

APD ID: 10400013117

Submission Date: 04/20/2017

Highlighted data reflects the most recent changes

Operator Name: LEGACY RESERVES OPERATING LP

Well Name: LEA UNIT

Well Number: 55H

[Show Final Text](#)

Well Type: OIL WELL

Well Work Type: Drill

Section 1 - Geologic Formations

Formation ID	Formation Name	Elevation	True Vertical Depth	Measured Depth	Lithologies	Mineral Resources	Producing Formation
17697	---	3662	0	0	OTHER : Quaternary	USEABLE WATER	No
15330	RUSTLER ANHYDRITE	1982	1680	1680	ANHYDRITE	NONE	No
17718	TOP SALT	1942	1720	1720	SALT	NONE	No
17723	BOTTOM SALT	512	3150	3150	SALT	NONE	No
17740	CAPITAN REEF	512	3150	3150		USEABLE WATER	No
15314	SAN ANDRES	-1048	4710	4710	LIMESTONE	NATURAL GAS,CO2,OIL	No
17760	DELAWARE SAND	-2004	5666	5666	SANDSTONE	NATURAL GAS,CO2,OIL	No
17721	BONE SPRING LIME	-4543	8205	8205	LIMESTONE	NATURAL GAS,CO2,OIL	No
17769	AVALON SAND	-5098	8760	8760	SHALE	NATURAL GAS,CO2,OIL	No
15338	BONE SPRING 1ST	-5839	9501	9501		NATURAL GAS,CO2,OIL	No
17737	BONE SPRING 2ND	-6372	10034	10035		NATURAL GAS,CO2,OIL	Yes

Section 2 - Blowout Prevention

Pressure Rating (PSI): 5M

Rating Depth: 11000

Equipment: Legacy Reserves plans to use a 13-5/8" 5000-psi working pressure BOP system consisting of a double ram BOP with one ram being pipe and one ram being blind, a 5000-psi annular type preventer, a 5000-psi choke manifold and 80 gallon accumulator with floor, five remote operating stations and an auxiliary power system. A rotating head will be utilized as needed. A drill string safety valve in the open position will be available on the rig floor. A mud gas separator will be available for use if needed. A 3M BOP will be used to drill from the surface casing shoe (~1800') to the intermediate casing shoe (~5600'). The BOP will be a 5M system, however the "A" section wellhead will be a 3M wellhead (see attached BOP Diagram). The BOP unit will be hydraulically operated. The BOP will be operated at least once per day while drilling and the blind rams will be operated when out of hole during trips. No abnormal pressure or temperature is expected while drilling.

Requesting Variance? NO

Variance request:

Operator Name: LEGACY RESERVES OPERATING LP

Well Name: LEA UNIT

Well Number: 55H

Testing Procedure: The BOPs will be tested by an independent service company to 250 psi low and 5000 psi high.

Choke Diagram Attachment:

Lea_55H_choke_04-19-2017.pdf

BOP Diagram Attachment:

Lea_55H_BOP_04-19-2017.pdf

Section 3 - Casing

Casing ID	String Type	Hole Size	Csg Size	Condition	Standard	Tapered String	Top Set MD	Bottom Set MD	Top Set TVD	Bottom Set TVD	Top Set MSL	Bottom Set MSL	Calculated casing length MD	Grade	Weight	Joint Type	Collapse SF	Burst SF	Joint SF Type	Joint SF	Body SF Type	Body SF
1	SURFACE	17.5	13.375	NEW	API	N	0	1800	0	1800	3662	1862	1800	J-55	54.5	STC	1.42	3.86	DRY	2.59	DRY	2.59
2	INTERMEDIATE	12.25	9.625	NEW	API	N	0	4000	0	4000	3662	338	4000	J-55	40	LTC	1.25	2.56	DRY	1.6	DRY	1.6
3	INTERMEDIATE	12.25	9.625	NEW	API	N	4000	5600	4000	5600	338	-1938	1600	HCK-55	40	LTC	1.45	2.54	DRY	4.23	DRY	4.23
4	PRODUCTION	8.75	5.5	NEW	API	N	0	17678	0	10500	3662	-6838	17678	P-110	20	OTHER - BTC	2.03	1.28	DRY	1.6	DRY	1.6

Casing Attachments

Casing ID: 1 **String Type:** SURFACE

Inspection Document:

Spec Document:

Tapered String Spec:

Casing Design Assumptions and Worksheet(s):

Lea_55H_casings_design_assumptions_04-19-2017.pdf

Operator Name: LEGACY RESERVES OPERATING LP

Well Name: LEA UNIT

Well Number: 55H

Casing Attachments

Casing ID: 2 **String Type:** INTERMEDIATE

Inspection Document:

Spec Document:

Tapered String Spec:

Casing Design Assumptions and Worksheet(s):

Lea_55H_casings_design_assumptions_04-19-2017.pdf

Casing ID: 3 **String Type:** INTERMEDIATE

Inspection Document:

Spec Document:

Tapered String Spec:

Casing Design Assumptions and Worksheet(s):

Lea_55H_casings_design_assumptions_04-19-2017.pdf

Casing ID: 4 **String Type:** PRODUCTION

Inspection Document:

Spec Document:

Tapered String Spec:

Casing Design Assumptions and Worksheet(s):

Lea_55H_casings_design_assumptions_04-19-2017.pdf

Section 4 - Cement

Operator Name: LEGACY RESERVES OPERATING LP

Well Name: LEA UNIT

Well Number: 55H

String Type	Lead/Tail	Stage Tool Depth	Top MD	Bottom MD	Quantity(sx)	Yield	Density	Cu Ft	Excess%	Cement type	Additives
SURFACE	Lead		0	1800	1100	1.93	13.5	2123		Class C cement	4% bwoc bentonite II + 2% bwoc Calcium Chloride + 0.25 lbs/sack Cello Flake + 0.005% bwoc Static Free + 0.005 gps FP-6L
SURFACE	Tail				200	1.34	14.8	268		C cement	1.5% bwoc Calcium Chloride + 0.005 lbs/sack Static Free + 0.005 gps FP-6L
INTERMEDIATE	Lead		0	3901	1400	1.33	14.8	2982		Class C cement	4% bwoc bentonite II + 5% bwoc MPA-5 + 0.25% bwoc FL- 52 + 5 lbs/sack LCM-1 + 0.125 lbs/sk cello flake + 0.005 lbs/sk defoamer + 0.005 gpsFP-6L + 1.2% bwoc Sodium Metasilicate + 5% bwow Sodium Chloride
INTERMEDIATE	Tail				200	1.33	14.8	266		Class C cement	none
INTERMEDIATE	Lead		3950	5600	1400	1.33	14.8	266		Poz (fly ash) Class C cement	4% bwoc bentonite II + 5% bwoc MPA-5 + 0.25% bwoc FL- 52 + 5 lbs/sack LCM-1 + 0.125 lbs/sk cello flake+ 0.005 lbs/sk defoamer + 0.005 gpsFP-6L + 1.2% bwoc Sodium Metasilicate + 5% bwow Sodium Chloride
INTERMEDIATE	Tail				200	1.33	14.8	266		Class C cement	none
PRODUCTION	Lead		0	1767 8	1600	2.38	11.9	3808		Poz (fly ash) Class H cement	10% bwoc bentonite II + 5% bwow sodium chloride + 5 pps LCM-1 + 0.005 lbs/sk Static Free + 0.005 gps FP-6L
PRODUCTION	Tail				1700	1.62	13.2	2754		Class H	CSE-2 + 4% bwow sodium chloride + 3 pps LCM- 1 + 0.6% bwoc FL-25 + 0.005 gps FP-6L + 0.005% bwoc Static Free

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Section 5 - Circulating Medium

Mud System Type: Closed

Will an air or gas system be Used? NO

Description of the equipment for the circulating system in accordance with Onshore Order #2:

Diagram of the equipment for the circulating system in accordance with Onshore Order #2:

Describe what will be on location to control well or mitigate other conditions: Sufficient mud materials will be kept on location at all times in order to combat lost circulation or unexpected kicks. Mud logging program: 2 man unit from approximately after setting intermediate casing. No open hole logs, DSTs or cores are planned.

Describe the mud monitoring system utilized: A Pason PVT system will be rigged up prior to spudding this well. A volume monitoring system that measures, calculates and displays readings from the mud system on the rig to alert the rig crew of impending gas kicks and lost circulation. In order to effectively run open hole logs and casing, the mud viscosity and fluid loss properties may be adjusted.

Circulating Medium Table

Top Depth	Bottom Depth	Mud Type	Min Weight (lbs/gal)	Max Weight (lbs/gal)	Density (lbs/cu ft)	Gel Strength (lbs/100 sqft)	PH	Viscosity (CP)	Salinity (ppm)	Filtration (cc)	Additional Characteristics
5600	1050 0	OTHER : Fresh water/brine	8.4	8.6							
1800	5600	OTHER : Brine water	9.8	10							
0	1800	SPUD MUD	8.4	8.9							
1050 0	1050 0	OTHER : Fresh water/brine	8.9	9.1							

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Section 6 - Test, Logging, Coring

List of production tests including testing procedures, equipment and safety measures:

Mud logging, H2S plan, BOP and choke plans all in place for testing, equipment, safety

List of open and cased hole logs run in the well:

MUDLOG

Coring operation description for the well:

No coring planned

Section 7 - Pressure

Anticipated Bottom Hole Pressure: 4620

Anticipated Surface Pressure: 2310

Anticipated Bottom Hole Temperature(F): 162

Anticipated abnormal pressures, temperatures, or potential geologic hazards? NO

Describe:

Contingency Plans geohazards description:

Contingency Plans geohazards attachment:

Hydrogen Sulfide drilling operations plan required? YES

Hydrogen sulfide drilling operations plan:

Lea_55H_H2S_04-20-2017.pdf

Section 8 - Other Information

Proposed horizontal/directional/multi-lateral plan submission:

Lea_55H_horizontal_drilling_plan_04-20-2017.pdf

Other proposed operations facets description:

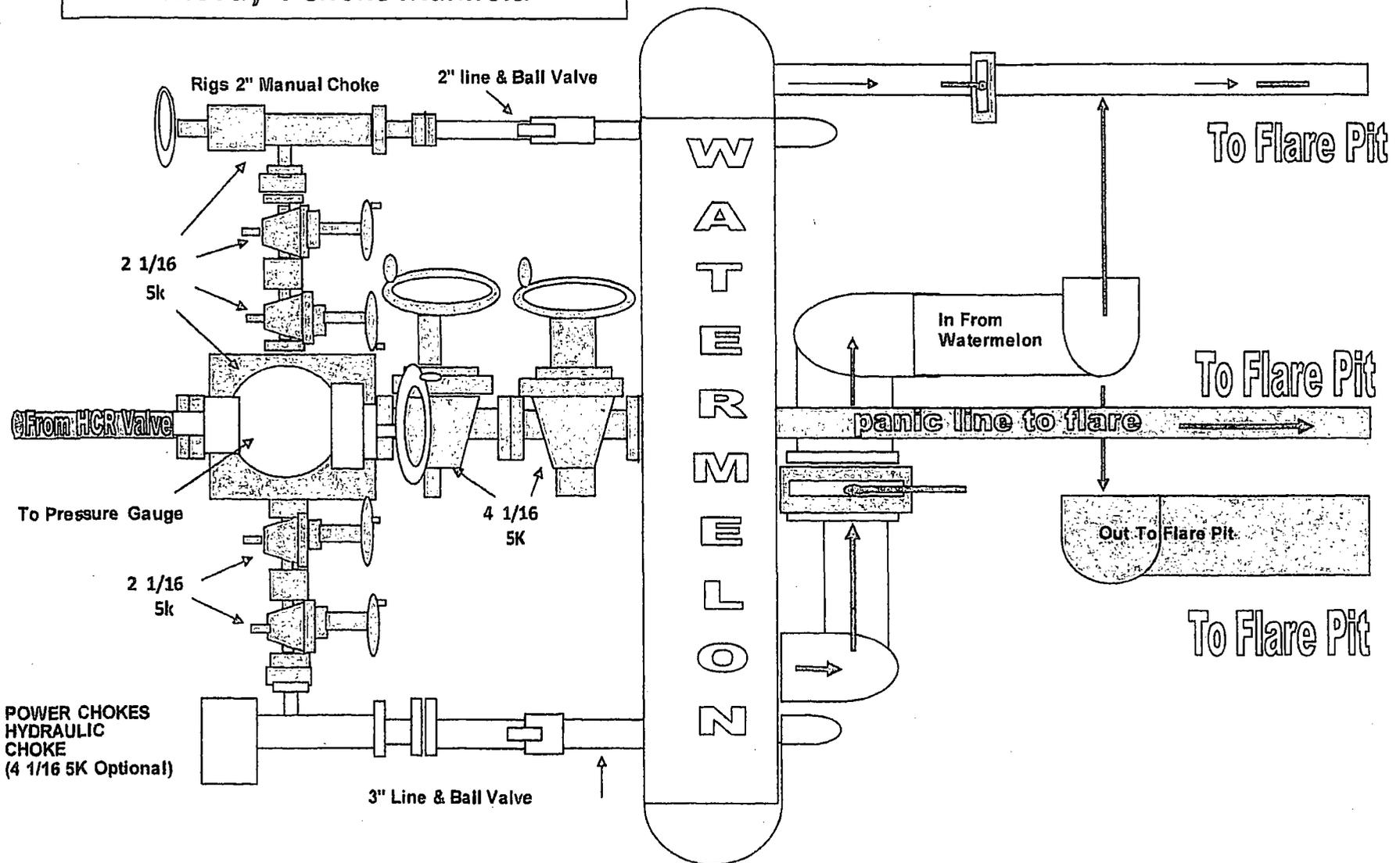
Attached is the general drill plan

Other proposed operations facets attachment:

Lea_55H_general_drilling_plan_04-20-2017.pdf

Other Variance attachment:

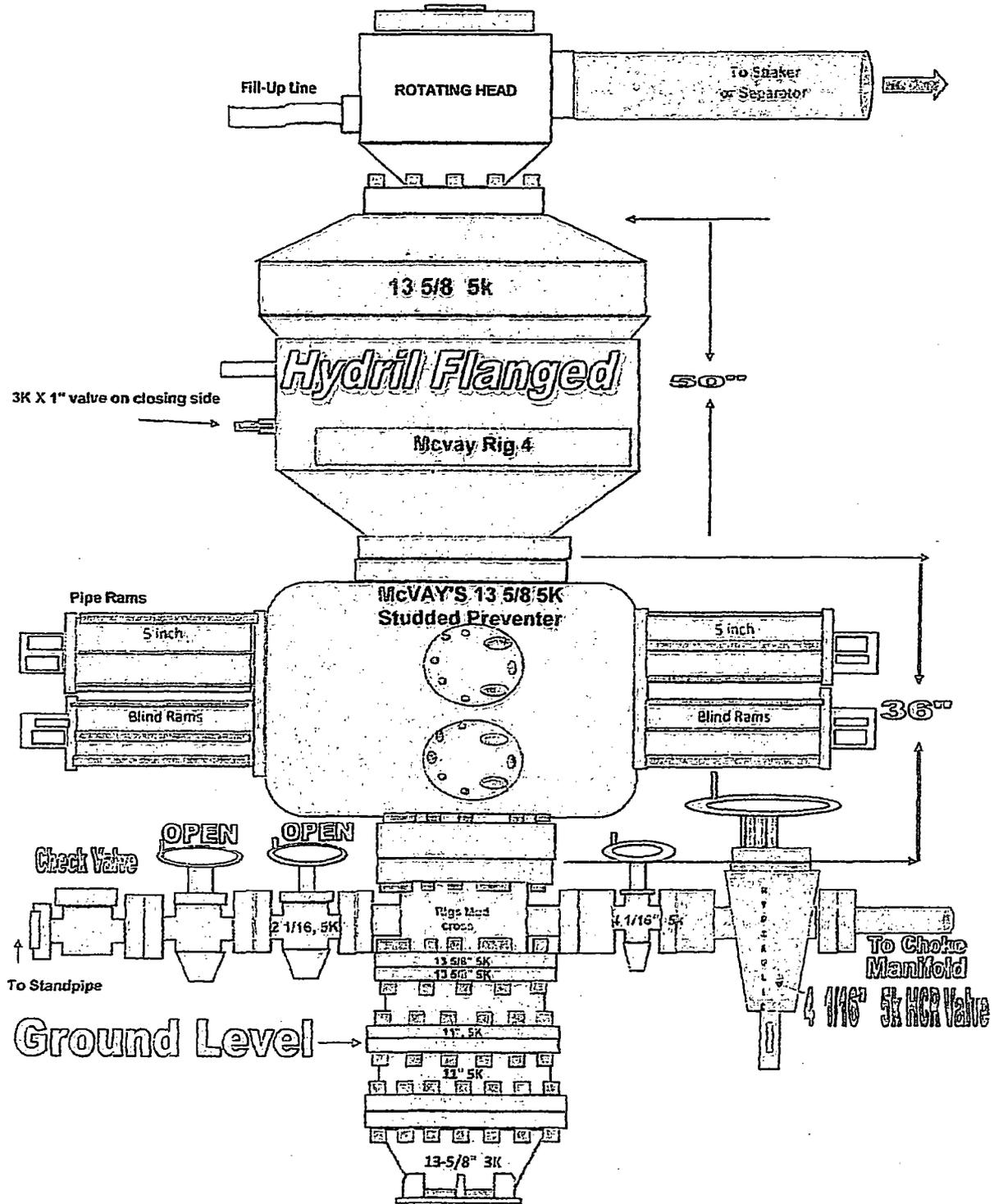
McVay 4 Choke Manifold



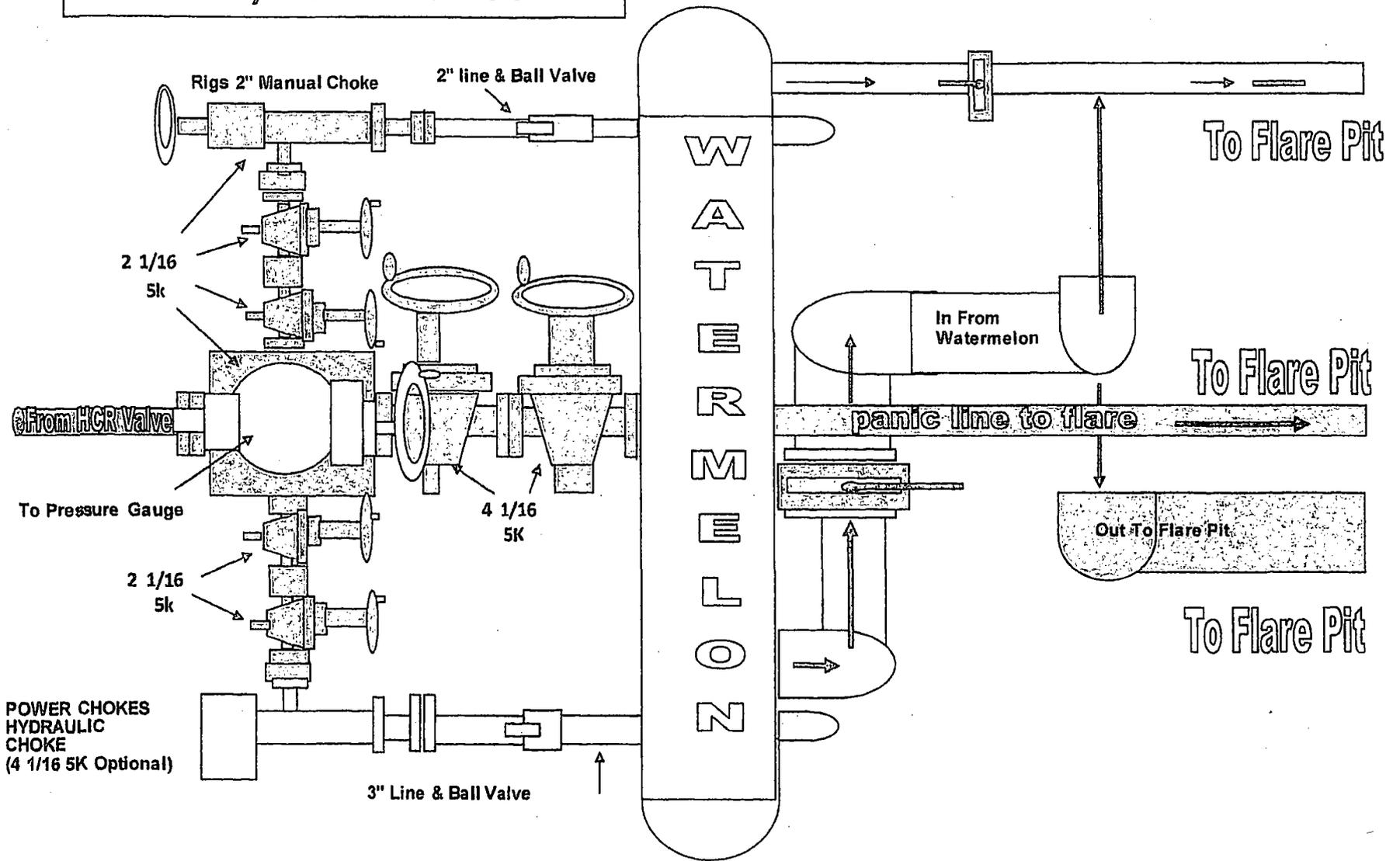
*We use the same choke manifolds for all aspects of our operations & all are rated to 10K;

* All connections downstream from BOP thru chokes Are Flanged, All connections downstream from chokes are Flanged .

McVay Rig 4



McVay 4 Choke Manifold



*We use the same choke manifolds for all aspects of our operations & all are rated to 10K;

* All connections downstream from BOP thru chokes Are Flanged, All connections downstream from chokes are Flanged .



Midwest Hose
& Specialty, Inc.

Internal Hydrostatic Test Graph

February 19, 2017

Customer: Hobb

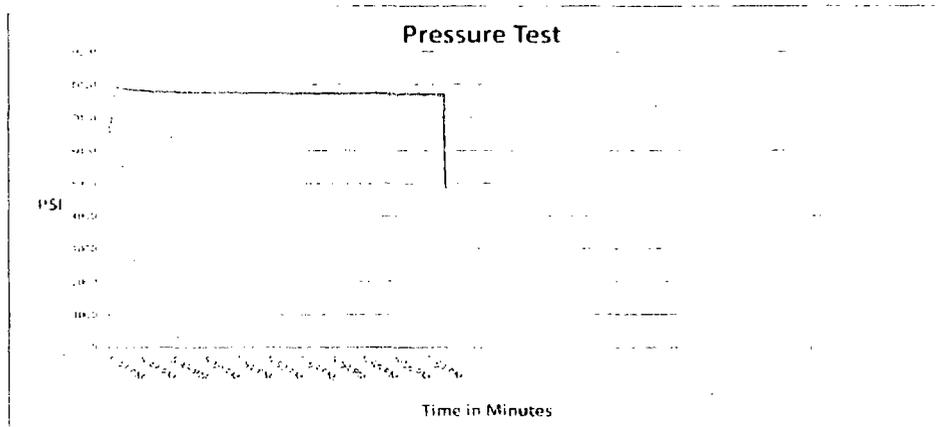
Pick Ticket #: 384843

Hose Specifications

Hose Type	Length
P	20
I.D.	O.D.
5.07	5.07
Working Pressure	Rated Pressure
500 PSI	500 PSI

Verification

Type of Fitting	Coupling Method
4 1/2" SA	Swage
Die Size	Fitted O.D.
3.67	5.57
Hose Serial #	Hose Assembly Serial #
18938	384843



Test Pressure
500 PSI

Time Held at Test Pressure
10.24 Minutes

Actual Burst Pressure

Peak Pressure
500 PSI

COMMENTS: Hose assembly pressure tested with water at ambient temperature.

Tested By: Richard Dumas

Approved By: Charles A. ...



Midwest Hose
& Specialty, Inc.

Internal Hydrostatic Test Certificate

General Information		Hose Specifications	
Customer	HOBBS	Hose Assembly Type	Rotary/Vibrator
MWH Sales Representative	CHARLES ASH	Certification	API 7K/FSL LEVEL2
Date Assembled	2/19/2017	Hose Grade	D
Location Assembled	OKC	Hose Working Pressure	5000
Sales Order #	318810	Hose Lot # and Date Code	10958-08/13
Customer Purchase Order #	356945	Hose I.D. (Inches)	3.5"
Assembly Serial # (Pick Ticket #)	384842	Hose O.D. (Inches)	5.45"
Hose Assembly Length	20FT	Armor (yes/no)	NO
Fittings			
End A		End B	
Stem (Part and Revision #)	R3.5X64WB	Stem (Part and Revision #)	R3.5X64WB
Stem (Heat #)	13105653	Stem (Heat #)	13105653
Ferrule (Part and Revision #)	RF3.5X5330	Ferrule (Part and Revision #)	RF3.5X5330
Ferrule (Heat #)	34038185	Ferrule (Heat #)	3403818
Connection - Flange Hammer Union Part	4-1/16 5K	Connection (Part #)	4-1/16 5K
Connection (Heat #)		Connection (Heat #)	
Nut (Part #)		Nut (Part #)	
Nut (Heat #)		Nut (Heat #)	
Dies Used	5.62"	Dies Used	5.53"
Hydrostatic Test Requirements			
Test Pressure (psi)	7,500	Hose assembly was tested with ambient water temperature.	
Test Pressure Hold Time (minutes)	10 1/2		
Date Tested	Tested By	Approved By	
2/19/2017	<i>Richard D. ...</i>	<i>John S. ...</i>	



Midwest Hose
& Specialty, Inc.

Certificate of Conformity

Customer: HOBBS	Customer P.O.# 356945
Sales Order # 318810	Date Assembled: 2/19/2017
Specifications	
Hose Assembly Type: Rotary/Vibrator	Rig #
Assembly Serial # 384842	Hose Lot # and Date Code 10958-08/13
Hose Working Pressure (psi) 5000	Test Pressure (psi) 7500
Hose Assembly Description:	TRH56D-645KH-645KH-20.00' FT
<p>We hereby certify that the above material supplied for the referenced purchase order to be true according to the requirements of the purchase order and current industry standards.</p>	
Supplier: Midwest Hose & Specialty, Inc. 3312 S I-35 Service Rd Oklahoma City, OK 73129	
Comments:	
Approved By	Date
	2/20/2017

Surface Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
13.375"	J-55	54.5	1130 psi	2730 psi	514 kips	STC	1800'	98,100 lbs	8.5 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Complete internal evacuation of the casing, utilizing a collapse force equivalent to the mud gradient (0.44 psi/ft) in which the casing will be ran.
- Cementing operations in which, utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal force equivalent to the fresh water displacement fluid (0.433 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Complete Evacuation:

$$1,130\text{psi} / [(0.44\text{psi/ft})(1,800')] = \mathbf{1.42}$$

Cementing Operations:

$$1,130\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(1,800')] = \mathbf{1.86}$$

Burst: $DF_B = 1.25$

Base Assumption

- Casing pressure test as per Onshore Oil and Gas Order No. 2 (0.22 psi/ft or 1500 psi), utilizing an external force equivalent to the mud gradient (0.44 psi/ft) in which the casing will be ran.

Burst Calculations: Internal Yield Rating / Internal Force

Casing Pressure Test:

$$2,730\text{psi} / [(1500\text{psi}) - (0.44\text{psi/ft})(1,800')] = \mathbf{3.86}$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight and not considering the effects of buoyancy.

Tensile Calculations: Joint Strength / Axial Load

Overpull:

$$514\text{ kips} / (100,000\text{ lbs.} + 98,100\text{ lbs.}) = \mathbf{2.59}$$

Intermediate Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
9.625"	J-55	40	2570 psi	3950 psi	520 kips	LTC	4000'	160,000 lb	10.0 ppg
9.625"	HCK-55	40	4230 psi	3950 psi	694 kips	LTC	1600'	64,000 lb	10.0 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Complete internal evacuation of the casing, utilizing a collapse force equivalent to the mud gradient (0.52 psi/ft) in which the casing will be ran.
- Cementing operations in which, utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal back-up force equivalent to the fresh water displacement fluid (0.433 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Complete Evacuation:

$$J-55: 2570\text{psi} / [(0.52\text{psi/ft})(4,000')] = 1.25$$

$$HCK-55: 4230\text{psi} / [(0.52\text{psi/ft})(5,600')] = 1.45$$

Cementing Operations:

$$J-55: 2570\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(4000')] = 1.91$$

$$HCK-55: 4230\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(5600')] = 2.24$$

Burst: $DF_B = 1.25$

Base Assumption

- Casing pressure test as per Onshore Oil and Gas Order No. 2 (0.22 psi/ft or 1500 psi), utilizing an internal force equivalent to the displacement fluid of 8.6 ppg and external force equivalent to 8.4 ppg.
- Gas kick at the casing shoe, in which a 0.7 psi/ft shoe test is assumed, and 0.2 psi/ft gas gradient is assumed.

Burst Calculations: Internal Yield Rating / Burst Force

Casing Pressure Test:

$$J-55: 3950\text{psi} / [(1500\text{psi} + 1789\text{psi}) - (1747\text{psi})] = 2.56$$

$$HCK-55: 3950\text{psi} / [(1500\text{psi} + 2504\text{psi}) - (2446\text{psi})] = 2.54$$

Gas Kick:

$$J-55: 3950\text{psi} / [(0.7\text{psi/ft})(5600') - (0.2\text{psi/ft})(5600')] = 1.41$$

$$HCK-55: 3950\text{psi} / [(0.7\text{psi/ft})(5600') - (0.2\text{psi/ft})(4000')] = 1.27$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight of the string and not considering the effects of buoyancy.

Tensile Calculations: Joint Strength / Axial Load

Overpull:

J-55: 520 kips / (100,000 lbs. + 224,00 lbs.) = **1.6**

HCK-55: 694 kips / (100,000 lbs. + 64,100 lbs.) = **4.23**

Production Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
5.5"	P-110	20	11080 psi	12360 psi	641 kips	BTC	17,700'	354,000 lb	9.1 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Cementing operations in which utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal back-up force equivalent to the fresh water displacement fluid (0.433 psi/ft).
- Production operations in which the pipe is completely evacuated with an external force equivalent to the pore pressure gradient (0.52 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Cementing Operations:

$$11,080\text{psi} / [(0.66\text{psi/ft} - 0.433\text{psi/ft})(10,500'\text{TVD})] = \mathbf{3.13}$$

Production Operations:

$$11080\text{psi} / (10,500'\text{ TVD})(0.52\text{psi/ft}) = \mathbf{2.03}$$

Burst: $DF_B = 1.25$

Base Assumption

- Frac pressure utilizing an internal force of 9500 psi along with a frac fluid gradient equivalent to 0.468 psi/ft and an external force equal to the minimum fluid gradient (0.433 psi/ft) in which the casing will be ran.
- Production operations in which the casing is completely filled with a gas equivalent gradient of 0.2 psi/ft and an external force equivalent to pore pressure of 0.5 psi/ft.

Burst Calculations: Internal Yield Rating / Burst Force

Frac Pressure:

$$12,360\text{psi} / [(9500\text{ psi}) + (0.468 - 0.433\text{psi/ft})(10,500'\text{TVD})] = \mathbf{1.28}$$

Production Operations:

$$12,360\text{psi} / [(0.5\text{ psi/ft} - 0.2\text{ psi/ft})(10,500'\text{TVD})] = \mathbf{3.92}$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight of the string and considering the effects of buoyancy (factor =0.86).

Tensile Calculations: Joint Strength / Axial Load

Overpull:

$$641,000\text{ lbs} / [(100,000\text{ lbs.}) + (354,000\text{ lbs.})(0.86)] = \mathbf{1.6}$$

Contingency String (If Necessary)										
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight	
13.375	H-40		48	770	1730	322 ST&C		375	18000	8.5

Surface Casing										
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight	
8.625	J-55		24	1370	2950	244 ST&C		425	10200	9.9

Production Casing										
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight	
5.5	J-55		17	4910	5320	272 LT&C		4100	69700	9.9

Casing Parameters

Tensile

$$SF_t = \text{Tensile} / \text{Weight} ; \text{ Must exceed } 2.0$$

13.375 Contingency	322000	/	18000	=	17.89
8.625 Surface	244000	/	10200	=	23.92
5.5 Production	272000	/	69700	=	3.90

Collapse

$$SF_c = \text{Collapse} / (\text{Mud Gradient} \times \text{TVD}) ; \text{ Must exceed } 1.18$$

13.375 Contingency	770	/	165.5588	=	4.65
8.625 Surface	1370	/	218.5376	=	6.27
5.5 Production	4910	/	2108.245	=	2.33

Burst

$$SF_b = \text{Burst} / (\text{Mud Gradient} \times \text{TVD}) ; \text{ Must exceed } 1.18$$

13.375 Contingency	1730	/	165.5588	=	10.45
8.625 Surface	2950	/	218.5376	=	13.50
5.5 Production	5320	/	2108.245	=	2.52

Surface Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
13.375"	J-55	54.5	1130 psi	2730 psi	514 kips	STC	1800'	98,100 lbs	8.5 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Complete internal evacuation of the casing, utilizing a collapse force equivalent to the mud gradient (0.44 psi/ft) in which the casing will be ran.
- Cementing operations in which, utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal force equivalent to the fresh water displacement fluid (0.433 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Complete Evacuation:

$$1,130 \text{ psi} / [(0.44 \text{ psi/ft})(1,800')] = 1.42$$

Cementing Operations:

$$1,130 \text{ psi} / [(0.77 \text{ psi/ft} - 0.433 \text{ psi/ft})(1800')] = 1.86$$

Burst: $DF_B = 1.25$

Base Assumption

- Casing pressure test as per Onshore Oil and Gas Order No. 2 (0.22 psi/ft or 1500 psi), utilizing an external force equivalent to the mud gradient (0.44 psi/ft) in which the casing will be ran.

Burst Calculations: Internal Yield Rating / Internal Force

Casing Pressure Test:

$$2,730 \text{ psi} / [(1500 \text{ psi}) - (0.44 \text{ psi/ft})(1,800')] = 3.86$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight and not considering the effects of buoyancy.

Tensile Calculations: Joint Strength / Axial Load

Overpull:

$$514 \text{ kips} / (100,000 \text{ lbs.} + 98,100 \text{ lbs.}) = 2.59$$

Intermediate Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
9.625"	J-55	40	2570 psi	3950 psi	520 kips	LTC	4000'	160,000 lb	10.0 ppg
9.625"	HCK-55	40	4230 psi	3950 psi	694 kips	LTC	1600'	64,000 lb	10.0 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Complete internal evacuation of the casing, utilizing a collapse force equivalent to the mud gradient (0.52 psi/ft) in which the casing will be ran.
- Cementing operations in which, utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal back-up force equivalent to the fresh water displacement fluid (0.433 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Complete Evacuation:

$$\text{J-55: } 2570\text{psi} / [(0.52\text{psi/ft})(4,000')] = \mathbf{1.25}$$

$$\text{HCK-55: } 4230\text{psi} / [(0.52\text{psi/ft})(5,600')] = \mathbf{1.45}$$

Cementing Operations:

$$\text{J-55: } 2570\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(4000')] = \mathbf{1.91}$$

$$\text{HCK-55: } 4230\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(5600')] = \mathbf{2.24}$$

Burst: $DF_B = 1.25$

Base Assumption

- Casing pressure test as per Onshore Oil and Gas Order No. 2 (0.22 psi/ft or 1500 psi), utilizing an internal force equivalent to the displacement fluid of 8.6 ppg and external force equivalent to 8.4 ppg.
- Gas kick at the casing shoe, in which a 0.7 psi/ft shoe test is assumed, and 0.2 psi/ft gas gradient is assumed.

Burst Calculations: Internal Yield Rating / Burst Force

Casing Pressure Test:

$$\text{J-55: } 3950\text{psi} / [(1500\text{psi} + 1789\text{psi}) - (1747\text{psi})] = \mathbf{2.56}$$

$$\text{HCK-55: } 3950\text{psi} / [(1500\text{psi} + 2504\text{psi}) - (2446\text{psi})] = \mathbf{2.54}$$

Gas Kick:

$$\text{J-55: } 3950\text{psi} / [(0.7\text{psi/ft})(5600') - (0.2\text{psi/ft})(5600')] = \mathbf{1.41}$$

$$\text{HCK-55: } 3950\text{psi} / [(0.7\text{psi/ft})(5600') - (0.2\text{psi/ft})(4000')] = \mathbf{1.27}$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight of the string and not considering the effects of buoyancy.

Tensile Calculations: Joint Strength / Axial Load

Overpull:

J-55: $520 \text{ kips} / (100,000 \text{ lbs.} + 224,00 \text{ lbs.}) = 1.6$

HCK-55: $694 \text{ kips} / (100,000 \text{ lbs.} + 64,100 \text{ lbs.}) = 4.23$

Production Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
5.5"	P-110	20	11080 psi	12360 psi	641 kips	BTC	17,700'	354,000 lb	9.1 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Cementing operations in which utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal back-up force equivalent to the fresh water displacement fluid (0.433 psi/ft).
- Production operations in which the pipe is completely evacuated with an external force equivalent to the pore pressure gradient (0.52 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Cementing Operations:

$$11,080\text{psi} / [(0.66\text{psi/ft} - 0.433\text{ psi/ft})(10,500'\text{TVD})] = \mathbf{3.13}$$

Production Operations:

$$11080\text{psi} / (10,500'\text{ TVD})(0.52\text{psi/ft}) = \mathbf{2.03}$$

Burst: $DF_B = 1.25$

Base Assumption

- Frac pressure utilizing an internal force of 9500 psi along with a frac fluid gradient equivalent to 0.468 psi/ft and an external force equal to the minimum fluid gradient (0.433 psi/ft) in which the casing will be ran.
- Production operations in which the casing is completely filled with a gas equivalent gradient of 0.2 psi/ft and an external force equivalent to pore pressure of 0.5 psi/ft.

Burst Calculations: Internal Yield Rating / Burst Force

Frac Pressure:

$$12,360\text{psi} / [(9500\text{ psi}) + (0.468 - 0.433\text{psi/ft})(10,500'\text{TVD})] = \mathbf{1.28}$$

Production Operations:

$$12,360\text{psi} / [(0.5\text{ psi/ft} - 0.2\text{ psi/ft})(10,500'\text{TVD})] = \mathbf{3.92}$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight of the string and considering the effects of buoyancy (factor =0.86).

Tensile Calculations: Joint Strength / Axial Load

Overpull:

$$641,000\text{ lbs} / [(100,000\text{ lbs.}) + (354,000\text{ lbs.})(0.86)] = \mathbf{1.6}$$

Contingency String (If Necessary)									
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight
13.375	H-40		48	770	1730	322 ST&C	375	18000	8.5

Surface Casing									
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight
8.625	J-55		24	1370	2950	244 ST&C	425	10200	9.9

Production Casing									
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight
5.5	J-55		17	4910	5320	272 LT&C	4100	69700	9.9

Casing Parameters

Tensile

SF_t = Tensile / Weight ; Must exceed 2.0

13.375 Contingency	322000	/	18000	=	17.89
8.625 Surface	244000	/	10200	=	23.92
5.5 Production	272000	/	69700	=	3.90

Collapse

SF_c = Collapse / (Mud Gradient x TVD) ; Must exceed 1.18

13.375 Contingency	770	/	165.5588	=	4.65
8.625 Surface	1370	/	218.5376	=	6.27
5.5 Production	4910	/	2108.245	=	2.33

Burst

SF_b = Burst / (Mud Gradient x TVD); Must exceed 1.18

13.375 Contingency	1730	/	165.5588	=	10.45
8.625 Surface	2950	/	218.5376	=	13.50
5.5 Production	5320	/	2108.245	=	2.52

Surface Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
13.375"	J-55	54.5	1130 psi	2730 psi	514 kips	STC	1800'	98,100 lbs	8.5 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Complete internal evacuation of the casing, utilizing a collapse force equivalent to the mud gradient (0.44 psi/ft) in which the casing will be ran.
- Cementing operations in which, utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal force equivalent to the fresh water displacement fluid (0.433 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Complete Evacuation:

$$1,130\text{psi} / [(0.44\text{psi/ft})(1,800')] = \mathbf{1.42}$$

Cementing Operations:

$$1,130\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(1,800')] = \mathbf{1.86}$$

Burst: $DF_B = 1.25$

Base Assumption

- Casing pressure test as per Onshore Oil and Gas Order No. 2 (0.22 psi/ft or 1500 psi), utilizing an external force equivalent to the mud gradient (0.44 psi/ft) in which the casing will be ran.

Burst Calculations: Internal Yield Rating / Internal Force

Casing Pressure Test:

$$2,730\text{psi} / [(1500\text{psi}) - (0.44\text{psi/ft})(1,800')] = \mathbf{3.86}$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight and not considering the effects of buoyancy.

Tensile Calculations: Joint Strength / Axial Load

Overpull:

$$514\text{ kips} / (100,000\text{ lbs.} + 98,100\text{ lbs.}) = \mathbf{2.59}$$

Intermediate Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
9.625"	J-55	40	2570 psi	3950 psi	520 kips	LTC	4000'	160,000 lb	10.0 ppg
9.625"	HCK-55	40	4230 psi	3950 psi	694 kips	LTC	1600'	64,000 lb	10.0 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Complete internal evacuation of the casing, utilizing a collapse force equivalent to the mud gradient (0.52 psi/ft) in which the casing will be ran.
- Cementing operations in which, utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal back-up force equivalent to the fresh water displacement fluid (0.433 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Complete Evacuation:

$$\text{J-55: } 2570\text{psi} / [(0.52\text{psi/ft})(4,000')] = \mathbf{1.25}$$

$$\text{HCK-55: } 4230\text{psi} / [(0.52\text{psi/ft})(5,600')] = \mathbf{1.45}$$

Cementing Operations:

$$\text{J-55: } 2570\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(4000')] = \mathbf{1.91}$$

$$\text{HCK-55: } 4230\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(5600')] = \mathbf{2.24}$$

Burst: $DF_B = 1.25$

Base Assumption

- Casing pressure test as per Onshore Oil and Gas Order No. 2 (0.22 psi/ft or 1500 psi), utilizing an internal force equivalent to the displacement fluid of 8.6 ppg and external force equivalent to 8.4 ppg.
- Gas kick at the casing shoe, in which a 0.7 psi/ft shoe test is assumed, and 0.2 psi/ft gas gradient is assumed.

Burst Calculations: Internal Yield Rating / Burst Force

Casing Pressure Test:

$$\text{J-55: } 3950\text{psi} / [(1500\text{psi} + 1789\text{psi}) - (1747\text{psi})] = \mathbf{2.56}$$

$$\text{HCK-55: } 3950\text{psi} / [(1500\text{psi} + 2504\text{psi}) - (2446\text{psi})] = \mathbf{2.54}$$

Gas Kick:

$$\text{J-55: } 3950\text{psi} / [(0.7\text{psi/ft})(5600') - (0.2\text{psi/ft})(5600')] = \mathbf{1.41}$$

$$\text{HCK-55: } 3950\text{psi} / [(0.7\text{psi/ft})(5600') - (0.2\text{psi/ft})(4000')] = \mathbf{1.27}$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight of the string and not considering the effects of buoyancy.

Tensile Calculations: Joint Strength / Axial Load

Overpull:

J-55: 520 kips / (100,000 lbs. + 224,00 lbs.) = **1.6**

HCK-55: 694 kips / (100,000 lbs. + 64,100 lbs.) = **4.23**

Production Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
5.5"	P-110	20	11080 psi	12360 psi	641 kips	BTC	17,700'	354,000 lb	9.1 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Cementing operations in which utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal back-up force equivalent to the fresh water displacement fluid (0.433 psi/ft).
- Production operations in which the pipe is completely evacuated with an external force equivalent to the pore pressure gradient (0.52 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Cementing Operations:

$$11,080\text{psi} / [(0.66\text{psi/ft} - 0.433\text{ psi/ft})(10,500'\text{TVD})] = \mathbf{3.13}$$

Production Operations:

$$11080\text{psi} / (10,500'\text{ TVD})(0.52\text{psi/ft}) = \mathbf{2.03}$$

Burst: $DF_B = 1.25$

Base Assumption

- Frac pressure utilizing an internal force of 9500 psi along with a frac fluid gradient equivalent to 0.468 psi/ft and an external force equal to the minimum fluid gradient (0.433 psi/ft) in which the casing will be ran.
- Production operations in which the casing is completely filled with a gas equivalent gradient of 0.2 psi/ft and an external force equivalent to pore pressure of 0.5 psi/ft.

Burst Calculations: Internal Yield Rating / Burst Force

Frac Pressure:

$$12,360\text{psi} / [(9500\text{ psi}) + (0.468 - 0.433\text{psi/ft})(10,500'\text{TVD})] = \mathbf{1.28}$$

Production Operations:

$$12,360\text{psi} / [(0.5\text{ psi/ft} - 0.2\text{ psi/ft})(10,500'\text{TVD})] = \mathbf{3.92}$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight of the string and considering the effects of buoyancy (factor =0.86).

Tensile Calculations: Joint Strength / Axial Load

Overpull:

$$641,000\text{ lbs} / [(100,000\text{ lbs.}) + (354,000\text{ lbs.})(0.86)] = \mathbf{1.6}$$

Contingency String (If Necessary)										
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight	
13.375	H-40		48	770	1730	322 ST&C		375	18000	8.5

Surface Casing										
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight	
8.625	J-55		24	1370	2950	244 ST&C		425	10200	9.9

Production Casing										
Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight	
5.5	J-55		17	4910	5320	272 LT&C		4100	69700	9.9

Casing Parameters

Tensile

SF_t = Tensile / Weight ; Must exceed 2.0

13.375 Contingency	322000	/	18000	=	17.89
8.625 Surface	244000	/	10200	=	23.92
5.5 Production	272000	/	69700	=	3.90

Collapse

SF_c = Collapse / (Mud Gradient x TVD) ; Must exceed 1.18

13.375 Contingency	770	/	165.5588	=	4.65
8.625 Surface	1370	/	218.5376	=	6.27
5.5 Production	4910	/	2108.245	=	2.33

Burst

SF_b = Burst / (Mud Gradient x TVD); Must exceed 1.18

13.375 Contingency	1730	/	165.5588	=	10.45
8.625 Surface	2950	/	218.5376	=	13.50
5.5 Production	5320	/	2108.245	=	2.52

Surface Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
13.375"	J-55	54.5	1130 psi	2730 psi	514 kips	STC	1800'	98,100 lbs	8.5 ppg

Collapse: $DF_c = 1.25$

Base Assumptions

- Complete internal evacuation of the casing, utilizing a collapse force equivalent to the mud gradient (0.44 psi/ft) in which the casing will be ran.
- Cementing operations in which, utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal force equivalent to the fresh water displacement fluid (0.433 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Complete Evacuation:

$$1,130\text{psi} / [(0.44\text{psi/ft})(1,800')] = 1.42$$

Cementing Operations:

$$1,130\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(1,800')] = 1.86$$

Burst: $DF_B = 1.25$

Base Assumption

- Casing pressure test as per Onshore Oil and Gas Order No. 2 (0.22 psi/ft or 1500 psi), utilizing an external force equivalent to the mud gradient (0.44 psi/ft) in which the casing will be ran.

Burst Calculations: Internal Yield Rating / Internal Force

Casing Pressure Test:

$$2,730\text{psi} / [(1500\text{psi}) - (0.44\text{psi/ft})(1,800')] = 3.86$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight and not considering the effects of buoyancy.

Tensile Calculations: Joint Strength / Axial Load

Overpull:

$$514\text{ kips} / (100,000\text{ lbs.} + 98,100\text{ lbs.}) = 2.59$$

Intermediate Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
9.625"	J-55	40	2570 psi	3950 psi	520 kips	LTC	4000'	160,000 lb	10.0 ppg
9.625"	HCK-55	40	4230 psi	3950 psi	694 kips	LTC	1600'	64,000 lb	10.0 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Complete internal evacuation of the casing, utilizing a collapse force equivalent to the mud gradient (0.52 psi/ft) in which the casing will be ran.
- Cementing operations in which, utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal back-up force equivalent to the fresh water displacement fluid (0.433 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Complete Evacuation:

$$\text{J-55: } 2570\text{psi} / [(0.52\text{psi/ft})(4,000')] = \mathbf{1.25}$$

$$\text{HCK-55: } 4230\text{psi} / [(0.52\text{psi/ft})(5,600')] = \mathbf{1.45}$$

Cementing Operations:

$$\text{J-55: } 2570\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(4000')] = \mathbf{1.91}$$

$$\text{HCK-55: } 4230\text{psi} / [(0.77\text{psi/ft} - 0.433\text{psi/ft})(5600')] = \mathbf{2.24}$$

Burst: $DF_B = 1.25$

Base Assumption

- Casing pressure test as per Onshore Oil and Gas Order No. 2 (0.22 psi/ft or 1500 psi), utilizing an internal force equivalent to the displacement fluid of 8.6 ppg and external force equivalent to 8.4 ppg.
- Gas kick at the casing shoe, in which a 0.7 psi/ft shoe test is assumed, and 0.2 psi/ft gas gradient is assumed.

Burst Calculations: Internal Yield Rating / Burst Force

Casing Pressure Test:

$$\text{J-55: } 3950\text{psi} / [(1500\text{psi} + 1789\text{psi}) - (1747\text{psi})] = \mathbf{2.56}$$

$$\text{HCK-55: } 3950\text{psi} / [(1500\text{psi} + 2504\text{psi}) - (2446\text{psi})] = \mathbf{2.54}$$

Gas Kick:

$$\text{J-55: } 3950\text{psi} / [(0.7\text{psi/ft})(5600') - (0.2\text{psi/ft})(5600')] = \mathbf{1.41}$$

$$\text{HCK-55: } 3950\text{psi} / [(0.7\text{psi/ft})(5600') - (0.2\text{psi/ft})(4000')] = \mathbf{1.27}$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight of the string and not considering the effects of buoyancy.

Tensile Calculations: Joint Strength / Axial Load

Overpull:

J-55: 520 kips / (100,000 lbs. + 224,00 lbs.) = 1.6

HCK-55: 694 kips / (100,000 lbs. + 64,100 lbs.) = 4.23

Production Casing

Size	Grade	#/ft	Collapse	Burst (Internal Yield)	Tensile	Coupling	Length	Dry Weight	Mud Weight
5.5"	P-110	20	11080 psi	12360 psi	641 kips	BTC	17,700'	354,000 lb	9.1 ppg

Collapse: $DF_C = 1.25$

Base Assumptions

- Cementing operations in which utilizes a collapse force equivalent to the gradient of the planned cement slurry (0.77 psi/ft) and an internal back-up force equivalent to the fresh water displacement fluid (0.433 psi/ft).
- Production operations in which the pipe is completely evacuated with an external force equivalent to the pore pressure gradient (0.52 psi/ft).

Collapse Calculations: Collapse Rating / Collapse Force

Cementing Operations:

$$11,080 \text{ psi} / [(0.66 \text{ psi/ft} - 0.433 \text{ psi/ft})(10,500' \text{ TVD})] = 3.13$$

Production Operations:

$$11,080 \text{ psi} / (10,500' \text{ TVD})(0.52 \text{ psi/ft}) = 2.03$$

Burst: $DF_B = 1.25$

Base Assumption

- Frac pressure utilizing an internal force of 9500 psi along with a frac fluid gradient equivalent to 0.468 psi/ft and an external force equal to the minimum fluid gradient (0.433 psi/ft) in which the casing will be ran.
- Production operations in which the casing is completely filled with a gas equivalent gradient of 0.2 psi/ft and an external force equivalent to pore pressure of 0.5 psi/ft.

Burst Calculations: Internal Yield Rating / Burst Force

Frac Pressure:

$$12,360 \text{ psi} / [(9500 \text{ psi}) + (0.468 - 0.433 \text{ psi/ft})(10,500' \text{ TVD})] = 1.28$$

Production Operations:

$$12,360 \text{ psi} / [(0.5 \text{ psi/ft} - 0.2 \text{ psi/ft})(10,500' \text{ TVD})] = 3.92$$

Tensile: $DF_T = 1.6$

Base Assumption

- A downward force of 100,000 lb. overpull is applied at the base of the casing along with the weight of the string and considering the effects of buoyancy (factor = 0.86).

Tensile Calculations: Joint Strength / Axial Load

Overpull:

$$641,000 \text{ lbs} / [(100,000 \text{ lbs.}) + (354,000 \text{ lbs.})(0.86)] = 1.6$$

Contingency String (If Necessary)

Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight
13.375	H-40		48	770	1730	322 ST&C	375	18000	8.5

Surface Casing

Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight
8.625	J-55		24	1370	2950	244 ST&C	425	10200	9.9

Production Casing

Size	Grade	#/ft	Collapse	Yield	Tensile	Coupling	Length	Weight	Mud Weight
5.5	J-55		17	4910	5320	272 LT&C	4100	69700	9.9

Casing Parameters

Tensile

$$SF_t = \text{Tensile} / \text{Weight} ; \text{Must exceed } 2.0$$

13.375 Contingency	322000	/	18000	=	17.89
8.625 Surface	244000	/	10200	=	23.92
5.5 Production	272000	/	69700	=	3.90

Collapse

$$SF_c = \text{Collapse} / (\text{Mud Gradient} \times \text{TVD}) ; \text{Must exceed } 1.18$$

13.375 Contingency	770	/	165.5588	=	4.65
8.625 Surface	1370	/	218.5376	=	6.27
5.5 Production	4910	/	2108.245	=	2.33

Burst

$$SF_b = \text{Burst} / (\text{Mud Gradient} \times \text{TVD}) ; \text{Must exceed } 1.18$$

13.375 Contingency	1730	/	165.5588	=	10.45
8.625 Surface	2950	/	218.5376	=	13.50
5.5 Production	5320	/	2108.245	=	2.52