PE8601 / well drilling equipment and Operation

Unit-V

1. **Describe the Engineer's method of drilling operations.**

Definitions:

→ wait and weight well control method or someone calls Engineer's method is a method of control well and with one circulation.

→ Kill weight mud is displaced into drill string and kick is removed while displacing a well bore.

Steps of the wait and weight Method for well controls are as follows:

1. Shut in the well
2. Allow pressure to stabilize and record stabilized shut in casing pressure, Initial shut in drill pipe pressure, and pit gain.
3. perform well control calculations.
4. Bottom hole pressure based on drill pipe pressure.
5. Drillpipe pressure schedule.
6. Maximum pressure casing pressure during well control operation.
7. Maximum pit gain during calculation.

8. Raise mud weight in the system to required kill mud weight.
9. Establish circulation to required kill rate by holding casing pressure constant.
10. Follow drillpipe schedule until kill weight mud to the bit.
11. Hold drillpipe pressure constant once kill weight mud out of the bit until complete circulation.
12. Check mud weight out and ensure that mud weight out is equal to kill mud weight.
13. Shut down and flow check to confirm if a well is static
14. Circulate and condition mud if required.

Phase I:-

→ During this phase the drilling fluid, weighted to the density, is placed in the drillpipe when the drillpipe is filled with heavier mud, the standpipe pressure is gradually reduced.

→ The expected drillpipe pressure versus the number of pump strokes must be prepared in advance. Only by pumping with a constant number of strokes and simultaneously maintaining the standpipe pressure in accordance with the schedule can one keep the bottom hole pressure constant and above the formation pressure.

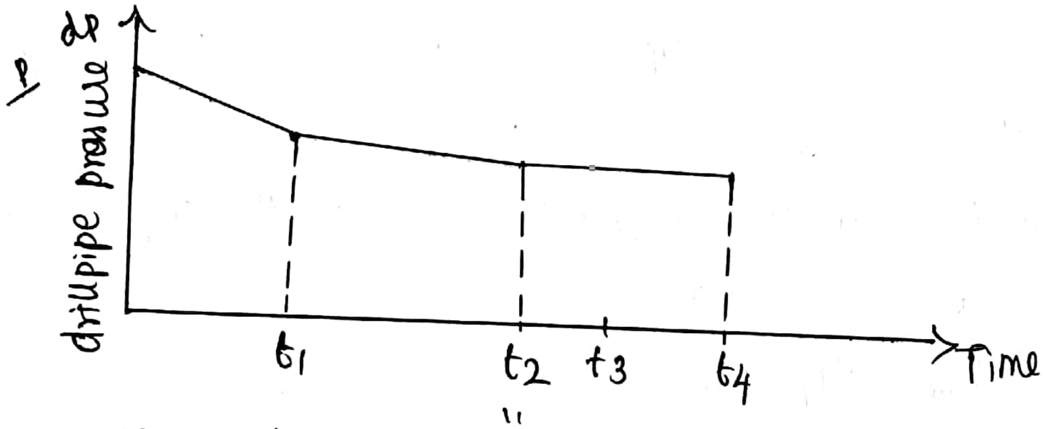
→ The Annulus pressure at the surface generally rises due to formation fluid explosion, although for some formation fluid the casing pressure may decrease. This depends on phase behaviour of the formation fluid and irregularities in the hole geometry.

phase 2:-

→ This phase is initiated when the kill mud begins filling the annulus and is finished when the formation fluid reaches the choke. The standpipe pressure remains essentially constant by proper adjustment of the choke.

phase 3:

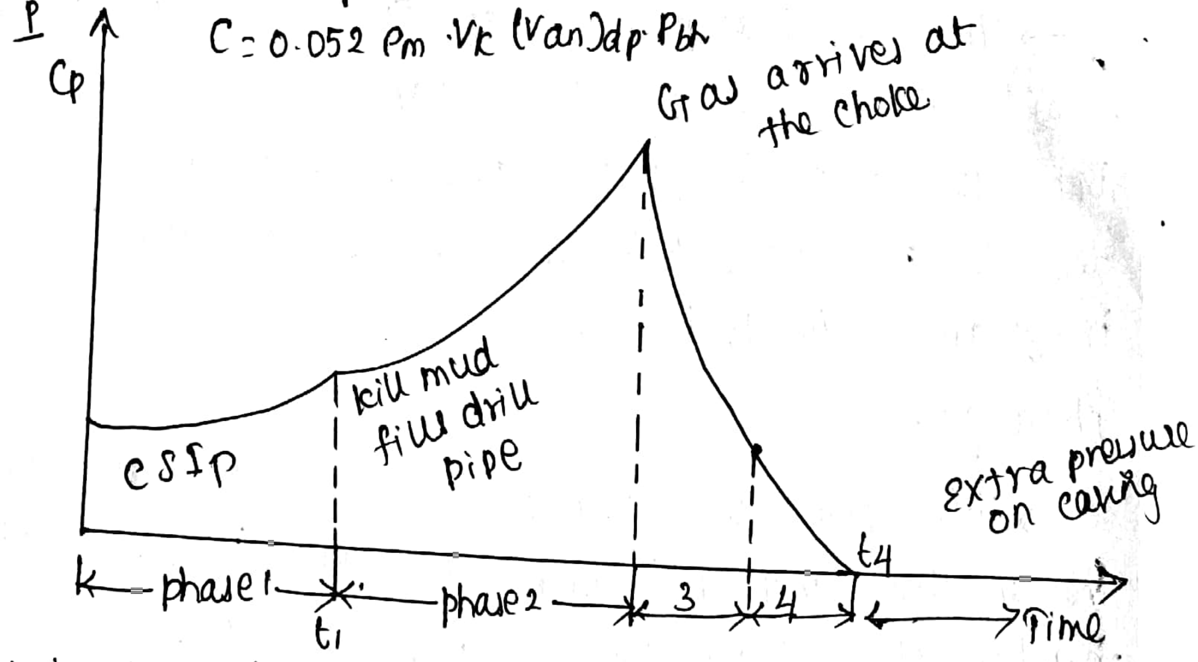
→ The formation fluid is circulated out of the hole while heavier mud fills the annulus. Again the choke operator maintains the drillpipe pressure constant and constant pumping speed.



Engineer's method "Drillpipe pressure V. time".

$b = P_{dp} + 0.052\, \rho_m \cdot D_1$

$C = 0.052\, \rho_m \cdot V_k\, (V_{an})_{dp} \cdot P_{bh}$



Engineer's method - Casing pressure vs. time.

t_1 : kill mud at the bottom of the hole, t_2 : formation fluid reaches the choke, t_3 : kick fluid out of the hole, t_4 : pressure overbalance is restored.

Phase 4:-

→ During this phase the original mud that follows the kick fluid is circulated out of the hole and a kill mud fills up the annulus. The choke is opened more and more to keep the drillpipe pressure constant.

→ At the end of this phase the safe pressure overbalanced is recorded.

$$P_{bh} = P_{dp} + 0.052\, \rho_m . D$$

$$G = \frac{V_k . P_{bh}}{P_{max}}$$

$$P_{max} = \frac{\sqrt{b^2 + 4.c} + b}{2}$$

$$b = \frac{P.dp + V_{dp} \cdot (V_{an})_{dp}}{D} + 0.052\, \rho_{km} . D_1$$

$$C = 0.052\, \rho_{km} \cdot (V_{an})_{dp} \cdot P_{bh}$$

P_{bh} [psi] - bottom hole pressure

G - pit volume increase when top of kick reaches the depth

P_{max} - maximum casing pressure.

Q. Any four ways to kill a well in detail:-

Definition:

→ A well kill is the operation of placing a column of heavy fluid into a well bore to prevent the flow of reservoir, fluids without the need for control equipment at the surface

→ Reverse circulation
→ Bull heading
→ Forward circulation
→ Lubricate and bleed.
→ Reverse well kills during drilling operations.

Reverse circulation :-

→ This is often the tidiest way of making a planned well kill. It involves pumping kill fluid down the 'A' annulus of the well, through a point of communication b/w it and the production tubing just above the production packer and up the tubing, displacing the lighter well bore fluids, which are allowed to flow to production.

→ The point of communication was traditionally a device called a sliding sleeve, or sliding side door, which is a hydraulically operated device, built in the production tubing.

→ During normal operation, it would remain closed sealing off the tubing and the annulus, but for events such as this, it would be opened to allow the free flow of fluids b/w the two regions.

Bull heading :-

→ This is the most common method of a contingency well kill. if there is a sudden need to kill a well quickly without the time of rigging up for circulation.

→ This involves simply pumping the kill fluid directly down the well bore, forcing the well bore fluids back into the reservoir.

→ This can be effective at achieving the central aim of a well kill.

→ building up a sufficient hydrostatic head in the burst-pressure capabilities of the tubing or casing, and can risk damaging the reservoir by forcing undesired materials into it.

→ The principal advantage is that it can be done with little advanced planning.

Forward circulation:-

→ This is similar to reverse circulation, except the kill fluid is pumped into the production tubing and circulated out through the annulus.

→ Though effective, it is not as desirable since it is preferred that the well bore fluids be displaced out to production, rather than the annulus.

Lubricate and bleed:-

→ This is the most time-consuming form of well kill. It involves repeately pumping in small quantities of kill mud into the wellbore and then bleeding off excess pressure.

→ It works on the principle that the heavier kill mud will sink below the lighter well bore fluids and so bleeding off the pressure will remove the latter, leaving an increasing quantity of kill mud in the well bore with successive steps.

3. Predict the pressure control inside formation when the well is affected by the following a) Faulting b) Compaction

Faulting:-

fault types :-

* Strike - slip where the offset is predominately horizontal parallel to the fault plane.

* Dip-slip; offset is predominately vertical and/or perpendicular to the fault plane.

* oblique - slip, combining significant strike and dip slip.

→ only dip-slip and oblique -slip can cause the abnormal pressure because there are some changes in elevation of the reservoir.

→ The reservoir has the same formation pressure of 6500 psi. As time goes by, the earth movement causes fault to the reservoir.

→ one reservoir is uplifted 1000 ft TVD apart. The pressure is abnormal for that depth.

Compaction:-

→ Compaction pressure highly influences the pore size as well as number of pores. With increase in compaction pressures the surface contact area of the powder particles increase which reduce the porosity.

→ The maximum value of the density and hardness is obtained for 700 MPa and 3 min dwell time.

4. **Explain in detail about shut in procedure:-**

definition:-

→ When one or more warning signs of kicks are observed steps should be taken to shut in the well.

→ it is important b/w a small flow - well and a full flowing well, because both can very quickly turn into a big blowout.

Initial shut in procedures:-

→ considerable discussion has occurred regarding the merits of "hard shut in" procedures vs "soft shut in procedures".

→ in hard shut in procedure, the annular preventer are closed immediatly after the pumps are shut down.

→ in soft shut in procedures, the choke is opened before closing the preventers.

→ Most used in shut in procedure is hard shut in procedure.

→ Hard shut in procedure depends on the following,

* Drilling - Land or bottom supported offshore rig
* Tripping - land or bottom - supported offshore rig
* Drilling - Floating rig
* Tripping - floating rig
* Diverter procedures - all rigs

i) **Drilling - Land or bottom supported offshore rig:-**

→ These rigs do not move drilling during normal drilling operations

→ They include land and barge rigs Jack-ups and platform rigs.

Shut in procedure:-

when a primary kick warning signs has been observed do the following immediately.

1. Raise the kelly until a tool Joint is above the rotary table
2. Stop the mud pumps
3. Close the annular preventer.
4. Notify company personnel.
5. Read and record the shut in drillpipe pressure, the shut in casing pressure, and the pit gain.

ii) **Tripping - Land or bottom supported offshore rig**

→ high percentage of well-control problems occur when a trip is being made.

Shut in procedures:

1. Set the top tool joint on the slips.
2. install and make up a full-opening, fully opened safety valve on the drillpipe
3. close the safety valve and the annular preventer.
4. notify company personnel.
5. pickup and make up the kelly.

6. Open the safety valve
7. Read and record the shut in drillpipe pressure, shut in casing pressure and pit gain.

(iii) <u>Drilling- Floating rig:</u>

→ A Floating rig moves during normal drilling operations. The primary types of floating vessels are semisubmersibles and drillships.

<u>Shut in procedures:</u>

1. Raise the kelly to the level previously designated during the spacing out procedure.
2. Stop the mud pumps
3. close the annular preventer.
4. Notify company personnel
5. Close the upper set of pipe rams.
6. Reduce the hydraulic pressure on the annular preventer.
7. Lower the drillpipe until the pipe is supported entirely by the rams.
8. Read and record the shut in drillpipe pressure, shut in casing pressure, and pit gain.

iv) <u>Tripping – Floating rig:</u>

→ The procedures for kick closure during a tripping operation on a floater is a combination of floating drilling procedures.

1. Set the top tool Joint on the slips
2. install and makeup a full-opening, fully opened safety valve in the drillpipe.

3. close the safety valve and the annular preventer
4. Notify company personnel
5. pick-up and make up the kelly
6. Reduce the hydraulic pressure on the annular preventer
7. Lower the drillpipe until the rams support it.
8. Read and record.

v) Diverter procedures:- all rigs:-

→ Special attention must be given to this procedure so that the well is not shut in until after the diverter lines are opened.

Shut in procedures:-

1. Raise the kelly until a tool joint is above the rotary table.
2. Increase the pump rate to maximum output.
3. Open the diverter line valve.
4. Close the diverter unit
5. Notify company personnel.

5. Mention any four causes of overpressure in Zones:-

* Drilling problems with overpressured Reservoirs
* Geological cause of overpressured reservoirs
* prediction of overpressure before drilling
* Detection of overpressure while drilling.

(i) Drilling problems with overpressured Reservoirs

Blowouts :- Uncontrolled production of formation fluids

caving :- high pore pressure is low permeability rocks cause them to stress relieve or "cave" into the borehole.

Stuckpipe :- The drill pipe adheres to the side of the borehole due to the swelling of the borehole walls behind the bit.

Lost circulation :- By raising the mud weight to control the formation pressure at the bit, the formation may rupture. The mud will then run out into a cavity of its own making.

ii) Geological cause of overpressured reservoirs:

* Thermal cracking of organic matter :-

→ The Thermal cracking of organic matter may cause an increase in the volume of fluids, which would in turn cause an increase in pressure.

Aquathermal effects:

→ aquathermal effects also cause overpressure. The temp increases as sediment is . buried, causing an increase an increase in the volume of water.

→ This is turn results in an increase in pressure if the sediment is buried, causing an increase in the volume of water. This in turn results in an increase in pressure if the sediment is sealed by an impermeable layer.

(iii) prediction of overpressure before drilling & seismic detection:

→ As shales compact the velocity of seismic waves increases so that seismic wave velocity normally increases with depth.

→ Interval velocity can be determined from the surface by the common depth point method of seismic acquision.

→ If the interval velocity increases normally with depth and then decreases, it is possible that a zone of overpressure exists.

(iv) Detection of overpressure while drilling :-

drilling rate:-

→ if the drilling rate increases, it can be infered than an overpressured zone is being encountered. The rate increases because bottom hole conditions change from overbalanced to underbalanced.

→ The abnormal high pressures can be calculated by,

$$\text{d exponent} = \frac{\log \frac{R}{60N}}{\log \frac{12W}{10^6 D}}$$

where,

R - Rate of penetration in feet per hour

N - Rotary speed in revolutions per minute

W - weight on bit in pounds

D - hole diameter in inches.

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8. **What are the warnings signals of a well kick?**

→ Warning signs and possible kick indicators can be observed at the surface. Each crew member has the responsibility to recognize and interpret these signs and take proper action.

Warning signal:-

(i) Flow rate increase (primary indicator)

→ An increase in flow rate leaving the well, while pumping at a constant rate, is a primary kick indicator.

→ The increased flow rate is interpreted as the formation aiding the rig pumps by moving fluid up the annulus and forcing formation fluids into the well bore.

(ii) pit volume increase :- (primary indicator)

→ If the pit volume is not changed as a result of surface-controlled actions, an increase indicators a

→ Kick is occuring. Fluids entering the wellbore displace an equal volume of mud at the flowline, resulting in pit gain.

(iii) Flowing well with pumps off (primary indicator):-

→ when the rig pumps are not moving the mud, a continued flow from the well indicates a kick is in progress.

→ An exception is when the mud in the drillpipe is considerably heavier than in the annulus, such as in the case of a slug.

(iv) pump pressure decrease and pump stroke increase (Secondary indicator).

→ A pump pressure change may indicate a kick. initial fluid entry in to the borehole may cause the mud to flocculate and temporarily increase the pump pressure.

(v) Improper hole fill-ups on trips:

→ when the drillstring is pulled out of the hole the mud level should decrease by a volume equivalent to the removed steel

→ gas or saltwater may have entered the hole, the well may not flow until enough fluid has entered to reduce the hydrostatic pressure below the formation pressure.

vi) String weight change:-

→ when a kick occurs, a low density formation fluids begin to enter a borehole the buoyant force of the mud system is reduced, and the string weight observed at the surface begins to increase.

(vii) cut mud weight indicator:-

→ core volume cutting

→ connection air

→ aerated mud circulated from the pits and downhole pressure.

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7. Explain the following in detail?

a) kill sheets, (b) kill procedures.

a) kill sheets:-

definition:

→ a kill sheet is normally used during conventional operations. it contains pre recorded data, formulas for the various calculations, and a graph - or other means - for determining the required pressures on the drillpipe as the kill mud is pumped.

Example:

Prerecorded data:-

Original mud weight = 13.1 lbm/gal

slow pump rate = 21 spm at 800 psi

Drill pipe volume = 203 bbl

Annulus volume = .1916 bbl/strokes

Drillpipe strokes = $\frac{\text{Drill pipe volume (bbl)}}{\text{pump output (bbl/stroke)}}$

$= \frac{203 \text{ bbl}}{.1916 \text{ bbl/stroke}}$

= 1060 strokes.

Kick data:

P_{SIDP} = 240 psi

P_{SIC} = 375 psi

Pit gain = 31 bbl

True vertical depth = 15000 ft

Kill mud Data:-

Mud weight increase = $\frac{P_{SIDP} \times 19.23}{\text{Depth}}$

= 0.3 lbm/gal

Kill mud weight = original weight + increase

= 13.1 lbm/gal + 0.3 lbm/gal = 13.4 lbm/gal

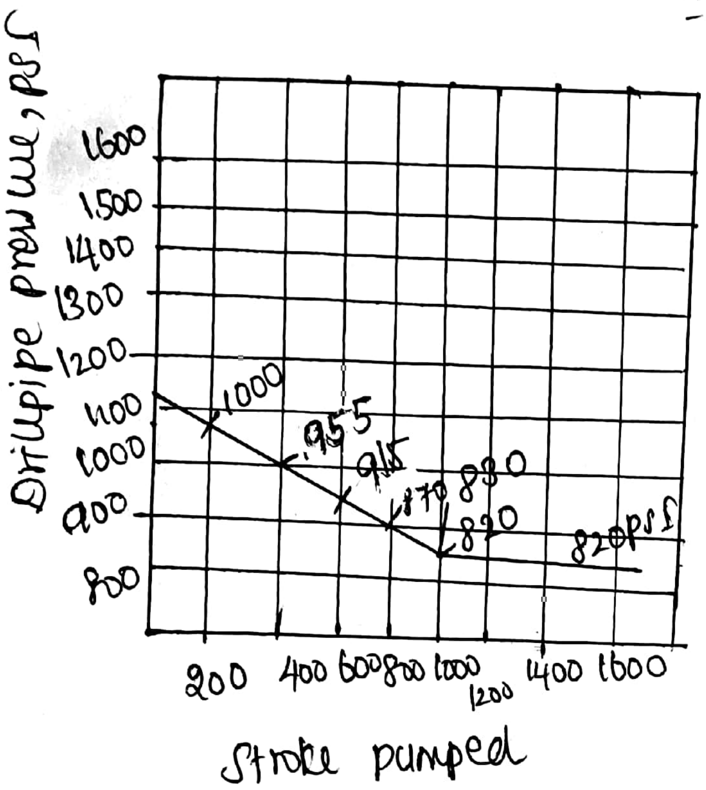
Pump pressure:-

initial drillpipe pressure = P_{SIDP} + slow pump pressures

= 1040 psi

Final drill pipe pressure = (kill mud weight × slow pump pressure) / original mud weight

= 820 psi



Pressure profile

Strokes	Pressure, psi
200	1000
400	960
600	915
800	870
1000	830
1055	820

b) Kill procedures:

Refer question (2).