Managing & mitigating Casing Wear

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Disclaimer

**General Safety Standards**

This document, figures, table's text or calculations, do not represent any specific safety standard, nor regulation, and create no new or otherwise legal obligations.

Their intent is to serve only as an well planning, design and construction advisory guide, where all informational contained in content is intended to assist employers and employees in providing a safe, healthful and environmentally complaint workplace, or through effective prevention assurance programs adapted to the needs of each place of employment tools, equipment, practices and procedures used.

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*Kingdom Drilling Services Ltd, August 2009*
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Casing Wear Protection

Drillpipe Protectors (Installation Strategy/Programme)

Rotating tool-joints subjected to lateral loads will result in the wear and tear of crescent or "moon-shaped" grooves in the casing. The wear rate is not constant, but decreases with increasing wear depth approaching an asymptotic value as casing wear exceeds about 40%.

Drillpipe / Casing protectors are often used in areas of wells where wellbore and drillstring geometry incurs high-lateral loads on the tool joints and casing that may cause and result in excessive casing wear.

This wear reduces both the burst and collapse pressure ratings of the casing and in extreme cases can wear right through the casing, resulting in costly remedial intervention measures required.

Procedure & Recommendations:

Drillpipe / casing protectors are not normally required in the 12-¼” hole section as wall forces are fairly low, and if the drilling time is relatively short, there is minimal wear on the casing.

For the smaller wellbore section(s), drill-string simulator and casing wear programs are used to calculate estimated torque, drag & lateral loads using the actual well profile.

As a "rule of thumb" wall-force in excess of 6,000lbs/30m (100ft) is often taken as the limit likely to initiate casing wear whilst drilling a moderate section length.

If the maximum cased hole wall-force is above 6,000lbs/30m (100ft) (assuming tool-joints are to operators specification), then the section should be reviewed using a casing wear program. (or the vendor’s program can be used). Such programs can be used to calculate the number of pipe protectors required for each pipe joint of the drill-string. The number of pipe protectors is determined by the tool-joint load and the design factor for the pipe protector. (Different makes of protectors will be capable of supporting different lateral loads.)

Note: Drillpipe / casing protectors should not be run into the open hole.
General Information

The proper use of pipe protectors can reduce both rotating torque and casing wear. Non-rotating drillpipe protectors has been shown to reduce torque by up to 30%.

It should also be remembered that certain types of hard banding can also cause rapid casing wear with significantly lower wall-forces.  
(Note, there have also been cases of damaging / ripping off protectors on wear bushings while back-reaming)

Wall-forces arise from four primary sources:

1. **Tension around curvature** - considering the drill-string as a simple flexible string, if this string is pulled around a bend it tends to want to straighten and exert a force against the bend. Under typical drill-string configurations, the tensile loads experienced can be in the order of 100,000 lbs and this effect causes the majority of wall-force found in the well.

2. **Wellbore inclination** - A component of force of gravity tends to pull the drill-string directly against the wellbore wall. In horizontal wells the whole of the drill-string weight is taken directly against the wall, whilst in vertical wells, the weight is taken up by tension in the drill-string. The influence of this gravitational wall-force increases with the step-out of the well and it’s inclination angle.

3. **Bending Forces** - Although it is easy to think of the forces involved in bending joints of drillpipe or even casing under the large radii involved in drilling operations the bending forces are not particularly significant.

4. **Buckling forces** - Drillstring buckling is a concern in certain operations typically experienced in horizontal wells.

The majority of wall-forces therefore arise due to a combination of tension around curvature and wellbore inclination.  
(Dynamic effects, such as resonant vibrations of the drill-string, etc., are not usually taken into account.)
Ten Guidelines To Minimising Casing Wear:-

1. **Hard-banding**: Ensure hard-banding is smooth & flush before running in the hole. You do not always need fingers of hard-banding on the 18 degree tool joint taper: They cause increased wear at the casing couplings and add considerably to re-hard-banding costs.

2. **Well Design**: Select build rates to minimise the risk of severe local dog-legs while drilling. Expect to get a real dog-leg of 1.75 times your planned value. Check the casing design’s sensitivity to these dog-legs by running a casing wear model.

3. **Wall Thickness**: Wear depends on contact pressure, not wall force. You will lose the first 0.15" of wall thickness very quickly as the area between tool-joint and casing changes from line contact to crescent shape. Use a thicker wall thickness to compensate.

4. **Design Risks**: Evaluate the risk of having to make a side-track and, if necessary, increase the safety factor in the original casing design.

5. **Localised connector wear**: Ensure that the casing around the kick-off or dogleg area is well supported / centralised to minimise localised wear of the casing couplings.

6. **Metallurgy**: Wear resistance of casing steel depends on mechanical properties determined by the material’s microstructure and chemical composition (independent of grade). Tests have indicated that increasing carbon content leads to improved wear resistance. Given the opportunity to choose between samples of casing with identical mechanical properties, choose the sample with the higher carbon content.

7. **X-overs**: Tripping wear is only a problem for cross-overs in combination strings. The hard-banding on the 18 degree tool-joint taper will wear any protruding corners. (Note: the taper hard-banding cannot be ground smooth flush and is normally very abrasive)

8. **Drillpipe protectors**: Manage protectors properly at the rig site. ODs must be 1/2 in. greater than the tool-joint and loading must not exceed 2 000 lbs per protector. Introduce protectors gradually to the string to minimise start-up torque (Caution – some simulations result in loads in lb/ft and some protectors are less than 1 ft long)

9. **Casing Integrity**: Metal recovery at the ditch magnet can only be used as a qualitative warning tool. (Mud loggers report metal recovery every 6 hours). Check the casing’s remaining burst and collapse strengths using the guidelines set out in the casing design manual.

10. **Callipers**: Do not run a baseline log as casing wear affects small sections of the casing internal circumference, leaving insufficient worn surfaces to deduce the nominal diameter. For high accuracy in muds or brine <1.3 S.G. use Schlumberger USIT or UCI acoustic tools. When > 1.3 S.G., use a mechanical calliper tool such as the Kinley 15 or 30 multi-finger calliper, or the Sondex 60 arm multi-finger tool. Acoustic tools cannot be used in heavier muds/brines due to high attenuation of the ultrasonic signals.
Monitoring For Casing Wear

Metal Collection on the Rig

Background
Casing wear can be from a variety of causes, some of which have been outlined below:

1. **Grinding:** Take's place when parts of the Drill String come into contact with the casing. The Drill String exerts a force normal to its surface that tends to "grind" any tough, abrasive cuttings from the formations penetrated against the ID of the wells casing bringing about wear.

2. **Gouging:** Take's place when the Drill Sting (generally in the area of the Tool joint) has its sharp edges / surfaces in the form of:
   a) Transition from the 'taper" to the OD of the Tool Joint (wear occurs when Running In/Pulling Out of the hole)
   b) Tungsten carbide in the area of the tool joint (Wear occurs when the Drill String is rotated) come into contact with the casing. Such action tends to remove pieces of the casing as the normal force experienced by the Drill String drives it into the casing.

3. **Galling:** Take's place when the Drill String (under extreme in normal force) is forced into the casing. The force with which the String is brought into contact with the casing under this set of conditions is great enough to squeeze any fluid separating these two surfaces away. Such a force then acts in an environment lacking lubrication to weld the surfaces together. The "rotation" or movement associated with the Drill String later acts to rip or otherwise remove one welded surface from the other. The pieces of metal "ripped" from one surface or another as described in the process outlined above contribute to either casing or drill string wear.
For an operator to gain some idea as to the magnitude of the Wear in question, procedures similar to those outlined below are generally followed.

**Procedure**

1. Install one or more magnets in the "possum belly" (reservoir located between the "flow line" and the "shaker screens") in a section of the "drilling fluid flow stream" that is relatively "quiet" or flowing smoothly.

   1.1 The number of magnets required is dependant upon the metal to be collected.

   1.2 The objective should be to have sufficient magnets in place to effectively remove all the metal from the "flow-stream".

2. Collect the material adhering to the Magnets at appropriate intervals.

   2.1 Generally the time for collection has to do with the "length of metallic hairs" possible under given conditions of fluid flow.

   2.2 If the magnet is placed in a low velocity section of the flow system and the flow exhibited by such flow when passing the magnet is relatively low, the metallic hairs can grow 1/2" to 3/4" of an inch long before the shearing of additional particles from the "hairs" will take place. Under the foregoing conditions, the "hairs" will not grow longer than the 1/2" to 3/4" long stated - any particle hanging on after this length will soon be swept away by any surge in the fluid velocity passing the magnet.

   2.3 What the serviceman must determine is the length of the "hair growth" possible under conditions of fluid flow surrounding the magnet, i.e. if it takes 24 hours to collect hairs 1/2" to 3/4" long then the metal should be scraped from the magnet at this interval.

   2.4 If on other hand, it takes just 3 hours to grow "metallic hairs" 1/2" to 3/4" of an inch long, then the magnets must be cleaned every 3 hours.

   2.5 Collecting at a longer interval, say every 6 hours, will enable 1/2 the metal only to be collected which would represent 1/2 the metal capable of being picked up by the magnet over the same period of time.

   2.6 Check the "pump rate" or "flow rate" of the mud circulating system to determine if same has changed during the Drilling of the Well in the following way:

   2.7 Reduced:- Time between sample collections can be increased.

   2.8 Increased:- Time in between sample collections should be decreased because we are interested in metal collection over a period of time and the number of collections cycles has nothing to do with that objective.
3. Clean Metal from the Magnets. Cleaning can be accomplished through using;

3.1 Spatula, knife or card to run over the surface of the magnet and scrape the metal off the magnet into a large container or bucket.

3.2 Cloth to run over the surface of the magnet to remove the metal from the magnet into a large container/bucket.

3.3 Be sure to rinse the cloth out thoroughly in the bucket using pure mud base fluid i.e. Oil or Water.

4. Separate the metal from the mud in the "ooze" cleaned from the Magnet by:

4.1 Pouring mud base fluid into the container in sufficient quantity to take the mud into solution and thereby help free the metal from the "ooze".

4.2 Stir the contents of the bucket/container to help take the mud into solution and free the metal.

4.3 Decant the fluid/fluid containing mud from the bucket gently (pour off the fluid gently so as not to lose any of the metal cuttings)

4.4 Repeat the process as described in (a) until one can easily see the "silver" colour of the metal on the bottom.

5. Weigh the metal collected;

5.1 When the cleaning process is finished, drain as much of the water off from the metal cuttings as possible.

5.2 Use a weigh scale to weigh the metal cuttings:

6. Record the weight of the metal collected together with the time same was weighed and repeat the collection/ measuring process as required.

7. Maintain a daily chart of the weights taken together with the time of such measurement to determine the effects of the protectors in reducing casing wear.
Comments

1. The important thought to keep in mind is that procedures should be followed exactly each time it is performed, to either maintain accuracy or relativity (i.e. relative means that the samples were collected either perfectly or using a method that makes this mistake constant so as not to affect the relativity of the numbers).

2. Magnitudes of metal collection:
   
   2.1 0-500- grams collected per day: Casing Wear is not a problem
   
   2.2 500 - 1 000 grams per day: Casing Wear is a problem
   
   2.3 1 000 - 6 000 grams collected per day: A hole in the casing is imminent (soon to take place)
   
   2.4 To reduce Casing Wear, the serviceman should study the pipe as it is pulled from the hole. Shiny joints are an indication of locations where protectors could be installed to reduce wear.

3. Helix's on the drill pipe tubes are an indication of conditions of extreme Wear and the installation of protectors every eight feet along the tube in this area would be of great benefit.

4. If signs of Wear on the pipe cannot be found, and metal collections still provide and indication that same is taking place.
   
   4.1 The wear bushing in the:
      
      4.1.1 Ball joint (Movable Offshore Rig)
      
      4.1.2 Wellheads
      
      Should be pulled and checked.

   4.2 Wear if found in these areas can be correlated to:
      
      4.2.1 The rig being off the centre of the hole.
      
      4.2.2 Large currents forcing the Riser from a position over the well.
      
      4.2.3 Temporary Guide Base being set on a sea floor having to great an angle from horizontal.

All of which means that protectors must be installed on the drill string members passing through the area of the BOP and Well Heads or these protective devices will be seriously damaged.