ram Conversion, August 4, 2004, BP-HZN-2179MDL00169270, Exhibit 6094; BP Drilling and Well Operations Practice, E&P Defined Operating Practice, GP10-00, October 2008, Issue 1, , BP-HZN-2179MDL00057263 - BP-HZN-2179MDL00057372, (Exhibit 93)

[56] *Ibid*

[57] Email String, Brad Johnson, Ken Taylor, et. al., Re: Picks of 18-10 Stripper, December 6-19, 2006, CAM_CIV_)149241-244, (Exhibit 381)

[58] Transocean Change Proposal, Change Title: 18-3/4" Annular stripper packer, March 9, 2006, TRN-MDL00118981 - TRN-MDL00118987, Exhibit 1870

[59] Email String, Brad Johnson, Ken Taylor, et. al., Re: Picks of 18-10 Stripper, December 6-19, 2006, CAM_CIV_)149241-244, (Exhibit 381)

[60] Email, George Coltrin, David Sims, et al, Subject: Updated: Risk Assessment – use of Annular in place of VBR in subsea stack – DW Horizon, Attachment: Proposal BP DW RAss Cortez Bank 71-p-2007.pdf, October 16, 2007, BP-HZN-MBI00038925 – BP-HZN-MBI00038931, Exhibit 1158

[61] BP Drilling and Well Operations Practice, E&P Defined Operating Practice, GP10-00, October 2008, Issue 1, Section 15 Well Control; 15.3: Conventional Well Control Equipment, BP-HZN-2179MDL00057261 - BP-HZN-2179MDL00057372, Exhibit 93

[62] BP Drilling and Well Operations Practice, E&P Defined Operating Practice, GP10-00, October 2008, Issue 1, Section 2 General, BP-HZN-2179MDL00057261- BP-HZN-2179MDL00057372, Exhibit 93

[63] BP Drilling and Well Operations Practice, E&P Defined Operating Practice, GP10-00, October 2008, Issue 1, Section 15 Well Control; 15.2: Well Control Practices, BP-HZN-2179MDL00057261 - BP-HZN-2179MDL00057372, Exhibit 93

[64] BP Drilling and Well Operations Practice, E&P Defined Operating Practice, GP10-00, October 2008, Issue 1, Section 15 Well Control, BP-HZN-2179MDL00057261 - BP-HZN-2179MDL00057372, Exhibit 93; BP Well Control, GP 10-10, November 18, 2008, BP-HZN-2179MDL00408010, Exhibit 215

[65] BP Well Control, GP 10-10, November 18, 2008, BP-HZN-2179MDL00408011, Exhibit 215

[66] Deposition of Jack Carter Erwin taken on June 6-7, 2011, 508:2 – 508:5

[67] Horizon's Total BOP Functions Cycles On MC252 #1, BP-HZN-2179MDL00104402 – BP-HZN-2179MDL00104404, Exhibit 6170

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[68] Code of Federal Regulations Title 30 Part 250 Oil and Gas and Sulphur Operations in the Outer Continental Shelf, Subpart A, Section 250.451 (b)&(d), What must I do in certain situations involving BOP equipment or systems? [68 FR 8423, Feb. 20, 2003, as amended at 75 FR 63374, Oct. 14, 2010]

[69] Deposition Testimony of Fereidoun Abbassian taken May 3-4, 2011, 146:6 – 146:20

[70] Deposition Testimony of Fereidoun Abbassian taken May 3-4, 2011, 146:6 – 146:20

[71] Deposition Testimony of Michael Williams taken on July 20, 2011, 62:18 – 63:13

[72] Deposition Testimony of Chris Pleasant taken on March 14-15, 2011, 406:17 – 407:1

[73] BP Well Control Manual, Volume 2: Fundamentals of Well Control, BPA-D-002, December 2000, Issue 3 BP-HZN-2179MDL00336656, Exhibit 2390; Macondo History of Kicks, October 26, 2009 – April 20, 2010, Exhibit 3498

[74] Deposition Testimony of John Keeton taken on August 18, 2011, 62:20 – 63:7

[75] Deposition of Jack Carter Erwin taken on June 6-7, 2011, 159:4 – 161:1

[76] BP Drilling and Well Operations Practice, E&P Defined Operating Practice, GP10-00, October 2008, Issue 1, Section 15 Well Control, BP-HZN-2179MDL00057261 - BP-HZN-2179MDL00057372, Exhibit 93; BP Deepwater Horizon Accident Investigation Report, September 8, 2010, Page 184, Exhibit 1; BP Well Control, GP 10-10, November 18, 2008, BP-HPZ-2179MDL00408010, Exhibit 215

[77] R&B Falcon, Deepwater Horizon, TL BOP Stack, Operation and Maintenance Manual, TRN-HCEC-00007822, (Exhibit 3343)

[78] R&B Falcon, Deepwater Horizon, TL BOP Stack, Operation and Maintenance Manual, TRN-HCEC-00007822, (Exhibit 3343

[79] R&B Falcon, Deepwater Horizon, TL BOP Stack, Operation and Maintenance Manual, TRN-HCEC-00007822, (Exhibit 3343

[80] Letter from Transocean to BP America Production Company, Subject: Letter Agreement from Conversion of VBR to a Test Ram, CONTRACTOR-5121-2002-011, October 11, 2004, TRN-HCEC-00064131 - TRN-HCEC-00064132, Exhibit 6120

[81] Letter from Transocean to BP America Production Company, Subject: Letter Agreement from Conversion of VBR to a Test Ram, CONTRACTOR-5121-2002-011, October 11, 2004, TRN-HCEC-00064131 - TRN-HCEC-00064132, Exhibit 6120

[82] Email, Brian Morel, Murry Sepulvado, et al, Subject: Rev 1 Procedure, Attachment: Macondo Drilling Production Interval BP01.ZIP, April 12, 2010, BP-HZN2179MDL00272297 – BP-HZN-2179MDL00272317, Exhibit 1968

[83] Application for Permit to Drill New Well, Request date May 13, 2009/Approval date May 22, 2009 BP-HZN-2179MDL00237054 – BP-HZN-2179MDL00237083, Exhibit 6171

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[84] Application for Permit to Drill New Well, Request date May 13, 2009/Approval date May 22, 2009 BP-HZN-2179MDL00000884 – BP-HZN-2179MDL00000911, Exhibit 1896; Application for Revised New Well, Request date January 25, 2010/Approval date January 29, 2010 BP-HZN-2179MDL0005471 – BP-HZN-2179MDL0005480

[85] Deepwater Horizon Daily Drilling Reports, February 2010 – April 2010

[86] Macondo History of Kicks, October 26, 2009- April 20, 2010, (Exhibit 3498)

[87] Transocean Well Control Handbook, HQS-OS-HB-01, Section 3.3 Damage to BOP Sealing Elements, 3.3.1 Annular Preventer, March 31, 2009, TRN-HCEC-00005533, Exhibit 596

[88] Deposition Testimony of Michael Williams taken on July 20, 2010, 60:22 – 63:8

[89] Deposition Testimony of David McWhorter taken on July 7-8, 2011, 350:1 – 350:23

[90] Deposition Testimony of David McWhorter taken on July 7-8, 2011, 202:7 – 202:10

[91] Macondo Well Incident, Transocean Investigation Report, Volume I, June 2011

[92] Deposition Testimony of Martin Breazeale taken on May 16-17, 2011, 74:3 – 74:13

[93] Deposition Testimony of William Stringfellow taken on April 11-12, 2001, 700:6 – 701:4

[94] West Engineering Services, Shear Ram Capabilities Study for U.S. Minerals Management Service, September 2004, Exhibit 1300

[95] Deposition Testimony of Melvin Whitby taken on July 18-19, 2011, 212:2 – 212:23

[96] Cameron Engineering Bulletin 891D, September 8, 2004, CAM-CIV-0003276

[97] Deposition Testimony of Fereidoun Abbassian taken May 3-4, 2011, 53:24 – 55:23

[98] West Engineering Services, Incorporated, Evaluation of Secondary Intervention Methods in Well Control for U.S. Minerals Management Service, Solicitation 1435-01-01-RP-31174, March 2003, TRN-MDL-00494919 – TRN-MDL-00495005, Exhibit 1166

[99] Email, Michael Byrd, Curtis Jackson, et al, Subject: PREP Exercise, November 14, 2001, BP-HZN-2179MDL03106206 - BP-HZN-2179MDL03106207, Exhibit 4423

[100] Email, Carter Erwin, Jason Van Lue, et al, Subject: Re: Status? May 3, 2010, CAM-CIV-0080104, Exhibit 7023;Deposition Testimony of Michael Byrd taken on July 13-14, 2011, 465:16 – 466:2

[101] Deposition Testimony of William Stringfellow taken on April 11-12, 2001, 695:3 – 695:8

[102] Email, Michael Byrd, Curtis Jackson, et al, Subject: PREP Exercise, November 14, 2001, BP-HZN-2179MDL03106206 - BP-HZN-2179MDL03106207, Exhibit 4423;

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[103] Deposition Testimony of David McWhorter taken on July 7-8, 2011, 109:9 – 109:13

[104] Deposition Testimony of Melvin Whitby taken on July 18-19, 2011, 51:10 – 52:24

[105] Deposition Testimony of Tony Hayward taken on June 6, 2011, June 8, 2011, 324:24 – 325:18

[106] BP-HZN-2179MDL00237079

[107] BP-HZN-2179MDL00005473

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[111] Code of Federal Regulations Title 30 Part 250 Oil and Gas and Sulphur Operations in the Outer Continental Shelf, Subpart D, Section 250.401 *What must I do to keep wells under control?* [68 FR 8423, Feb. 20, 2003

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[122] Application for Permit to Drill New Well*,* May 13, 2009, BP-HZN-2179MDL00237054 –237083, (Exhibit 6171)

[123] Code of Federal Regulations Title 30 Part 250 *Oil and Gas and Sulphur Operations in the Outer Continental Shelf*, Subpart D, Section 250.401 *What must I do to keep wells under control?* [68 FR 8423, Feb. 20, 2003

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[125] BP Initial Exploration Plan, Mississippi Canyon Block 252, OSC-G 32306, February 2009, BP-HZN-2179MDL00001095-1218, (Exhibit 768).

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[130] Laperyrouse, Norton J., *Formulas and Calculations for Drilling, Production and Work-Over,* BP-HZN2179MDL01338583 - 01338755, (Exhibit 2098); Deposition testimony of Martin Breazeale, May 16, 2011, 88:11 – 90:8

[131] Laperyrouse, Norton J., *Formulas and Calculations for Drilling, Production and Work-Over,* BP-HZN2179MDL01338583 - 01338755, (Exhibit 2098); Deposition Testimony of Patrick Joseph Campbell, July 12, 2011, 17:22 – 21:16; BP Gulf of Mexico MMS APD Worksheet, MC 252 #1 – Macondo Prospect, 11.875 Liner, Page 1, BP-HZN-BLY00063678, (Exhibit 7004)

[132] BP Gulf of Mexico MMS APD Worksheet, MC 252 #1 – Macondo Prospect, 11.875 Liner, Page 1, BP-HZN-BLY00063678, (Exhibit 7004)

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[150] Deposition Testimony of Billy Dean Ambrose , July 18, 2011, 545:17 – 546:3

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[154] Deposition Testimony of John Guide, May 9-10, 2011, 259:21 – 265:5; *MACONDO*, *The Gulf Oil Disaster,* Chief Counsel's Report: National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011, Page 94, (Exhibit 986)

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[167] Deposition Testimony of Billy Dean Ambrose, July 18, 2011, 598:7 – 599:1

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[210] Horizon's Total BOP Functions Cycles On MC252 #1, BP-HZN-2179MDL00104402-00104404, (Exhibit 118)

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[212] WWCI Job Call-In Report, Wild Well Control, March 9, 2010, WW-MDL-00000028-00000030, (Exhibit 3911); BP *Deepwater Horizon Accident Investigation Report,* September 8, 2010, Page 17, (Exhibit 1)

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[253] BP Deepwater Horizon Accident Investigation Report, September 8, 2010, Section 3.4 Resumed Routine Activity Prior to Recognition of the Well Control Event, p. 97-98, (Exhibit 1)

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[257] *Ibid, 97-98*

[258] *Ibid*

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[260] *Ibid, 101*

[261] *Ibid, 84*

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[263] *Ibid, 28, 100-101; Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 30

[264] BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, Section 3.4 Resumed Routine Activity Prior to Recognition of the Well Control Event, p. 101, (Exhibit 1)

[265] *Ibid, p. 91*

[266] *Ibid*, 105

[267] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 31

[268] *Ibid*

[269] BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 104, (Exhibit 1)

[270] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 30, 117; BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 11, (Exhibit 1)

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[271] Deposition Testimony of Martin Breazeale, May 16-17, 2011, 131:18 – 132:11; Deposition Testimony of Mark David Hay, June 29-30, 2011, 64:12 – 64:18; Excerpt from BP Well Control Manual, BPA-D-002, Volume 3 HPHT Guidelines, 3.3 *Shut-in Whilst Drilling*, page 4-3, December 2000, Issue 3, BLY-HZN-BLY00033831, (Exhibit 7005); *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 31; BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 11, (Exhibit 1)

[272] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 31

[273] *Ibid*

[274] *Ibid*

[275] *Ibid*

[276] *Ibid*

[277] DET Norkse Vertias, Final Report for the United States Department of Interior, Forensic Examination of Deepwater Horizon Blowout Preventer, Volumes I-II, March 20, 2011

[278] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 31

[279] *Ibid*

[280] BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 103, (Exhibit 1)

[281] Macondo Well Incident, Transocean Investigation Report, Volume I, June 2011, p. 31

[282] BP Deepwater Horizon Accident Investigation Report, September 8, 2010, p. 44, (Exhibit 1)

[283] *Ibid*

[284] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 31

[285] *Ibid*

[286] *Ibid*

[287] Deposition Testimony of Chris Pleasant, March 14-15, 2011, 645:20 – 647:13

[288] BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 29, (Exhibit 1)

[289] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 31

[290] Deposition Testimony of Billy Dean Ambrose, July 18-19, 2011, 788:6 – 788:16; BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 26, (Exhibit 1)

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[291] BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 26, (Exhibit 1)

[292] *Ibid, 25*

[293] *Ibid, 26, 92*

[294] *Ibid, 104*

[295] Deposition Testimony of Chris Pleasant, March 14-15, 2011, 324:11 – 325:12; *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, Page 31; BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p.44, (Exhibit 1)

[296] BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 161-162, (Exhibit 1)

[297] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 31; BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, p. 44, (Exhibit 1)

[298] *Ibid*

[299] Deposition Testimony of Henry Thierens, June 6-10, 2011, 683:6 – 683:13

[300] *Macondo Well Incident*, Transocean Investigation Report, Volume I, June 2011, p. 31

[301] *Ibid*

[302] Deposition Testimony of Chris Pleasant, March 14-15, 2011, 55:6 – 55:10; Deposition Testimony of Mark David Hay, June 29-30, 2011, 43:16 – 44:15

[303] Deposition Testimony of Chris Pleasant, March 14-15, 2011,, 57:25 – 59:2

[304] Deposition Testimony of William LeNormand, June 20-21, 2011, 271:14 – 272:8

[305] Deposition Testimony of Fereidoun Abbassian, May 3-4, 2011, 484:3 – 484:25

[306] Deposition Testimony of William Stringfellow, April 11-12, 2001, 86:22 – 87:17

[307] Transocean Event Log, April 20, 2010, TRN-MDL-00038789 – TRN-MDL-00038836, (Exhibit 1159)

[308] *MACONDO, The Gulf Oil Disaster*, Chief Counsel's Report: National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011, p. 21, (Exhibit 986)

[309] Deposition Testimony of William Stringfellow, April 11-12, 2001, 89:1 – 89:18

[310] BP *Deepwater Horizon Accident Investigation Report*, September 8, 2010, Appendix AA,(Exhibit1)

[311] Deposition Testimony of Fereidoun Abbassian, May 3-4, 2011, 697:1 – 697:11

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[312] *Ibid*

[313] *MACONDO, The Gulf Oil Disaster*, Chief Counsel's Report: National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011, p. 42, (Exhibit 986)

[314] Det Norkse Vertias, Final Report for United States Department of the Interior, Forensic Examination of Deepwater Horizon Blowout Preventer, Volume I-II, Section 6.2.3.2, March 20, 2011; Email String, Transocean employees, December 29, 2010, TRN-INV-01831528, "*It looked to me as if the body was washed out probably due to the shear rams closing on the flowing well."*

[315] *Ibid;* Deposition Testimony of Patrick Joseph Campbell,July 12-13, 2011, 157:17 – 160:1

[316] Det Norkse Vertias, Final Report for United States Department of the Interior, Forensic Examination of Deepwater Horizon Blowout Preventer, Volume I, Section 6.1.4.2, March 20, 2011