Evaluation of Casing Design Basis for

Macondo Prospect

Mississippi Canyon Block 252

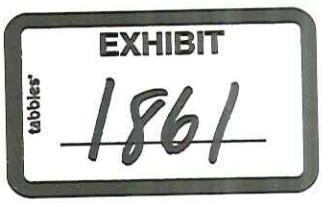
OCS-G-32306 Well No.1

Revision 2

14 May 2009

Steve Morey
EPT Drilling

EPT



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Casing Summary

Macondo Prospect: Based on the detailed analysis the following tubulars are recommended:

Jet:	36" 552.69 ppf, 1.500" wall, Grade X80, NOV/GP XLW
Conductor:	28" 218.27 ppf, 0.750" wall, Grade X56, NOV/GP XLW
Surface:	22" 224.49 ppf, 1.000" wall, Grade X80, NOV/GP XLF
Surface Liner:	18" 116.09 ppf, 0.625" wall, Grade P110, TenarisHydril 511
Intermediate:	16" 96.00 ppf, 0.575" wall, Grade P110, TenarisHydril 511
Intermediate Liner:	13-5/8" 88.20 ppf, 0.625" wall, Grade Q125, VAM SLIJ-II
SET Drilling Liner:	12.140" 46.55 ppf, 0.370" wall, Grade EX80, XPC
Production Casing:	9-7/8" 62.8 ppf, 0.625" wall, Grade Q125, VAM SLIJ-II

Casing weights and grades were selected by; 1) the minimum required to meet the design requirements, and/or 2) standardized combinations for ease of procurement and minimization of BP OCTG stock, and/or 3) the standard tubulars for DW GOM wells. To use up BP stock other connections from the BP Approved Connection List for the are acceptable. The SF_A could change with a change in connection, but nothing significant is anticipated. Based on the above tubular recommendations, a dispensation from the BP Drilling and Well Operations Policy is required for the 22" Surface casing, 16" Intermediate casing, 12.140" Drilling liner, and 9-7/8" Production casing.

Revision 1 changes the 16" from 109.00 ppf and a full string to 96.00 ppf and a liner with the TOL in the 22" 1.500" wall X80 surface casing. Also the 11-7/8" drilling liner is changed to a 13.625" SET.

Revision 2 changes the setting depth of the 22", 18", 16", 13-5/8" and 11-7/8". PTD is changed to 20200 ft and the PP and FG were revised slightly.

This is a sub-sea well designed for production. Evaluation for the mitigation for APB (Annular Pressure Build-up), for the drilling case, is recommended.

Introduction

The design basis for this well was evaluated using the BP Casing Design Manual (CDM) recommended loads (see Tables B.1 – B.4), the requirements of the BP Drilling and Well Operations Policy (DWOP), and the Advanced Guidelines for Deepwater Well Design. The evaluation was done using the Landmark StressCheck Version 2003.16 Build 1061 software.

Burst: Current suggested BP drilling design load recommendations for internal yield, or burst, are based on a gas gradient to the surface equivalent to the formation fracture pressure at the casing shoe, ***Frac @ Shoe w/Gas Gradient Above*** (FAS), internal with pore pressure in the open hole and mud and/or cement mix fluid density inside pipe external, for drilling loads. The secondary ***Gas Kick Profile*** (GKP) is based on a 100 bbl influx and a kick intensity (KI) of 2.0 ppg. The use of the Limited Kick (LK) load

case, with a statistically calculated kick intensity (KI) per CDM BPA-D-003 6.5.2, has been discontinued. For development wells, where no hydrocarbons are expected before the next casing string is set, a load case based on a water gradient to surface equivalent to the formation fracture pressure at the casing shoe, ***Lost Returns with Water*** (LRW), internal with pore pressure and mud and/or cement mix fluid density external, for drilling loads, may be used. A fourth drilling load case that may be considered is based on historical data that implies that kicks generally have an influx of no more than 20 bbl and that the surface pressure is infrequently greater than 1/3 the BHP, ***Frac @ Shoe w/1/3 BHP at Surface*** (1/3 BHP). For production loads, the burst recommendation is based on a ***Tubing Leak*** at the surface plus the hydrostatic head of the packer fluid (TL) internal with pore pressure and mud and/or cement mix fluid density external. For injection applications (water injection, formation fracturing, etc.) the load cases are ***Stimulation Surface Leak*** (SSL) and ***Injection Down Casing*** (IDC) The SSL models maximum injection pressure at the surface plus the hydrostatic head of the packer fluid internal, with pore pressure and mud and/or cement mix fluid density external. The IDC models maximum injection pressure at the surface plus the hydrostatic head of the injection fluid internal, with pore pressure and mud and/or cement mix fluid density external.

Collapse: The collapse recommendation for drilling loads is based on ***Lost Returns with Mud Drop*** (LRMD) until the hydrostatic head equalizes with the loss formation pore pressure. The default is maximum exposed drilling mud density internal below the fluid level and the mud density pipe was set in external. More extreme could be the ***Partial/Full Evacuation*** (P/F Evac) load case depending on the fluid level and internal fluid density selected. For production loads the mud density the casing was set in is external with full evacuation internal below the packer and packer fluid density above the packer internal, ***Above/Below Packer*** (A/B Pkr).

Abbreviations

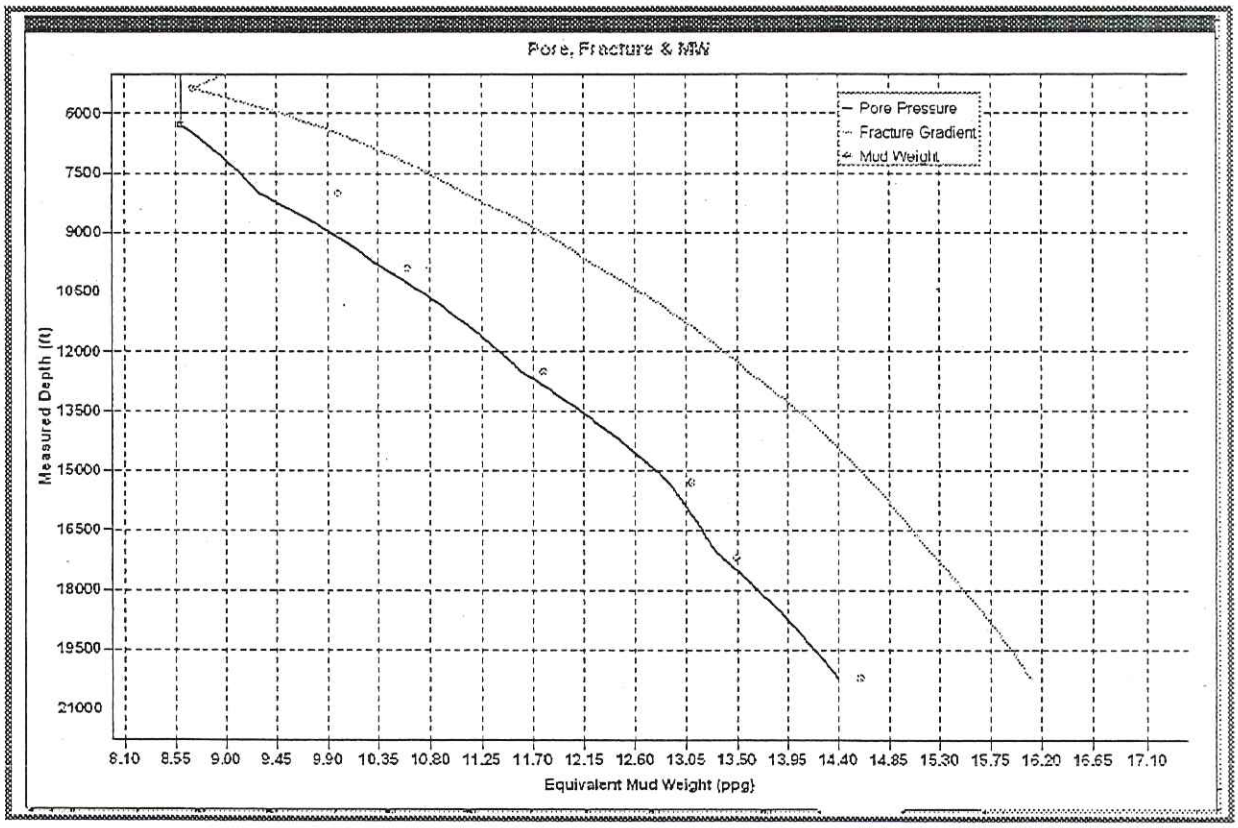
1/3 BHP: Burst load case for fracture at shoe w/1/3 BHP at Surface
A/B Pkr: Collapse load case for Above/Below Packer
APB: Annular Pressure Build-up due to thermal effects and trapped annuli
bbl: Barrel/barrels of fluid
BML: Below mud line
BU: Back-up, external fluid
CDM: BP Casing Design Manual, BPA-D-003
CMTG: Collapse load case for cementing operations
DWOP: BP Drilling and Well Operations Policy, BPA-D-001
IDC: Burst load case for Injection Down Casing
FAS: Burst load case for Frac @ Shoe w/Gas Gradient Above
KI: Kick intensity
GKP: Burst load case for Gas Kick Profile
LRMD: Collapse load case for Lost Returns with Mud Drop
LRW: Burst load case for Lost Returns with Water
m: meters
MD: Measured depth
MIY: Minimum Internal Yield
PP: Pore pressure

P/F Evac: Collapse load case for Partial/Full Evacuation
ppf: Pounds per foot, mass of steel tubes
ppg: pounds per gallon, density of fluid
PT: Pressure test
PTD: Proposed total depth
SF_X: Safety factors; $_B$-burst, $_C$-collapse, $_A$-axial $_{VME}$-triaxial
sg: Specific gravity
SSC: Sulfide Stress Cracking
SSL: Burst load case for Stimulation Surface Leak
TL: Burst load case for Tubing leak
TOC: Top of cement
TOL: Top of liner
TVD: True vertical depth

Macondo Prospect Description

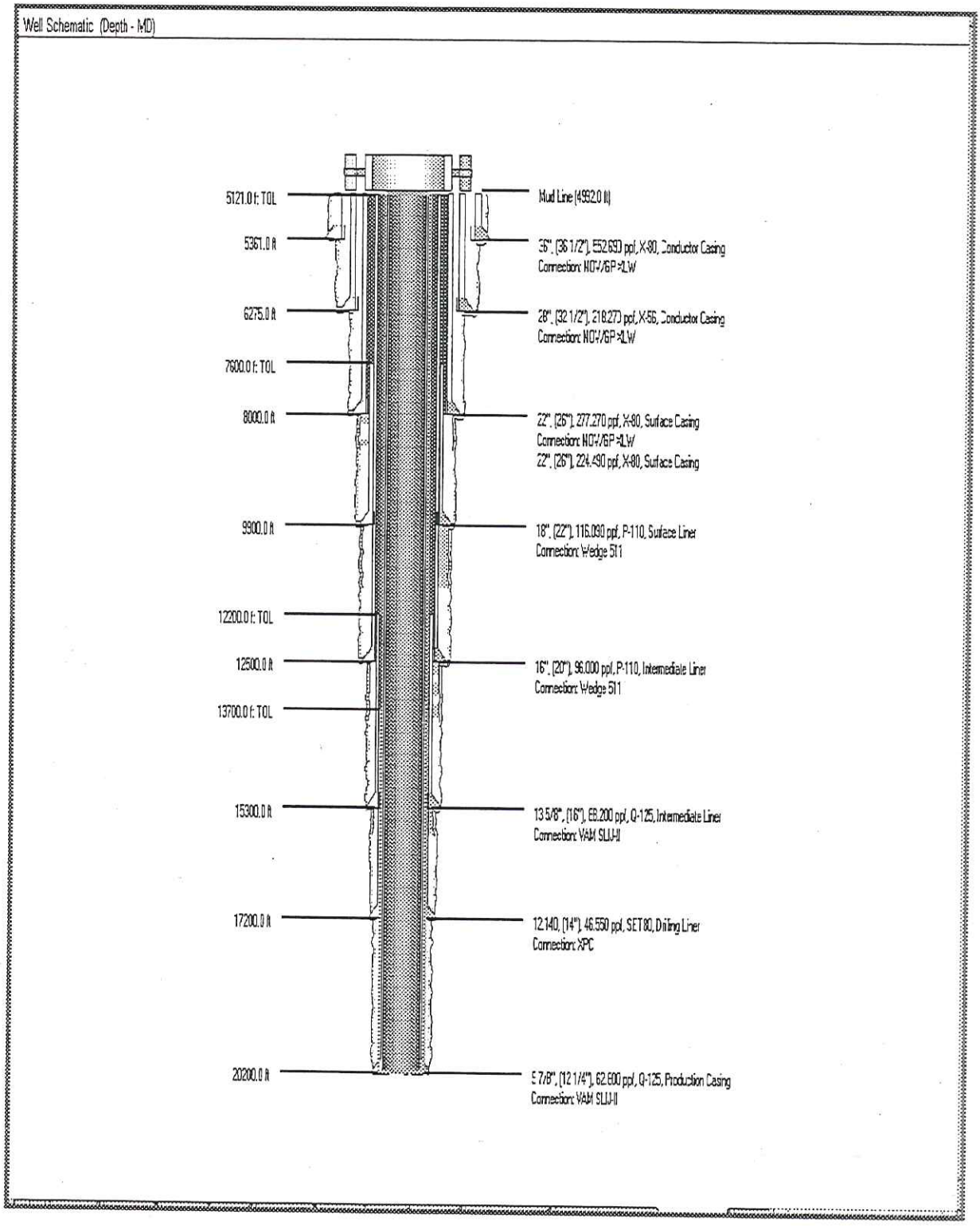
This evaluation is for a medium pressured, average temperature, 20600 ft TVD/MD development well with an anticipated maximum PP of 13.8 ppg (14780 psi) at PTD. The bottom hole temperature is estimated at 267°F. The well will be drilled as a subsea well in 4992 ft of water. Pore pressures, fracture gradients, temperatures, casing sizes, and setting depths were supplied by the Macondo Prospect drilling team based on geophysical, geological, and offset information, see attachments 1, 2, and 3.

Figure 1: Macondo Prospect MC252 Proposed Formation Pressure Profiles R2



The casing pressure test (PT) loads were selected to provide results at or near the worst case burst load and have not been checked for compliance with any government requirements. The final design factors do not include any allowance for casing wear.

Figure 2: Macondo Prospect MC252Proposed Casing R2



Macondo Prospect Design Detail

Jet: 36" 552.69 ppf, 1.500" wall, Grade X80, NOV/GP XLW set 5081-5361 ft.
Meets the BP DWOP requirements. No dispensation required.

Conductor: 28" 218.27 ppf, 0.750" wall, Grade X56, NOV/GP XLW set 5081-6275 ft.
Meets the BP DWOP requirements. No dispensation required.

Surface: 22" 277.27 ppf, 1.250" wall Grade X80 DQ S90 set 4992-5175; 22" 224.49 ppf, 1.000" wall, Grade X80, NOV/GP XLF set 5081-8000 ft.
Does not meet the BP DWOP requirements.

a) FAS: SF_B 0.83, SF_{VME} 0.99 w/7.6 ppg BU

Changing the load to a GKP load case, based on a 100 bbl influx with a KI of 2.0 ppg, results in acceptable design factors.

b) GKP: SF_B 2.26, SF_{VME} 2.55 w/7.6 ppg BU

Note: The above factors are based on top of the 16" liner being hung in the supplemental adapter in the 1.250" wall section. If the 1.000" wall pipe is exposed the factors will be lower, but still acceptable.

A dispensation is required to use the BP GKP load case for the burst load case.

Surface Liner: 18" 116.09 ppf, 0.625" wall, Grade P110, TenarisHydril 511 set 7600-9900 ft
Meets the BP DWOP requirements. No dispensation required.

a) FAS: SF_B 2.22, SF_{VME} 2.78 w/7.6 ppg BU

Intermediate Casing: 16" 96.00 ppf, 0.575" wall, Grade P110, TenarisHydril 511 set 5121-12500 ft
Does not meet the BP DWOP burst design requirements.

a) FAS: SF_B 0.72, SF_{VME} 0.91 w/7.6 ppg BU

Changing the load to a GKP load case, based on a 100 bbl influx with a KI of 2.0 ppg, results in acceptable design factors.

b) GKP: SF_B 1.02, SF_{VME} 1.21 w/7.6 ppg BU

This result is close enough with the very conservative 7.6 ppg external fluid density, an increase of less than 1.0 ppg increases the SF_B and SF_{VME} factors to greater than the recommended minimum of 1.10 and 1.25 respectively.

A dispensation is required to use the BP GKP load case for the burst load case.

Intermediate Liner: 13-5/8" 88.20 ppf, 0.625" wall, Grade Q125, VAM SLIJ-II set 12200-15300 ft

Meets the BP DWOP requirements. No dispensation required.

a) FAS: SF_B 1.31, SF_{VME} 1.55 w/7.6 ppg BU

Drilling Liner: 12.140" 46.55 ppf, 0.370" wall, Grade EX80, XPC set 13700-17000 ft

Does not meet the BP DWOP burst design requirements.

a) FAS: SF_B 0.56, SF_{VME} 0.70 w/7.6 ppg BU

The minimum SF's in a) occur in the liner overlap section. SC does not understand liner geometry and uses the 7.6 ppg back-up fluid density from the TOC to the surface. This is not a reasonable assumption because even as the worst case, the 7.6 ppg density fluid would only extend to the TOL, not back to the surface. For liner applications we can assume that the minimum PP in the open hole section from the previous shoe is the fluid density in the liner overlap section (Mud weight above TOC). For this liner the minimum PP in the open hole section up to the 13-5/8" casing shoe is 12.2 ppg. This results in acceptable design factors.

b) FAS: SF_B 0.98, SF_{VME} 1.22 w/12.2 ppg BU above TOC and PP below TOC

The SET liner is basically a metal wall cake and is not intended for well control design applications, these results are pretty good.

A dispensation is required to use minimum open hole PP as the external fluid density for the FAS burst load case.

Attachment 4 is the Enventure SET data sheet from the same type of SET run in the Isabela well

Production Casing: 9-7/8" 62.80 ppf, 0.625" wall, Grade Q125 set 5081-20200 ft

Meets the BP DWOP production burst design requirements.

a) TL: SF_B 1.17, SF_{VME} 1.28 w/7.6 ppg BU

Does not meet the BP DWOP production collapse design requirements.

b) A/B Pkr: SF_C 0.71, w/a 0 ppg fluid density below the packer

To improve these results we can increase the collapse resistance of the pipe or decrease the collapse load requirements. The A/B Pkr load case default is a design with PP external and zero (0) pressure internal, this would simulate a well that would not flow and was jetted of all fluid to below the perforations. This would certainly be a worst case scenario; however I have seen it happen so know it can occur. If we assume that we will not jet the well dry, the minimum internal load is from a column of dry gas at the abandonment pressure, and the external load is original PP the collapse load is acceptable. I assumed an abandonment pressure of 5150 psi at the perforations or about 3130 psi (assuming 0.1 psi/ft) at the wellhead, which is equivalent to about 4.9 ppg fluid density.

c) A/B Pkr: SF_C 1.00, w/a 4.9 ppg fluid density below the packer

This Production casing design does not have tapered string for any potential large SSSV in the tubing string.

A dispensation is required to use the alternate fluid density below the packer for the production collapse load case.

Well Summary

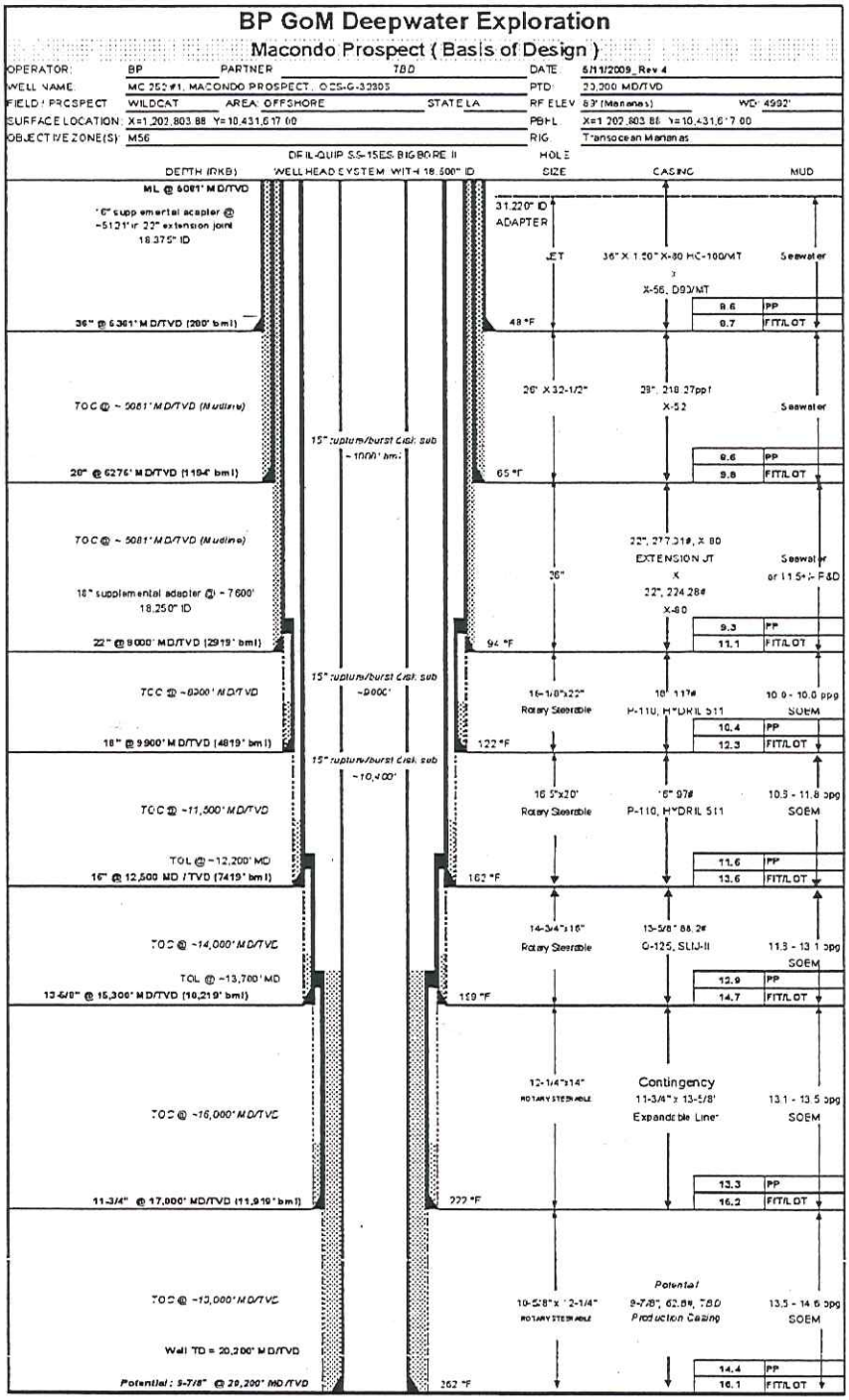
The well summary table below, from StressCheck, is from the file that has the acceptable design/load case options discussed above for each casing string.

StressCheck Well Summary for the Macondo Prospect MC252 R2

String	OD Weight Grade	Connection	MD Interval (ft)	Drift Dia. (in)	Minimum Safety Factors Burst	Collapse	Axial	Triaxial
Conductor Casing	36", 552.690 ppf, X-80	NOV/GP XLW	5081.0-5361.0	32.813	11.04 C	1.32	5.68 C	2.77
Conductor Casing	28", 218.270 ppf, X-56	NOV/GP XLW	5081.0-6275.0	26.313	2.63	1.60	3.73	2.93
Surface Casing	22", 277.270 ppf, X-80	NOV/GP XLW	5081.0-5175.0	19.313	2.26	8.07	4.69	2.55
	22", 224.490 ppf, X-80	N/A	5175.0-8000.0	19.813	1.72	3.08	4.36	2.00
Surface Liner	16", 116.090 ppf, P-110	Wedge 511	7600.0-9900.0	16.563	2.22	3.25	3.95 C	2.78
Intermediate Liner	16", 96.000 ppf, P-110	Wedge 511	5121.0-12500.0	14.75	* 1.03	2.90	1.75 C	* 1.23
Intermediate Liner	13 5/8", 88.200 ppf, Q-125	VAM SLIJ-II	12200.0-15300.(	12.250 A	1.31	3.83	3.06 C	1.55
Drilling Liner	12.140, 46.550 ppf, SET 80	XPC	15700.0-17260.(	11.244	* 0.98 C	1.61	1.99 C	* 1.22
Production Casing	9 7/8", 62.800 ppf, Q-125	VAM SLIJ-II	5081.0-20200.0	8.500 A	1.18	1.00	2.00 C	1.28

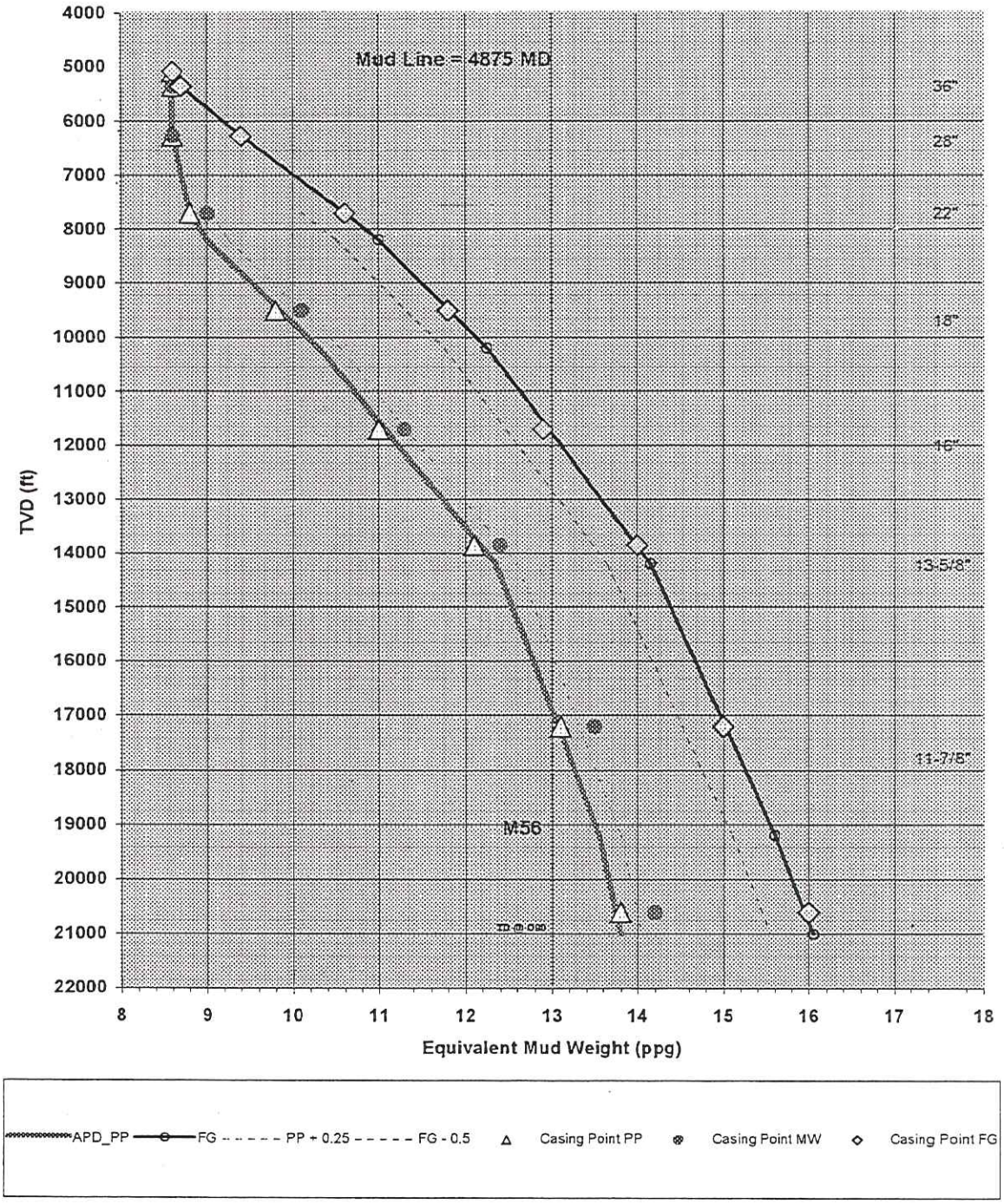
* S.F. Below D.F.
C Conn Critical
A Alternate Drift

Attachment 1: Schematic and Well Data R2



Attachment 2: PP/MW/FG Pressure Prediction

MC 252 - Macondo Prospect , PP/MW/FG Pressure Prediction



Attachment 3: Well Data

Data for MMS PP/MW/FG chart - MC 252 Macondo - rev B: 2/4/09

Feb 4, 2009 updated WD to 4992' from shallow hazard work

New casing depths: PP/MW/FG curves updated

added 192' for WD increase over original Draft Casing plan

Depth	PP	FG	PP + 0.25	FG - 0.5
5081	8.6	8.6		
5361	8.6	8.7		
6267	8.6	9.4		
7692	8.8	10.6	9.05	10.1
8192	9	11	9.25	10.5
10192	10.3	12.25	10.55	11.75
14192	12.35	14.15	12.6	13.65
19192	13.55	15.6	13.8	15.1
21000	13.8	16.05	14.05	15.55

Casing Point Data

Size	MD	PP	MW	FG	Top of Casing	Footage Req'd	Csg Wt./ft	Air String Wt. Klbs
ML	5081	8.6	8.6	8.6	-	-	-	-
36	5361	8.6	8.6	8.7	4865	496		
28	6275	8.6	8.6	9.4	4870	1405	218	306
22	7700	8.8	9.0	10.6	4865	2835	224	635
18	9500	9.8	10.1	11.8	7100	2400	117	281
16	11700	11.0	11.3	12.9	4905	6795	97	659
13.625	13850	12.1	12.4	14.0	11200	2650	88.2	234
11.875	17200	13.1	13.5	15.0	13150	4050	71.8	291
9.875	20600	13.8	14.2	16.0	4865	15735	62.3	980

Attachment 4: Isablla SET Data

ENVENTURE

Solid Expandable Tubular (SET™)

[illegible]

Customer:	BP
Well Name:	[illegible]
GMT Number:	[illegible]

External Base Casing		SET Liner / Launcher Properties	
Nominal Outside Diameter	[illegible]	SET Liner Grade	[illegible]
Nominal Inside Diameter	[illegible]	SET Liner Nominal Yield Strength	[illegible]
Nominal Drift Diameter	[illegible]	SET Liner Minimum Ultimate Strength	[illegible]
Nominal Weight	[illegible]	Expansion Cone Outside Diameter	[illegible]
Maximum Inside Diameter	[illegible]	Expansion Ratio	[illegible]
Casing Grade	[illegible]	Launcher Outside Diameter	[illegible]
Connection Type	[illegible]	Launcher Nominal Yield Strength	[illegible]
Connection ID (Pin Bore)	[illegible]	Launcher Nominal Internal Yield Pressure	[illegible]
Customer Equipment ID Restriction (Other ID)	N/A	Launcher Collapse Pressure	[illegible]
		Launcher - Base Casing Nominal ID Clearance	[illegible]
Running Conditions		Launcher - Base Casing Nominal ID Flow Area	[illegible]
SET String Length	[illegible]	Launcher OD - Open Hole ID Clearance	[illegible]
Dogleg Severity	[illegible]	Launcher OD - Open Hole ID Flow Area	[illegible]
Dogleg Severity Stress	[illegible]	Launcher OD - Base Casing Connection ID Clearance	[illegible]
Mud Weight	[illegible]	Launcher OD - Base Casing Connection ID Flow Area	[illegible]
Bottomhole Temperature	[illegible]	Launcher OD - Base Casing Other ID Clearance	N/A
Maximum Combined Tension		Launcher OD - Base Casing Other ID Flow Area	N/A
Maximum Combined Compression			
Nominal Open Hole ID	[illegible]	**Pre-Expansion Connection Limitations**	
		Down Hole Torque	[illegible]
		Dogleg Severity	[illegible]
SET System Components		Tension	[illegible]
Expansion Cone Diameter	[illegible]	Compression	[illegible]
Launcher Diameter	[illegible]		
Anchor Hanger - Set in Base Casing Elastomer Thickness	[illegible]	**Expansion Assembly Limitations**	
Anchor Hanger - Set in Open Hole Elastomer Thickness	N/A	Down Hole Torque	N/A
Connection Sleeves in Base Casing	[illegible]	Tension	N/A
Connection Sleeves in Open Hole	[illegible]	Compression	N/A

ENVENTURE

Solid Expandable Tubular (SET™)
11.750" OD 47.0 lb/ft x 11.620" OD 60.2 lb/ft

Customer: BP
Well Name: MC252 #3 Sidetrack
GMT Number: 54637

Pre-Expanded Specification		Post Expanded Specification	
Expansion Forces / Pressures			
Initiation Pressure		Initiation Force	
Pipe Body Expansion Pressure	~ 2500 psi	Pipe Body Expansion Force	500 k
Anchor Hanger – Set in Base Casing Expansion Pressure		Anchor Hanger – Set in Base Casing Expansion Force	
Anchor Hanger – Set in Open Hole Expansion Pressure		Anchor Hanger – Set in Open Hole Expansion Force	
Connection Sleeve Expansion Pressure in Base Casing		Connection Sleeve Expansion Force in Base Casing	
Connection Sleeve Expansion Pressure in Open Hole		Connection Sleeve Expansion Force in Open Hole	
Connection Sleeves (CS) in the Base Casing			
Sleeve Thickness	0.065 in.	Post Expansion Sleeve Thickness	0.075 in.
Pre-Expansion Outside Diameter	12.154 in.	Post Expansion Outside Diameter	12.356 in.
CS OD - Base Casing Drift ID Clearance	0.053 in.	Nominal Casing ID To CS OD Clearance	0.077 in.
CS OD - Base Casing Nominal ID Clearance	0.203 in.	Pin Box ID To CS OD Clearance	0.000 in.
CS OD - Base Casing Connection ID Clearance	0.134 in.	Other ID To CS OD Clearance	N/A
CS OD - Base Casing Other ID Clearance	N/A		
*+ 0.000" = Dimensional Clearance			
*-0.000" = Dimensional Interference			
Connection Sleeves in the Open Hole			
Sleeve Thickness	0.065 in.	Post Expansion Sleeve Thickness	0.075 in.
Pre-Expansion Outside Diameter	12.154 in.	Post Expansion Outside Diameter	12.356 in.
CS OD - Base Casing Drift ID Clearance	0.053 in.	Open Hole Nominal ID To CS OD Clearance	1.662 in.
CS OD - Base Casing Nominal ID Clearance	0.203 in.		
CS OD - Base Casing Connection ID Clearance	0.134 in.		
CS OD - Base Casing Other ID Clearance	N/A		
CS OD - Open Hole Nominal ID Clearance	1.459 in.		
*+ 0.000" = Dimensional Clearance			
*-0.000" = Dimensional Interference			
Anchor Hanger - Set in Base Casing			
Elastomer Thickness	0.250 in.	Post Expansion Outside Diameter	12.520 in.
Outside Diameter with Elastomer	12.156 in.		
Anchor Hanger OD - Base Casing Drift ID Clearance	0.053 in.	Elastomer Compression at Nominal Internal Diameter	45.37 %
Anchor Hanger OD - Base Casing Nominal ID Clearance	0.153 in.	Elastomer Compression at Maximum Internal Diameter	37.03 %
Anchor Hanger OD - Base Casing Connection ID Clearance	0.100 in.		
Anchor Hanger OD - Base Casing Other ID Clearance	N/A	Elastomer Compression at Base Casing Connection ID	34.28 %
Anchor Hanger - Set in Open Hole			
Elastomer Thickness	N/A	Post Expansion Outside Diameter	N/A
Outside Diameter with Elastomer	N/A		
Nominal Open Hole Diameter	N/A	Elastomer Compression at Nominal Open Hole Diameter	N/A
Maximum Open Hole Diameter	N/A	Elastomer Compression at Maximum Open Hole Diameter	N/A
Anchor Hanger OD - Base Casing Drift ID Clearance	N/A		
Anchor Hanger OD - Base Casing Nominal ID Clearance	N/A		
Anchor Hanger OD - Base Casing Connection ID Clearance	N/A		
Anchor Hanger OD - Base Casing Other ID Clearance	N/A		
Anchor Hanger OD - Open Hole Nominal Diameter Clearance	N/A		