International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2019), e-ISSN: 2455-2585
Volume 7, Issue 1, January-2021

Technical reference on field operations for DirectionalDrillers

Ashish Kumar Gupta[1], Ravindra Kumar Jain[2], Mukesh Kumar Gupta[2]

M. Tech - Energy Degree Scholar, Suresh Gyan Vihar University, Jaipur-India,

Centre of Excellence-Renewable & Sustainable Energy Studies, Suresh Gyan Vihar University, Jaipur – India

***Email: guptaupes@gmail.com, ORCID:** 0000-0002-1537-9995*

***Abstract:** As drilling an oil well is very expensive process therefore any mistake or misunderstanding of a subject could cost the companies a hefty amount however over the globe companies have training program to learn & teach the candidate about the basic process but in oil filed learning by book and have practical knowledge on field is completely different things, therefore it would be beneficial if there are any technical guide lines in place prior to visit the filed location. The objective of this project to provide best practice guide lines on practical work to new candidate to get familiar with different & complicated step involved in the industry, this project mainly focused in training the directional drillers who are just passed out from the college or just joined the industry. Fresh hands work along with senior hand and in the development stage they view the goings "behind the shoulder"' of a senior directional driller, opportunities are given to them to handle the basic operations. Failure to follow the proper field practical method can result in an unfortunate event of human error. Following the correct operation guide lines (best practice), performance can be improved upon more efficiently and faster ways. Ultimately eliminating non-productive time for our client & improve reputation of companies.*

Keywords— Oil &Gas Field, Drilling, Directional Drilling, Rig, Hole Problem

Introduction

In oil well drilling, surface as well subsurface problems of any well bore which prevents or obstruct further drilling should be liquidated. Remedial operations and actions undertaken to restore these problems require unproductive rig time and money and consequently increase the well cost. So basic understanding, and precautions are essential as a directional hand. Even though Directional Driller plays the major role in preventing such troubles, the necessity of rig side knowledge is a must for all team members.

1. Preparations at Baseoffice

Pre-job meeting

- Understand the well plan & drilling complications involved with them.
- Collect offset well data previously drilled at this location.
- Check exception certificates for wells with collision chances.
- Collect the rig pack & wall plot from Drilling Engineering Team Verify the reference points for depth (RKB / MSL) & north reference (True/Grid).
  - Consult on size and weight drill pipe to be used, for RSS Vs hydraulic program.
  - Know about the tool status & transportation stage.
  - Enquire the name of the rig & located field.

2. Safe travel tips

Road transport

- Travel only on company authorized vehicles.
- Avoid wearing company coveralls at public places to not to expose your identity for security measures.
- Strictly avoid using or exhibiting your laptop in remote areas. Keep safety belts on & travel in safe speeds.
- Check with driver weather have all the required certification prior commence the journey.

Arrival on rig

- Visit the client representative company man as soon as possible. Verify well plan is matching with client plan.
- Alert about the minimum requirements to run the job (Ex. 1000 gpm & 180 rpm for 12 ¼" jobs)
- Get the water depth & spacing between MSL to RKB levels.
- Enquire about the list of bits on board (if they are supplied by the client). What are the timings survey sheet & steer report to be delivered?
- Get a short briefing of the situation and tentative time of picking up BHA. Ask when and where the daily meetings are held?
- Don't assume things. Communication is the key factor. Maintain it.

3. Preparations & procedures

Initial checks

- Check the slot number physically & spacing distance at platform (Should be available Barge engineer). Collect the operational requirement minimum information
- Open the protectors and strap tools (ID-OD calipers & long measuring tape needed). Prepare fishing diagrams.
- Physically check the connection thread types (Thread identifier gauge needed or check with a protector of same type) Service minor damaged threads if necessary or replace with spare tools.
- Occasionally rental jars do have non-regular threads. (Availability of cross overs has to be checked in advance) Some stabilizers have different threads on the pin and box end. Check both ends.
- Collect and preserve the inspection papers generally kept inside the tools (failing which could cause choking of the string).
- Check the quantity and type of bits available on board. Prepare an inventory sheet.
- For riser less sub-sea spudding operations prepare the bit with a bright or florescent color paint.
- Check that the rollers turn if it's a re-run bit. It's good practice to gauge any bit (new or old) prior to lowering
- Confirm the size and quantity of jets available on board. Confirm the availability of breaker plate for PDC bits. Examine availability of bit breakers & sleeve breakers with correct size & blade configuration
- Check the availability of the float valve (Flow restrictor & Jets in case of RSS job) & service with spares if necessary.
- If float subs to be used physically check the seating of float valve inside the bore

Basic BHA suggestions

- Run prog & find if the motor can provide the required DLS (Consider 80 % of the theoretical values for practical use)
- Generate a BHA and ensure to the theoretical steer behaviors & tendencies.
- Insert stabilizers and space them as per requirements (For directional control, bending forces and formation stand-off).

- Run hydraulic program & check the results (Consider changing the bit Jets accordingly).
- Run drill safe program & check for buckling threats (Consider spacing out tubular efficiently).
- From bit specification sheet find the allowable range of WOB (Available in web pages of the manufacturer). Check that you have enough weight available before buckling.

- Calculate the amount of DC, HWDP and size of lower DP with regards to WOB and buckling. And in directional holes the real WOB is considerably less than that observed at surface.

In a straight deep hole deviation could reach up to 6° to 8°.A well is said to be directional if the hole inclination is >5°.

String weight laying on formation = M x Sinα ,

where M is the hanging wt below that point and α *is the hole angle from vertical. For directional wells having high angle, a part of string weight always acts on the low side of the hole*

Practically, the buoyed weight of the string below jar should be at least 15-20% more than the maximum anticipated bit weight to ensure that the drill pipes are never subjected to buckling during drilling operations.

$$W = \underset{BHA}{(W.O.B \times S.F)/Cos\alpha \times Kb,}$$

where, WOB= Maximum anticipated wt. on bit (T), Kb = Buoyancy factor, α *= Hole angle from vertical (degrees), W=Air wt. of BHA should be (T), S.FBHA = Safety Factor (1.15 for normal formation & 1.20 for hard formation)*

- Plan to keep jar on tension while drilling (Some clients prefer to be on compression).
- By any means never release the total buoyed weight below jar, as that could bring jar to undesirable neutral zone. As a rule of thumb only 80% of buoyed weight below jar could be used as the max WOB.
- Place jar middle of a stand (To avoid fast wearing of threads, diff at racking at MB finger & misfire while racking).
- Run EDI to calculate the required of NMDC with regards to survey quality (acceptable Δ Fac dDip should be <0.5°).
- Prefer a gradually tapered string to smoothen the uniform load transfer
- See that the minimum ID of any tool is greater than the maximum OD of the source fishing tool. Note the type of tubular & maximum over pull that can be applied to the BHA components.

4. Handle B.H.A.

Preparations of threads

- Clean tool joint box and pin by proper cleaning agents such as kerosene, diesel, carbon tetrachloride or benzene.
- Inspect threads and galling surface (Matting surfaces should be perfectly plane and smooth).

Standard making-up procedure

- Check gauge and the tong load cell is properly charged with Martin Decker fluid & calibrated adequately.
- Use proper size slips for a tubular. Set slips at correct position, not much above. Don't let pipe to ride on slips. Don't attempt to make-up different threads or over torque wrong threads.
- Hand tight small size bits by holding the breaker insert handles and turning.
- Use two tongs always while handling joints. Position make-up tong perpendicular to the pulling line.

Make-up torque varies up on size, grade, thickness, OD.ID and class of pipes. Reduced values for lesser tool joint OD.
Under-torqueing will cause galling & erosion; over torqueing end up in breaking the pin or generate micro cracks which in turn lead to an underground breakage. Over torqueing also swell the tool joint.
As per API specifications the maximum shoulder swell allowed before replacement is 0.8 mm for shallow and medium depth holes & 0.4 for deeper holes.

- Improper tightening (under torqueing or over torqueing) definitely damages the threads. Place the slips in a position opposite to the pulling direction of tongs. Tap gently with sledge hammer if the setting is not good.

5. Tripping in & clear shoe track

RIH

- Extra cation to be taken while tripping through the wellhead, BOP, liner top to avoid damaging them.
- Tripping speed should be restricted to avoid surging through **weak formations.**
- If a float valve is installed, then fill the pipe every 1000m and at the shoe.
- If possible suggest installing a wiper rubber to avoid drop of junk / hand tools.

Circulate in casing

- If it is necessary, to circulate inside the casing with a motor then pump and rotate as slow as possible to avoid damaging the bit shoulder and gauge. Reciprocate to avoid puncturing the casing
- With rotary assemblies and straight motors this should not be a problem.
- The pump pressure will be high due to cold mud and should creep down after a while
- The torque will probably be high due to rough casing / cement and should creep down after a while

Drilling cement rubber plugs, shoe-track & rat-hole

- Most common is to drill with moderate RPM, moderate flow & very low WOB. The main thing is to avoid ripping off big chunks of rubber that can wedge on the BHA and that the plug starts rotating with the bit. If there is no progress, then consider drill with high WOB with feeble flow (Proposed by Herzog). By monitoring the shakers, the progress could be analyzed, as the plugs are manufactured with different color. Special attention has to take to avoid getting stuck by 'Flash setting'.
- Rotate as slow as possible with average motors operational flow and use high WOB.

Cement related stuck up: Cement related sticking occurs when blocks of cement fall into the well bore from casing rat holes or cement plugs jamming drill string. It also occurs when drill string is run in soft or green cement, that flash sets when pressure is applied. The green cement could set suddenly due to the high pressure generated with circulation

- The Clue is to reduce the total bit RPM with adequate cooling to avoid damaging the heel - shoulder - gauge rows. The faster the shoe-track is drilled the lesser the damage will be seen on the bit. Drill out the last half of the meter with reduced WOB to avoid punching out the shoe. Ream the shoe area before proceeding.

Telescopic holes: Casings sometimes do not reach the drilled depth and have to be short landed with shoe much above bottom. This leaves a larger open hole from which small hole is drilled. In such cases the annular velocity falls abruptly in reaching over from smaller to large well bore. This leads to gradual accumulation of cuttings in the transition zone. During tripping the cuttings fall into hole resulting in severe pipe-sticking situation.

- Clean out the rathole in steps of two meters a time and pulling back into the shoe to avoid wedging the BHA if cement blocks fall in.
- Few meters of new formation have to be opened for testing either by LOT or FIT. Circulate with bit just outside the shoe prior to formation testing.

When a new bit reaches the bottom, it should be 'broken-in' properly using low bit weights and rotary speed for the first meter drilled. This action allows any microscopic irregularities in the bearing surfaces to be smoothened and allows the bottom hole pattern of the new cutters to be established in the rock
'Drill off test' (Proposed by Lubinski 1958) to be conducted with a new bit at new formation when note low ROP maintain a constant WOB & RPM (near maximum available) is selected.
_ROP is noted and reconfirmed
_Change WOB in steps keeping RPM constant
_Change RPM in steps while keeping WOB constant
_Figure out optimum WOB & ROP combination for best results
Rule of Thumb: Average WOB = 1 ton / 5 sq inch of bit area. (Eg. 8 ½" bit > 8.5 x 8.5 =72.25 / 5 = 14.5 tones)

6. Commence Drilling Formation

Kick off

Use a big stabilizer above the motor to avoid rattling around in the hole. Start with low flow and drill fast. Don't let enough time to wash the ledge away. Below 5°inclinations the BUR would be with 55% of the expected output of the motor handbook. Between 5° and 10° the results could be expecting about 75%. Line up the azimuth fast. The higher the inclination the harder the azimuth to turn.

Do not be tempted to get back on plan with high doglegs. This will generate more torque, which could result in key seat. Excessive torque possibly restrict the chances of drilling down the well. The string rest on the lower or upper side of the wall, in an inclined portion depending upon the configuration of the well. Thus partial weight of string is pushed to the side of the well wall with a force. Due to bending and string tension at a severe dog leg portion while trying to straighten a thrust force is created on the contact formation. With this force with tool joint rotation energy is sufficient to dig a smaller hole along with main hole, which resembles as a key slot. Either at medium hard formations or at hard to soft transition portions key seats get generated (In tectonically disturbed areas having thrust faults & folds).

Tool face

This is the high side indication of the motor and has to be aligned to the direction of interest. Due to formation resistance an anticlockwise turn in tool face is noticed and termed as 'Reactive torque'. To counter balance this, a positive is turn is given to the string. This can be fed on bottom or off bottom depending on the formation tendency and urgency. This negative force directly proportional to some factors like applied WOB & formation hardness. And special efforts to be taken as depth and hole angle increase. With very slow ROP it might seem like the tool face is creeping all the time. Don't overreact. A minimal distance had to be slid before the torque evens out. In the process of a big turn the profile should always drop at the beginning and build back up again towards the end of the turn. This is since the azimuth will turn faster at lower inclinations.

WOB & Buckling

Always calculate the maximum WOB so that the drill pipe won't buckle and stay below their buckling limit. Worn out drill pipe has the tendency more to buckle.

RPM & DLS

Most of the directional tool tools have RPM restrictions. The most restricted is usually the bent mud motor. Increased dogleg severity reduces the RPM allowance window until no rotation is allowed. In RSS jobs where the ROP is considerably high, it has proved that maintaining RPM 180 and flow 1000 gpm could sweep cuttings out as a conveyer belt.

Abrupt change in deviation (inclinational or azimuth) is termed as 'dog leg'. Steer tools might pass through high dogleg areas, where as other strings like casing string or TLC logging tools would find difficulty in passing by.

Flow (SPM)

Most of the tools have flow restrictions, both maximum and minimum. The restricting factor here is usually the mud motor and the MWD. In general, more flow is better. Heat buildup during sudden pump stoppage while drilling should be avoided as this would affect the bit adversely. For optimum hydraulics the pressure drop across the bit should be 50-65% of the total available surface pressure. The minimum jet velocity required is about 53.5 to 68.5 mts/sec. For holes ranging from 6 to 8 ½" the minimum jet velocity should be 7.6 mts /sec per inch of bit diameter. And for holes 12 ¼" and above it should be 6 mts/ sec.

ROP

Rate of penetration can be restricted to avoid plugging the annulus, to avoid over loading the hole or for logging reasons. In the top hole it is wise to drill a joint fast and then circulate a while before drilling a new joint, instead of holding back the ROP and dropping angle.

BHA behavior

The BHA will behave differently from formation to formation and from field to field.

Depending on the formation drill ability, dip angle, hole angle and direction two identical BHA's will not behave the same on the same rig. Always compare wells with similar angle and direction. Stringers can cause problems like hanging, skidding off resulting in high DLS and slow drilling.

Valuable information of formation can be gathered by assess the cuttings at shakers with shape, size and amount.

Bit has again has tendency to drill parallel to the bedding. Dips have marked effect on the drift of borehole. Directional drilling becomes more challenging task to achieve target in such formations. Most tricone bits will exhibit some right- hand walk tendency. PDC bits on the other hand due to their symmetrical cutting action tend to drill straight ahead. If the well is planned to be drilled with tricone bits, then it's advisable to lead well to the left and allow the natural tendency of the bits to pull the well back on course.

Survey & Connection

Taking a survey before connection is best practice as string can be moved up in case of a stuck-up and this provided time to decide on survey. The survey interval depends on the well complexity. In a critical situation a 'Check shot' survey had to be punched for decision making. Usually the survey intervals will be listed in the well program and normally it's once in a stand.

While recording surveys the circulation & pipe movement is stopped. This could be an inducing situation for a stuck-up. Hence record the survey in minimum time possible and announcement to be made as quick as possible.

Vibrations & Stick Slip

React immediately to vibrations and stick slip. If ignored the ROP will decrease and the BHA will take a beating. Critical rotary speeds in drill pipe which cause vibrations are often the cause for pipe fatigue. Critical speed varies with length and size of drill stem and hole size. As a rule of thumb, to mitigate stick slip Increase RPM and reduce WOB

Stick-slip is one of the modes of drilling vibration. Any vibration will lead to fatigue failures over periods of time. The oscillating nature of vibration causes areas of stress concentration and the stress will be accumulated over time and ended in fatigue failure. Stick-slip is defined as:' Rotational slowing down and accelerations of BHA components, or peak to peak RPM difference over a time interval. Stick-slip measurement value has always be compared with the surface RPM value.

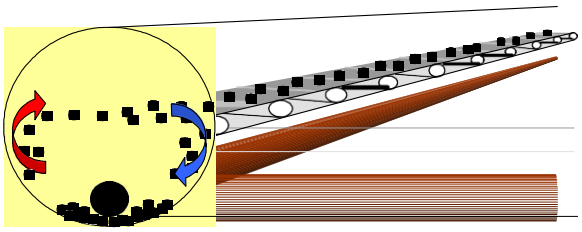
The severity of stick slip is best represented in percentage (%) of average surface RPM. Stick slip severity= (stick slip value/ surface RPM) x 100

Cutting removal

Build-up sections between 45 – 55 degrees might experience avalanche effects. The result is severe accumulation of cuttings in a shorter interval. When using motor and sliding is performed, be aware that almost all the cuttings will accumulate in the wellbore until rotation is started. A high percentage of sliding per stand might result in high ECD therefore accumulation of cuttings on the low side. This is not applicable when using PowerDrive, which uses 100% string rotation when drilling. If rock cuttings are not removed adequately from the hole bottom, the bit is in a 'Flounder' situation. The 'flounder point' is defined as that point at which addition of WOB or RPM will not increase ROP.

Rotation will turn the conveyor belt on and off

High RPM is the key of hole cleaning. Rotation works as a conveyer belt to transport generated cuttings down hole. For holes bigger than 8 1/2" the switch of conveyer belt will be ON only with RPM more than 120 and for smaller holes the GEAR will change from LOW to HIGH at 120 RPM. It's neither the pipe rotation nor the tool joints that cleans the hole, but the fluid film rotating around the pipe acts as a 'VISCOUS COUPLING' to clear off the cuttings.



7. Hole Problems & causes

Rubber pieces retrieved at shale shaker

Chunking: The rubber stator known as 'Elastomer' inside the motor can be washed away in small pieces. Surface indications are pressure fluctuations when the rubber passes through the bit nozzles and rubber on the shakers. Occasionally bit jets get plugged with these pieces. Drilling can be continued if the motor has power and the plugging isn't too severe.

Survey results are different from sliding tool-face

Scribe misalignment: Impact loads while drilling or reaming through boulders or tight hole, the connections of MWD and motor or the bend housing sleeve could get over torqued. This could result an offset of the scribe line. This is most common on the 6 3/4" and smaller motors. To identify this problem, compare your steered tool faces with the calculated tool faces from survey sheet. If there is a constant difference, then this may be the problem. Continue drilling with a corrected toolface if the plan allows this.

Unpredicted results of DLS

Low DLS: Due to hanging & lack of side force due to worn stabilizer, steering tool output coud be compromised. This needs to identify in early stage and corrective action should be taken to adhere with planned trajectory.

High DLS: Side-tracking off a hard cement plug can cause high DLS as the bit suddenly jumps off the plug. This DLS should be reamed off straight away to avoid problems. If this happens just below the shoe the problem worsens. Sudden change in formation and stringer / cemented lenses can also be a reason for the bit to skid off. To avoid this hold back on the WOB until the bit enters the harder formation. Doglegs that generated in opposite directions are a lot complicated than the doglegs that go in the same direction.

Raise or fall of surface pressure

Washout / plugging: A plugged or blown jet is identified by the sudden pressure change. Re-calculate hydraulics to match this pressure loss for new TFA and check the difference. If the difference isn't correct this should be treated as a washout or plugged string. A washout can be identified by a slow and continuous drop in pump pressure. The faster and longer it's pumped the bigger the washout. Inspection of surface system and changes in mud weight has to verified to make sure the washout is down hole prior to POOH. String to be pulled out wet, without pumping 'Slug' to locate the washout zone. Plugging will usually occur suddenly. Foreign objects enter the circulating system and block passageways. Partial plugging above the MWD will

weaken the MWD pulses. To avoid this pipe screens to be installed and inspected periodically at each connection time.

Sudden pressure drop with loss in string weight

Twist off: A twist off is usually caused by the failure crack extending around the tubular and causing the tubular to break. A twist off is identified by a sudden large pressure drop and possibly loss of considerable string weight. Field experience shows that in most of the cases drill pipe fails from its tool joint (1 mt off the tool joint on either end of the pipe) and drill collar fails from its connection. Circulation to be stopped immediately and remaining string to be tripped out carefully. There are chances of the motor-rotor hanging on its catching device, which can be retrieved at surface.

Increase in pressure with restrictions on string movement

Packing off can be caused by cuttings build-up or the hole caving in. Usually restricted movement of the pipe is possible. Move and rotate the pipe slowly until the pressure starts to bleed off. Start the pumps slowly and try to wash away the obstruction with rotation. Don't pull or lower the pipe until a good circulation rate is gained. The most effective way of handling

- Shut off the pumps.(If situation permits, keep a slow rate just to keep a channel open*)*
- Run back in the hole ASAP at least 2-3 stands, more if required.
- Before turning up the pumps, see if the string can rotate, if possible keep rotating.
- Bring up the pumps gradually, when possible to full flow.
- Don’t attempt to back-ream until at least 2 bottoms up, and or torque and pressure are the same.

Pull out and if see the same problem in the same place, this would rather show a formation problem than cutting beds. If they were cuttings, they will have moved by now.

High Drilling Torque

Possible causes could be: Under gauged bit, unstable formations, cavings, due to low mud weight, high DLS, poor mud properties, stiff BHA / drill string, insufficient hole cleaning. Possible cures could be: New bit, mud additives, torque reducing subs, more limber BHA / drill string, better hole cleaning.

Increase in rotary torque with less cutting at shaker

Junk problems; Junk is any object in the hole which is not desired in the well. Lost roller cone or even PDC cutters are large enough to stick with string. Foreign material wedging the BHA can move with the string movement. Junk could be any item accidentally dropped from surface, that could beTong dies, slip handle, hand tools, rotary segments, BOP studs etc. If string hanging on junk then never try to jar past the problem. Instead, try to get above the junk by gently working, rotating and pumping the string upwards.

Break off torque

Break off torque should be monitored and noted at every connection to apprehend the downhole condition, an increasing behavior would indicate the possible differential stuck up situation.

Reduction in pressure without reducing discharge

Well control; This could be indication of a kick. During a drilling break stop drilling and carry out a flow check for to identify any intrusion of hydrocarbon in the system. Sometimes reduction in mud weight could also reflect such results. Detailed reading material on procedures for well control is available. That will give a clear picture of the necessity of recording ‘Slow Pump Rate’ details.

Conclusion

After reading and understanding the root causes, following some basic practices high angle wells can be drilled successfully. The directional driller plays a equally responsible role in drilling a well safely & quickly.

Best floor practices to adapt

- Monitor cuttings on shaker in case of hole not getting flushed properly; circulate to clean the hole before making any connection.
- Avoid allowing cutting beds to build up. Periodical checkup of all solid removal equipment’s for their proper functioning may help reduce well complications.
- Never POOH through tight spots at high speed. In case of increase drag better to pump out the string.
- In case of held up never force the string to go down. Circulate and clean the hole. Initiate circulation with low GPM and gradually increasing the pump stroke to normal.
- In case of string stuck during POOH never activate jar upward this would aggravate the problem. Always try

to go down and activate the jar downward.

- In case string stuck during RIH activate jar upward. In both the cases make up as soon as possible to circulate and clean the hole.
- While reaming down in case of severe held up extra caution should be taken due to high angle and soft formation, well may get sidetracked.
- As the well angle increases more GPM would help to flush the cutting form the hole.
- In case of motor stalling pump pressure will shoot up; pick up string immediately to avoid motor damage.
- In case of hole packing off due to cutting build up; lower pump spm and try to bleed off the pressure and gradually increase spm when circulation establishes. If it is not possible to establish circulation try hydraulic hammering by opening and closing bleeding valve.
- High angle wells develop more torque and drag it is therefore very important to torque the joints at their required value to avoid any kind of premature failure.

References

- Drilling operations manual, Institute of drilling technology, Dehradun, India
- INM Field alert # 4 dated 12.03.04, Schlumberger, Mumbai, India
- Training to reduce unscheduled events, Randy smith drilling schools, LA, USA
- Down hole problem, Drilling technology & simulator centre, Baroda, India
- IADC Drilling Manual, 11th Edition
- Drillers module_ Sexco Forex