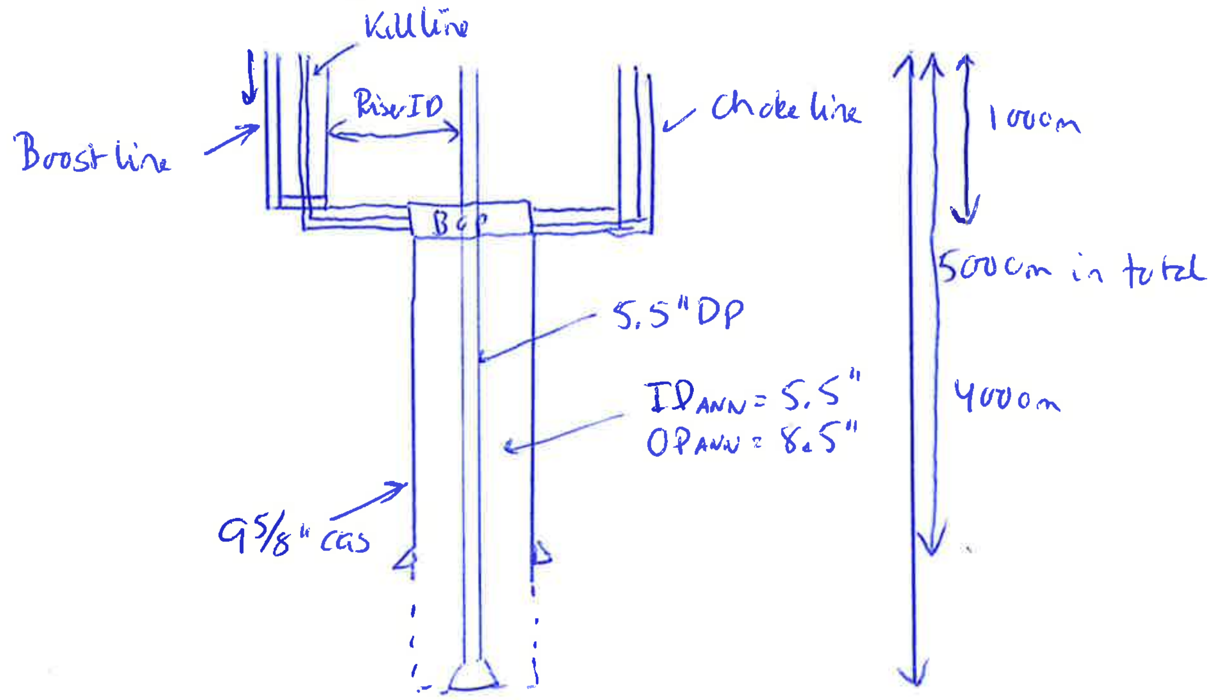
Exam 2015 (Some of the exercises)

Exercise 4. A well is 5000m deep. MW = 1.7sg
Water based mud (kick will be in free gas form and migrate in static wells. BOP at seabottom. Riser to surface with ID = 19"
Riser length = 1000m

A 9 5/8" casing with ID = 8.5" is set at 4000m.
Continued drilling an 8 1/2" hole.



a) In the annulus below BOP, we must have that the annular flow velocity must be at least 150 ft/min.

What must the minimum flowrate in liters per minute be?

$Q = V \cdot A$

$V = 150 \frac{ft}{min} = \frac{150 \cdot 0.3048m}{60s} = 0{,}762 \, m/s$

$8.5" \rightarrow 0{,}2159m$, $5.5" \rightarrow 0{,}1397m$, $A = \frac{\pi}{4} \cdot (0.2159^2 - 0.1397^2) = 0{,}02127 \, m^2$

$Q = A \cdot V = 0{,}02127 \cdot 0{,}762 = 0{,}01620 \, m^3/s = 16{,}2 \, l/s \cdot 60 = \underline{972 \, lpm}$

Exercise 4b, Exam 2015

Let us assume that a flowrate of 1000 lpm was adequate for hole cleaning in annulus. A boost line ensures additional flow in riser to ensure cuttings transport there.

What must the flowrate from the boost line into the riser be in liters per minute to also ensure that the cuttings is transported in the riser

To ensure cuttings transport in riser, we must obtain the same v in riser as in the well. We know that cuttings transport worked in well when $Q = 1000$ lpm

$$V_{well,crit} = \frac{Q}{A_{well}} \quad , \quad V_{Riser,crit} = \frac{\overset{\text{from well}}{Q} + \overset{\text{from boost line}}{Q_1}}{A_{Riser}}$$

$$\frac{Q}{A_{well}} = \frac{Q + Q_1}{A_{Riser}}$$

$$Q_1 = Q\left(\frac{A_{Riser}}{A_{well}} - 1\right) = 1000\left(\frac{0.1675}{0{,}02127} - 1\right) = \underline{\underline{6874\ lpm}}$$

A_{Riser}: $19'' \rightarrow 0{,}4826\,m$, $5.5'' \rightarrow 0{,}1397\,m$

$$A_{riser} = \frac{\pi}{4}\cdot(0.4826^2 - 0.1397^2) = 0.1675\,m^2$$

$$A_{well} = 0{,}02127\,m^2$$

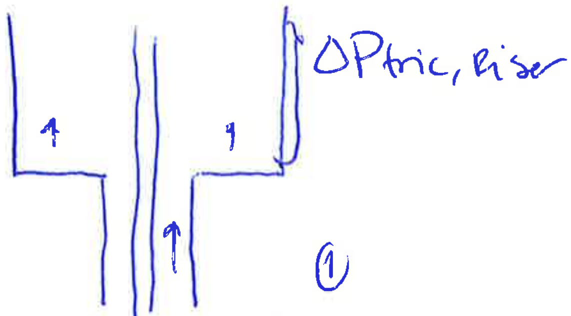
c) 1000 lpm, $f_{ric,ANN} = 25$ bar, $MW = 1.7$, $TVD_{TD} = 5000\,m$

Calculate ECD: $ECD = \dfrac{1{,}7 \times 5000 \times 0{,}0981 + 25}{5000 \times 0{,}0981} = \underline{\underline{1{,}75\,sg}}$

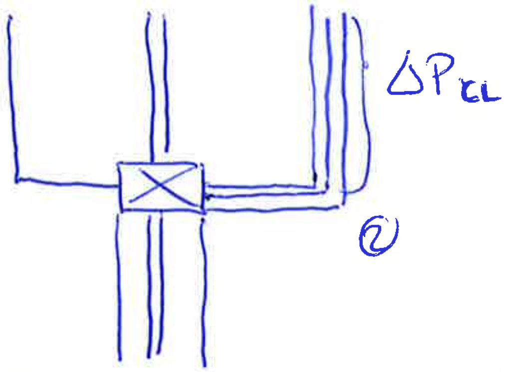
d) If a kick is taken, BOP is closed and a bit later the kick will be circulated out through the chokeline. A specific kill rate will be used e.g 500 lpm. Choke line has a small ID = 3" (with some friction)

③

In order to do this safely, one need to approximate the friction in the chokeline. ~~In operations~~
They do this by measuring the pump pressure when circulating up riser and when circulating up through chokeline



BOP is open, we circulate up through riser



BOP is closed, we circulate up throug choke line

Let us assume that we use the same flowrate and MW (same mud), there are only 1 difference, In one case we have Riser friction, in the other chokeline friction.

$$P_{pump_1} = \cancel{\Delta P_{fric,DP}} + \cancel{\Delta P_{fric,BIT}} + \cancel{\Delta P_{fric,well}} + \Delta P_{fric,Riser}$$
$$P_{pump_2} = \cancel{\Delta P_{fric,DP}} + \cancel{\Delta P_{fric,BIT}} + \cancel{\Delta P_{fric,well}} + \Delta P_{fric,\cancel{Riser}\ chokeline}$$

$$P_{pump2} - P_{pump1} = \Delta P_{fric,CL} - \Delta P_{fric,Riser}$$

How do operator estimate the chokeline friction?

1) Pump mud up riser with planned killrate (500 lpm) and note $pump_1 = 220$ bar
2) Close BOP, circ with same rate up chokeline and note $pump_2 = 230$ bar
3) Then they say that the chokeline friction is $\Delta P_{fric,chokeline} = 10$ bar

Explain what is the assumption

We have $P_{pump2} - P_{pump1} = \Delta P_{fric,CL} - \Delta P_{fric,Riser}$. We see that they have assumed riser friction to be zero. Why, it has so large OD that friction is very small.

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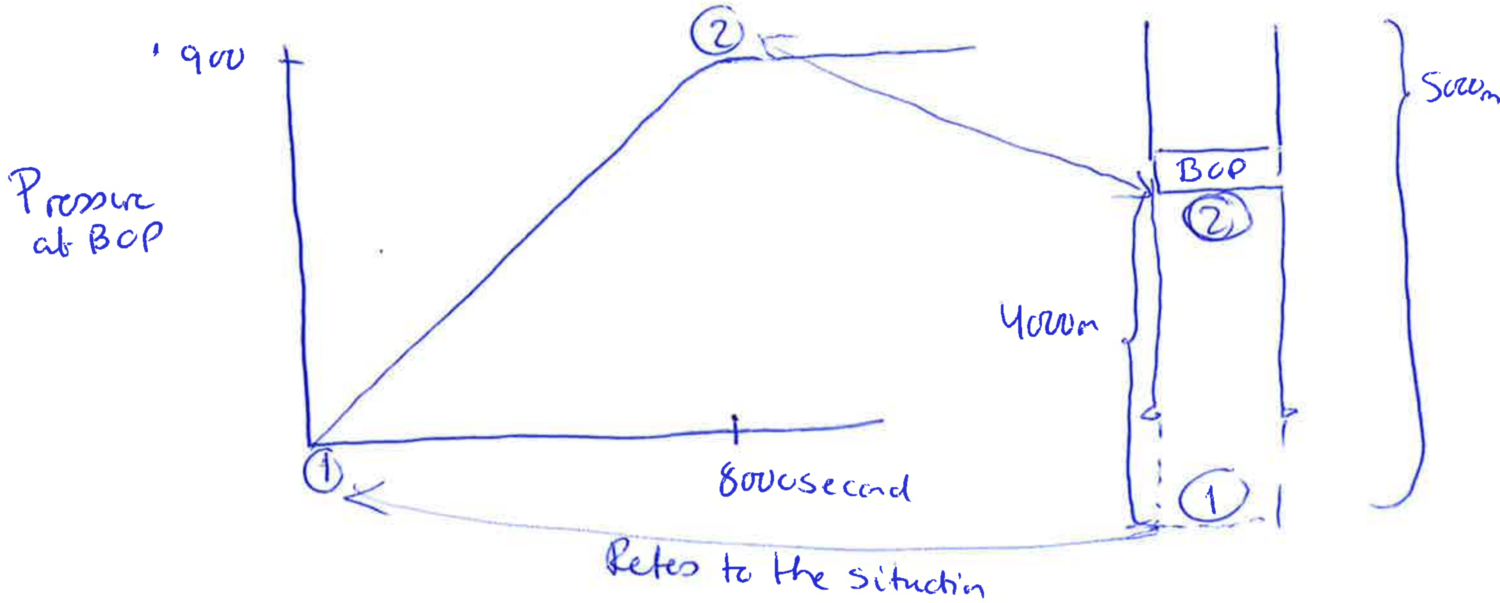


e) A kick is taken at 5000meters. BOP is closed and in this case we let the kick migrate in closed well until it is beneath the BOP

What is the pore pressure of the zone that induced the kick?

$(P \cdot V)_1 = (P \cdot V)_2$

This is the pressure of the kick bubble when it has migrated to surface

This is the pressure of the kick at bottom, equal to ~~the~~ pore pressure

If the mud is incompressible and the well volume is fixed (no fractures, formation expansion etc) kick volume will be fixed during migration $V_1 = V_2$

$\Rightarrow P_1 = P_2$

We read from graph that ~~$P_1 = 900$~~ $P_2 = 900 bar$, $\underline{P_1 = 900 bar}$

What is the S value in the gas slip relation?

$V_g = K \cancel{V_{mix}} + S$

This is ~~approx~~ zero in closed well

distance = $V \cdot t$ or distance = $S \cdot t$

$S = \frac{\text{distance}}{t} = \frac{4000}{8000} = 0{,}5 \, m/s$

from figure

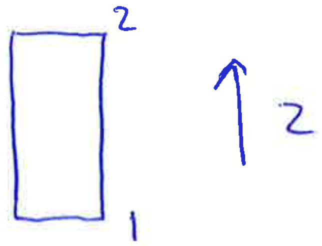
Exam 2015

Exercise 5

a) A transient model since pressure is varying in time. We are studying the time dynamics of a migrating kick.

b) $\frac{\partial}{\partial z} P = -\left(\rho_e g + \frac{\Delta P_{fric}}{\Delta z}\right)$

$P_1 = P_2 + \rho_e g \Delta z + \Delta P_{fric}$



When will P_1 have smallest value when comparing upward and downward flow?

The answer was P_1 is highest when we have ~~x~~ upward flow, $P_1 = P_2 + \rho_e g \Delta z + \Delta P_{fric}$, If the flow is downward one have $P_1 = P_1 + \rho_e g \Delta z - \Delta P_{fric}$

(Maybe the exercise should have been stated more precisely and said that we ~~x~~ assume P_2 be the same in both cases)

But, the essence was to understand that friction changes sign.