BHA Components

Non-magnetic BHA components

- To reduce the magnetic interference by steel components, non-magnetic drill collars and/or stabilisers made of materials such as Monel and stainless steels, can be used.
- Apart from higher cost, these materials generally have a lower fatigue strength.

Variable gauge stabilisers (VGS)

- main advantage is provision of inclination control without having to slide.
- By default the VGS positioned just above the downhole motor.
- Running a VGS below the downhole motor is non-standard and requires particular attention during the design phase.
- It is best practice to have only a two fold objective for the section where the VGS is applied. This means either maintain angle/drop, or maintain angle /build. Generally only limited drop rates can be expected when using a VGS in rotary mode.

Shock-subs

- used to combat axial bit vibration in order to improve run length and penetration rate.
- should only be used when:
  - Drilling hard formations
  - In combination with tri-cone bits
  - In low angle sections (<30deg)
- Only effective when placed as close to the bit as possible.
- When analysis of MWD vibration data has confirmed the presence of axial vibration in offset wells it is not recommended to use shock-subs in combination with PDC bits.
- Two key parameters, which determine the effectiveness of the shock sub, are its spring rate and stroke length.

Near bit stabilisers (NBS)

- are almost gauge stabilisers (1/32” to 1/16” undergauge)
- positioned directly above the bit. They are also known as dog-subs or rocky back stabilisers.
- Amongst directional drillers there exists mixed opinions on the merits of near bit stabilisers. They report cases where NBS’s have performed well, but also cases where no positive or even a negative effect on steering was observed.
- It is generally accepted though that NBS’s limit borehole spiralling and polish the borehole wall. The smoother borehole wall is thought to lead to improved tool-face control and less stabiliser hang-ups.
- When using near bit stabilisers consider:
  - Due to the increased bit offset when using a NBS, the stress level on the bent sub will increase. This is not perceived as a problem though in low curvature wells.
  - Have appropriate bit/dog sub breaker plates available to be able to disconnect the dog-sub from bit.
  - A NBS/bit combination provides more gauge protection than a bit on its own.
  - The increased risk on BHA failure since there is an additional connection in the hole.

Rotary steerable systems

- have demonstrated to increase the drilling performance through higher rates of penetration (ROPs), improved hole cleaning, reduced wellbore tortuosity, less differential sticking risk and the absence of orientating and sliding drilling time.
- are complex tools that are vulnerable to torsional stick slip vibrations. Therefore stick slip mitigation is key to prevent downhole tool failures. For every drilling operation, there exists a critical rotary speed whereby stick slick is present if the string is rotated with a rotary speed below this speed.
- can be run below downhole motors for performance drilling reasons.

Jar Placement

- Jars can be run in tension or in compression but should not be run at the neutral point in order to avoid accidental firing of the jar. This should be checked for the minimum and maximum weight-on bit since the neutral point in the BHA will move up and down when drilling off.
- Normally, jar is run below the neutral point whereby the jar will be extended (opened position) when running-in the hole.
- To avoid jar down when tagging bottom the following procedures need to be followed:
  - Slowly lower the string as the bit approaches bottom. The weight indicator will read a slight reduction in string weight when the bit tags bottom.
  - Continue to slowly lower string allowing the jar to completely close and move through detent without causing an impact. A slight movement of the weight indicator might be detectable as the jar exits detent.
  - Now additional weight can be added.
  - The time to close the jar without firing will vary depending on the wear of the jar and the downhole temperature.
- To avoid jar-up when making a connection or tripping out of the hole with the jar in compression, the procedure below should be followed:
  - Slowly raise string off bottom, allowing the jar to open and move through detent without causing an impact. Again slight movement of the weight indicator needle will be observed as the jar exits detent. Now the jar is in the open positions and normal practices of pulling out can continue.
- The impact created by the jar is the result of a complex pattern of compressive and tensile stress waves that travel through the BHA. The effectiveness is usually measured by the amplification factor which is defined as the ratio of maximum impact force over static preload force. Amplification factors between 5 and 9 are acceptable.
- Two types of checks should be made:
  - Static: Is there enough over-pull available to set the Jar in tension? Similarly can the jar be set in compression to the full detent load or does pipe buckling prohibit this?
  - Dynamic: What is the optimal spacing within the BHA to achieve maximal impact at the stuck point and avoid over load of the jar? Can the reflected shock wave damage the jar?

Jar ‘rules-of-thumb’

- Normally about 5 to 6 singles of HWDP between jar and accelerator is optimal for maximum impact. Similarly have at least one stand of HWDP or DC above the accelerator.
- NS-2 recommends to change out the jar after 150 hrs and limits the use of jars to 250 hrs.
- Avoid placing stabilizers or other BHA tools above the tool that have a larger O.D. than the jar.
- Place jar and accelerator in the string above BHA elements that are likely to become stuck and above hole geometry and hole sections that are likely to cause sticking.
- Do not run jar or accelerator in the “neutral” point zone. Play with the amount of HWDP between jar and accelerator to achieve this.
- Avoid having large changes in cross sectional area in the lower BHA components, as this will scatter and reflect the jar impacts. Tool-joints will have a similar scattering effect so that a jar placed within HWDP will have a reduced impact.
- In case drill collars are used, always have more collars below the jar than on top of it. This prevents the relatively weak jar being loaded by a dynamic load of twice its impact force, caused by the stuck point reflection. The force wave reflected at the top DC / HW transition relieves forces and should arrive back at the jar before the stuck point reflection does.
- It is important that the free stroke of the accelerator is larger than that of the Jar. By doing so the movement within the accelerator does not reach its limit so that the accelerator is most effectively used.
- Be aware that non-pressure compensated jars will have a pump-open force. Because of this effect a jar will have a beneficial thrusters effect.
- When the jar and accelerator pass through a local high dog-leg area such as a whipstock it is good practice to proceed with low rotary speed and bit weight.

Jarring accelerators

- Jarring accelerators are used to increase the chance on recovery of a stuck-pipe incident.
- jarring accelerator stores strain energy over a significantly less length than that required for the drillstring. This is accomplished by compressing a series of springs inside the tool or compressing gas or a compressible fluid, such as silicon, inside the tool.
- Do not run jar without accelerator. Either run both or don't run at all. Running a Jar on its own does not give a much higher recovery change when compared with no jar in the string.
- Jarring accelerators are particularly useful when:
  - The overpull applied downhole to the jar is limited. This typically occurs for inclined, ERD or horizontal wells where drillstring strength and drag are issues.
  - There is insufficient pipe stretch. This typically applies to top-hole sections, where there is insufficient elongation and energy stored in the drill pipe to accelerate the collars during the free stroke of the jar.
  - Accelerators will effectively reflect shock waves. Hence shock loading of surface equipment when using jars at shallow depth is minimized in case accelerators are used. This is key to protect top-drives during a shallow jarring operation.

Turbine drilling

- As a ‘rule-of-thumb’, assume 100-110 bar pressure drop over the turbine for 8.5” hole.
- Do not use turbines with shaft locking devices to free the bit or part the shaft. They have no added advantage but have led to premature failure of the housing.
- Avoid using plain stabs in long horizontal sections with abrasive formations. Turbine housing wear will occur, which has led to premature failure because body connections do not have spare capacity to allow significant OD wear.
- The planned flow-rate and turbine pressure drop should be checked against both turbine and MWD requirements. A mismatch can lead to an unplanned roundtrip.
- Unplanned preventable roundtrips have occurred because the directional tendency of the turbine was not properly assessed. Particular the mid body stabiliser dimension is critical.

Float subs

- Float subs are run to prevent backflow up the string. This may be for well control purposes or simply to protect expensive MWD/LWD/PDM equipment from mud/cuttings flow up the string whilst running-in hole.
- When planning float subs consider that:
- A non-ported float will increase the time running in hole as the pipe needs to be filled-up.
- When using a non-ported float sub and downhole motor it is cumbersome to assess the bottom hole pressure in a well control situation. It may be required to pressure-up the string until the choke pressure responds, to read the ‘drill pipe’ pressure.
- Certain types of float subs present a flow restriction and may restrict the use of certain LCM materials in case of losses.
- Float subs will increase swab/surge pressures when running pipe in hole.
- The float in the string is an obstruction for W/L tools (back-off, RA tool recovery). DO NOT place the float above planned back-off points in the string.
- Do not plan a float sub when the liner lap needs to be inflow tested.
- Float subs are useful when running into a well with a poorly balanced mud system.
- The larger bore of the float sub will reduce it strength.
- In case of a bit – float sub combination, the length of bit and sub together (taking a washout into account) should not allow the bit and sub to keel over completely in the hole. By adhering to this rule the chance of recovery from a failure is maximised.
- The guidelines for float subs are:
- Top hole: A (non-ported) float valve (NRV) shall be installed in all bottom hole assemblies which are used in top hole drilling in order to prevent uncontrollable flow up the drillstring. A drop-in dart sub by it self is not sufficient.
- For all other hole sections where normal close-in procedures for well control can be applied: The float sub may be used to avoid backflow due to swabbing or from delta's in mud weight annulus/drillstring