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No 18

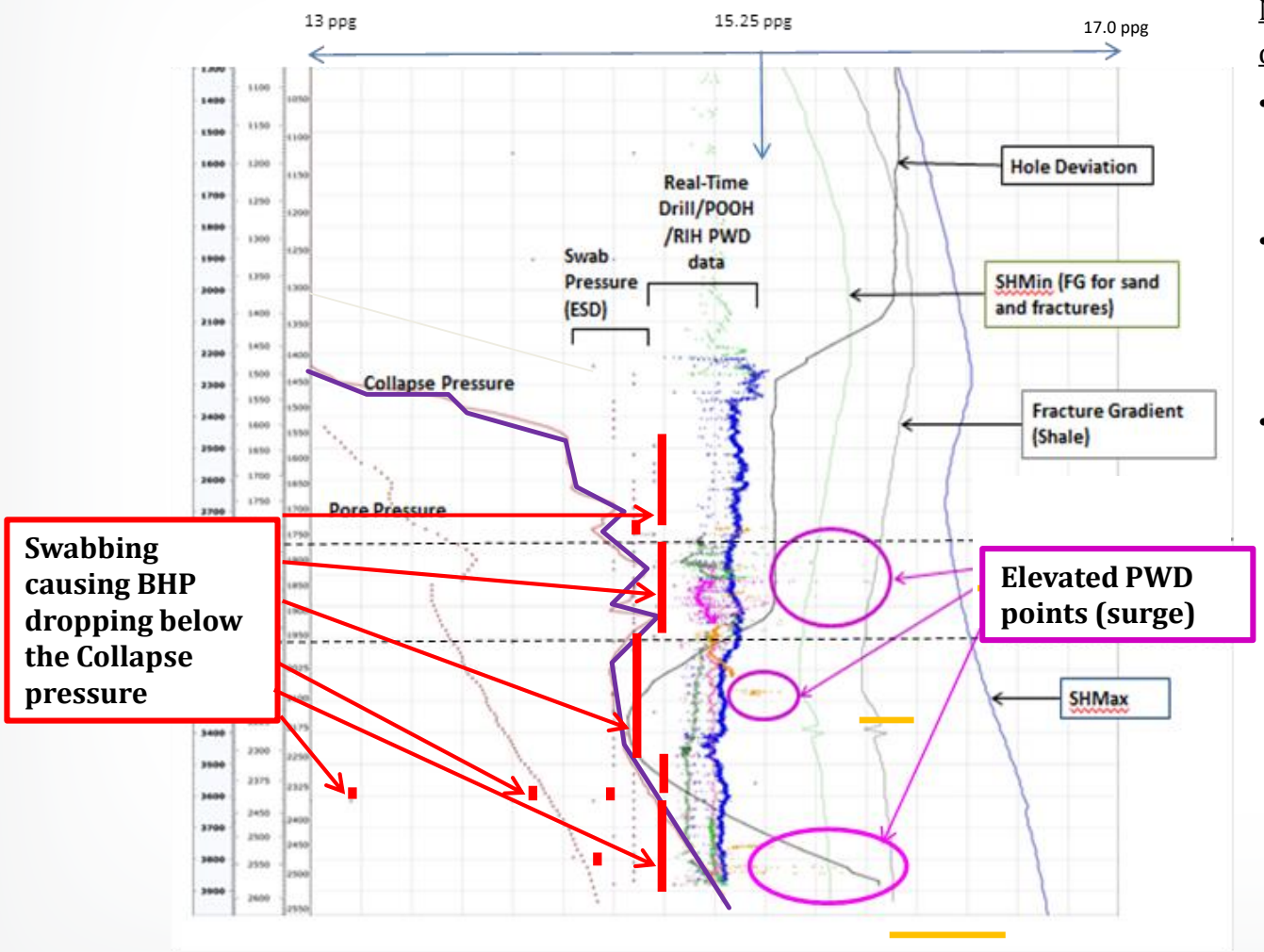
Influx while drilling with a Managed Pressure Drilling Unit in use

Background – Defining MPD

Definition:

- Managed Pressure Drilling is a means of controlling pressure seen by the well at a particular depth by the use of a closed loop system.
- It is achieved by application of surface pressure via an MPD choke in addition to the hydrostatic pressure of the mud column and enables overbalanced drilling close to, but above the pore pressure at all times throughout the drilling operation.
- The desired pressure within the well is controlled by the MPD choke whose set points are given by a real time hydraulic model.
- MPD maintains a relatively constant pressure avoiding the fluctuations resulting from the loss of frictional pressure during periods of no circulation.
- In an MPD closed loop system, volumes in and out of the well are precisely recorded & monitored enabling a fast response to well conditions.
- MPD has the ability to compensate for swab and surge pressures.
- MPD can precisely control the applied pressure seen by the well which can be adjusted up or down efficiently.

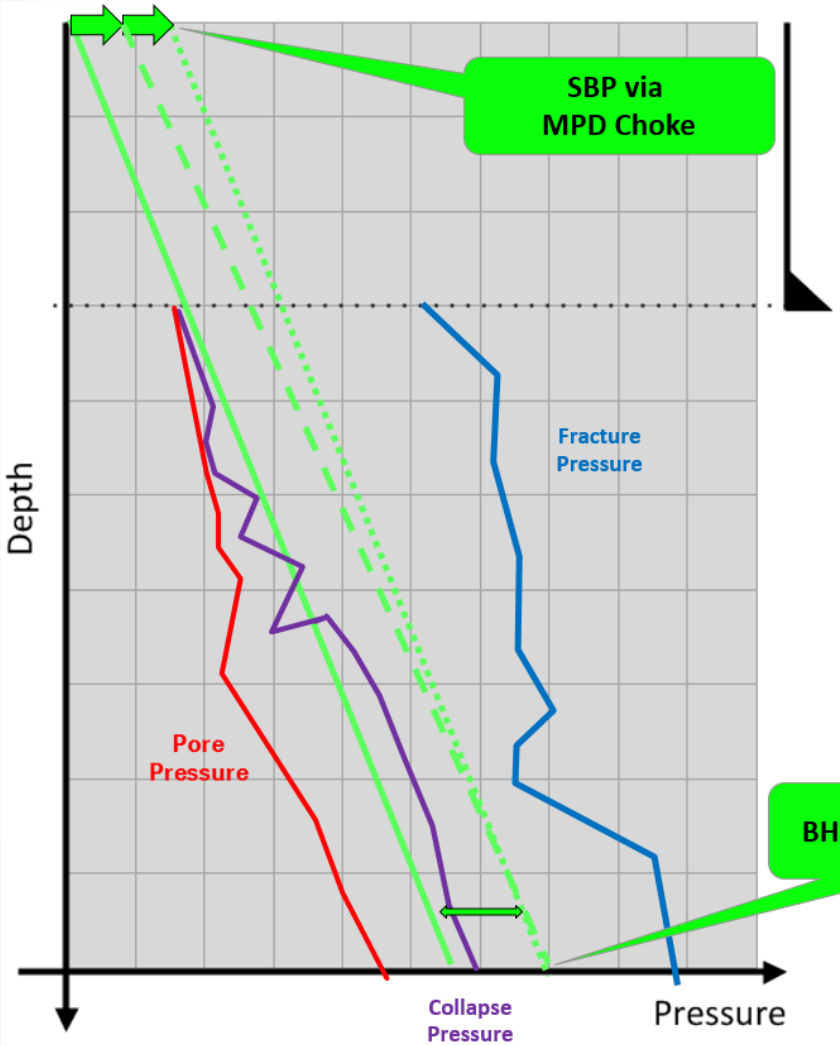
Background - Purpose



Main reasons for using MPD on this field:

- Narrow mud weight window throughout 12 ¼" section.
- Mitigating cyclic loading on the wellbore which has been known to induce formation failure.
- Maintaining a closed loop pressure system on the wellbore to enhance well monitoring ability and quicker response.

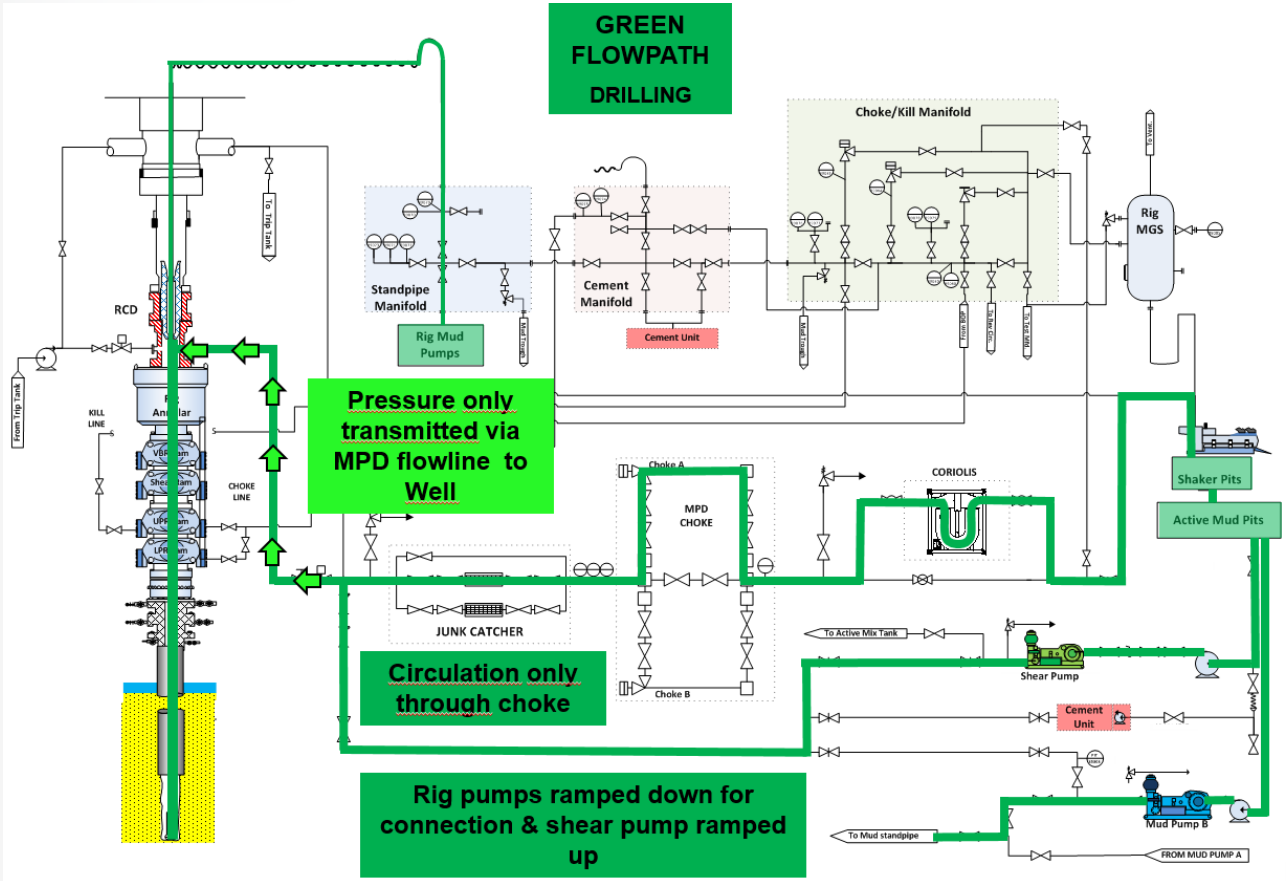
Background - Principle



Principle drilling with constant BHP

- During conventional drilling, the mud weight and narrow window usually lead to ECD exceeding fracture gradient in weak zone higher up in the section, or fall below collapse pressure curve closer to TD with pumps off or when pulling up.
- With MPD the static mud weight is still in overbalance to the pore pressure but might be lower than the collapse curve (solid green line).
- During MPD drilling a Surface Back Pressure (SBP) is added and ECD is managed between set points in order to stay inside the window (dashed green line).
- To compensate for the loss of ECD on connections, SBP is added to keep the pressure at the zone of interest equal to the drilling ECD (dotted green line) at a certain point - hence, the increasing slope on the curve.
- Note – the open hole section sees elevated pressures when using MPD.
- In this example the zone of interest is bottom hole, but can be anywhere higher up in the section.

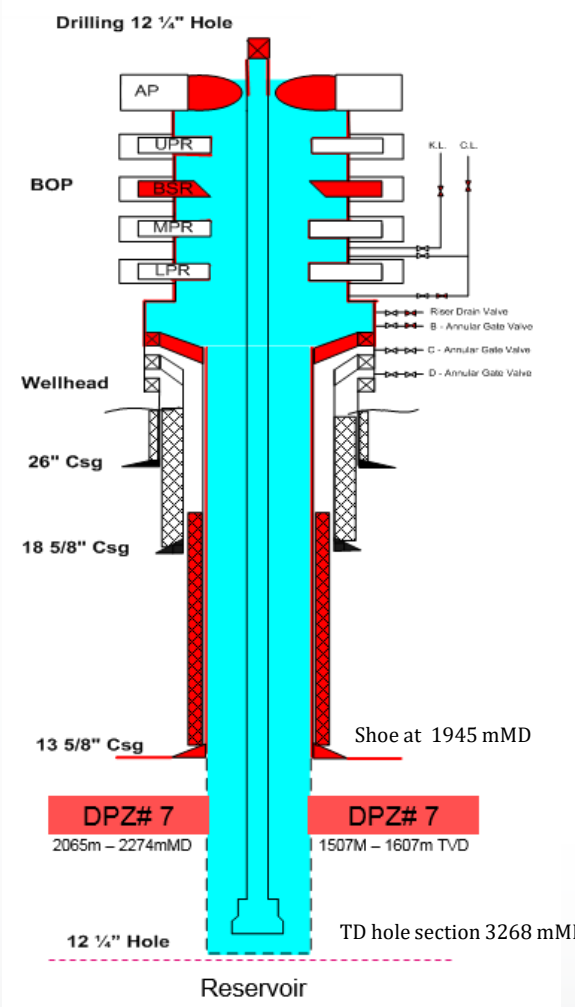
Background – Rig up



- The Well is an enclosed system sealed by an RCD or rotating control device installed on top of the annular preventer.
- Fluids in and out of this sealed system can be monitored accurately.
  - Flow in (from Mud pump encoders)
  - Flow out using accurate MPD Coriolis flowmeters
- Figure shows flow path during drilling.

Well status – MPD operation overburden

Barrier drawing with RCD isolated

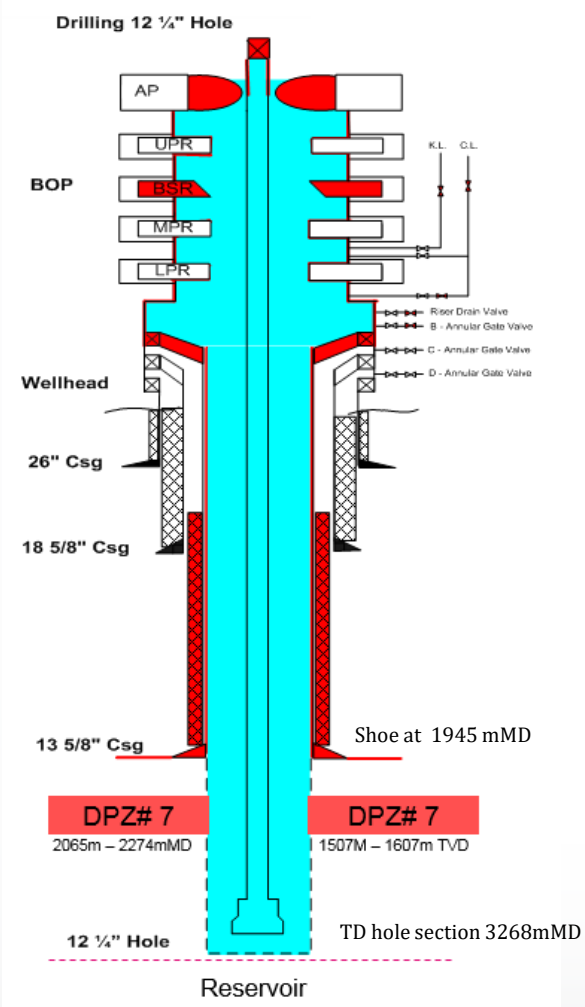


- Platform drilling operations
- Weak DPZ#7 zone present in 12 ¼'' section (gas bearing)
- Drilled out 13 5/8" Casing Shoe and 3m of new formation and performed FIT to 15.6ppg - OK
- Drilled 12 ¼" section in MPD mode using 13.9ppg OBM to 30m below DPZ#7.
- Maintained ECD with ~200psi MPD surface back pressure on connections (MPD set point at 14.6ppg).
- Increased mud weight to 14.1ppg and drilled 12-1/4" hole to section TD at 3268mMD (5m TVD above top reservoir), using 910 gpm pump rate maintaining 14.60-14.76ppg ECD with ~165 / 200 psi MPD surface back pressure on connections (set point at 14.6 / 14.7 ppg).
- Observed losses to well at TD. Losses increased to 90bbl/hr. Reduced pump rate to 250 gpm maintaining 14.3ppg EMW with MPD surface back pressure and losses reduced to 20-bbls/hr.

- Question 1: What actions are now possible ?
- Question 2: What risks should be evaluated before changing pump rate?
- Question 3: How will the pressure profile in open hole be affected?

Well status – MPD operation overburden

Barrier drawing with RCD isolated

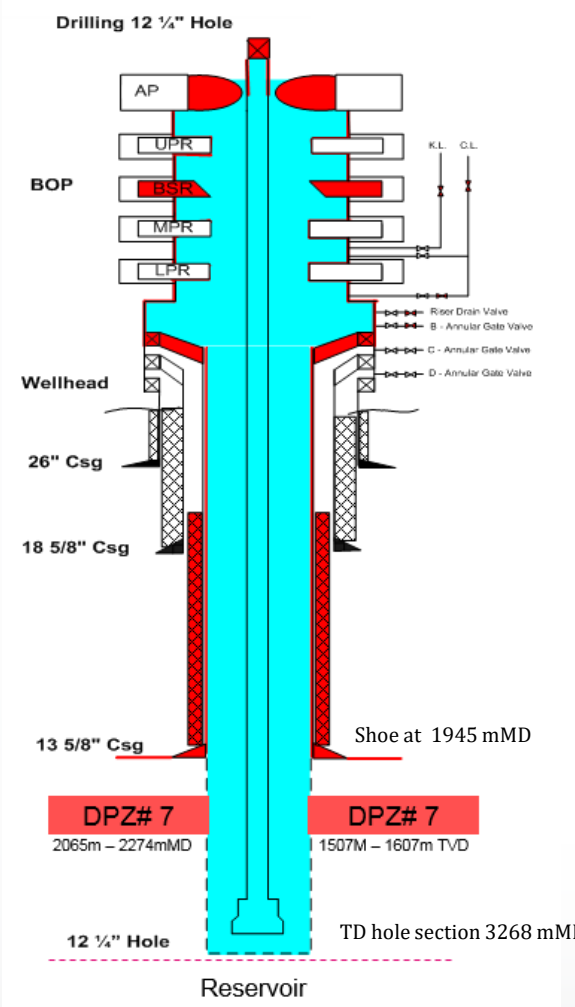


- Pumped and displaced 70-bbls LCM pill at low rate. Losses reduced to zero.
- Pulled back string and observed losses commencing again. Losses increased to +220bbls/hr while racking stand at 3241m. No MPD back pressure.

- Question 4: What is correct approach for handling the situation?
- Question 5: Is it ok to continue POOH?

Well status – MPD operation overburden

Barrier drawing with RCD isolated

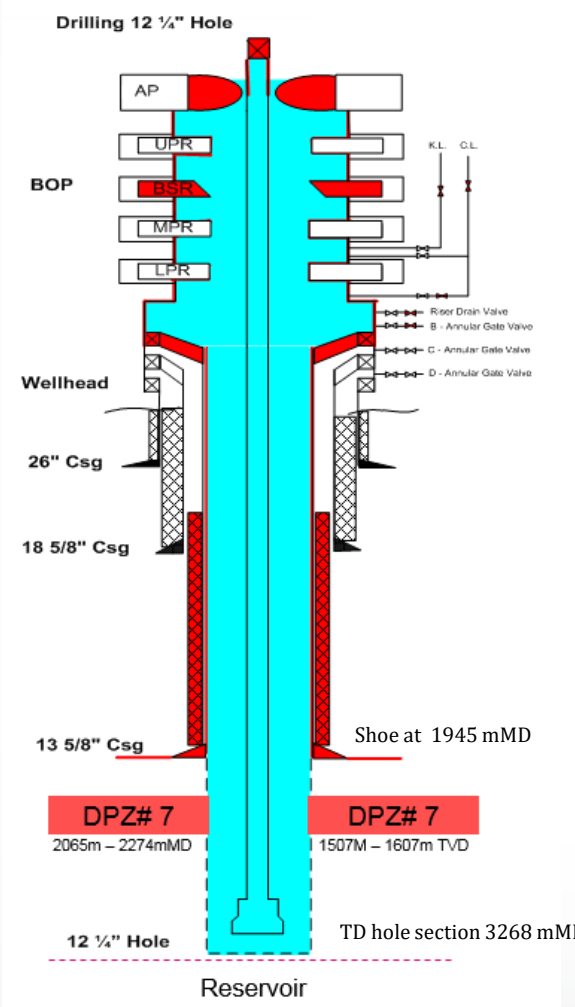


- Continued POOH to 3209m. Surface back pressure 156psi, EMW 14.45ppg. MPD set point reduced to 14.4ppg as 14.6ppg gave total losses and unable to hold any pressure. MPD was taken off line to pump LCM –chokes fully open.
- Disengaged top drive and stripped out to 3157m. No MPD back pressure applied.
- Observed losses gradually decrease to "zero". Total losses during loss events 168-bbls.
- Continued to strip out to 2960mMD, dry pipe.

- Question 6: What should be the next step ?

Well status – MPD operation overburden

Barrier drawing with RCD isolated

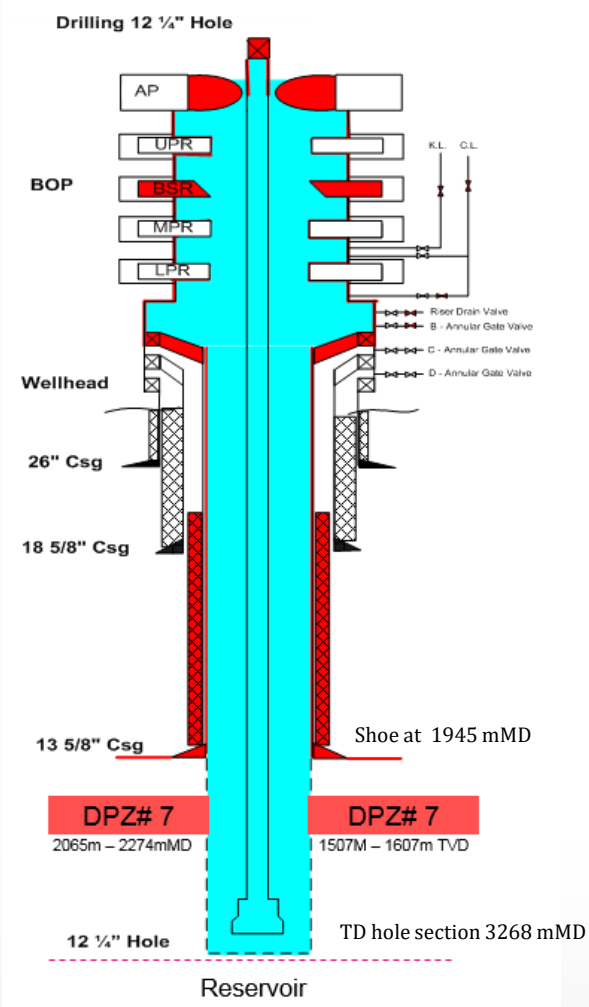


- RIH to 3060m to position pipe for pumping a FracCem slurry.
- Held pre-job meeting for FIT testing well to 14.7ppg by way of MPD surface back pressure only.
- Observed well ballooning back 13bbls.
- Attempted FIT to 14.7ppg EMW (270psi applied at surface) with MPD system. Lost total 25-bbls during FIT test.
- Observed Well ballooning back 16-bbls after test.

- Question 7: What could be happening down hole?
- Question 8: How to distinguish between ballooning and kick?

Well shut in with 250 psi SICP

Barrier drawing with RCD isolated

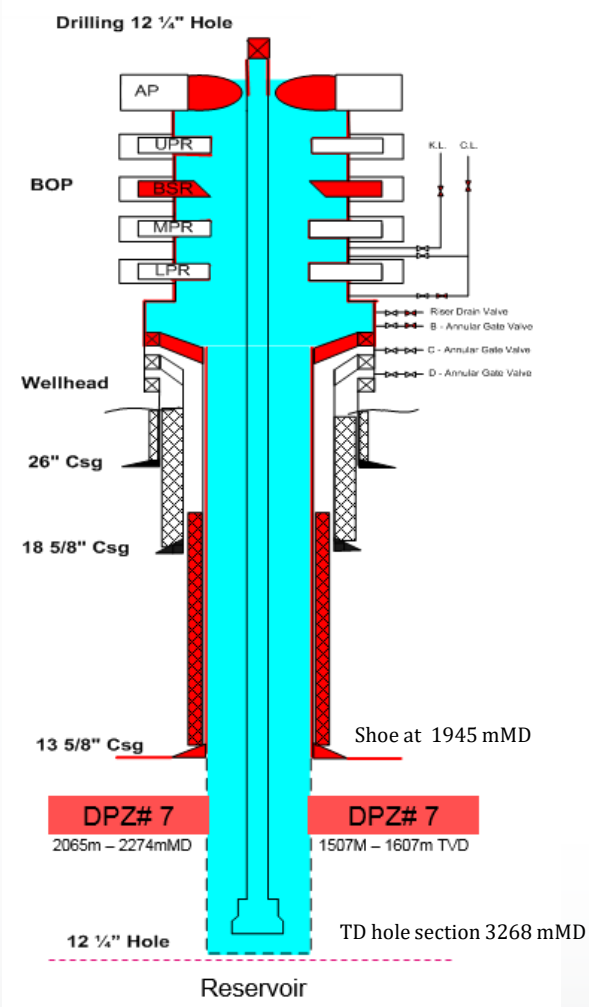


- Aborted cement job.
- Broke circulation and circulated with 100gpm, observing gain rate ~30 bbls/hr. Still lined up through MPD system.
- Shut in well on Upper Pipe RAM due to more than 5 bbls gain. SICP ~250 psi. Circulated through rig choke and MGS.
- Assessed risk associated with resume using MPD equipment and decided to line back on MPD circulation w/250 psi back pressure so that string could be moved - String stuck!
- Tried to free pipe several times without success.
- Active system gaining.

- Question 9: What is the situation now ?
- Question 10: What should be the way forward?

Handling the situation

Barrier drawing with RCD isolated



- **Yes – the pipe is stuck** and annulus packed off!

- Selected solution:
  - RU wireline and punched string at 2445m.
  - SIDPP = 28psi
  - SICP = 843psi
  - Started kill operation with Wait and Weight method
  - Pumped down 14.2ppg MW
  - Circulated 14.2ppg MW around.
  - Flow Checked – Dead well
  - Cut string and plugged hole.

- Question 10: What could explain the significant difference between SIDPP and SICP?

Learnings and recommendations

- Know where you are applying pressure using MPD.
- Understand the difference in pressure gradient across the open hole section when changing MW vs. when changing MPD pressure.
- MPD operations are tricky and must be understood by all involved with the operation.
- Stuck pipe is a secondary problem when dealing with a kick, the kick is first priority.
- Deal with one problem at the time (losses – gains).
- When ballooning occurs, it could bring back more than the Mud.
- Clearly define scenarios for when MPD shall and shall not be used to handle instabilities in the well.
- Advantage with MPD:
    - Ability to control BHP with high accuracy.
- Disadvantage with MPD
    - Difficult to control losses with MPD unit if pressure is governed by collapse curve as the formation will collapse.
    - Less margin to fracture gradient at weak point when controlling BHP using back pressure rather than MW.
    - Choke likely to get plugged if cavings present.