SUBSEA KILL SHEET EXERCISE No. 5

Name: _____ Date: _____

Complete the Subsea vertical kill sheet provided on pages 2 and 3. Then answer questions 1 to 12. Please round calculations as per good well control practice.

Well data :

Hole size	8 ½ inches
Hole depth (Below RKB)	6,080 feet MD, 6040 ft TVD
Casing shoe depth	9 $^{5}/_{8}$ inches, 5000 ft MD/TVD
RKB to mean sea level (MSL)	50 feet
Internal capacities:	
Drill pipe	5 inch (S-135-NC50), capacity 0.0178 bbl/ft
Heavy wall drill pipe	5 inch, length 400 ft, capacity 0.0088 bbl/ft
Drill collars	6 ½ inch x 2$^{13}/_{16}$inch, length 600 ft, capacity 0.0077bbls/ft
Choke line	3 inch ID, length 515 ft, capacity 0.0087 bbls/ft
Marine riser	length 500 feet, capacity 0.3892 bbls/ft
Annulus capacities:	
Drill collars in open hole	0.0292 bbl/ft
Drill pipe and HWDP in open hole	0.0459 bbl/ft
Drill pipe and HWDP in casing	0.0505 bbl/ft
Drill pipe in Marine riser	0.3638 bbl/ft
Mud pump data:	
Pump output at 98% volumetric efficiency	0.102 bbl/stroke
Slow circulation rate data:	
@ 45 spm through the riser	400 psi
@ 45 spm through the choke line	500 psi
Other relevant information:	
Active surface fluid volume	460 bbl
Drill pipe, 5 inch closed end displacement	0.0254 bbl/ft
Seawater density	8.6 ppg
Surface line volume	14 bbls
Formation strength test data:	
Surface leak-off pressure with 10.0 ppg mud	1500 psi
Kick Data:	
The well kicked at 6040 vertical depth	
Shut in drill pipe pressure	600 psi
Shut in Casing pressure	870 psi
Recorded pit gain	19 bbls
Mud weight in hole	10.4 ppg

The well will be killed using the Wait and Weight method

Answer the following TWELVE questions from the data above. The attached kill sheet may be used to assist you with your calculations

International Well Control Forum
Subsea BOP Vertical Well Kill Sheet (Field Units)

DATE : _____

NAME : _____

FORMATION STRENGTH DATA:

SURFACE LEAK -OFF PRESSURE FROM FORMATION STRENGTH TEST (A) ____ psi

DRILLING FLUID DENSITY AT TEST (B) ____ ppg

MAX. ALLOWABLE DRILLING FLUID DENSITY =

(B) + (A) / SHOE T.V. DEPTH x 0.052 = (C) ____ ppg

INITIAL MAASP =

((C) - CURRENT DENSITY) x SHOE T.V. DEPTH x 0.052)

= ____ psi

CURRENT WELL DATA:

SUBSEA BOP DATA:

MARINE RISER LENGTH ____ feet

CHOKELINE LENGTH ____ feet

DRILLING FLUID:

DENSITY ____ ppg

CASING SHOE DATA:

SIZE ____ inch

M. DEPTH ____ feet

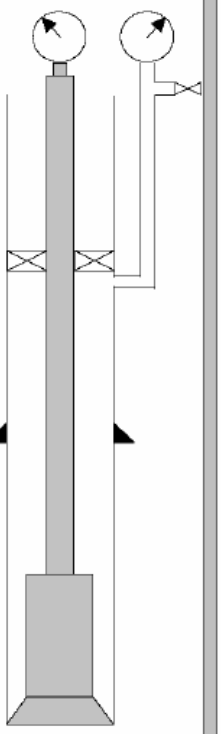
T.V. DEPTH ____ feet

HOLE DATA:

SIZE ____ inch

M. DEPTH ____ feet

T.V. DEPTH ____ feet



PUMP NO. 1 DISPL.	PUMP NO. 2 DISPL.
bbls / stroke	bbls / stroke

SLOW PUMP RATE DATA:	(PL) DYNAMIC PRESSURE LOSS [psi]					
	PUMP NO. 1			PUMP NO. 2		
	Riser	Choke Line	*Choke Line Friction*	Riser	Choke Line	*Choke Line Friction*
SPM						
SPM						

PRE-RECORDED VOLUME DATA:	LENGTH feet	CAPACITY bbls / feet	VOLUME barrels	PUMP STROKES Strokes	TIME Minutes
DRILL PIPE	x	=		VOLUME / PUMP DISPLACEMENT	
HEVI WALL DRILL PIPE	x	=			
DRILL COLLAR	x	=			
DRILL STRING VOLUME			(D)	(E) strokes	minutes
DC x OPEN HOLE	x	=			
DP / HWDP x OPEN HOLE	x	=	+		
OPEN HOLE VOLUME			(F)	strokes	minutes
DP x CASING	x	=	(G) +	strokes	minutes
CHOKELINE	x	=	(H) +	strokes	minutes
TOTAL ANNULUS/CHOKELINE VOLUME			(F+G+H) = (I)	strokes	minutes
TOTAL WELL SYSTEM VOLUME			(D+I) = (J)	strokes	minutes
ACTIVE SURFACE VOLUME			(K)	strokes	
TOTAL ACTIVE FLUID SYSTEM			(J+K)	strokes	
MARINE RISER x DP	x	=		strokes	

Dr No SSV 04/01
(Field Units)
27-01-2000

International Well Control Forum
Subsea BOP Vertical Well Kill Sheet (Field Units)

DATE : _____

NAME : _____

KICK DATA : SIDPP [ ] psi SICP [ ] psi PIT GAIN [ ] barrels

KILL FLUID DENSITY

KMD = CURRENT DRILLING FLUID DENSITY + SIDPP / (TVD x 0.052)

..... + _____ / X 0.052 = ... ppg

INITIAL CIRCULATING PRESSURE

ICP = DYNAMIC PRESSURE LOSS + SIDPP

..... + ... = ... psi

FINAL CIRCULATING PRESSURE

FCP = (KILL FLUID DENSITY / CURRENT DRILLING FLUID DENSITY) x DYNAMIC PRESSURE LOSS

_____ x ..... = ... psi

(L) = ICP - FCP = ... - ..... = ... psi

(L) x 100 / (E) = _____ X 100 = ... psi / 100 strokes

INITIAL DYNAMIC CASING PRESSURE AT KILL PUMP RATE

SICP - CHOKE LINE FRICTION ..... - ..... = ... psi

STROKES	PRESSURE [psi]

STATIC & DYNAMIC DRILL PIPE PRESSURE [psi] →

STROKES →

Dr No SSV 04/02 (Field Units) 27-01-2000

1. Calculate the pressure safety margin at the casing shoe in this static condition, assuming the top of the kick is below the casing shoe.

Answer_____ psi

4 points

2. How many strokes are required to pump from pump to bit?

Answer_____ strokes

4 points

3. How many strokes are required to pump from the bit to casing shoe?

Answer_____ strokes

4 points

4. How much time is required to circulate the total well system volume?

Answer_____ minutes

4 points

5. How many strokes are required to displace the marine riser to kill fluid before opening the BOP?

Answer_____ strokes

4 points

6. What is the kill mud density?

Answer_____ ppg

4 points

7. What is the Initial Circulating Pressure?

Answer_____ psi

4 points

8. What is the Final Circulating Pressure?

Answer_____ psi

4 points

9. What is the Initial dynamic casing pressure at kill pump rate?

Answer_____ psi

4 points

10. What is the MAASP after circulation of the kill mud?

Answer_____ psi

4 points

11. Calculate the pressure drop per 100 strokes of kill mud fluid pumped inside the drill string.

Answer_____ psi/100 strokes

4 points

12. If all the influx is at the bottom of the hole, calculate the gradient of the influx.

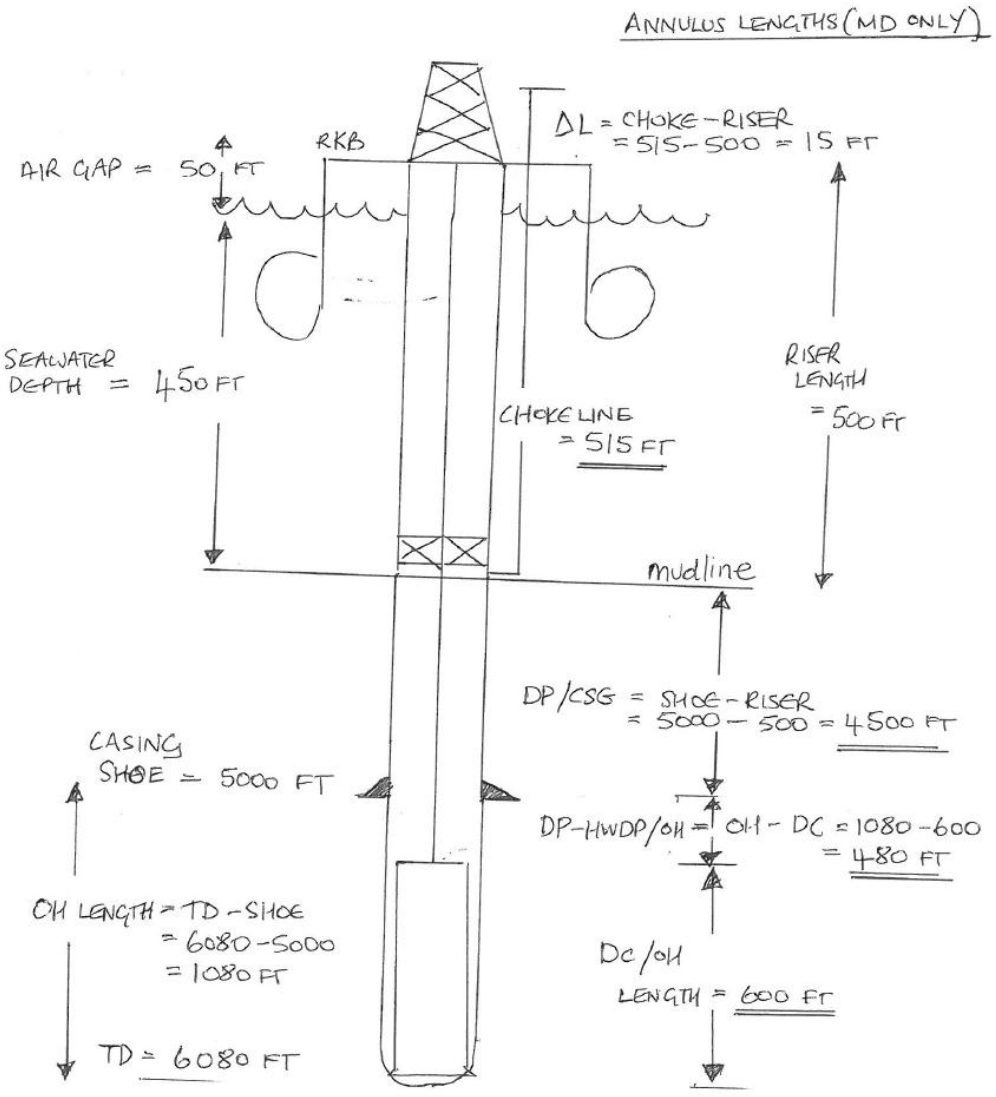
Answer_____ psi/ft

4 points

SUBSEA KILL SHEET EXERCISE NO. 5

Answers

Before attempting to fill in the kill sheet, draw a simple sketch of the well to determine the total annulus lengths. An example is shown below. Only use measured depths and remember that total annulus length (including the choke line) may not equal measured depth if the Choke line length is greater than the Riser length.



CHECK! = TOTAL ANNULU LENGTH – ΔL = MD
= (600 + 480 + 4500 + 515) FT – 15 FT
= 6095 – 15
= 6080 = MD

WELLTRAIN™

WELL CONTROL PRE-KICK SHEET (SUBSEA ONLY)

Name: Instructor Date: February 2012 Level:

(All depths measured from RKB)

Measured Depth: 6080 ft. True Vertical Depth: 6040 ft.

Measured Depth to Casing Shoe: 5000 ft. Casing Shoe TVD: 5000 ft.

Water Depth: 450 ft. Air Gap: 50 ft.

CAPACITIES AND VOLUMES

DRILL STRING DATA	O.D. (in)	I.D. (in)	Wt. (lb/ft)	CAPACITY (bbl/ft)	x LENGTH (ft)	= VOLUME (bbls)
DRILL PIPE				0.0178	5080	90.42
HWDP				0.0088	400	3.52
DRILL COLLARS				0.0077	600	4.62

CHECK THAT TOTAL LENGTH = MEASURED DEPTH

Total Length	Total Drillstring
6080 (ft)	98.56 (bbls)

ANNULUS DATA	CAPACITY (bbl/ft)	x LENGTH (ft)	= VOLUME (bbls)
CHOKE LINE	0.0087	515	4.48
DP/HWDP IN CASING	0.0505	4500	227.25
DP/HWDP IN OPEN HOLE	0.0459	480	22.03
COLLARS IN OPEN HOLE	0.0292	600	17.52

Note: Total Length may not equal Measured Depth if choke line is longer than the riser.

Total Length	Total Annulus
6095 (ft)	271.28 (bbls)

Bit to Shoe Volume: 39.55 (bbls)

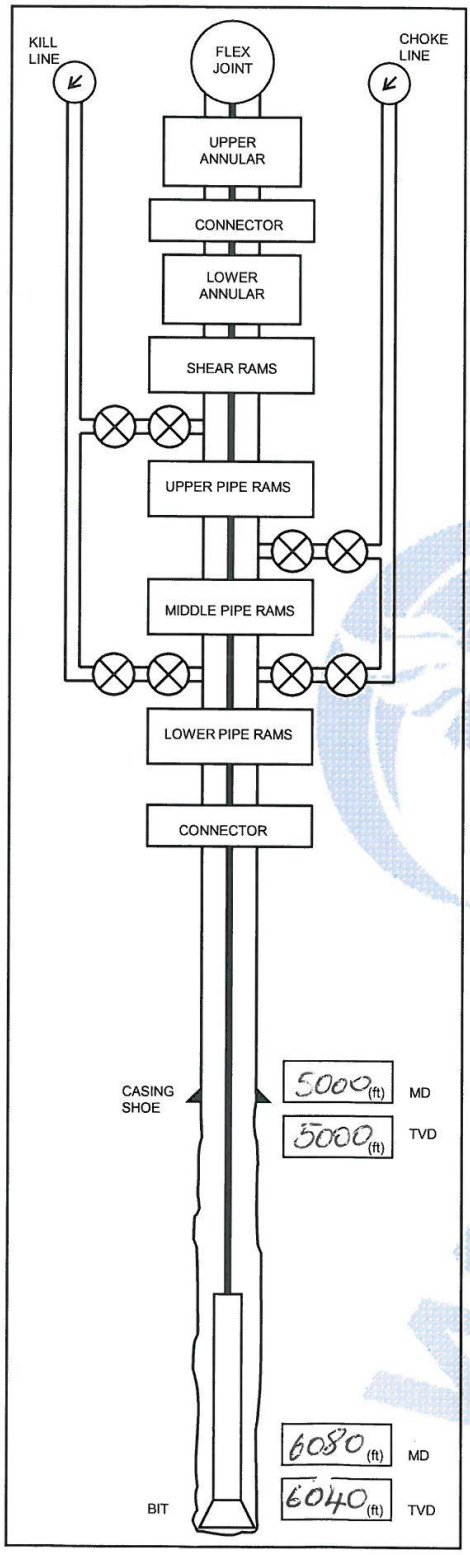
TOTAL SYSTEM VOLUME

TOTAL DRILLSTRING (SURFACE TO BIT)		TOTAL ANNULUS (BIT TO SURFACE)		TOTAL SYSTEM VOLUME
98.56 (bbls)	+	271.28 (bbls)	=	369.84 (bbls)

RISER DATA	CAPACITY (DP/RISER) (bbl/ft)	x LENGTH (ft)	= VOLUME (bbls)
DP/RISER ANNULUS VOLUME	0.3638	500	181.9

K3 Vertical API Field Units
Revised December 2011

WELL CONTROL PRE-KICK SHEET (SUBSEA ONLY)



Read and record SLOW CIRCULATING RATES

Pump No.	Pump Output
1	0.102 (bbls/stk)

S.C.R	CHOKE LINE		RISER		CHOKE LINE FRICTION
..... spm	(psi)	-	(psi)	=	(psi)
..... spm	(psi)	-	(psi)	=	(psi)
45 ..... spm	500 (psi)	-	400 (psi)	=	100 (psi)

Drill String Data

Drill String Volume (bbls)		Pump Output (bbls/stk)		Surface to Bit Strokes
98.56	÷	0.102	=	967

Surface to Bit Strokes		Slow Circulating Rate (spm)		Surface to Bit Time
967	÷	45	=	21.5 (min)

Open Hole Data

Bit to Shoe Volume (bbls)		Pump Output (bbls/stk)		Bit to Shoe Strokes
39.55	÷	0.102	=	388

Bit to Shoe Strokes		Slow Circulating Rate (spm)		Bit to Shoe Time
388	÷	45	=	8.6 (min)

Annulus Data

Bit to Surface Volume (bbls)		Pump Output (bbls/stk)		Bit to Surface Strokes
271.28	÷	0.102	=	2660

Bit to Surface Strokes		Slow Circulating Rate (spm)		Bit to Surface Time
2660	÷	45	=	59.1 (min)

Riser Data

DP/Riser Volume (bbls)		Pump Output (bbls/stk)		BOP to Surface Strokes
181.9	÷	0.102	=	1784

BOP to Surface Strokes		Slow Circulating Rate (spm)		BOP to Surface Time
1784	÷	45	=	39.6 (min)

K3 Vertical API Field Units
Revised December 2011

WELLTRAIN™

WELL CONTROL KICK SHEET (SUBSEA ONLY)

Name: Instructor

Read and record SIDPP, SICP and PIT GAIN

S.I.D.P.P.	PIT GAIN	S.I.C.P.
600 psi	19 bbls	870 psi

Day: ..... Date: February 2012 Time: .....

Max. Mud Wt.

[Surface Leak Off Test: 1500 (psi) ÷ Casing T.V.D. from RKB: 5000 (ft) ÷ 0.052] + Leak Off Test Mud Weight: 10.0 (ppg) = **Maximum Mud Weight**: 15.7 (ppg)

OR

Formation Breakdown Gradient: ..... (psi/ft) ÷ 0.052 = **Maximum Mud Weight**: ..... (ppg)

M.A.S.P.

[Maximum Mud Weight: 15.7 (ppg) - Drilling Mud Weight: 10.4 (ppg)] X 0.052 X Casing T.V.D. from RKB: 5000 (ft) = **Maximum Allowable Annulus Surface Pressure**: 1378 (psi)

M.A.C.P.

Casing Burst

Casing Yield: ..... X Safety Factor: 0.8 = **Maximum Allowable Casing Pressure**: ..... (psi)

Kill Mud Wt.

[S.I.D.P.P.: 600 (psi) ÷ T.V.D. from RKB: 6040 (ft) ÷ 0.052] + Drilling Mud Weight: 10.4 (ppg) = **Kill Mud Weight**: 12.4 (ppg)

NEW M.A.A.S.P.

[Maximum Mud Weight: 15.7 (ppg) - Kill Mud Weight: 12.4 (ppg)] X 0.052 X Casing T.V.D. from RKB: 5000 (ft) = **New Maximum Allowable Annulus Surface Pressure**: 858 (psi)

K3 Vertical API Field Units
Revised December 2011

WELL CONTROL KICK SHEET (SUBSEA ONLY)

Pressure Step Down Chart

1) Calculate I.C.P. **2)** Calculate F.C. P. **3)** Calculate Step-down.
4) In the left column record strokes in 100 stroke intervals, until final circulating pressure is reached
5) Record I.C.P. in top right column, and deduct the pressure step down ΔP until F.C.P. is reached
6) Calculate adjusted choke line friction (using Kill Mud).
7) Calculate complete circulation, in strokes and time

ΔP x 100: 54 (psi/100 stks)

I.C.P.

SCR Riser 400 (psi) + SIDPP 600 (psi) = **Initial Circulating Pressure** 1000 (psi)

F.C.P.

SCR Riser 400 (psi) X [Kill Mud 12.4 (ppg) ÷ Drilling Mud 10.4 (ppg)] = **Final Circulating Pressure** 477 (psi)

ΔP

[ICP 1000 (psi) - FCP 477 (psi)] ÷ Surface to Bit strokes 967 (stks) = **Pressure Step-down** 0.54 (psi/stk)

I.D.C.P.

SICP 870 (psi) - Choke Line Friction 100 (psi) = **Initial Dynamic Casing Pressure** 770 (psi)

Adjusted Choke Line Friction

Choke Line Friction 100 (psi) X [Kill Mud 12.4 (ppg) ÷ Drilling Mud 10.4 (ppg)] = **Adjusted Choke Line Friction** 119 (psi)

Complete Circulation Data

Surface to Bit Strokes 967 + Bit to Surface strokes 2660 = **Total Strokes to Kill Well** 3627

Surface to Bit Time 21.5 (min) + Bit to Surface Time 59.1 (min) = **Total Time to Kill Well** 80.6 (min)

Riser Data

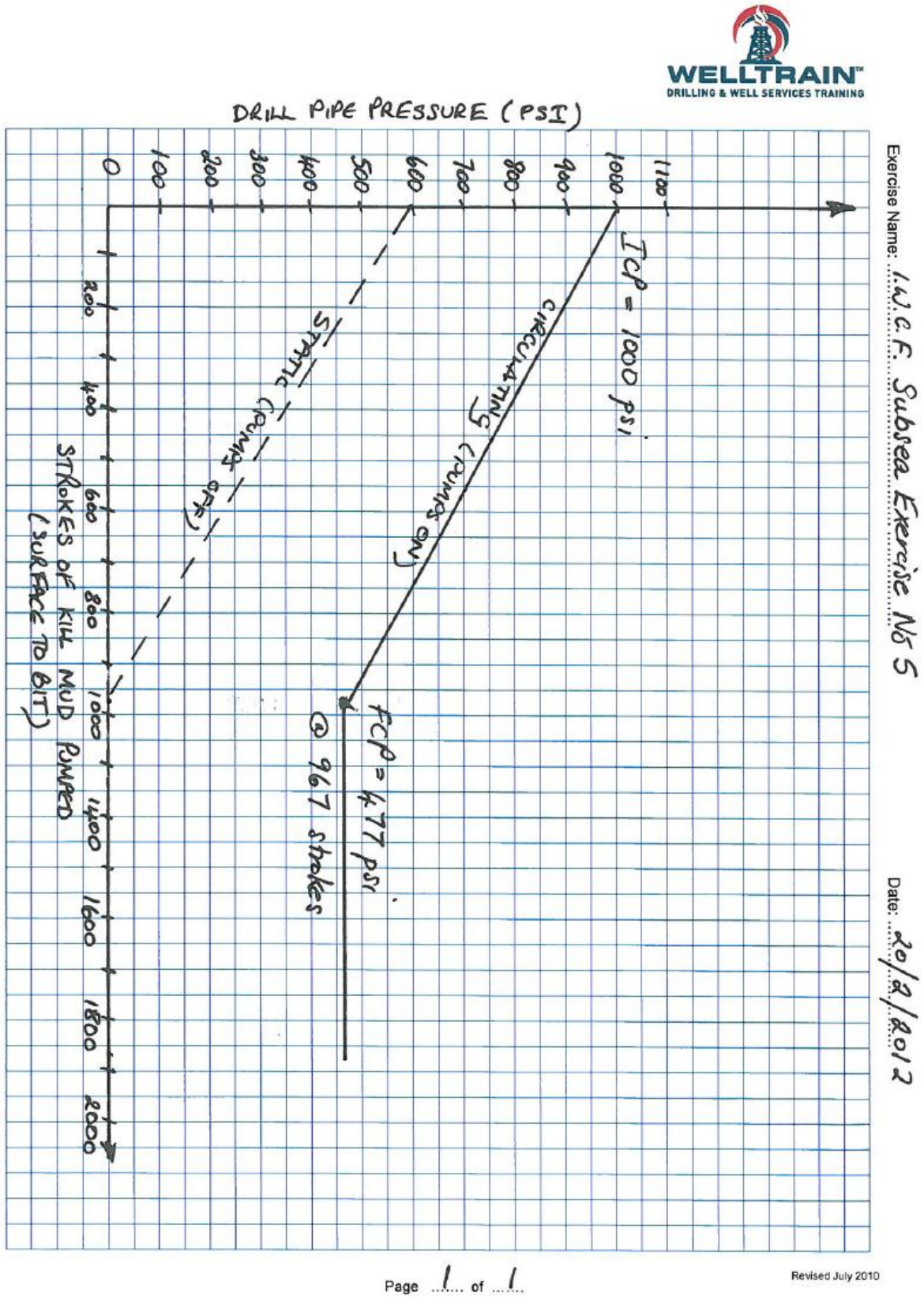
DP/Riser Volume 181.9 (bbl) ÷ Pump Output 0.102 (bbl/stk) = **Riser Strokes** 1784

Riser strokes 1784 ÷ Slow Circulating Rate 45 (spm) = **Time to Displace Riser** 39.6 (min)

Strokes to Bit	Minimum D.P psi	Safety Margin
0	ICP = 1000	
100	946	
200	892	
300	838	
400	784	
500	730	
600	676	
700	622	
800	568	
900	514	
967	477	

K3 Vertical API Field Units
Revised December 2011

Updated 24/4/2012 - D.P.


WELLTRAIN
DRILLING & WELL SERVICES TRAINING
DRILL PIPE PRESSURE (PSI)
0
100
200
300
400
500
600
700
800
900
1000
1100
200
400
600
800
1000
1200
1400
1600
1800
2000
STROKES OF KILL MUD PUMPED
(SURFACE TO BIT)
STATIC (PUMP OFF)
CIRCULATING (PUMP ON)
ICP = 1000 PSI
FCP = 477 PSI
@ 967 strokes
Exercise Name: I.W.C.F. Subsea Exercise No 5
Date: 20/2/2012
Page 1 of 1
Revised July 2010

SUBSEA KILL SHEET EXERCISE NO. 5

Answers

1. **508 psi**

   Pressure Safety Margin = MAASP – SICP

   = 1378 psi – 870 psi

   = 508 psi

2. **1104 strokes**

   From Kill Sheet, surface to bit strokes = 967 stokes

   Surface line strokes = 14 bbls ÷ 0.102 bbl/stroke = 137 strokes

   Pump to Bit stokes = 967 + 137 = 1104 strokes

3. **388 strokes**

4. **80 - 81 minutes (80.6 minutes)**

5. **1782 - 1786 strokes (1784 strokes)**

6. **12.4 ppg**

7. **1000 psi**

8. **477 psi**

9. **770 psi**

10. **858 psi**

    New MAASP = (Max. Allowable Mud Density – Kill Mud Density) x 0.052 x TVD_{shoe}

    = (15.7 ppg – 12.4 ppg) x 0.052 x 5000 ft.

    = 858 psi

11. 54 psi/100 strokes

    = 239.2 feet

12. Volume of Influx around Drill Collars = DC/OH annular capacity(bbls/ft) x DC Collar length

= 0.0292 bbls/ft x 600 feet

= 17.52 bbls

Voulme of Influx around HWDP = Kick Volume - 17.52 bbls

= 19 bbls – 17.52 bbls

= 1.48 bbls

Height of Influx above Drill Collars = 1.48 bbls ÷ HWDP/OH annular capacity (bbls/ft)

= 19 bbls ÷ 0.0459 bbls/ft

= 32.2 feet

Total Influx height = 600 + 32.2 feet = 632.2 feet

Formation Pressure = SIDDP + HP string

= 600 + (10.4 ppg x 0.052 x 6040 ft)

= 600 psi + 3266.4 psi

= 3866.4 psi

HSP mud in annulus = 10.4 ppg x 0.052 x (6040 ft -632.2 ft)

= 10.4 ppg x 0.052 x 5407.8 ft.

= 2924.5 psi

Kick Hydrostatic = Formation Pressure – SICP – HSP mud in annulus

= 3866.4 psi – 870 psi – 2924.5 psi

= 71.9 psi

Gradient of Influx (psi/ft) = Kick Hydrostatic (psi) ÷ Height of Influx (ft)

= 71.9 psi ÷ 632.2 feet

= 0.113 psi/ft

International Well Control Forum
Subsea BOP Vertical Well Kill Sheet (API Field Units)

DATE: FEBRUARY 2012
NAME: INSTRUCTOR

FORMATION STRENGTH DATA:

SURFACE LEAK -OFF PRESSURE FROM FORMATION STRENGTH TEST (A) 1500 psi

MUD WEIGHT AT TEST (B) 10.0 ppg

MAXIMUM ALLOWABLE MUD WEIGHT = (B) + (A) / (SHOE T.V. DEPTH x 0.052) = (C) 15.7 ppg

INITIAL MAASP =

((C) - CURRENT MUD WEIGHT) x SHOE T.V. DEPTH x 0.052)

(15.7 − 10.4) x 0.052 x 5000 FT = 1378 psi

CURRENT WELL DATA:

SUBSEA BOP DATA:

MARINE RISER LENGTH 500 feet

CHOKELINE LENGTH 515 feet

DRILLING MUD:

WEIGHT 10.4 ppg

CASING SHOE DATA:

SIZE 9 5/8 inch

M. DEPTH 5000 feet

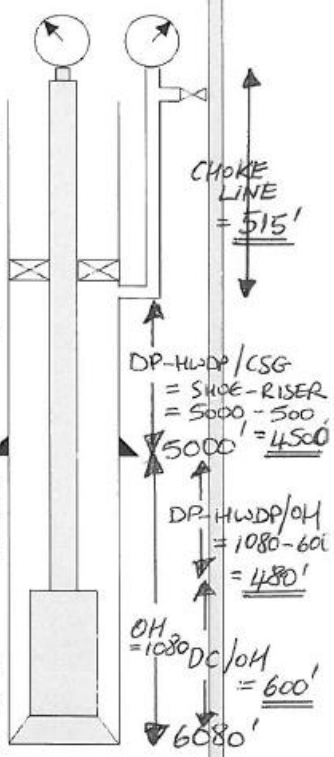
T.V. DEPTH 5000 feet

HOLE DATA:

SIZE 8 1/2 inch

M. DEPTH 6080 feet

T.V. DEPTH 6040 feet



PUMP NO. 1 DISPL.	PUMP NO. 2 DISPL.
0.102 bbls / stroke	bbls / stroke

SLOW PUMP RATE DATA:	(PL) DYNAMIC PRESSURE LOSS [psi]					
	PUMP NO. 1			PUMP NO. 2		
	Riser	Choke Line	*Choke Line Friction*	Riser	Choke Line	*Choke Line Friction*
45 SPM	400	500	100			
45 SPM						

PRE-RECORDED VOLUME DATA:	LENGTH feet	CAPACITY bbls / feet	VOLUME barrels	PUMP STROKES Strokes	TIME Minutes
DRILL PIPE	5080	x .0178 =	90.424	VOLUME / PUMP DISPLACEMENT	
HEVI WALL DRILL PIPE	400	x .0088 =	3.52		
DRILL COLLAR	600	x .0077 =	4.62		
DRILL STRING VOLUME			(D) 98.564 bbls	(E) 967 strokes	21.5 Min
DC x OPEN HOLE	600	x .0292 =	17.52		
DP / HWDP x OPEN HOLE	480	x .0459 =	22.032 +		
OPEN HOLE VOLUME			(F) 39.552 bbls	388 strokes	8.6 Min
DP x CASING	4500	x .0505 =	(G) 227.25 +	strokes	Min
CHOKELINE	515	x .0087 =	(H) 4.4805 +	strokes	Min
TOTAL ANNULUS/CHOKELINE VOLUME		(F+G+H) = (I)	271.28 bbls	strokes	Min
TOTAL WELL SYSTEM VOLUME		(D+I) = (J)	369.84 bbls	3626 strokes	80.6 Min
ACTIVE SURFACE VOLUME		(K)	460 bbls	strokes	
TOTAL ACTIVE FLUID SYSTEM		(J+K)	829.84 bbls	8136 strokes	
MARINE RISER x DP	500	x .3638 =	181.9 bbls	1784 strokes	

Dr No SSV 04/01
(Field Units)
27-01-2000

CHECK 1 KILL MUD HYDROSTATIC = 12.4ppg x 0.052 x 6040 ft
= 3894.6 psi
FORMATION PRESSURE = SIDPP + STRING HYD. = 600 + (10.4 x 0.052 x 6040)
OVERBALANCE = 28 PSI = 3866.4

International Well Control Forum

Subsea BOP Kill Sheet - Vertical Well (API Field Units)

DATE: FEBRUARY 2012

NAME: INSTRUCTOR

KICK DATA: SIDPP 600 psi SICP 870 psi PIT GAIN 19 barrels

KILL MUD WEIGHT (KMW) = CURRENT MUD WEIGHT + SIDPP / (TVD x 0.052)
10.4 + 600 / (6040 x 0.052) = 12.4 ppg

INITIAL CIRCULATING PRESSURE (ICP) = DYNAMIC PRESSURE LOSS + SIDPP
400 + 600 = 1000 psi

FINAL CIRCULATING PRESSURE (FCP) = KILL MUD WEIGHT / CURRENT MUD WEIGHT x DYNAMIC PRESSURE LOSS
12.4 / 10.4 x 400 = 477 psi

(L) = ICP - FCP = 1000 - 477 = 523 psi

(L) x 100 / (E) = 523 x 100 / 967 = 54.08 psi / 100 strokes

INITIAL DYNAMIC CASING PRESSURE AT KILL PUMP RATE = SICP - CHOKE LINE FRICTION
870 - 100 = 770 psi

STROKES	PRESSURE [psi]
0	1000
100	946
200	892
300	838
400	784
500	730
600	676
700	622
800	568
900	514
967	477