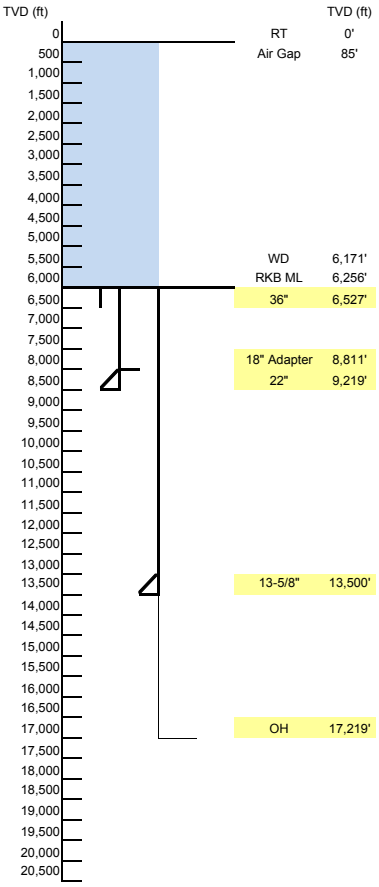
13-5/8"



Design Details

Casing Size in	Casing Weight lb/ft	Casing Grade	Thread Type	Burst Rating psi	Collapse Rating psi	Tension Ratings Body kips	Tension Ratings Conn kips
13-5/8	88.2	HCQ-125	SLIJ-II	10,030	6,370	3,191	2,393
OH	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Casing Size in	Depth Top MD ft	Depth Top TVD ft	Depth Shoe or TD MD ft	Depth Shoe or TD TVD ft	Pore lb/gal	MW lb/gal	BF	Fracture Gradient lb/gal
13-5/8	6,244'	6,244'	13,500'	13,498'	10.0	10.7	0.84	13.2
OH	13,500'	13,498'	17,219'	16,400'	11.2	11.2	0.83	14.2

Casing Size in	MW in Csg Post Cmt lb/gal	Gradient Split Gas %	Gradient Split Mud %	Pore Pressure psi	Fracture Pressure psi	Gas Gradient psi/ft	Equ. Gradient psi/ft
13-5/8	11.2	50%	50%	7,019	9,265	0.15	0.353
OH	11.2	50%	50%	9,551	12,110	0.15	0.366

Less Than 10,000' gas 0.1 psi/ft — Above 10,000' 30% Mud / 70% Gas
Deeper Than 10,000' gas .15 psi/ft — Depper than 10,000' 50% Mud / 50% Gas

Surface Pressure Calculations

$MASP_{pore} = P_{pore} - (\gamma_{equiv})(TVD_{next})$

$MASP_{pore}$ = 9,551 - 0.366 x 16,400' = **3,546** psi

$MASP_{frac} = P_{frac} - (\gamma_{gas})(TVD_{shoe})$

$MASP_{frac}$ = 9,265 - 0.150 x 13,498' = **7,240** psi

$MASP_{MMS}$ = Minimum of [$MASP_{pore}$] or [$MASP_{frac}$]

$MASP_{MMS}$ = **3,546** psi

$MAWP = MASP_{MMS} + (\gamma_{equiv})(TVD_{mudline}) - (8.65)(0.052)(TVD_{water})$

MAWP = 3,546 + 0.366 x 6,256' - 0.4446 x 6,171' = **3,093** psi

$MASP_{MMS\ ML} = MASP_{MMS} + (\gamma_{equiv})(TVD_{mudline})$

$MASP_{MMS\ ML}$ = 3,546 + 0.366 x 6,256' = **5,837** psi

Maximum Anticipated Pressure Below Mud Line at MAWP

$MAP_{bml\ int}$ (TVD) $= MASP_{MMS} + (\gamma_{equiv})(TVD_{int}) - (Ppore)(0.052)(TVD_{int})$

$MAP_{bml\ shoe}$ (TVD) = 3,546 + 0.366 x 13,498' - 8.6 x 0.052 x 13,498' = **2,487** psi

Casing Pressure Test Calculations

$P_{test\ surf}$ = Minimum of B, or C (A criteria not used since pressure test will be required after running production liner):

$P_{test\ surf}$ = **5,161** psi

A. MAWP + 500 psi

B. 70% OCTG Rating - (rmud- Ppore)(0.052)(TVD)

C. 70% Hanger Rating - (rmud - P_{pore})(0.052)(TVD)

A. = 3,093 + 500 = **3,593** psi

B. = 13-5/8" Top 70% x 10,030 - (11.2 - 8.6) x 0.052 x 6,244' = **6,161** psi

B. = 13-5/8" Bottom 70% x 10,030 - (11.2 - 8.6) x 0.052 x 13,498' = **5,161** psi

C. = 14" Hanger 70% x 10,000 - (11.2 - 8.6) x 0.052 x 6,244' = **6,140** psi

Pressure Test Requirements						
Item	Annular	Rams	Casing			
psi	3,600	3,600	5,200	w/	11.2	ppg mud

Maximum Pressure Calculation At Casing Test Pressure

$P_{test} = P_{test\ surf} + (\rho_{mud} - Ppore)(0.052)(TVD)$

P_{WH} = 5,200 + (11.2 - 8.6) x 0.052 x 6,256' = **6,062** psi

P_{shoe} = 5,200 + (11.2 - 8.6) x 0.052 x 13,498' = **7,060** psi

Maximum Pressures	ML	Shoe
MASP	3,093	2,487
P_{test}	6,062	7,060

Casing Design Calculatior

$SF_{burst} = P_b$ / (MAWP, MAP_{bml}, or P_{test})

SF_{burst} = 10,030 / 6,062 **1.65** 13-5/8" at Top

SF_{burst} = 10,030 / 7,060 **1.42** 13-5/8" at Bottom

SF_{burst} = 10,000 / 6,062 **1.65** 14" Hanger

$SF_{collapse}$ (For loss of Riser Margin) $= P_c$ / $((\rho_{mud\ when\ run})(0.052)(TVD) - ((8.65)(0.052)(P_{Riser})+(\rho_{mud\ to\ drill})(0.052)(P_{csg}))$

$SF_{collapse}$ = 6,370 / ((10.7) x (0.052) x (6,244') - (2,776) + (0)) = **9.12** 13-5/8" at Top

$SF_{collapse}$ = 6,370 / ((10.7) x (0.052) x (13,498') - (2,776) + (4,218)) = **12.33** 13-5/8" at Bottom

$SF_{collapse}$ = 10,000 / ((10.7) x (0.052) x (6,244') - (2,776) + (0)) = **14.32** 14" Hanger

Mud Drop to Balance an 8.55 ppg at next section TD =

Mud_{Drop} = Next Section TVD x (Next Section TD EMW (ppg) - 8.55) / Next Section TD EMW (ppg)

Mud Drop = 16,400 X (11.2 - 8.55) / (11.2) = 3,880

$SF_{collapse} = P_c$ / $((\rho_{mud\ when\ run})(0.052)(TVD)$ - (Internal Pressure)

$SF_{collapse}$ = 6,370 / ((10.7) x (0.052) x (6,244') - (1,377)) = **3.04** 13-5/8" at Top

$SF_{collapse}$ = 6,370 / ((10.7) x (0.052) x (13,498') - (5,601)) = **3.34** 13-5/8" at Bottom

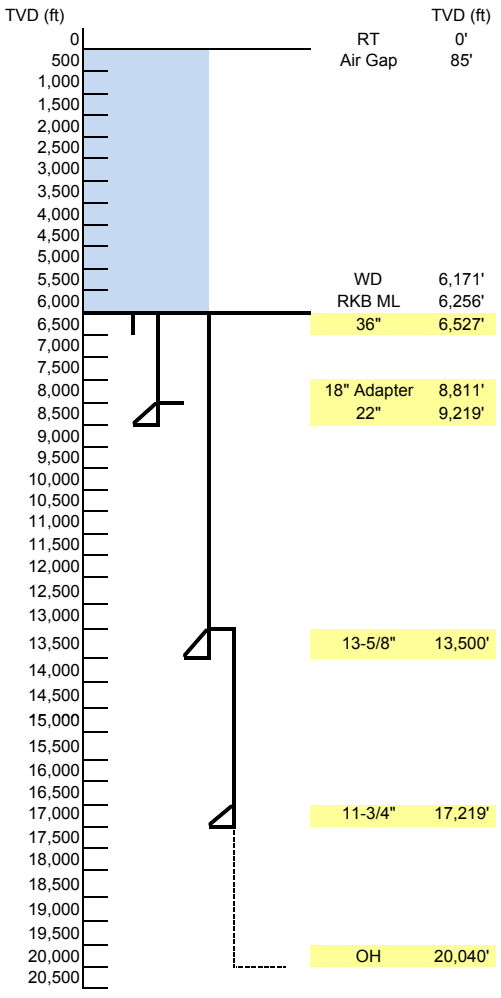
$SF_{collapse}$ = 10,000 / ((10.7) x (0.052) x (6,244') - (1,377)) = **4.77** 14" Hanger

$SF_{tension} = T_{joint}$ / $[(W_c)(MD_{shoe} - MD_{casing\ top})(BF) + T_{overpull} + (W_{c\ liner})(MD_{liner\ shoe} - MD_{liner\ top})(BF)]$

$SF_{tension}$ = 2,393 / [(537) + 200 + 0 = **3.25** 13-5/8" SLIJ-2

Casing Design Criteria			
Size (in)	Burst	Collapse	Tension
13-5/8	1.42	3.04	3.25
14" Hanger	1.65	4.77	3.25

13-5/8" x 11-3/4"



Design Details

Casing Size in	Casing Weight lb/ft	Casing Grade	Thread Type	Burst Rating psi	Collapse Rating psi	Tension Ratings Body kips	Tension Ratings Conn kips
13-5/8	88.2	HCQ-125	SLIJ-II	10,030	6,370	3,191	2,393
11-3/4	65	HCQ-125	ST-L	9,940	5,810	2,352	1,383
OH	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Casing Size in	Depth Top MD ft	Depth Top TVD ft	Depth Shoe or TD MD ft	Depth Shoe or TD TVD ft	Pore lb/gal	MW lb/gal	BF	Fracture Gradient lb/gal
13-5/8	6,244'	6,244'	13,500'	13,498'	10.0	10.7	0.84	13.2
11-3/4	13,144'	13,142'	17,219'	16,400'	11.2	11.2	0.83	14.2
OH	17,219'	16,400'	20,040'	18,690'	12.8	12.8	0.81	14.8

Casing Size in	MW in Csg Post Cmt lb/gal	Gradient Split Gas %	Gradient Split Mud %	Pore Pressure psi	Fracture Pressure psi	Gas Gradient psi/ft	Equ. Gradient psi/ft
13-5/8	11.2	50%	50%	7,019	9,265	0.15	0.353
11-3/4	11.2	50%	50%	9,551	12,110	0.15	0.366
OH	12.8	50%	50%	12,440	14,384	0.15	0.408

Less Than 10,000' gas 0.1 psi/ft — Above 12,000' 30% Mud / 70% Gas
Deeper Than 10,000' gas .15 psi/ft — Depper than 15,000' 50% Mud / 50% Gas

Surface Pressure Calculations

$MASP_{pore} = P_{pore} - (\gamma_{equiv})(TVD_{next})$

$MASP_{pore}$ = 12,440 - 0.408 x 18,690' = **4,818** psi

$MASP_{frac} = P_{frac} - (\gamma_{gas})(TVD_{shoe})$

$MASP_{frac}$ = 12,110 - 0.150 x 16,400' = **9,650** psi

$MASP_{MMS}$ = Minimum of [$MASP_{pore}$] or [$MASP_{frac}$]

$MASP_{MMS}$ = **4,818** psi

$MAWP = MASP_{MMS} + (\gamma_{equiv})(TVD_{mudline}) - (8.65)(0.052)(TVD_{water})$

MAWP = 4,818 + 0.408 x 6,256' - 0.4446 x 6,171' = **4,626** psi

$MASP_{MMS\ ML} = MASP_{MMS} + (\gamma_{equiv})(TVD_{mudline})$

$MASP_{MMS\ ML}$ = 4,818 + 0.408 x 6,256' = **7,369** psi

Maximum Anticipated Pressure Below Mud Line at MAWP

$MAP_{bml\ int}(TVD) = MASP_{MMS} + (\gamma_{equiv})(TVD_{int}) - (Ppore)(0.052)(TVD_{int})$

$MAP_{bml\ 11\text{-}3/4"\ lnr\ top}$ (TVD) = 4,818 + 0.408 x 13,142' - 10.0 x 0.052 x 13,142' = **3,344** psi

$MAP_{bml\ shoe}$ (TVD) = 4,818 + 0.408 x 16,400' - 11.2 x 0.052 x 16,400' = **1,955** psi

Casing Pressure Test Calculations

$P_{test\ surf}$ = Minimum of A, B, or C:

$P_{test\ surf}$ = **3,058** psi

A. MAWP + 500 psi

B. 70% OCTG Rating - (rmud- Ppore)(0.052)(TVD)

C. 70% Hanger Rating - (rmud - P_{pore})(0.052)(TVD)

D. $P_{frac\ @\ liner\ shoe}$ + 500 psi - (ρ_{mud})(0.052)($TVD_{liner\ shoe}$)

A. = 4,626 + 500 = **5,126** psi

B. = 13-5/8" Top	70%	x	10,030	-	(	11.2	-	8.6	)	x	0.052	x	6,244'	=	**6,161**	psi
B. = 13-5/8" Bottom	70%	x	10,030	-	(	11.2	-	8.6	)	x	0.052	x	13,142'	=	**5,210**	psi
B. = 11 3/4" Top	70%	x	9,940	-	(	11.2	-	10.0	)	x	0.052	x	13,142'	=	**6,138**	psi
B. = 11 3/4" Bottom	70%	x	9,940	-	(	11.2	-	11.2	)	x	0.052	x	16,400'	=	**6,958**	psi
C. = 14" Hanger	70%	x	10,000	-	(	11.2	-	8.6	)	x	0.052	x	6,244'	=	**6,140**	psi
C. = 11 3/4" Liner Hanger	70%	x	7,000	-	(	11.2	-	10.0	)	x	0.052	x	13,142'	=	**4,080**	psi
D. =	12,110	+	500	-	(	11.2	x	0.052	)	x	16,400'	=	**3,058**	psi		

Pressure Test Requirements

Item	Annular	Rams	Casing			
psi	5,200	5,200	3,100	w/	11.2	ppg mud

Maximum Pressure Calculation At Casing Test Pressure

$P_{test} = P_{test\ surf} + (\rho_{mud} - Ppore)(0.052)(TVD)$

P_{WH} =	3,100	+	(	11.2	-	8.6	)	x	0.052	x	6,256'	=	**3,962**	psi
$P_{11\ 3/4"\ LH}$ =	3,100	+	(	11.2	-	10.0	)	x	0.052	x	13,142'	=	**3,920**	psi
P_{shoe} =	3,100	+	(	11.2	-	11.2	)	x	0.052	x	16,400'	=	**3,100**	psi

Maximum Pressures	ML	11-3/4 Lnr Top	Shoe
MASP	4,626	3,344	1,955
P_{test}	3,962	3,920	3,100

Casing Design Calculation

$SF_{burst} = P_b$ / (MAWP, MAP_{bml}, or P_{test})

SF_{burst} =	10,030	/	4,626	**2.17**	13-5/8" at Top
SF_{burst} =	10,030	/	3,920	**2.56**	13-5/8" at Bottom
SF_{burst} =	9,940	/	3,920	**2.54**	11-3/4" at Top
SF_{burst} =	9,940	/	3,100	**3.21**	11-3/4" at Bottom
SF_{burst} =	10,000	/	4,626	**2.16**	14" Hanger
SF_{burst} =	7,000	/	3,920	**1.79**	11-3/4" Liner Hanger

$SF_{collapse}$ (For loss of Riser Margin) = P_c / (($\rho_{mud\ when\ run}$)(0.052)(TVD) - ((8.65)(0.052)(P_{Riser})+($\rho_{mud\ to\ drill}$)(0.052)(P_{csg}))

$SF_{collapse}$ =	6,370	/	((	10.7	) x	(	0.052	) x	(	6,244'	) -	(	2,776	) +	(	0	))	=	**9.12**	13-5/8" at Top
$SF_{collapse}$ =	6,370	/	((	10.7	) x	(	0.052	) x	(	13,142'	) -	(	2,776	) +	(	4,010	))	=	**12.11**	13-5/8" at Bottom
$SF_{collapse}$ =	5,810	/	((	11.2	) x	(	0.052	) x	(	13,142'	) -	(	2,776	) +	(	4,010	))	=	**6.70**	11-3/4" at Top
$SF_{collapse}$ =	5,810	/	((	11.2	) x	(	0.052	) x	(	16,400'	) -	(	2,776	) +	(	5,908	))	=	**6.70**	11-3/4" at Bottom
$SF_{collapse}$ =	10,000	/	((	10.7	) x	(	0.052	) x	(	6,244'	) -	(	2,776	) +	(	0	))	=	**14.32**	14" Hanger
$SF_{collapse}$ =	5,900	/	((	11.2	) x	(	0.052	) x	(	13,142'	) -	(	2,776	) +	(	4,010	))	=	**6.80**	11-3/4" Liner Hanger

Mud Drop to Balance an 8.55 ppg at next section TD =

Mud Drop = 18,690 X (12.8 - 8.55) / (12.8) = 6,206

$SF_{collapse}$ = P_c / (($\rho_{mud\ when\ run}$)(0.052)(TVD) - (Internal Pressure)

$SF_{collapse}$ =	6,370	/	((	10.7	) x	(	0.052	) x	(	6,244'	) -	(	26	))	=	**1.85**	13-5/8" at Top
$SF_{collapse}$ =	6,370	/	((	10.7	) x	(	0.052	) x	(	13,142'	) -	(	4,617	))	=	**2.36**	13-5/8" at Bottom
$SF_{collapse}$ =	5,810	/	((	11.2	) x	(	0.052	) x	(	13,142'	) -	(	4,617	))	=	**1.91**	11-3/4" at Top
$SF_{collapse}$ =	5,810	/	((	11.2	) x	(	0.052	) x	(	16,400'	) -	(	6,785	))	=	**2.10**	11-3/4" at Bottom
$SF_{collapse}$ =	10,000	/	((	10.7	) x	(	0.052	) x	(	6,244'	) -	(	26	))	=	**2.90**	14" Hanger
$SF_{collapse}$ =	5,000	/	((	11.2	) x	(	0.052	) x	(	13,142'	) -	(	4,617	))	=	**1.65**	11-3/4" Hanger

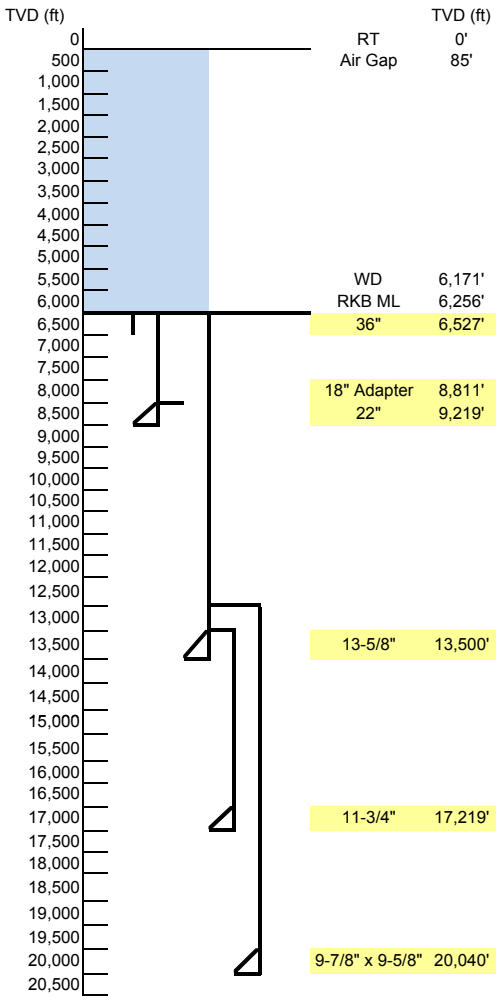
$SF_{tension} = T_{joint}$ / [(W_c)(MD_{shoe} - $MD_{casing\ top}$)(BF) + $T_{overpull}$ + ($W_{c\ liner}$)($MD_{liner\ shoe}$ - $MD_{liner\ top}$)(BF)]

$SF_{tension}$ =	2,393	/	[(	537	) +	200	+	223	=	**2.49**	13-5/8" SLIJ-II
$SF_{tension}$ =	1,000	/	[(	2	) +	200	+	220	=	**2.37**	11 3/4" Liner Hanger
$SF_{tension}$ =	1,383	/	[(	220	) +	200	+	0	=	**3.29**	11 3/4" ST-L

Casing Design Criteria

Size (in)	Burst	Collapse	Tension
13-5/8	2.17	1.85	2.49
11-3/4	2.54	1.91	3.29
14" Hanger	2.16	2.90	2.49
11 3/4" Liner Hanger	1.79	1.65	2.37

13-5/8" x 9-7/8" x 9-5/8"



	TVD (ft)
RT	0'
Air Gap	85'
WD	6,171'
RKB ML	6,256'
36"	6,527'
18" Adapter	8,811'
22"	9,219'
13-5/8"	13,500'
11-3/4"	17,219'
9-7/8" x 9-5/8"	20,040'

Design Details

Casing Size in	Casing Weight lb/ft	Casing Grade	Thread Type	Burst Rating psi	Collapse Rating psi	Tension Ratings Body kips	Tension Ratings Conn kips
13-5/8	88.2	HCQ-125	SLIJ-II	10,030	6,370	3,191	2,393
11-3/4	65	HCQ-125	ST-L	9,940	5,810	2,352	1,383
9-5/8	53.5	C-110	SLIJ-II	10,900	7,950	1,710	1,275
9-7/8	62.8	C-110	SLIJ-II	12,180	10,290	1,998	1,551

Casing Size in	Depth Top MD ft	Depth Top TVD ft	Depth Shoe or TD MD ft	Depth Shoe or TD TVD ft	Pore lb/gal	MW lb/gal	BF	Fracture Gradient lb/gal
13-5/8	6,244'	6,244'	13,500'	13,498'	10.0	10.7	0.84	13.2
11-3/4	13,144'	13,142'	17,219'	16,400'	11.2	11.2	0.83	14.2
9-5/8	13,044'	13,042'	18,600'	17,363'	11.6	12.8	0.81	14.5
9-7/8	18,600'	17,363'	20,040'	18,690'	12.8	12.8	0.81	14.8

Casing Size in	MW in Csg Post Cmt lb/gal	Gradient Split Gas %	Gradient Split Mud %	Pore Pressure psi	Fracture Pressure psi	Gas Gradient psi/ft	Equ. Gradient psi/ft
13-5/8	11.2	50%	50%	7,019	9,265	0.15	0.353
11-3/4	11.2	50%	50%	9,551	12,110	0.15	0.366
9-5/8	12.8	50%	50%	10,473	13,092	0.15	0.408
9-7/8	12.8	50%	50%	12,440	14,384	0.15	0.408

Less Than 10,000' gas 0.1 psi/ft — Above 12,000' 30% Mud / 70% Gas
Deeper Than 10,000' gas .15 psi/ft — Depper than 15,000' 50% Mud / 50% Gas

Surface Pressure Calculations

$MASP_{pore} = P_{pore} - (\gamma_{equiv})(TVD_{next})$

$MASP_{pore}$ = 12,440 - 0.408 x 18,690' = **4,818** psi

$MASP_{frac} = P_{frac} - (\gamma_{gas})(TVD_{shoe})$

$MASP_{frac}$ = 14,384 - 0.150 x 18,690' = **11,580** psi

$MASP_{MMS}$ = Minimum of [$MASP_{pore}$] or [$MASP_{frac}$]

$MASP_{MMS}$ = **4,818** psi

$MAWP = MASP_{MMS} + (\gamma_{equiv})(TVD_{mudline}) - (8.65)(0.052)(TVD_{water})$

MAWP = 4,818 + 0.408 x 6,256' - 0.4446 x 6,171' = **4,626** psi

$MASP_{MMS\ ML} = MASP_{MMS} + (\gamma_{equiv})(TVD_{mudline})$

$MASP_{MMS\ ML}$ = 4,818 + 0.408 x 6,256' = **7,369** psi

Maximum Anticipated Pressure Below Mud Line at MAWP

$MAP_{bml\ int}(TVD) = MASP_{MMS} + (\gamma_{equiv})(TVD_{int}) - (Ppore)(0.052)(TVD_{int})$

$MAP_{bml\ 9\text{-}5/8"\ lnr\ top}$ (TVD) =	4,818	+	0.408	x	13,042'	-	10.0	x	0.052	x	13,042'	=	**3,355**	psi
$MAP_{bml\ 9\text{-}5/8\ Xover}$ (TVD) =	4,818	+	0.408	x	17,363'	-	11.6	x	0.052	x	17,363'	=	**1,426**	psi
$MAP_{bml\ shoe}$ (TVD) =	4,818	+	0.408	x	18,690'	-	12.8	x	0.052	x	18,690'	=	**0**	psi

Casing Pressure Test Calculations

$P_{test\ surf}$ = Minimum of A, B, or C:

$P_{test\ surf}$ = **4,139** psi

A. MAWP + 500 psi (N/A - Produccion Liner)
B. 70% OCTG Rating - (rmud- Ppore)(0.052)(TVD)
C. 70% Hanger Rating - (rmud - P_{pore})(0.052)(TVD)

A. =	4,626	+	500	=	**5,126**	psi											
B. = 13-5/8" Top	70%	x	10,030	-	(	12.8	-	8.6	)	x	0.052	x	6,244'	=	**5,641**	psi
B. = 13-5/8" Bottom	70%	x	10,030	-	(	12.8	-	8.6	)	x	0.052	x	13,042'	=	**4,139**	psi
B. = 9 5/8" Top	70%	x	10,900	-	(	12.8	-	10.0	)	x	0.052	x	13,042'	=	**5,731**	psi
B. = 9 5/8" Bottom	70%	x	10,900	-	(	12.8	-	11.6	)	x	0.052	x	17,363'	=	**6,547**	psi
B. = 9 7/8" Top	70%	x	12,180	-	(	12.8	-	11.6	)	x	0.052	x	17,363'	=	**7,443**	psi
B. = 9 7/8" Bottom	70%	x	12,180	-	(	12.8	-	12.8	)	x	0.052	x	18,690'	=	**8,526**	psi
C. = 14" Hanger	70%	x	10,000	-	(	12.8	-	8.6	)	x	0.052	x	6,244'	=	**5,620**	psi
C. = 9 5/8" Liner Hanger	70%	x	10,000	-	(	12.8	-	10.0	)	x	0.052	x	13,142'	=	**5,087**	psi

Pressure Test Requirements					
Item	Annular	Rams	Casing		
psi	5,200	5,200	4,200	w/ 12.8	ppg mud

Maximum Pressure Calculation At Casing Test Pressure

$P_{test} = P_{test\ surf} + (\rho_{mud} - Ppore)(0.052)(TVD)$

P_{WH} =	4,200	+	(	12.8	-	8.6	)	x	0.052	x	6,256'	=	**5,583**	psi
$P_{9\text{-}5/8"\ LH}$ =	4,200	+	(	12.8	-	10.0	)	x	0.052	x	13,042'	=	**6,099**	psi
$P_{9\text{-}5/8"\ Xover}$ =	4,200	+	(	12.8	-	11.6	)	x	0.052	x	17,363'	=	**5,283**	psi
P_{shoe} =	4,200	+	(	12.8	-	12.8	)	x	0.052	x	18,690'	=	**4,200**	psi

Maximum Pressures	ML	9-5/8 Lnr Top	9-5/8" XO	Shoe
MASP	4,626	3,355	1,426	0
P_{test}	5,583	6,099	5,283	4,200

Casing Design Calculation

$SF_{burst} = P_b$ / (MAWP, MAP_{bml}, or P_{test})

SF_{burst} =	10,030	/	5,583	**1.80**	13-5/8" at Top
SF_{burst} =	10,030	/	6,099	**1.64**	13-5/8" at Bottom
SF_{burst} =	10,900	/	6,099	**1.79**	9-5/8" at Top
SF_{burst} =	10,900	/	5,283	**2.06**	9-5/8" at Bottom
SF_{burst} =	12,180	/	5,283	**2.31**	9-7/8" at Top
SF_{burst} =	12,180	/	4,200	**2.90**	9-7/8" at Bottom
SF_{burst} =	10,000	/	5,583	**1.79**	14" Hanger
SF_{burst} =	10,000	/	6,099	**1.64**	9-5/8" Liner Hanger

$SF_{collapse}$ (For loss of Riser Margin) = P_c / (($\rho_{mud\ when\ run}$)(0.052)(TVD) - ((8.65)(0.052)(P_{Riser})+($\rho_{mud\ to\ drill}$)(0.052)(P_{csg}))

$SF_{collapse}$ =	6,370	/	((	10.7	)	x	(	0.052	)	x	(	6,244'	)	-	(	2,776	)	+	(	0	))	=	**9.12**	13-5/8" at Top
$SF_{collapse}$ =	6,370	/	((	10.7	)	x	(	0.052	)	x	(	13,042'	)	-	(	2,776	)	+	(	4,517	))	=	**-177.39**	13-5/8" at Bottom
$SF_{collapse}$ =	7,950	/	((	12.8	)	x	(	0.052	)	x	(	13,042'	)	-	(	2,776	)	+	(	4,517	))	=	**5.73**	9-5/8" at Top
$SF_{collapse}$ =	7,950	/	((	12.8	)	x	(	0.052	)	x	(	17,363'	)	-	(	2,776	)	+	(	7,393	))	=	**5.73**	9-5/8" at Bottom
$SF_{collapse}$ =	10,290	/	((	12.8	)	x	(	0.052	)	x	(	17,363'	)	-	(	2,776	)	+	(	7,393	))	=	**7.41**	9-7/8" at Top
$SF_{collapse}$ =	10,290	/	((	12.8	)	x	(	0.052	)	x	(	18,690'	)	-	(	2,776	)	+	(	8,276	))	=	**7.41**	9-7/8" at Bottom
$SF_{collapse}$ =	10,000	/	((	10.7	)	x	(	0.052	)	x	(	6,244'	)	-	(	2,776	)	+	(	0	))	=	**14.32**	14" Hanger
$SF_{collapse}$ =	7,000	/	((	12.8	)	x	(	0.052	)	x	(	13,042'	)	-	(	2,776	)	+	(	4,517	))	=	**5.04**	9-5/8" Liner Hanger

Mud Drop to Balance an 8.55 ppg at next section TD =
Mud Drop = 18,690 X (12.8 - 8.55) / (12.8) = 6,206

$SF_{collapse}$ = P_c / (($\rho_{mud\ when\ run}$)(0.052)(TVD) - (nternal Pressure)
Not Applicable / Produccion Liner (Not Drilling Ahead)

$SF_{tension} = T_{joint} / [(W_c)(MD_{shoe} - MD_{casing\ top})(BF) + T_{overpull} + (W_{c\ liner})(MD_{liner\ shoe} - MD_{liner\ top})(BF)]$

$SF_{tension}$ =	2,393	/	[(	537	) +	200	+	315	=	**2.27**	13-5/8" SLIJ-II
$SF_{tension}$ =	990	/	[(	2	) +	200	+	313	=	**1.92**	9 5/8" Liner Hanger
$SF_{tension}$ =	1,275	/	[(	240	) +	200	+	73	=	**2.48**	9 5/8" SLIJ-II
$SF_{tension}$ =	1,551	/	[(	73	) +	200	+	0	=	**5.68**	9-7/8" SLIJ-II

Casing Design Criteria			
Size (in)	Burst	Collapse	Tension
13-5/8	1.64	9.12	2.27
9-5/8	1.79	5.73	2.48
9-7/8	2.31	7.41	5.68
14" Hanger	1.79	14.32	2.27
9 5/8" Liner Hanger	1.64	5.04	1.92

Water Depth	6,171 ft
Well Head Depth	6,244 ft

Rig: DD1

9-5/8" x 9-7/8" Production Liner

Burst - Tubing Leak

Well Head P - leak	7,000 psi
$\rho_{Pkr\ Fluid}$	12.50 ppg
TVD_{Pkr}	17,500 ft
9-5/8" x 9-7/8" XO TVD	17,363 ft
ρ_{Backup}	8.60 ppg
$P_{9\text{-}5/8"\ Burst}$	10,900 psi
$P_{9\text{-}7/8"\ Burst}$	12,180 psi

$P_{at\ XO}$	$PInj + (\rho_{Pkr\ Fluid})\ (0.052)\ (TVD_{XO} - TVD_{WH}) - (\rho_{backup})\ (0.052)\ (TVD_{XO})$
$P_{at\ XO}$	(7000) + (12.5) (0.052) (17363 - 6244) - (8.6) (0.052) (17363)
$P_{at\ XO}$	**6,463 psi**
SF =	$P_{9\text{-}5/8"\ Burst}\ /\ P_{at\ XO}$
SF =	(10900) / (6463)
SF =	**1.69**

Collapse

ρ_{Sand}	5.90 ppg
TVD_{Perfs}	18,500 ft
ρ_{Shale}	12.80 ppg
$P_{collapse}$	10,290 psi

$P_{Above\ Perfs}$	$(\rho_{Shale} - \rho_{Sand})\ (0.052)\ (TVD_{Perfs})$
$P_{Above\ Perfs}$	(12.8 - 5.9) (0.052) (18500)
$P_{Above\ Perfs}$	**6,638 psi**
SF =	$P_{Burst}\ /\ P_{Above\ Perfs}$
SF =	(10290) / (6638)
SF =	**1.55**

Water Depth	*6,171 ft*
Well Head Depth	*6,243 ft*

Rig: DD1

13-5/8" Production Casing

Burst - Tubing Leak

Well Head P - leak	*7,000 psi*
$\rho_{Pkr\ Fluid}$	*12.50 ppg*
ρ_{Backup}	*8.60 ppg*
$P_{13\text{-}5/8''\ Burst}$	*12,180 psi*

$P_{at\ XO}$	$PInj - (\rho_{backup})\ (0.052)\ (TVD_{WD})$
$P_{at\ XO}$	*(7000) - (8.6) (0.052) (6171)*
$P_{at\ XO}$	***4,240 psi***
SF =	$P_{13\text{-}5/8''\ Burst}\ /\ P_{at\ XO}$
SF =	*(12180) / (4240)*
SF =	***2.87***

Pressure Calculation Method

The first method of calculating maximum anticipated surface pressure is the pore pressure at TD of the next hole interval or at the deepest open hole depth to which the casing/liner is exposed, less the gas/mud gradient equivalent to the surface:

$$MASP_{pore} = P_{pore} - (\gamma_{equiv})\ (TVD_{next})$$

The pore pressure at the next relevant depth is:

$$P_{pore} = (\rho_{pore})\ (0.052)\ (TVD_{next})$$

The gas/mud gradient equivalent is:

$$\gamma_{equiv} = (Mud\%)\ (\rho_{mud})\ (0.052) + (Gas\%)\ (\gamma_{gas})$$

Where

Mud% = 30%, Gas% = 70%, and γ_{gas} = 0.10 psi/ft for TVD $\leq$ 10,000'

Mud% = 50%, Gas% = 50%, and γ_{gas} = 0.15 psi/ft for TVD > 10,000'

The second method of calculating maximum anticipated surface pressure is the fracture pressure at the current casing shoe, less the gas gradient to the surface:

$$MASP_{frac} = P_{frac} - (\gamma_{gas})\ (TVD_{shoe})$$

The fracture pressure at the current casing shoe is:

$$P_{frac} = (\rho_{frac})\ (0.052)\ (TVD_{shoe})$$

The gas gradient varies with depth accordingly:

γ_{gas} = 0.10 psi/ft for TVD $\leq$ 12,000'

γ_{gas} = 0.15 psi/ft for TVD > 12,000'

We take the lesser of $MASP_{pore}$ or $MASP_{frac}$:

$$MASP_{MMS} = \text{Minimum of } [MASP_{pore}] \text{ or } [MASP_{frac}]$$

The Maximum Anticipated Wellhead Pressure (MAWP) is the $MASP_{MMS}$ plus the gas/mud gradient to the mud line, less the sea water gradient:

$$MAWP = MASP_{MMS} + (\gamma_{equiv})\ (TVD_{mudline}) - (8.6)(0.052)(TVD_{water})$$

The $MASP_{MMS\ ML}$ is defined as the maximum internal pressure at the Mud Line

$$MASP_{MMS\ ML} = MASP_{MMS} + (\gamma_{equiv})\ (TVD_{mudline}) \text{ or } MAWP + (8.6)(0.052)(TVDwater)$$

The maximum anticipated casing/liner pressure below the mudline (MAP_{bml}) is the anticipated internal pressure (P_{int}) at the TVD of interest (TVD_{int}), less the formation pressure at depth of interest as backup

$$MAP_{bml}\ (TVD) = P_{int} - (FP)(0.052)(TVD_{int})$$

Where

$$P_{int} = MASP_{MMS} + (\gamma_{equiv})\ (TVD_{int})$$

Test Pressure Calculations

The casing test pressure at the surface is based on the MAWP+500 psi, or 70% of burst of the weakest exposed casing/liner at exposed depth with an 8.6 ppg backup at the liner top or pore pressure backup at the casing shoe, or 500 psi + fracture pressure at the shoe for liners whichever is less:

$P_{test\ surf}$ = Minimum of:

A. MAWP + 500 psi, or
B. 70% $P_{bexposed\ csg\ @\ liner\ top} - (\rho_{mud} - 8.6)(0.052)(TVD_{liner\ top})$, or
C. 70% $P_{bnew\ set\ csg} - (\rho_{mud} - P_{pore})(0.052)(TVD_{new\ csg\ shoe})$, or
D. $P_{frac\ @\ liner\ shoe} + 500\ psi - (\rho_{mud})(0.052)(TVD_{liner\ shoe})$

The equivalent pressure at the wellhead during the casing test is the surface test pressure plus the mud, gradient less the sea water gradient:

$$P_{test\ WH} = P_{test\ surf} + (\rho_{mud} - 8.6)(0.052)(TVD_{water})$$

Similarly, the equivalent test pressure at the shoe is the surface test pressure plus the mud gradient, less the pore pressure gradient:

$$P_{test\ shoe} = P_{test\ surf} + (\rho_{mud} - \rho_{pore})(0.052)(TVD_{shoe})$$

Nomenclature

$MASP_{pore}$ =	Maximum Anticipated Surface Pressure from pore pressure, psi
$MASP_{frac}$ =	Maximum Anticipated Surface Pressure from fracture at casing shoe, psi
$MASP_{MMS}$ =	Lesser of $MASP_{pore}$ or $MASP_{frac}$
MAWP =	Maximum Anticipated Wellhead Pressure, psi
MAP_{bml} =	Maximum Anticipated Pressure at point of interest, psi
P_b =	Casing burst rating, psi
P_{pore} =	Pore pressure, psi
P_{frac} =	Fracture pressure, psi
$P_{test\ surf}$ =	Casing test pressure at surface, psi
$P_{test\ WH}$ =	Equivalent casing test pressure at wellhead, psi
$P_{test\ shoe}$ =	Equivalent casing test pressure at shoe, psi
P_{int} =	Pressure at point of interest, psi
TVD_{next} =	True vertical depth of next casing shoe from rotary table, ft
TVD_{shoe} =	True vertical depth of casing shoe from rotary table, ft
TVD_{water} =	Water depth, ft
$TVD_{mudline}$ =	True vertical depth of mudline from rotary table, ft
TVD_{int} =	True vertical depth at point of interest, ft
γ_{equiv} =	Equivalent gradient of gas/mud mixture, psi/ft
γ_{gas} =	Gas gradient, psi/ft
ρ_{mud} =	Mud weight, lb/gal
ρ_{pore} =	Equivalent mud weight of pore pressure, lb/gal
ρ_{frac} =	Equivalent mud weight of fracture pressure, lb/gal

Burst Design

SF_{burst} = minimum of P_b / (MAWP, MAP_{bml}, or P_{test})

Collapse Design - Riser Margin

$SF_{collapse} = P_c / (P_e-(P_c+P_r))$

$P_e = (\rho_{mud\ when\ pipe\ run})(0.052)(TVD_{shoe})$

$P_{csg}= (\rho_{mud\ to\ drill})(0.052)(TVD_{shoe\text{-}RiserLenght})$

$P_{riser}= (8.6)(0.052)(_{RiserLenght})$

Collapse Design - Mud Drop to Balance a Pore Pressure of 8.55 ppg at Next Hole Section TD

$SF_{collapse} = P_c / (P_e$ - (Internal Pressure))

$P_e = (\rho_{mud\ when\ pipe\ run})(0.052)(TVD_{shoe})$

Internal Pressure = Mud colunm from Mud Drop Level to Point of interest

Tension Design

$SF_{tension} = T_{joint} / [(W_c)(MD_{shoe} - MD_{casing\ top})(BF) + T_{overpull} + (W_{c\ liner})(MD_{liner\ shoe} - MD_{liner\ top})(BF)]$

Nomenclature

BF=	Buoyancy factor, dimensionless
$MASP_{MMS}$ =	Maximum Anticipated Surface Pressure, psi
P_{pore} =	Pore pressure, psi
P_b =	Casing burst rating, psi
P_c =	Casing collapse rating, psi
P_i =	Pressure internal
P_e =	Pressure external
P_{csg}=	Pressure internal casing with mud weight
P_{riser}=	Pressure internal riser with seawater
SF_{burst} =	Safety factor for burst, dimensionless
$SF_{collapse}$ =	Safety factor for collapse, dimensionless
$SF_{tension}$ =	Safety factor for tension, dimensionless
T_{joint} =	Joint strength, lbs
$T_{overpull}$ =	Over-pull, lbs
TVD_{shoe} =	True vertical depth of casing shoe, ft
TVD_{water} =	Water depth, ft
MD_{shoe} =	Measured depth of casing shoe, ft
$MD_{casing\ top}$ =	Measured depth of casing top, ft
$MD_{liner\ shoe}$ =	Measured depth of liner shoe, ft
$MD_{liner\ top}$ =	Measured depth of liner top, ft
W_c =	Weight of casing, lbs/ft
$W_{c\ liner}$ =	Weight of liner to be hung off in previous string, lbs/ft
ρ_{mud} =	Mud weight, lb/gal