ENGINEERING CALCULATIONS

Jack 3 Prospect
OCS-G 17015 # 002
Walker Ridge 758
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1) The casing design was evaluated with the "Stess Check" design software program.

2) The attached sheets define:
- MASP, MAWP, Casing Test & BOP Test Calculations
- Example calculations
- Devon Deepwater Load Cases for Casing Design
- Walker Ridge Block 758 – Casing Design Summary

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Walker Ridge 758
MASP, MAWP, Casing Test, & BOP Test Calculations

Water Depth 6964 ft — **Print Date:** 10-Jan-08
Mudline Temp 38 — 9:42
RT-ELEV. 86 ft — Inputs

INPUT INFORMATION								
Section	1	2	3	4	1	1	1	1
Casing Size	22	22	22	22	16	13 5/8	11 7/8	10 1/8
Weight ppf	328	224.28	224.28	170.2	97	88.2	58.8	79.22
Grade	X80	X-80	X-80	X-60	HP-Q125	HCQ-125	HCQ-125	HCQ-125
Type	Conductor	Conductor	Conductor	Conductor	Drlg Liner 1	Drlg Liner 2	Drlg Liner 3	Prod Liner 1
Connection	H90D QT/MT	S90 QT/MT	S90 QT/MT	S60 QT/MT	SLSF	SLSF	Hydril 511	SLSF
Burst Rating	9,545	6,360	3,000	3,580	8,660	10,030	8,050	18,160
Collapse Rating	9,457	3,870	3,000	1,820	2,990	5,930	3,760	17,650
Pipe Body Tension	7,728,000	5,278,000	5,278,000	3,004,000	3,761,000	3,190,300	2,105,000	2,912,500
Joint Strength	3,740,000	2,120,000	2,120,000	1,410,000	2,360,000	2,393,000	1,169,500	2,039,000
Set Depth (TVD)	7,579	9,456	7,684	10,009	20,114	23,745	26,144	29,014
Set Depth (MD)	7,579	9,456	7,684	10,009	20,338	24,224	26,792	29,863
Top of Casing String (TVD)	7,050	7,579	7,679	9,456	7,579	19,920	23,494	23,394
Top of Casing String (MD)	7,050	7,579	7,679	9,456	7,579	20,135	23,956	23,848
Length of Casing	529	1,877	5	553	12,759	4,089	2,836	6,015
MW Casing Set In (utilized for CTP Calculation)	9.90	9.90	9.90	9.90	11.70	11.80	13.40	14.20
Depth of Deepest Exposed Shoe (TVD)	10,009	10,009	10,009	10,009	20,114	23,745	26,144	29,014
Depth of Deepest Exposed Shoe (MD)	10,009	10,009	10,009	10,009	20,338	24,224	26,792	29,863
Predicted FG of Deepest Exposed Shoe	12.20	12.20	12.20	12.20	12.50	14.10	14.90	15.30
Estimated Pore Pressure at Previous Deepest Exposed Shoe	8.60	8.60	8.60	8.60	9.30	9.50	11.30	13.20
Deepest Open Hole Depth (TVD)	20,114	20,114	20,114	20,114	23,745	26,144	29,014	29,014
Deepest Open Hole Depth (MD)	20,338	20,338	20,338	20,338	24,224	26,792	29,863	29,863
Pore Press (EMW) @ DOHD	10.60	10.60	10.60	10.60	11.30	13.10	14.00	14.00
MW Nxt Hole @ DOHD	11.70	11.70	11.70	11.70	11.80	13.40	14.20	14.20
Planned FIT/LOT	12.20	12.20	12.20	12.20	12.40	13.90	14.80	15.10
Fracture Gradient Anticipated Surface & Wellhead Pressures ($MASP_{FG}$ & $MAWP_{FG}$)								
Fracture Pressure of Deepest Exposed Shoe	6,350	6,350	6,350	6,350	13,074	17,410	20,256	23,084
Gas Gradient for Frac Grad A.S.P. (0-10Kft = 0.1, >10Kft = 0.15)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Fracture Pressure with gas to surface **$MASP_{FG}$**	**4,848**	**4,848**	**4,848**	**4,848**	**10,057**	**13,848**	**16,335**	**18,731**
Fracture Pressure with gas to mudline **$MAWP_{FG}$**	**5,906**	**5,906**	**5,906**	**5,906**	**11,115**	**14,906**	**17,392**	**19,789**
BHP Anticipated Surface & Wellhead Pressures ($MASP_{BHP}$ & $MAWP_{BHP}$)								
Deepest Open Hole Depth (TVD)	20,114	20,114	20,114	20,114	23,745	26,144	29,014	29,014
% Gas Replacement based on Deepest Open Hole Depth (TVD)	50%	50%	50%	50%	50%	50%	50%	50%
Gas / Mud Interface (TVD)	10,057	10,057	10,057	10,057	11,873	13,072	14,507	14,507
Mud Column (TVD)	10,057	10,057	10,057	10,057	11,873	13,072	14,507	14,507
Gas Gradient for BHP A.S.P. (0-10Kft = 0.1, >10Kft = 0.15)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Pore Pressure (psi) @ Deepest Open Hole Depth (TVD)	11,087	11,087	11,087	11,087	13,953	17,809	21,122	21,122
$MASP_{BHP}$ with % Gas Replacement	**3,460**	**3,460**	**3,460**	**3,460**	**4,887**	**6,740**	**8,234**	**8,234**
$MAWP_{BHP}$ with % Gas Replacement	**4,517**	**4,517**	**4,517**	**4,517**	**5,944**	**7,797**	**9,292**	**9,292**
Pressure @ Gas / Mud Interface	4,968	4,968	4,968	4,968	6,668	8,701	10,410	10,410
Casing Test and FIT/LOT Pressures								
MMS MASP (Lesser of $MASP_{FG}$ or $MASP_{BHP}$)	***3,460***	***3,460***	***3,460***	***3,460***	***4,887***	***6,740***	***8,234***	***8,234***
MMS MAWP (Lesser of $MAWP_{FG}$ or $MAWP_{BHP}$)	***4,517***	***4,517***	***4,517***	***4,517***	***5,944***	***7,797***	***9,292***	***9,292***
70% of Internal Yield **(MMS CFR 250.423 requirement)**	6,682	4,452	2,100	2,506	6,062	7,021	5,635	12,712
Test Mud Weight	9.90	9.90	9.90	9.90	11.70	11.80	13.40	14.20
CTP_{70} = (70% of MIYP - (Pi (Test Mud Weight) - Po (external backup assumed as pore pressure at previous shoe))	6,169	3,813	1,581	1,829	3,552	4,181	2,780	11,203
$CTP_{70\ 1st\ liner}$ = 70% of MIYP of Casing Liner Hung-In - (Pi (Test Mud Weight) - Po (external backup assumed as pore pressure at previous shoe)) at Liner Top TVD	N/A	N/A	N/A	N/A	N/A	3,472	1,815	986
$CTP_{70\ 2nd\ liner}$ = 70% of MIYP of Long Casing String First Liner Hung-In - (Pi (Test Mud Weight) - Po (external backup assumed as pore pressure at previous shoe)) at First Liner Top TVD	N/A	N/A	N/A	N/A	N/A	N/A	2,256	1,304
$CTP_{70\ long\ string}$ = 70% of MIYP of Long Casing String First Liner Hung-In - (Pi (Test Mud Weight) - Po (external backup assumed as pore pressure at previous shoe)) at First Liner Top TVD	N/A	N/A	N/A	N/A	5,460	5,420	4,790	4,474
FIT/LOT Pressure	**1,197**	**1,197**	**1,197**	**1,197**	**732**	**2,593**	**1,903**	**1,000**
FIT/LOT Pressure Eqv w/ First Drlg Liner Hung in Full String	1,442							
FIT/LOT Pressure Eqv w/ Second Drlg Liner Hung in First Drlg Liner	1,481				2,697			
FIT/LOT Pressure Eqv w/ Third Drlg Liner Hung in Second Drlg Liner	3,283	N/A			3,664	3,858		
FIT/LOT Pressure Eqv w/ Prod Liner Hung in Second Drlg Liner	2,695				3,590	3,920		
Packoff or Liner Hanger Pressure Capabilities	N/A				6,500	6,000	6,000	6,000
Differential on Packer - Initial Pressure Test					4,000	4,000	2,000	1,000
Differential on Packer - 1st Subsequent Liner Pressure Test		N/A			4,039	3,657	1,977	
Differential on Packer - 2nd Subsequent Liner Pressure Test					2,670	3,486		
Differential on Packer - 3rd Subsequent Liner Pressure Test					1,985			
CTP Casing Test Pressure		**1,581**			**3,664**	**3,920**	**1,903**	**1,000**
CTP Casing Test Pressure Rounded		***1,600***			***4,000***	***4,000***	***2,000***	***1,000***
BOP Test Pressures								
Test Pressure ***(MMS MASP + 500 psi)***	**3,960**	**3,960**	**3,960**	**3,960**	**5,387**	**7,240**	**8,734**	**8,734**
Mud Weight used for BOP Test	8.55	8.55	8.55	8.55	11.70	11.80	13.40	14.20
Mud Weight vs SeaWater Hydrostatic Difference	-	-	-	-	1,141	1,177	1,756	2,046
Surface Test Pressure not to exceed 70% of Annular Rating at Seafloor Conditions	7,000	7,000	7,000	7,000	5,859	5,823	5,244	4,954
Surface Test Pressure not to exceed 100% of Ram Rating at Seafloor Conditions	15,000	15,000	15,000	15,000	13,859	13,823	13,244	12,954
Ram BOP and ancilliary equipment Test Pressure	***4,000***	***4,000***	***4,000***	***4,000***	***5,400***	***7,300***	***8,800***	***8,800***
Annular BOP Test Pressure	***4,000***	***4,000***	***4,000***	***4,000***	***5,400***	***5,900***	***5,300***	***5,000***
APD RAM BOP AND ANCILLIARY EQUIP TEST PRESSURE		***4,000***			***5,400***	***7,300***	***8,800***	***8,800***
APD ANNULAR BOP TEST PRESSURE		***4,000***			***5,400***	***5,900***	***5,300***	***5,000***

APD RAM STUMP TEST PRESSURE = MMS MASP + 500 psi + MW vs SW Hydrostatic Difference	**10,780**	***11,000***	**APD ANNULAR STUMP TEST PRESSURE = 70% of Rated Working Pressure**		***7,000***

Example Calculations

Gas Gradient		Gas Replacement	
< 10,000'	0.10 psi/ft	< 12,000'	70% Gas / 30% Mud
≥ 10,000'	0.15 psi/ft	12,000' to 15,000'	60% Gas / 40% Mud
		≥ 15,000'	50% Gas / 50% Mud

22" Casing String MASP

$MASP_{FG}$ = (0.052 x FG at shoe x Casing Seat TVD) - (Gas Grad x Casing Seat TVD)

= (0.052 x 12.20 x 10,009) - (0.15 x 10,009)

= 4,848 psi

$MASP_{BHP}$ = Hole Depth TVD x ((0.052 x Pore Press) - (Gas Grad x Gas %) - (0.052 x Mud Weight x (1 - Gas %)))

= 20,114 x ((0.052 x 10.6) - (0.15 x 0.50) - (0.052 x - 0.5)))

= 3,460 psi

MMS MASP = lesser of **$MASP_{FG}$** or **$MASP_{BHP}$** = **= 3,460 psi**

22" Casing String CTP

CTP_{70} = (70% of MIYP - ((Pi - Po) x Casing Seat TVD x .052))

Pi = Test MW (MW casing set in)
Po = Pore Pressure from Previous Casing Seat

= (0.7 x 3,000) - ((9.9 - 8.6) x 7,684 x 0.052))

= 1,581 psi

CTP = lesser of **$MASP_{FG}$**, **$MASP_{BHP}$** or **CTP_{70}** = 1,581 psi => **= 1,600 psi**

11 7/8" Liner MASP

$MASP_{FG}$ = (0.052 x FG at shoe x Casing Seat TVD) - (Gas Grad x Casing Seat TVD)

= (0.052 x 14.90 x 26,144) - (0.15 x 26,144)

= 16,335 psi

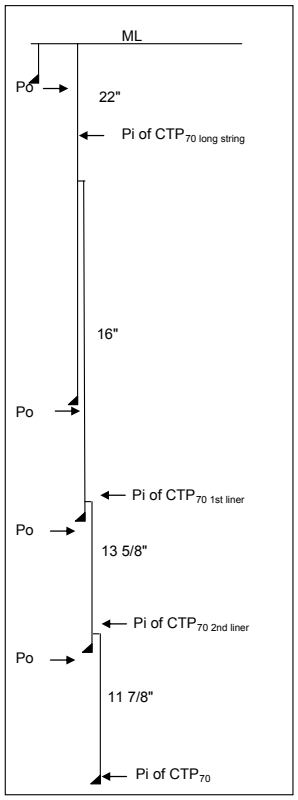
$MASP_{BHP}$ = Hole Depth TVD x ((0.052 x Pore Press) - (Gas Grad x Gas %) - (0.052 x Mud Weight x (1 - Gas %)))

= 29,014 x ((0.052 x 14.0) - (0.15 x 0.50) - (0.052 x - 0.5)))

= 8,234 psi

MMS MASP = lesser of **$MASP_{FG}$** or **$MASP_{BHP}$** = **= 8,234 psi**

11 7/8" Liner CTP



CTP_{70} = (70% of MIYP - ((Pi - Po) x Casing Seat TVD x .052))

Pi = Test MW (MW casing set in)
Po = Pore Pressure from Previous Casing Seat

= (0.7 x 8,050) - ((13.4 - 11.3) x 26,144 x 0.052))

= 2,780 psi

$CTP_{70\ 1st\ liner}$ = (70% of $MIYP_{1st\ liner}$ - ((Pi - Po) x TOL Depth TVD x .052))

Pi = Test MW (MW casing set in)
Po = Pore Pressure from Previous Casing Seat

= (0.7 x 8,660) - ((13.4 - 09.3) x 19,920 x 0.052))

= 1,815 psi

$CTP_{70\ 2nd\ liner}$ = (70% of $MIYP_{2nd\ liner}$ - ((Pi - Po) x TOL Depth TVD x .052))

Pi = Test MW (MW casing set in)
Po = Pore Pressure from Previous Casing Seat

= (0.7 x 10,030) - ((13.4 - 09.5) x 23,494 x 0.052))

= 2,256 psi

$CTP_{70\ long\ string}$ = (70% of $MIYP_{long\ string}$ - ((Pi - Po) x TOL Depth TVD x .052))

Pi = Test MW (MW casing set in)
Po = Pore Pressure from Previous Casing Seat

= (0.7 x 9,545) - ((13.4 - 08.6) x 7,579 x 0.052))

= 4,790 psi

$P_{FIT/LOT}$ = (FIT - Test MW) x Casing Seat TVD x .052

= (14.8 - 13.4) x 26,144 x 0.052

= 1,903 psi

CTP = **$P_{FIT/LOT}$** not to exceed **CTP_{70}**, **$CTP_{70\ 1st\ liner}$**, **$CTP_{70\ 2nd\ liner}$** or **$CTP_{70\ long\ string}$** = 1,815 psi **= 2,000 psi**

Devon Deepwater Load Cases for Casing Design

String	Burst	Collapse	Tension
	Criteria	Criteria	Criteria
Conductor, Surface, Intermediate & Drilling Liners	◦Gas Kick: 0.5 ppg and 50 bbls for development or 70 bbls for exploration. ◦Lost Returns with Water: Frac at shoe with water column to surface. ◦Frac at shoe with 1/3 BHP above. ◦Pressure Test. ◦Cement Pressure Test. ◦Maximum Anticipated Surface Pressure	◦Cementing: cement slurry in place. ◦Full Sea water Replacement ◦Lost Returns w/Mud Drop: partial evacuation to balance lowest pore pressure.	◦Running in Hole: include shock loads at 3-4 ft/sec. ◦Overpull while Running: suggest 100 kips. ◦Green Cement Pressure Test: large piston loads. ◦Service Loads: loads due to combined effects in burst and collapse.
Production	◦Tubing leak near surface applied to packer fluid. ◦Presssure test: based on anticipated SITP plus safety margin.	◦Cementing: cement slurry in place. ◦Partial Evacuation: balance with depleted reservoir, i.e. abandonment pressure. ◦Full evacuation for dry gas wells.	◦Running in Hole: include shock loads at 2-3 ft/sec ◦Overpull while Running: suggest 100 kips. ◦Green Cement Pressure Test: large piston loads. ◦Service Loads: loads due to combined effects in burst and collapse.
External pressure profile (All Strings)	◦C,S, & I: mud weight to TOC, cement mix water gradient TOC to previous shoe, pore pressure in open hole. ◦Prod: mud fluid density (note1) to TOC, cement mix-water gradient to outer shoe and pore pressure to TD.	◦Mud weight the string was set in.	N/A

Notes; 1) Consider mud deterioration if fluid has poor lon term solids suspension properties.
2) Not every load was utilized on every string.

Casing Design Summary

String	OD/Weight/Grade/Connection	MD Interval (Ft)	Minimum Safety Factor (Abs)			
			Burst	Collapse	Axial	Triaxial
Conductor	22" 382.3 ppf, X-80, H90D QT/MT	7,050 - 7,579	1.61	3.29	2.8	1.84
	22" 224.28 ppf, X-80, S90D QT/MT	7,579 - 9,456	1.37*	3.03	2.27	2.82
	22", 170.20 ppf, X-60, S60D QT/MT	9,456 - 10,009	1.66	1.3	(1.29)	1.71
Drilling Liner	16", 97 ppf, Q-125 HP SLSF	7,579 - 20,335	1.34	1.01	1.76	1.51
Drilling Liner	13 5/8", 88.20 ppf, HC Q-125, SLSF	20,135 - 24,224	1.21	1.25	(3.59)	1.51
Drilling Liner	11 7/8", 58.80 ppf, HC Q-125, Hydril 511	23,999 - 26,774	1.34	1.62	1.87	1.83
Prod Liner	10 1/8", 79.22 ppf, HC Q-125, SLSF	23,798 - 29,868	1.43	1.06	(1.54)	1.3

Note: ( ) in axial column denotes compression.
Note: Equal or better casing may be substituted pending availability/inventory.
Note: *Due to 3000 psi Burst Disk subs for APB mitigation installed in this section below 16" Supplemental Adapter.