Acronyms, Formulas & Well Control Forms

Acronyms, Formulas & Well Control Forms

Acronyms

AER	Alberta Energy Regulator
Ann. Cap.	Annular Capacity
ADP	Annular Discharge Pressure
ALRP	As Low as Reasonably Practical
APL	Annular Pressure Loss
ASP	Applied Surface Pressure
BOP	Blowout Preventer
BHA	Bottomhole Assembly
BHP	Bottomhole Pressure
CP	Casing Pressure
CSG	Casing
CT	Coiled Tubing
DC	Drill Collar
DP	Drill Pipe
DPP	Drill Pipe Pressure
DST	Drill Stem Testing
EOB	End of Build
EOBCP	End of Build Circulating Pressure
EOBMD	End of Build Measured Depth
EOBTVD	End of Build True Vertical Depth
ESD	Emergency Shut Down
EBHP	Effective Bottom Hole Pressure
ECD	Equivalent Circulating Density
EMD	Equivalent Mud Density
FCP	Final Circulating Pressure
FP	Formation Pressure
HP	Hydrostatic Pressure
HP/HT	High Pressure/High Temperature
HCR	High Closing Ratio (also known as ESD)
IADC	International Association of Drilling Contractors
ICP	Initial Circulating Pressure
KMD	Kill Mud Density
kPa	Kilopascal
KOP	Kick off Point
KOPCP	Kick off Point Circulating Pressure
KOPMD	Kick off Point Measured Depth
KOPTVD	Kick off Point True Vertical Depth
FLOC	Flocculated Water (used as a Drilling Fluid)

FOSV	Fully Opening Safety Valve
LOG	Leak-Off Gradient
LOP	Leak-Off Pressure
LWD	Logging-While-Drilling
MACP	Maximum Allowable Casing Pressure
MADFD	Maximum Allowable Drilling Fluid Density
MASP	Maximum Applied Surface Pressure
MDI	Mud Density Increase
MGS	Mud Gas Separator
MPD	Managed Pressure Drilling
MR	Mixing Rate
NMD	New Mud Density
OBM	Oil-Based Mud
OK	Overkill
OMD	Original Mud Density
PBD	Pump Bore Diameter
PID	Proportional-Integral-Derivative
PO	Pump Output
PVT	Pit Volume Totalizer
PVT	Pressure, Volume, and Temperature
PWD	Pressure-While-Drilling
RCD	Rotating Control Device
RCH	Rotating Control Head
RS	Reduced Speed
RSPP	Reduced Speed Pump Pressure
ROP	Rate of Penetration
SAGD	Steam Assisted Gravity Drainage
SAPP	Sodium Acid Pyrophosphate (thinner/dispersant)
SICP	Shut-In Casing Pressure
SIDPP	Shut-In Drill Pipe Pressure
SL	Stroke Length
SLSWC	Second Line Supervisor's Well Control
SPM	Strokes per Minute
SPP	Standpipe Pressure
STKS	Strokes
TVD	True Vertical Depth
TMD	Total Measured Depth
UBD	Underbalanced Drilling
WBM	Water-Based Mud
WC	Well Control
WBE	Wellbore Barrier Element
WBS	Well Barrier Schematics

List of Formulas

TVD for Pressure Calculations	=	True Vertical Depth (m)
TMD for Volume Calculations	=	Total Measured Depth (m)
Hydrostatic Pressure(HP) (kPa)	=	TVD (m) × Mud Density (kg/m^3) × 0.00981
		or
	=	TVD (m) × Gradient (kPa/m)
Gradient (kPa/m)	=	Mud Density (kg/m^3) × 0.00981
Density (kg/m^3)	=	$\frac{\text{Mud Gradient (kPa/m)}}{0.00981}$
Formation Pressure (FP) (kPa)	=	HP (kPa) + SIDPP (kPa)
Equivalent Circulating Density (kg/m^3)	=	(APL (kPa) ÷ TVD (m) ÷ 0.00981) + Mud Density (kg/m^3)
Equivalent Mud Density (kg/m^3)	=	Total Pressure (kPa) ÷ TVD (m) ÷ 0.00981
		or
	=	BHP (kPa) ÷ TVD (m) ÷ 0.00981
EBHP (kPa) (Drilling)	=	HP (kPa) + APL (kPa)
EBHP (kPa) (Trip Out)	=	HP (kPa) – Swab Pressure (kPa)
EBHP (kPa) (Trip In)	=	HP (kPa) + Surge Pressure (kPa)
Trip Margin Density Increase (kg/m^3)	=	Trip Margin Pressure Required (kPa) ÷ TVD (m) ÷ 0.00981

Gas Expansion Formula (Boyles Law)

$V^1 x P^1 = V^2 x P^2$

Therefore:

$$V_2 = \left(\frac{V_1 \times P_1}{P_2} \right)$$

where:

- V_1 = Initial pit gain entering the wellbore (m^3)
- P_1 = Initial pressure acting on the influx (kPa) (Formation Pressure)
- V_2 = Expanded volume of gas (m^3)
- P_2 = Pressure acting on the gas (kPa)
    - a) = HP above the bubble + New CP
    - b) = CP when gas at choke
    - c) = Degasser 100 kPa

Well Control Calculations

Density Increase (kg/m^3)	=	SIDPP (kPa) ÷ TVD (m) ÷ 0.00981
Kill Mud Density (KMD) (kg/m^3)	=	Density Increase (kg/m^3) + OMD (kg/m^3)
Remaining SIDPP (kPa)	=	Orig SIDPP(kPa) - $\left(\frac{\text{Orig SIDPP(kPa)x Stks Pmpd}}{\text{Stks to bit}} \right)$
Barite Required (kg/m^3)	=	$\frac{4{,}250 \times \text{Density Increase } (kg/m^3)}{4{,}250 - \text{KMD}(kg/m^3)}$
or		
Calcium Carbonate Required (kg/m^3)	=	$\frac{2{,}760 \times \text{Density Increase } (kg/m^3)}{2{,}760 - \text{KMD}(kg/m^3)}$
Barite Required (kg)	=	Barite (kg/m^3) × Total Volume (m^3)
or		
Calcium Carbonate Required (kg)	=	Calcium Carbonate (kg/m^3) × Total Volume (m^3)
Number of Sacks of Barite	=	$\frac{\text{Barite Required (kg)}}{40\text{(kg/sack)}}$ ***or*** $\frac{\text{Barite Required (kg)}}{20\text{(kg/sack)}}$

or

Number of Sacks of Calcium Carbonate = $\frac{\text{Calcium Carbonate Required (kg/m}^3\text{)}}{\text{25(kg/sack)}}$

(Dependent on sack size delivered to location)

Mixing Rate (MR) (sacks/mi) = $\frac{\text{Number of Sacks}}{\text{Reduced Circulating Time (min)}}$

Initial Circulating Pressure (ICP) (kPa) = RSPP (kPa) + SIDPP (kPa) + Overkill (kPa)

Final Circulating Pressure (FCP) (kPa) = $\left(\frac{\text{RSPP (kPa)} \times \text{KMD (kg/m}^3\text{)}}{\text{OMD (kg/m}^3\text{)}}\right)$ + Overkill (kPa)

Formulas specific to the Concurrent Method

Density Increase (kg/m^3) = * $\frac{40 \times \text{Mix Rate} \times [4{,}250 - \text{Original Density (kg/m}^3\text{)}]}{4{,}250 \times \text{PO (m3/min)} + (40 \times \text{Mix Rate})}$

or

= ** $\frac{25 \times \text{Mix Rate} \times [2{,}760 - \text{Original Mud Density (kg/m}^3\text{)}]}{2{,}760 \times \text{PO (m}^3\text{/min)} + (25 \times \text{Mix Rate})}$

FCP (kPa) = $\left(\frac{\text{RSPP (kPa)} \times \text{NMD (kg/m}^3\text{)}}{\text{OMD (kg/m}^3\text{)}}\right)$ + Remaining SIDPP (kPa)

Remaining SIDPP (kPa) = SIDPP(kPa) – [Density Increase(kg/m^3) × Depth(m) × 0.00981]

or

Remaining SIDPP (kPa) = TVD (m) × Remaining MDI (kg/m^3) × 0.00981

Note: * 40kg/sx (Dependent on sack size delivered to location)
**25kg/sx (Dependent on sack size delivered to location)

Volumetric Method

Volume to Bleed (m^3) = $\dfrac{\text{Pressure Increase (kPa)} \times \text{Annular Capacity } (m^3/m)}{\text{Mud Gradient (kPa/m)}}$

Migration Rate (m/min) = $\dfrac{\text{Change in SICP (kPa)}}{(\text{Mud Gradient (kPa/m)} \times \text{Time})}$

Leak-Off Calculations

LOP (kPa) = Applied Surface Pressure (kPa) + HP at Casing Seat (kPa)

or

= LOG (Leak-off Gradient) × Casing Depth (m)

Leak-off Gradient LOG (kPa/m) = $\dfrac{\text{LOP (kPa)}}{\text{Depth of Casing (m)}}$

Equivalent Mud Density EMD (kg/m^3) = $\dfrac{\text{Leak-off Gradient (kPa/m)}}{0.00981}$

MACP (kPa) = LOP (kPa) – HP (kPa)

MACP with increased mud density (kPa) = LOP at shoe (kPa) – New HP at casing shoe (kPa)

Fluid Level Drop While Pulling Dry and Wet Pipe

Pulling Dry Pipe (m) Drop in Fluid Level = $\dfrac{\text{Length of Pipe (m)} \times \text{Displacement } (m^3/m)}{(\text{Annular Capacity } (m^3/m) + \text{Pipe Capacity } (m^3/m))}$

Pulling Wet Pipe (m) Drop in Fluid Level = $\dfrac{\text{Length of Pipe (m)} \times \text{Wet Displacement } (m^3/m)}{\text{Annular Capacity } (m^3/m)}$

Wet Displacement (m^3/m) = Displacement of Pipe(m^3/m) + Capacity of Pipe(m^3/m)

Loss of HP = Drop in level (m) × Density (kg/m^3) × 0.00981

Pill Pumping Calculation

1. Length of Pill (m) = $\dfrac{\text{Pill Volume (m}^3\text{)}}{\text{Drill Pipe Capacity (m}^3\text{/m)}}$

2. Differential Pressure (kPa) = Length of Pill (m) × (Pill Gradient (kPa/m) – Mud Gradient (kPa/m))

3. Empty Pipe Length (m) *after pill settles* = $\dfrac{\text{Differential Pressure (kPa)}}{\text{Mud Gradient (kPa/m)}}$

Recovery (m^3) = Empty Pipe (m) × Drill Pipe Capacity (m^3/m)

or

$$= \text{Volume of Pill (m}^3\text{)} \times \left(\frac{\text{Pill Density (kg/m}^3\text{)}}{\text{Mud Density (kg/m}^3\text{)}} - 1 \right)$$

Accumulator Calculations

1. Fluid Required (L) = Litres to Close Annular Preventer + Litres to Close Pipe Ram Preventers + Litres to Open Hydraulic Valve

Critical Sour = Close Annular and Open HCR and Close, Open, Close One Ram and Shear Pipe in Use

2. Total Fluid Required (L) with 50% Safety Margin = Fluid Required × 1.5

This value is to be used in the Accumulator Size formula below.

Note: Safety margin is established by company policies and manufacturer's specifications.

3. Accumulator Size (L)

$$= \left(\frac{\text{Remaining Pressure (kPa)} \times \text{Total Fluid Required (L)}}{\text{Pressure on Accumulator (kPa)} - \text{Remaining Pressure (kPa)}} \right) \times \left(\frac{\text{Pressure on Accumulator (kPa)}}{\text{Precharge Pressure (kPa)}} \right)$$

4. Bottles Required = $\dfrac{\text{Accumulator Size in Litres}}{\text{Bottle Size (usable fluid)}}$

Nitrogen Backup Calculations

5. Usable Nitrogen/btl (L)

$$= \left(\frac{\text{Bottle Pressure (kPa)}}{\text{Remaining Pressure (kPa)}} - 1 \right) \times \text{Bottle Size (L)}$$

6. Nitrogen Bottles Required = $\dfrac{\text{Fluid Required (without Safety Factor)}}{\text{Usable Nitrogen/btl (L)}}$

Pump Pressures

$$P_2 = P_1 \times \left(\frac{SPM_2}{SPM_1}\right)^2$$

where:

P_2 = New pump pressure (kPa)
P_1 = Original pump pressure (kPa)
SPM_2 = Increased pump speed (strokes/min)
SPM_1 = Original pump speed (strokes/min)

$$P_2 = P_1 \times \left(\frac{Q_2}{Q_1}\right)^2$$

where:

P_2 = New pump pressure (kPa)
P_1 = Original pump pressure (kPa)
Q_2 = Increased flow rate (m^3/m)
Q_1 = Original flow rate (m^3/m)

Rule of Thumb:

WBM Hydraulic Lag Time (Pressure Transmission) = 2sec/305m. Surface to TD

Ex. 3050m pressure lag = 20sec.

Kick Gradient

$$\text{Length of Kick (m)} = \frac{\text{Pit Gain } (m^3)}{\text{Annular Volume } (m^3/m)}$$

Appropriate drill string component (drill collars, HWDP or drill pipe)

$$\text{*Gradient of Kick (kPa/m)} = \text{Gradient of Mud (kPa/m)} - \left[\frac{(\text{SICP (kPa)} - \text{SIDPP (kPa)})}{\text{Length of Kick (m)}}\right]$$

Gas Gradient	*1.35 kPa/m - 2.70 kPa/m*
Oil Gradient	*5.80 kPa/m - 8.15 kPa/m*
Water Gradient	*9.80 kPa/m - 11.5 kPa/m*

$$\text{*Length of Kick} = \frac{(\text{SICP-SIDPP})}{(\text{Gradient of Mud (kPa/m)} - \text{Gradient of Kick (kPa/m)})}$$

*for vertical well only INC MACP FORM

*formula is not applicable to oil based or other muds into which a gas influx is soluble

Stripping and Snubbing Calculations

1,000 mm	=	1 m
Area (m^2)	=	0.785 × Tool Joint Diameter(m) × Tool Joint Diameter(m) *where:* *0.785 = constant*
Wellbore Force (daN)	=	Pressure × Area (m^2)× 100 *where:* *Pressure = SICP (kPa)* *100 = constant*
Total Force Acting on String (daN)	=	Friction Force in BOP + Wellbore Force
Length of Pipe to Snub (m)	=	Total force (daN) ÷ Mass (kg/m) ÷ 0.981 *where:* *0.981 = constant* *Note: The constant 0.981 in the formula is required because the units are in decanewtons not Newtons.*

List of Formula Units

daN	decaNewton
kg	kilogram
kPa	kiloPascal
L	Litre
m	metre
m^2	square metre
m^3	cubic metre
mm	millimetre
min	minute
MPa	MegaPascal

Order of Operations (BEDMAS)

BEDMAS is an acronym that reminds us of the correct order of operations:

- **B** – **Brackets**
  - First Priority
- **E** – **Exponents**
  - Second Priority
- **D** – **Division**
  - Third Priority
- **M** – **Multiplication**
  - Third Priority
- **A** – **Addition**
  - Fourth Priority
- **S** – **Subtraction**
  - Fourth Priority

BEDMAS tells us that brackets are the highest priority, then exponents, then both division and multiplication, and finally addition and subtraction. This means that we evaluate exponents before we multiply, divide before we subtract, etc.

Example 1 (Brackets)

$$15 - (6 + 1) + 30 \div (3 \times 2)$$

BEDMAS tells us to evaluate what's in the brackets first. Therefore, we get the following:

$$15 - (6 + 1) + 30 \div (3 \times 2)$$
$$= 15 - 7 + 30 \div (3 \times 2)$$
$$= 15 - 7 + 30 \div 6$$
$$= 15 - 7 + 5$$
$$= 8 + 5$$
$$= 13$$

Example 2 (Nested Brackets)

There is no limit on how many sets of brackets we can use in an equation. So you could see an expression that looks like this:

$$(8 - (5 + 1)) \times 3$$

To evaluate an expression like this, we simply follow BEDMAS twice! Once we notice the outer brackets, we realize that we need to first evaluate the sub-expression they contain using BEDMAS. Next, we notice the inner-brackets and then we realize that we need to evaluate that sub-expression first.

A simple rule that summarizes this strategy is:

- **When dealing with brackets inside brackets (called nested brackets), evaluate what's inside the inner-most brackets first.**

Remember that this rule is just BEDMAS. It's nothing new. Using this rule, our sample expression would be evaluated as follows:

$(8 - (5 + 1)) \times 3$

$= (8 - 6) \times 3$

$= 2 \times 3$

$= 6$

Example 3 (Exponents)

There are two important rules to remember when dealing with exponents:

1. Any number to the exponent 1 is equal to itself.
2. Any number (except for 0) to the exponent 0 is equal to 1.

$2^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32$

$7^0 = 1$

$3^2 = 3 \times 3 = 9$

$5^1 = 5$

$0^5 = 0$

Example 4

$8 + 4 \times 3 \div 2$

$= 8 + 12 \div 2$

$= 8 + 6$

$= 14$

From BEDMAS, we see that the division and multiplication must be done before the addition.

Forms

The Enform forms presented in the following pages as well as the Check List are guides to help **Prepare, Execute, and Review** the Well Control Procedures in this manual. These forms can be used for all well control methods. They are available here for your use in the field should you require them. Enform does not accept any liability whatsoever in there use or resulting outcomes on the well.

Checklist

Used for Equipment and Data Check on pages Chapter 4-54 to 4-57

Well Control Data Sheets

Used to collect necessary data for well configurations listed below for all methods of well control:

- Vertical Hole
- Deviated Hole
- Vertical Liner
- Deviated Liner

Well Control Operations Record Sheet

Used to record all Kill Operations.

Well Control Kill Sheet

Used to calculate all the parameters required to kill the well with a weighted drilling fluid (mud):

- Casing: 1st Circulation for Concurrent and Low Choke.
- Casing: 2nd Circulation for Driller's, Wait & Weight, and Concurrent.
- Liner: 2nd Circulation for Driller's, Wait & Weight, and Concurrent.
- Deep Liner: Multiple strings DP, HWDP, DC.
- Well Control Kill Sheet Graph
  - ➢ Used to show the change from the Initial Circulating Pressure (ICP) to the Final Circulating Pressure (FCP) as the kill fluid is pumped down the Drill Pipe.
- Volumetric Method Kill Sheet
- Deviated Horizontal Kill Sheet
  - ➢ A pressure graphs used to show the change from ICP (Initial Circulating Pressure) to KOPCP (Kick off Point Circulating Pressure) to EOBCP (End of Build Circulating Pressure) to FCP (Final Circulating Pressure)

Blank Kill Sheet for Well Control

WELL:			
	MD	TVD	UNITS
Depth			m
Surface casing – Specifications			mm
Set at			m
Annulus Length (to liner top)			m
BOP RATING		KPa	
Intermediate Casing – Specifications			
Top			m
Set at			m
KICK OFF POINT (KOP)			m
END OF BUILD (EOB)			m
Hole Size			mm

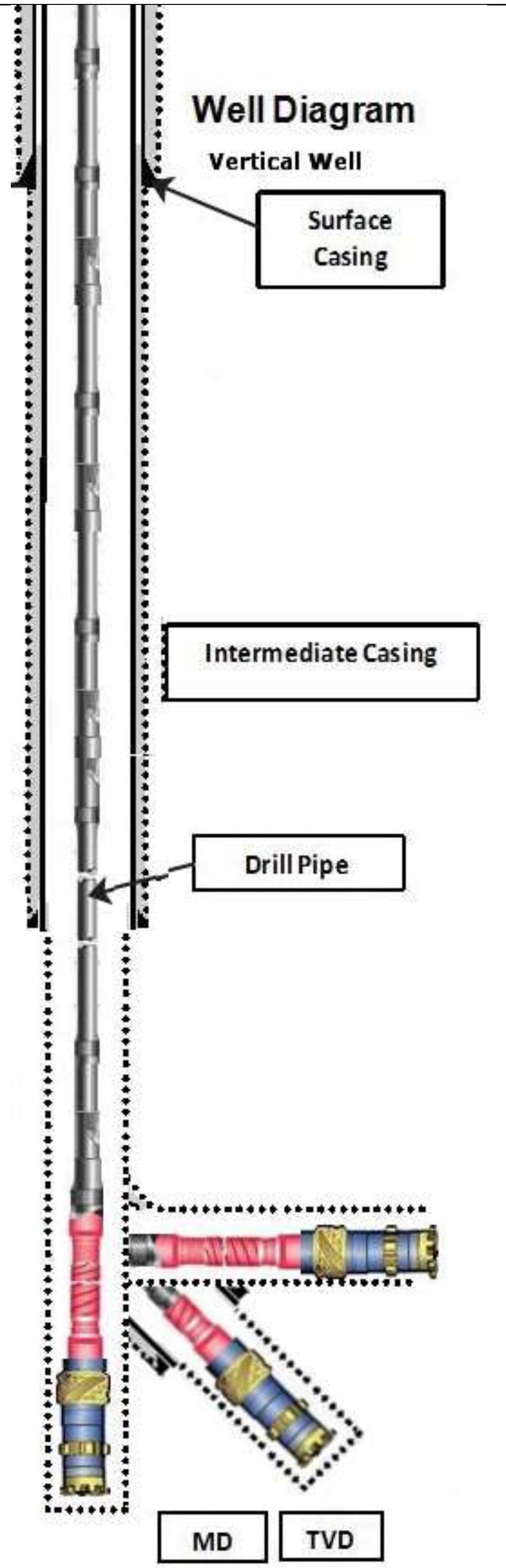
DRILL STRING			
	Length	Specifications	Capacity m3/m
Push Pipe			
Drill Pipe			
Heavy Weight			
Drill Collars			

ANNULAR CAPACITY		
DC to open hole annular capacity		m^3/m
Tubulars in open hole annular capacity		m^3/m
Tubulars in casing annular Capacity		m^3/m
Original Mud Density (OMD)		Kg/m^3
Leak Off Gradient (LOG)		KPa/m

PUMP SPECIFICATIONS					
	Bore	Stroke	Reduced Speed	RSPP	Displacement
Pump #1					
Pump #2					

Surface Line Volume *		m^3
Mud Tank Volume		m^3
Shut in Drill Pipe Pressure (SIDPP)		KPa
Shut In Casing Pressure (SICP)		KPa
Pit Gain		m^3
OverKill (If Used)		KPa

* Account for surface line volume when pumping kill mud to the bit. Reset strokes when kill mud reaches floor, then follow drill pipe schedule pumping kill mud to the bit.



Well MD		m	Well TVD		m	SICP		kPa	Pump Output		m^3/stk
Kick Size		m^3	Shoe TVD		m	SIDPP		KPa	Reduced Strokes		stks/min

VOLUMES, DISPLACEMENT TIMES AND STROKES – Use Measured Depth (MD)

	Length (m)	Capacity (m^3/m)	Volume (m^3)	Strokes	Minutes
Strokes to Displace Surface Lines					
Surface to KOP or (Surface to BHA if Vertical)				(L)	
KOP to EOB (Vertical Well Leave Blank)				(M)	
EOB to BHA (Vertical Well Leave Blank)				(N1)	
Heavy Weight Drill Pipe				(N2)	
Drill Collar				(N3)	
Drill String Volume (Surface to Bit)			(D)		
DC in Open Hole					
Tubulars in Open Hole					
Open Hole Volume (Bit to casing Shoe)			(E)		
Washout (Estimated %)	(E) x 10%		10%		
Open Hole Volume with Washout (Bit to Surface)			(F)		
Tubulars in Casing			(G)		
Total Annulus Volume	H=F+G		(H)		
Total Well System Volume (Surface to Surface)	I=D+H		(I)		
Active Surface Volume			(J)		
Total active Fluid System	=I+J				

Initial MACP – Use True Vertical Depth at Casing Shoe (TVD)

LOP = Shoe TVD ____ m × Leak off Gradient ____ kPa/m = ____ kPa

HP = Shoe TVD ____ m × Original Mud Density ____ kg/m^3 × 0.00981 = ____ kPa

Current MACP = LOP ____ kPa – HP ____ kPa = ____ kPa

Mud Density Increase **(MDI)** = SIDPP ____ kPa ÷ TVD ____ m ÷ 0.00981 = ____ kg/m^3

Kill Mud Density = Original Mud Density ____ kg/m^3 + MDI ____ kg/m^3 = ____ kg/m^3

New MACP with Kill Mud – Use True Vertical Depth (TVD)

New HP = Shoe TVD ____ m × Kill Mud Density ____ kg/m^3 × 0.00981 = ____ kPa

New MACP = LOP ____ kPa – New HP ____ kPa = ____ kPa

BARITE REQUIREMENTS

$$\text{Barite Required} = \frac{4250\text{kg/m}^3 \times \text{Density Increase} \;\_\_\_\_\; \text{kg/m}^3}{[4250\text{kg/m}^3 - \text{Kill Mud Density} \;\_\_\_\_\; \text{kg/m}^3]} = \_\_\_\_ \text{ kg/m}^3$$

Total Barite = Barite required ____ kg/m^3 × Total active Fluid System ____ m^3 = ____ kg

Number of Sacks = Total Barite ____ kg ÷ 40 kg/sack = ____ Sacks

Mixing Rate (If mixed on the fly) = Number of Sacks ____ ÷ Total Minutes ____ = ____ Sacks/min

(for Concurrent Method Proceed to PG 4)

PROCEED TO NEXT PAGE FOR CONCURRENT METHOD

CIRCULATING PRESSURES

ICP = RSPP [ ] kPa + SIDPP [ ] kPa + OK [ ] kPa = [ ] kPa

FCP= RSPP [ ] kPa × $\frac{\text{Kill Mud Density [ ] kg/m}^3}{\text{Original Mud Density [ ] kg/m}^3}$ + OK [ ] kPa = [ ] kPa

RSPP with KMD at KOP (O) **(O)**

[FCP [ ] kPa – RSPP [ ] kPa] × $\frac{\text{KOP MD [ ] m}}{\text{TD MD [ ] m}}$ + RSPP [ ] kPa = [ ] kPa

REMAINING SIDPP at KOP (P) **(P)**

SIDPP [ ] kPa – [MDI [ ] kg/m^3 × KOP TVD [ ] m × 0.00981] = [ ] kPa

CIRCULATING PRESSURE AT KOP (KOP CP) = (O) + (P) **(KOP CP)**

(O) [ ] kPa + (P) [ ] kPa = [ ] kPa

RSPP with KMD at EOB (R) **(R)**

[FCP [ ] kPa – RSPP [ ] kPa] × $\frac{\text{EOB MD [ ] m}}{\text{TD MD [ ] m}}$ + RSPP [ ] kpa = [ ] kPa

REMAINING SIDPP at EOB (S) (Note: if negative use "0") **(S)**

SIDPP [ ] kPa – [MDI [ ] kg/m^3 × EOB TVD [ ] m × 0.00981] = [ ] kPa

CIRCULATING PRESSURE AT EOB (EOB CP) = (R) + (S) **(EOB CP)**

(R) [ ] kPa + (S) [ ] kPa = [ ] kPa

PUMP PRESSURE DROP / Increase per 100 strokes (Note: if negative, increase Pressure)

Vertical Wells use top calculation only, Deviated and Horizontal wells require all three calculations below:

Surface to KOP = [ICP [ ] kPa – KOP CP [ ] kPa] × $\frac{100}{\text{(L) [ ] Strokes}}$ = [ ] kPa

(Or TD if Vertical) (Or FCP if Vertical) (Or Surface to bit if Vertical)

KOP to EOB = [KOP CP [ ] kPa – EOB CP [ ] kPa] × $\frac{100}{\text{(M) [ ] Strokes}}$ = [ ] kPa

EOB to FCP = [EOB CP [ ] kPa – FCP CP [ ] kPa] × $\frac{100}{\text{(N1, N2, N3) [ ] Strokes}}$ = [ ] kPa

FOR CONCURRENT METHOD ONLY

First Circulation:

Pump Output ____ m3/stk × R.S ____ stks/min = Pump Output ____ m^3/min

Increase in Density (This Circulation) = [(40×MR 1 sks/min)×(4250-OMD ____ kg/m^3) / (4250×Pump Output ____ m^3/min) + 40×MR 1 sks/min)] = ____ kg/m^3

New Mud Density = OMD ____ kg/m^3 + Increase in Density ____ kg/m^3 = ____ kg/m^3

BARITE REQUIREMENTS

Barite Required = 4250kg/m^3 × Density Increase ____ kg/m^3 / [4250kg/m^3 – Kill Mud Density ____ kg/m^3] = ____ kg/m^3

Total Barite = Barite required ____ kg/m^3 × Total active Fluid System ____ m^3 = ____ kg

Number of Sacks = Total Barite ____ kg ÷ 40 kg/sack = ____ Sacks

Mixing Rate (If mixed on the fly) = Number of Sacks ____ ÷ Total Minutes ____ = ____ Sacks/min

CIRCULATING PRESSURES

ICP = RSPP ____ kPa + SIDPP ____ kPa + OK ____ kPa = ____ kPa

FCP= RSPP ____ kPa × Kill Mud Density ____ kg/m^3 / Original Mud Density ____ kg/m^3 + OK ____ kPa = ____ kPa

PUMP PRESSURE DROP / Increase per 100 strokes (Note: if negative, increase Pressure)

Vertical Wells use top calculation only, Deviated and Horizontal wells require all three calculations below:

Surface to KOP = [ICP ____ kPa – KOP CP ____ kPa] × 100 / (L) ____ Strokes = ____ kPa

(Or TD if Vertical) (Or FCP if Vertical) (Or Surface to bit if Vertical)

Second Circulation:

Remaining MDI = Total MDI Required ____ kg/m^3 – Increase in Density ____ kg/m^3 = ____ kg/m^3

Remaining SIDPP = TVD ____ m × Remaining MDI ____ kg/m^3 × 0.00981 = ____ kPa

KMD = MDI ____ kg/m^3 + OMD ____ kg/m^3 = ____ kg/m^3

BARITE REQUIREMENTS

Barite Required = 4250kg/m^3 × Density Increase ____ kg/m^3 / [4250kg/m^3 – Kill Mud Density ____ kg/m^3] = ____ kg/m^3

Total Barite = Barite required ____ kg/m^3 × Total active Fluid System ____ m^3 = ____ kg

Number of Sacks = Total Barite ____ kg ÷ 40 kg/sack = ____ Sacks

Mixing Rate (If mixed on the fly) = Number of Sacks ____ ÷ Total Minutes ____ = ____ Sacks/min

ICP = RSPP ____ kPa + SIDPP ____ kPa + OK ____ kPa = ____ kPa

FCP =RSPP ____ kPa × Kill Mud Density ____ kg/m^3 / Original Mud Density ____ kg/m^3 + remaining SIDPP kPa + OK ____ kPa

= ____ kPa

WELL CONTROL OPERATIONS RECORD SHEET

ENFORM

WELL CONTROL METHOD: ______________________

KICK DATA

Well: ____ **Date:** ______________

RECORD CIRCULATING PRESSURES EVERY 2 MINUTES

TIME (hrs:min)	DPP (kPa)	CP (kPa)	TANK GAIN (m^3)	CHOKE POSITION (%)	REMARKS or PROBLEMS

RECORDED KICK DATA

Reduced Speed - RS		_______	spm
RS Pump Pressure - RSPP		_______	kPa
Overkill - OK		_______	kPa
Stabilized SIDPP		_______	kPa
Stabilized SICP		_______	kPa
M.A.C.P.		_______	kPa
Initial Pit Gain		_______	m^3
Mud (Drilling Fluid) Density		_______	kg/m^3

CIRCULATING DRILL PIPE PPRESSURES

RSPP	+	_______	kPa
SIDPP	+	_______	kPa
OK	+	_______	kPa
Initial Circulating Press. - ICP	=	_______	kPa
Pump Strokes to Bit		_______	stk
Final Circulating Press. - FCP		_______	kPa

INITIAL KILL CASING PRESSURE

SICP	+	_______	kPa
OK	+	_______	kPa
Initial Kill CP	=	_______	kPa

DPP REQUIRED TO CONTROL FORMATION

SIDPP	+	_______	kPa
RSPP	+	_______	kPa
MINIMUM	=	_______	kPa

M.A.C.P. Increase - NO WEIGHT MATERIAL ADDED

Gas To Surface Time		____:____	min
Initial DPP @ RS		_______	kPa
Lowest DPP @ GTS	-	_______	kPa
Allowable Increase in MACP	=	_______	kPa
Original MACP	+	_______	kPa
NEW MACP	=		kPa

WELL SHUT-IN @ ____:____ AM/PM

FINAL SHUT-IN PRESSURES

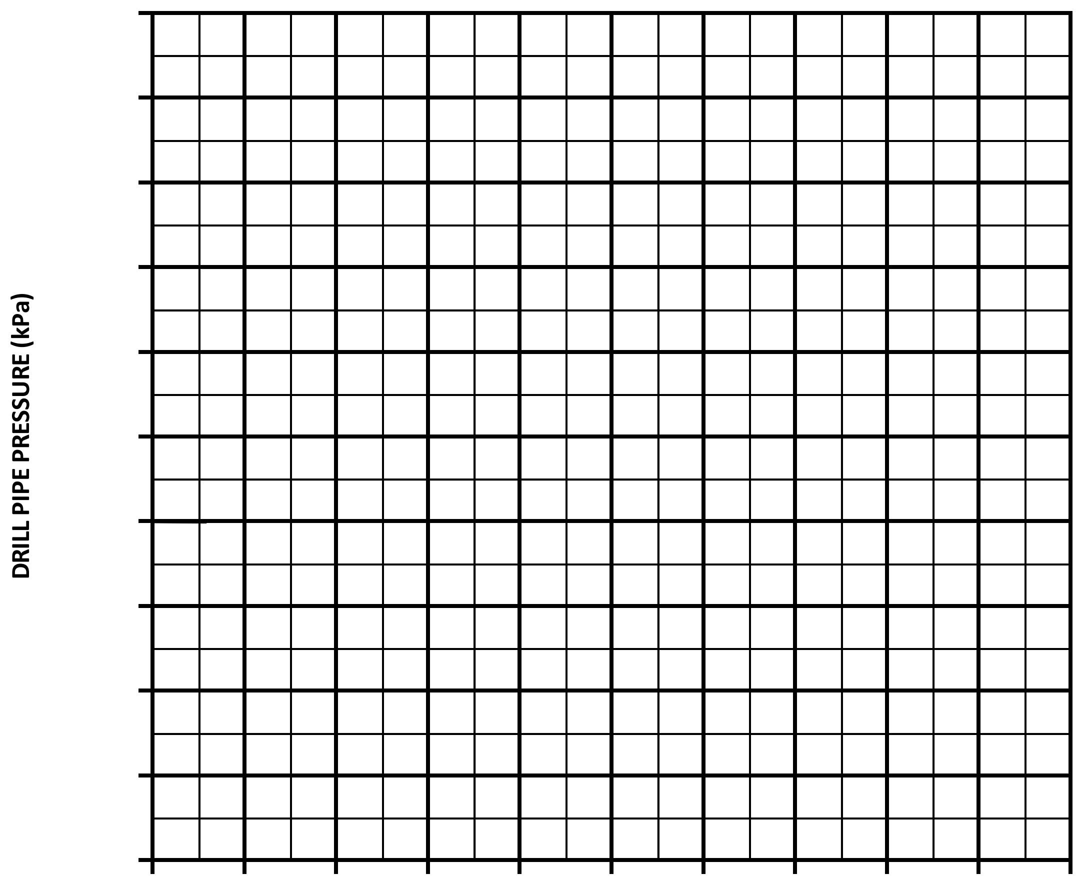
SIDPP	SICP	TIME

WELL CONTROL KILL SHEET GRAPH

Well Control Method: ______________________________

Well: ________________________________ **Date:** ______________

Maximum Allowable Casing Pressure With Kill Mud (MACP) ________ kPa
Strokes to Bit From Pre-recorded Information ________ Strokes
Reduced Speed (RS) or Circulating Rate Strokes Per Minute ________ spm
Initial Circulating Pressure (ICP) ________ kPa
Final Circulating Pressure (FCP) ________ kPa



STROKES or TIME

ICP												**FCP**
Strokes	**0**											**DP Strokes**
Time	**0**											**DP Time**

Note: Surface Line Equipment must be displaced prior to following DPP schedule

WELL CONTROL KILL SHEET - VOLUMETRIC METHOD

ENFORM

Well TVD ______________________ m

Well Name ______________________

Well TMD ______________________ m

Casing Depth ______________________ m

Date ______________________

Annular Capacity (m^3/m) : ______________________ m^3/m

Pressure Increase (kPa) : ______________________ kPa

OverKill (kPa) : ______________________ kPa

Mud Density (kg/m^3) : ______________________ kg/m^3

Starting Volume (m^3) : ______________________ (Pit Gain)

Volume to Bleed Off (m^3) : ______________________ (Use Formula Below)

Shut In @ (time) : ______________________ Hours

S I C P (kPa) : ______________________ kPa

MACP (kPa): ______________________ kPa

S I C P & Time	
OVERKILL	
PRESSURE INCREASE	
TOTAL >>>	
Time at First Press Build Up:____________	

Step 7 Time : ______ kPa

Step 6 Time : ______ kPa — Bleed ____ : ____ m^3 Cumulative Volume (m^3) ____ : ____ Time :

Step 5 Time : ______ kPa — Bleed ____ : ____ m^3 Cumulative Volume (m^3) ____ : ____ Time :

Step 4 Time : ______ kPa — Bleed ____ : ____ m^3 Cumulative Volume (m^3) ____ : ____ Time :

Step 3 Time : ______ kPa — Bleed ____ : ____ m^3 Cumulative Volume (m^3) ____ : ____ Time :

Step 2 Time : ______ kPa — Bleed ____ : ____ m^3 Cumulative Volume (m^3) ____ : ____ Time :

Step 1 Time : — Bleed ____ : ____ m^3 Cumulative Volume (m^3) ____ : ____ Time :

Volume to Bleed Off (m^3) :

$$\frac{(\text{Pressure Increase (kPa)} \times \text{Annular Capacity } (m^3/m))}{\text{Mud Gradient (kPa/m)}}$$

Migration Rate : Perculation Rate (meters/minute) =

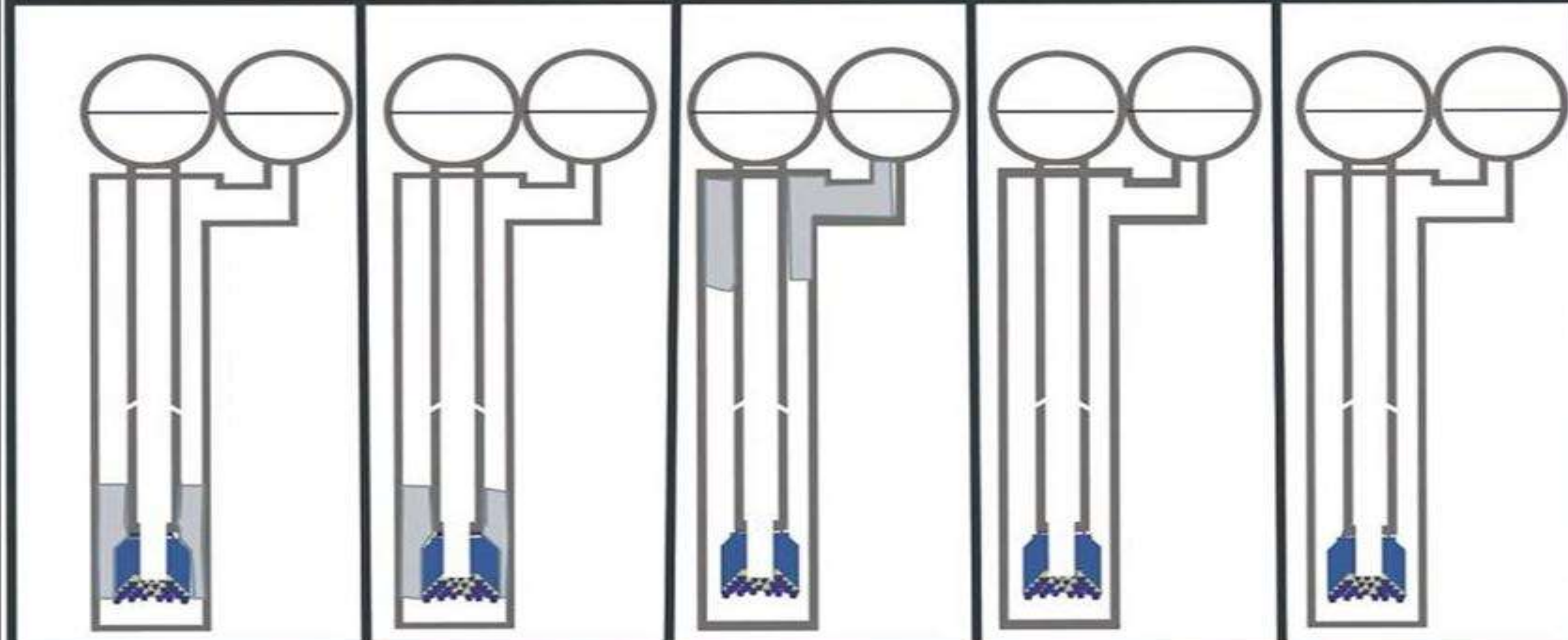
$$\frac{\text{Change in SICP (kPa)}}{(\text{Mud Gradient (kPa/m)} \times \text{Time (min)})}$$

DRILLER'S METHOD STEP ONE

KICK DATA

SIDPP ______ **kPa** WELL TVD ______m WELL TMD _____m RSPP _____ kPa @ _______spm

SICP ______ **kPa** **ORIGINAL MUD** ______ **kg/m³** **Overkill** _____ **kPa** **PIT GAIN** ____ **m³**



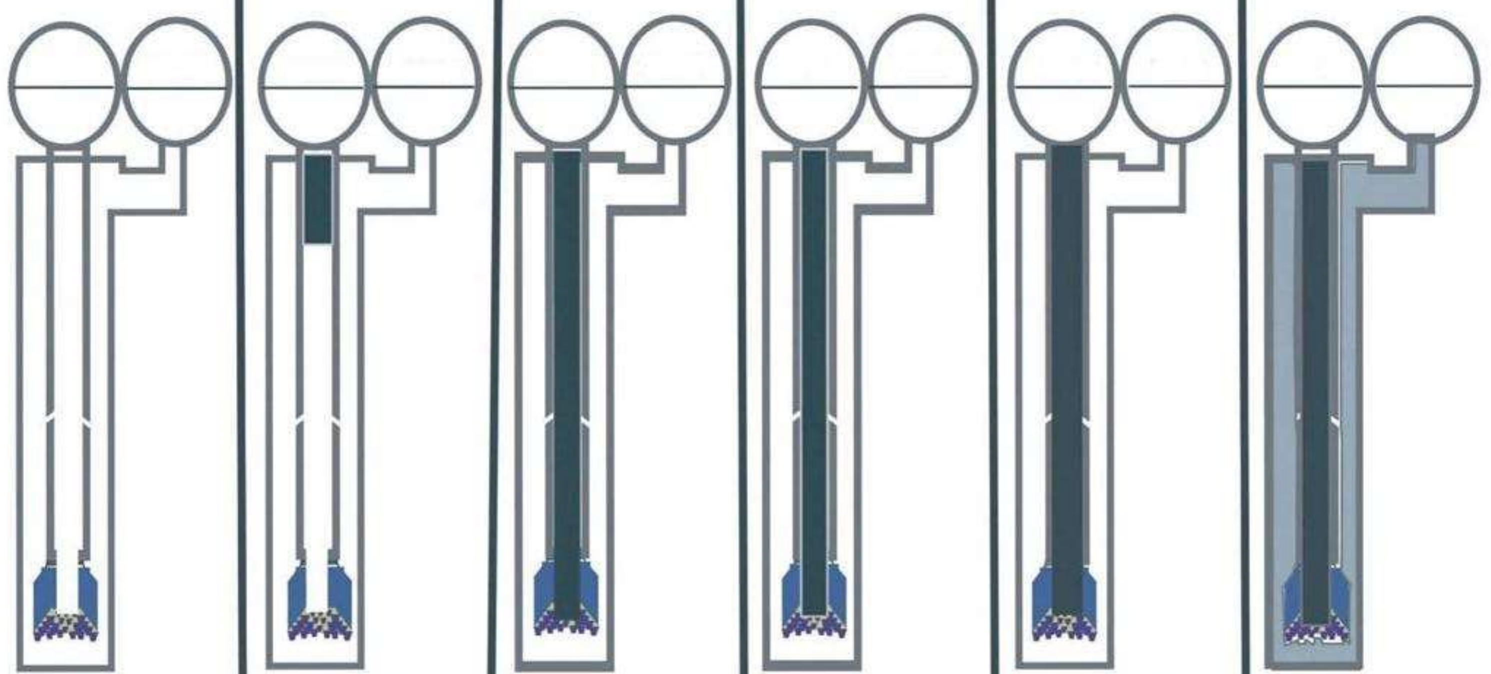
Well Shut In Pressures Stabilized	**Pump Started RSPP Established**	**Circulation Continues with Gas to Surface**	**Invading Fluid is Circulated from the Annnulus Tank Gain to Zero**	**Pump Stopped Well Shut In**

DRILLER'S METHOD STEP TWO

KICK DATA

SIDPP _____ **kPa** WELL TVD ______m WELL TMD _____m RSPP _____ kPa @ _______spm

SICP ______ **kPa** **ORIGINAL MUD** ______ **kg/m³** **Overkill** _____ **kPa** **KILL MUD** ______ **kg/m³**



Well Shut In after Step 1	**Pump Started @RSPP**	**Kill Mud Density Reaches the Bit**	**Pump Stopped**	**Circulation Resumed**	**Wellbore Displaced with Kill Mud Pump Stopped Trapped Pressure Bled Off**