**Kick Analysis**

**Formation Pressure (FP) With The Well Shut-in On a Kick**

*FP (psi) = SIDPP (psi) + [(mud wt (ppg) x 0.052 x TVD (ft)]*

Sample Case : Determine the formation pressure using the following data :

Shut-in drill pipe pressure = 500 psi  
Mud weight in drill pipe = 9.6 ppg  
True vertical depth = 10.000 ft

FP (psi) = 500 psi + (9.6 ppg x 0.052 x 10,000 ft)

= 500 psi + 4992 psi

= 5492 psi

**Bottom Hole Pressure (BHP) With The Well Shut-in On a Kick**

*BHP (psi) = SIDPP (psi) + [(mud wt. (ppg) x 0.052 x TVD (ft)]*

Sample Case : Determine the bottom hole pressure (BHP) with the well shut-

in on a kick :

Shut-in drill pipe pressure = 500 psi  
Mud weight in drill pipe = 9.6 ppg  
True vertical depth = 10.000 ft

BHP (psi) = 500 psi + (9.6 ppg x 0.052 x 10.000 ft)

= 500 psi + 4992 psi

= 5492 psi

**Shut-in Drill Pipe Pressure (SIDPP)**

*SIDPP (psi) = formation pressure (psi) — [(mud wt.(ppg) x 0.052 x TVD (ft)]*

Sample Case : Determine the shut-in drill pipe pressure using the following

Data :

Formation pressure = 12,480 psi  
Mud weight in drill pipe = 15.0 ppg  
True vertical depth = 15,000 ft

SIDPP (psi) = 12,480 psi — (15.0 ppg x 0.052 x 15,000 ft)

= 12,480 psi — 11.700 psi

= 780 psi

**Shut-in Casing Pressure (SICP)**

Sample Case : Determine the shut-in casing pressure using the following

data :

Formation pressure = 12,480 psi  
Mud weight in annulus = 15.0 ppg  
Feet of mud in annulus = 14,600 ft  
Influx gradient = 0.12 psi/ft  
Feet of influx in annulus = 400 ft

SICP (psi) = 12,480 — [(15.0 x 0.052 x 14,600) + (0.12 .x 400)]

= 12,480 — 11,388 + 48

= lO44 psi

**Height, Ft, of Influx**

*Height of influx (ft) = pit gain (bbl) : annular capacity (bbl/ft)*

Sample Case 1 : Determine the height (ft) of the influx using the following

data :

Pit gain = 2O bbl  
Annular capacity - DC/OH = 0.02914 bbl/ft  
(Dh = 8.5 inch — Dp = 6.5)

Height of influx (ft) = 20 bbl ÷ 0.02914 bbl/ft

= 686 ft

Sample Case 2 : Determine the height (ft) of the influx using the following

data:

Pit gain = 20 bbl  
Hole size = 8.5 inch  
Drill collar OD = 6.5 inch  
Drill collar length = 450 ft  
Drill pipe OD = 5.0 inch

Determine annular capacity (bbl/ft) for DC/OH :

Determine the number of barrels opposite the drill collars :

*Barrels = length of collars x annular capacity*

= 450 ft x 0.02914 bbl/ft . .

= 13.1

Determine annular capacity (bbl/ft) opposite drill pipe :

Determine barrels of influx opposite drill pipe :

*Barrels = pit gain (bbl) — barrels opposite drill collars*

= 20 bbl — 13.1 bbl

= 6.9

Determine height of influx opposite drill pipe :

*Height (ft) = 6.9 bbl ÷ 0.0459 bbl/ft*

= 150 ft

Determine the total height of the influx :

Height (ft) = 450 ft + 150 ft

= 600 ft

**Estimated Type of Influx**

Then : 1 – 3 ppg = gas kick  
 4 - 6 ppg = oil kick or combination  
 7 — 9 ppg = saltwater kick

Sample Case : Determine the type of the influx using the following data :

Shut-in casing pressure = 1044 psi  
Shut-in drill pipe pressure = 780 psi  
Height of influx = 400 ft  
Mud weight = 15.0 ppg

Therefore, the influx is probably “gas”

**Gas Migration in a Shut-in Well**

Estimating the rate of gas migration (ft/hr)

Vg = 12e(-0.37)(mud wt.(ppg)

= rate of gas migration (ft/hr)

Sample Case : Determine the estimated rate of gas migration using a mud

Weight of 11.0 ppg

Vg = 12e(-0.37)(11.0 ppg)

= 12e-4.07

= 0.205 ft/sec

= 0.205 ft/sec x 60 sec/min

= 12.3 ft/min x 60 min/hr

= 738 ft/hr

Determining the actual rate of gas migration after a welt has been shut-in on a kick :

Sample Case : Determine the rate of gas migration with the following data :

Stabilized shut-in casing pressure = 500 psi  
SICP after one hour = 700 psi  
Mud weight = 12.0 ppg  
Pressure gradient for 12.0 ppg mud = 0.624 psi/ft

Rate of gas migration (ft/hr) = 200 psi/hr : 0.624 psi/ft

= 320.5 ft/hr

**Hydrostatic Pressure Decrease at TD Caused by Gas Cut Mud**

**Method 1 :**

Sample Case : Determine the hydrostatic pressure decrease caused by gas cut

Mud using the following data :

Weight of uncut mud = 18.0 ppg  
Weight of gas cut mud = 9.0 ppg

**Method 2 :**

*P = (MG ÷ C) V*

Where, P = reduction in bottom hole pressure (psi)  
 MG = mud gradient psi/ft  
 C = annular volume (bbl/ft)  
 V = pitgain (bbl)

Sample Case : MG = 0.624 psi/ft  
 C = 0.0459 bbl/ft (Dh = 8.5 in. : Dp = 5.0 in.)  
 V = 20 bb1

Solution : P = (0.624 psi/ft : 0.0459 bbl/ft) 20

= 13.59 x 20

= 271.9 psi

**Maximum Surface Pressure From a Gas Kick in a Water Base Mud**

Where ;

MSPgk = maximum surface pressure resulting from a gas kick in a water base

mud  
P = formation pressure (psi)  
V = pit gain (bbl)  
KWM = kill weight mud (ppg)  
C = annular capacity (bbl/ft)

Sample Case : P = 12,480 psi

V = 2O bbl  
 KWM = 16.0 ppg  
 C = 0.0505 bbl/ft (Db = 8.5 in. x Dp = 4.5 in.)

Solution :

**Maximum Pit Gain From Gas Kick in Water Base Mud**

Where ;

MPGgk = maximum pit gain resulting from a gas kick in a water base mud  
P = formation pressure (psi)  
V = original pit gain (bbl)  
C = annular capacity (bbl/ft)  
KWM = kill weight mud (ppg)

Sample Case : P = 12,480 psi  
 V = 20 bbl  
 C = 0.0505 bbl/ft (8.5 in. x 4.5 in.)  
 KWM = 16.0 ppg

Solution :

**Maximum Pressures When Circulating Out a Kick (Moore Equations)**

The following equations will be used :

1. Determine formation pressure (psi):

*Pb = SIDP + [mud wt (ppg) x 0.052 x TVD (****ft)]***

2. Determine the height of the influx (ft):

*hi = ph gain (bbl) : annular capacity (bbl/ft)*

3. Determine pressure exerted by the influx (psi):

*Pi = Pb — [Pm(D — X) + SICP]*

4. Determine gradient of influx (psi/ft):

*Ci = Pi : hi*

5. Determine Temperature (°R) at depth of interest :

*Tdi = 700F + (0.012°F/ft x Di) + 460*

6. Determine A for unweighted mud :

*A = Pb – [Pm (D -\_X) — Pi]*

7. Determine pressure at depth of interest :

8. Determine kill weight mud (ppg):

*KWM (ppg) = SIDPP : 0.052 : TVD (ft) + 0MW (ppg)*

9. Determine gradient of kill weight mud (psi/ft):

*pKWM = KWM (ppg) x 0.052*

10. Determine FEET that drill string volume will occupy in the annulus

*Di = drill string vol (bbl) ÷ annular capacity (bbl/ft)*

11. Determine A for weighted mud :

*A = Pb – [pm (D – X) Pi] + [Di (pKWM – pm)]*

Sample Case : Assumed condition

Well depth = 10,000 ft

Surface casing = 9-5/8 in. @ 2500 ft  
 Casing ID = 8.921 in.  
 capacity = 0.077 bbl/ft  
 Hole size = 8.5 in.  
 Drill pipe = 4.5 in. - 16.6 lb/ft  
 Drill collar OD = 6-1/4 in.  
 length = 625 ft  
 Mud weight = 9.6 ppg  
 Fracture gradient @ 2500 ft = 0.73 psi/ft (14.04 ppg)

Mud volumes :

8-1/2 in. hole = 0.07 bbl/ft  
 8-1/2 in. hole x 4.1/2 in. drill pipe = 0.05 bbl/ft  
 8-1/2 in. hole x 6-1/4 in. drill collars = 0.032 bbl/ft  
 8.921 in. casing x 4-1/2 in. drill pipe = 0.057 bbl/ft  
 Drill pipe capacity = 0.014 bbl/ft  
 Drill collar capacity = 0.007 bbl/ft  
 supercompressibility factor (Z) = 1.0

The well kicks and the following information is recorded :

SIDP = 260 psi  
 SICP = 500 psi  
 Pit gain = 20 bbl

Determine the following :

Maximum pressure at shoe with drillers method  
 Maximum pressure at surface with drillers method  
 Maximum pressure at shoe with wait and weight method  
 Maximum pressure at surface with wait and weight method

Determine maximum pressure at shoe with drillers method :

1. Determine formation pressure :

Pb = 260 psi + (9.6 ppg x 0.052 x 10,000 ft)

2. Determine height of influx at TD :

Hi = 2O bbl ÷ O.032 bbl/ft

= 625 ft

3. Determine pressure exerted by influx at TD :

Pi = 5252 psi — [0.4992 psi/ft (10,000 — 625)] + 500

= 5252 psi — (4680 psi + 500)

= 5252 psi — 5180 psi

= 72 psi

4. Determine gradient of influx at TD :

Ci = 72 psi ÷ 625 ft

= 0.1152 psi/ft

5. Determine height and pressure of influx around drill pipe :

h = 20 bbl ÷ 0.05 bbl/ft

= 400 ft

Pi = 0.ll52 psi/ft x 400

= 46 psi

6. Determine T °R at TD and at shoe :

T °R @ 10.000 ft = 70 + (0.012 x 10,000) + 460

= 70 + 120 + 460

= 650

T °R @ 2500 ft = 70 + (0.012 x 2500) + 460

= 70 + 30 + 460

= 560

7. Determine A :

A = 5252 psi — [0.4992 (10,000 — 2,500) + 46]

= 5252 psi — (3744 — 46)

= 1462 psi

8. Determine maximum pressure at shoe with drillers method :

Determine maximum pressure at surface with drillers method :

1. Determine A :

A = 5252 — [0.4992 (10,000) + 46]

= 5252 — (4992 + 46)

= 214 psi

2. Determine maximum pressure at surface with drillers method :

Determine maximum pressure at shoe with wait and weight method :

1. Determine kill weight mud :

KWM (ppg) = 260 psi ÷ 0.052 ÷ 10,000 ft + 9.6 ppg

= 10.1 ppg

2. Determine gradient (pm), psi/ft for KWM :

pm = 10.1 ppg x 0.052

= 0.5252 psi/ft

3. Determine internal volume of drill string :

Drill pipe vol = 0.014 bbl/ft x 9375 ft = 131.25 bbl

Drill collar vol = 0.007 bbl/ft x 625 ft = 4.375 bbl

Total drill string volume = 135.625 bbl

4. Determine FEET drill string volume occupies in annulus :

Di = 135.625 bbl : 0.05 bbl/ft

= 2712.5

5. Determine A :

A = 5252 — [0.5252 (10,000 — 2,500) — 46] + [2715.2 (0.5252 — 0.4992)]

= 5252 - (3939 - 46) + 70.6

= 1337.5

6. Determine maximum pressure at shoe with wait and weight method :

Determine maximum pressure at surface with wait and weight method :

1. Determine A :

A = 5252 — [0.5252 (10,000) — 46] + [2712.5(0.5252 — 0.4992)]

= 5252 — (5252 — 46) + 70.525

= 24.5

2. Determine maximum pressure at surface with wait and weight method :

Nomenclature :

A = pressure at top of gas bubble (psi)  
Ci = gradient of influx (psi/ft)  
D = total depth (ft)  
Di = feet in annulus occupied by drill string volume  
hi = height of influx (ft)  
MW = mud weight (ppg)  
Pb = formation pressure (psi)  
Pdi = pressure at depth of interest (psi)  
Ps = pressure at surface (psi)  
Pi = pressure exerted by influx (psi)  
pKWM = pressure gradient of kill weight mud (ppg)  
pm = pressure gradient of mud weight in use (ppg)  
T0F = temperature degrees Fahrenheit at depth-of interest  
T0R = temperature degrees Rankine at depth of interest  
SIDP = shut-in drill pipe pressure (psi)  
SICP = shut-in casing pressure (psi)  
X = depth of interest (ft)  
Zb = gas supercompressibility factor TD  
Zdi = gas supercompressibility factor at depth of interest

**GAS FLOW INTO THE WELLBORE**

Flow rate into the wellbore increases as wellbore depth through a gas sand increases :

*Q = 0.007 x md x Dp x L ÷ u x ln(Re ÷ Rw) 1,440*

Where ;

Q = flow rate (bbl/min)  
md = permeability (millidarcys)  
Dp = pressure differential (psi)  
L = length of section open to wellbore (ft)  
u = viscosity of intruding gas (centipoise)  
Re = radius of drainage (ft)  
Rw = radius of wellbore (ft)

Sample Case : md = 200 md  
 Dp = 624 psi  
 L = 20 ft  
 u = 0.3 cp  
 ln(Re ÷ Rw) = 2.0

Q = 0.007 x 200 x 624 x 20 ÷ 0.3 x 2.0 x 1440

= 20 bbl/min

Therefore : If one minute is required to shut-in the well, a pit gain of 20

bbl occurs in addition to the gain incurred while drilling the

20-ft section.