Drilling Problems

Pipe Sticking
Lost Circulation
Hole Deviation
Pipe Failures
Borehole Instability
Mud Contamination
Formation Damage
Hole Cleaning

General Equipment & Personnel

Pipe Sticking

Can not pull up – can not go down – can not rotate

YOU ARE STUCK

Differential pressure

A portion of the drill string is embedded in the mud cake on the walls of the hole. It is held there by the pressure difference between in hole and the formation. The pull force to free the pipe is a function to the differential pressure, coefficient of friction and the total contact area of the pipe on the hole wall.

The coefficient of friction is a function of the mud. An oil based mud with have a $\mu$ of .04, a water based mud up to .35.

The contact area, $A_c$, is expressed in terms of arc length, $\psi_{arc}$, and the length.

$$\psi_{arc} = 2 \sqrt{\left(\frac{d_h}{2} - t_{mc}\right)^2 - \left(\frac{d_h}{2} - t_{mc} - \frac{d_h - t_{mc}}{d_{hd} - d_{od}}\right)^2}\]$$

$t_{mc}$ mud cake thickness inches

$$A_c = \psi_{arc} L_{ep}$$

$$F_{pull} = \mu A_c \Delta P$$

The causes of differential sticking,

Unnecessary high differential pressures
Thick mud cake (continuous high fluid loss to formation)
Low-lubricity mud cake (high coefficient of friction)
Excessive embedded pipe length (time delay in operations)
Ways to minimize differential sticking
   Proper mud characteristics (weight, fluid loss)
   Collar shape (spiral or square collars)
   Keep drilling solids low in the mud
   Keep rotating the drill string

Indications
   Increase in torque and drag
   Inability to move the pipe
   Circulation of drill fluid is not interrupted

When it happens
   Spot oil around the stuck portion
   Lower mud weight
   Back-off above the stuck portion then washover it
   Place a packer above it

Mechanical Sticking
   High Accumulation of cuttings in the annulus
   Borehole Instability – hole caving, sloughing, plastic squeezing
   Key Seat

Accumulation of cuttings can occur in wells that do not have the adequate hole cleaning. This is common in directional or horizontal wells. Increasing circulating pressure while drilling, or increase in drag when tripping are indications of a problem. It is a good idea to circulate bottoms up before tripping the pipe as this cleans the hole.

Minimizing
   Proper drilling hydraulics, rate and viscosity
   High rotation rate in directional holes

Borehole Instability problems are common in shale sections of the hole. Shale can plastically flow inward or slough causing mechanical sticking. Salt also exhibits plastic behaviors. Any formation can collapse if the mud weight is not high enough to control it. Indications of trouble are an increase in the torque, increase in circulating pressure or even the blocking of returns to the surface.
Minimizing
Proper mud design, weight and water loss

A key seat is formed by the drill string pressing against the side of the hole and cutting groove. This happens when the hole is not straight. The problem occurs when pulling out of the hole the BHA will catch on this groove.

Minimizing
Keeping the hole in proper alignment

When it happens
First define the problem, what stuck ya
Rotating and reciprocate the drill string if possible
Increase the pump rate, watch the pressure
Increase mud weight for hole instability
Back off, use jars
Washover
Worse case, sidetrack
Lost Circulating
The uncontrolled flow of drilling fluids into a downhole formation. This can be either a partial lost, some returns to the surface or a complete loss with no returns to the surface. This happens when the drilling encounters a highly fracture zone, one with low pressure-high permeability or a cavern. If drilling is continued with no returns it is called Dry or Blind drilling.

Prevention
- Maintain proper mud weight
- Minimize annular friction pressure
- Maintain adequate hole cleaning
- Set casing to protect weaker formations
- If anticipated, treat mud with lost circulation materials

If it happens
- Pump lost circulation materials in the mud
- Seal the zone with cement or other blockers
- Set casing
- Dry drill (clear water)
Hole Deviation
When the hole deviates from the vertical or planned course. The bit tends to walk while drilling. Formation dip and rock properties can influence the path of the bit. This can cause both technical and legal problems.

Causes
- Heterogeneous nature of the rock
- Drill string characteristics
- Applied WOB
- RPM of the drill string

Remedies
- Lower WOB
- Slow the rotation
- Change the BHA, add stabilizers etc

Drill Pipe Failures
Common failures
- Twist off
- Parting
- Burst or collapse
- Fatigue
- Leaking

Most of these are prevented by starting with a good string. Drill pipe and collars should be constantly inspected, and regularly tested.
Borehole Instability

Causes
- Mechanical in situ stresses
- Erosion due to drilling fluids
- Chemical interaction of fluids and formations

Problems
Hole Closure
- Increase in torque and drag
- Pipe sticking
- Running and seating casing

Hole Enlargement
- Difficulty in cementing
- Increase chance of hole deviation
- Hydraulic problems in cleaning the hole
- Trouble logging the well

Fracturing
- Lost circulation and kick potential

Collapse
- Pipe sticking
- Loss of the hole

Producing Formation Damage
- Defined as “the impairment of the unseen by the inevitable, causing unknown reduction in the un-quantifiable.”
A reduced permeability near the wellbore caused by drilling, cementing or workover fluids. This is called skin.

Mechanisms
- Solids plugging
- Clay particle swelling or dispersion
- Saturation change
- Emulsion blockage
- Filtrate blockage
- Precipitation of soluble salts
Remedies
   Lower mud weight
   Water loss control

Hole cleaning
   Problems
      Pipe sticking
      Premature bit wear
      Slow drilling
      Formation damage – fracturing
      Excessive torque and drag
      Trouble in logging and cementing

Factors
   Annular velocity
   Hole inclination angle
      Flow rate max’s @ 65-67°
   Drill string rotation
   ROP
   Drilling fluid properties
   Characteristics of the cuttings