A SOLUTION MODEL FOR STUCK-PIPE & FISHING CHALLENGES IN GEOTHERMAL DRILLING: A CASE OF THE OLKARIA GEOTHERMAL FIELD

Nester Ouma Nyakiti,
KenGen
Olkaria Geothermal projects, Naivasha
P.O Box 785-20117
KENYA
Email: nnyakiti@kengen.co.ke

ABSTRACT

Stuck pipe and fishing challenges occur while drilling a well. Stuck pipe presents an undesirable well condition when the drill string movement is deterred either in the vertical path or in rotation. Fishing operations, also being closely related and usually as a result of stuck pipe scenario, is yet another condition of dilemma when either part of the drill string, handling, accessory or well logging tools are lost in the well. Worldwide, it is estimated that stuck pipe and fishing operations contribute to 25% of the drilling cost. These two conditions are not only risky but equally consume the rig's productive time. While a number of technologies, tools and expertise are available for stuck pipe and fishing challenges, statistics still indicate high failure rates leading to costly well abandonment or complex side-tracking efforts. Further, statistically documented literature on stuck pipe and fishing operations in geothermal drilling within Africa is also scanty. It is against this backdrop that this paper seeks to provide a systematic way of evaluating and overcoming various forms of stuck pipe and fishing challenges and further develop a solution model to be adopted by various drilling contractors and crews in geothermal drilling. The lessons leant while drilling wells in the Olkaria geothermal field shall form the basis of this investigation.

1. STUCK PIPE IN GEOTHERMAL DRILLING

The drilling industry is diverse. Drilling involves extraction of different resources including oil, gas, and steam among other useful reservoir fluids. Geothermal drilling involves sinking wells to depths below 2000m to 3500m in search of high enthalpy steam. The process involves the use of a drilling rig. A series of steel tubular, otherwise known as the drill string, are connected together to achieve the target drilling depth. The drill string connected to the bit transverse weak and unconsolidated formation with high caving tendencies. Further, while drilled formation (cuttings) have to be suspended out of hole to surface, a process which requires use of special aerated or mud enriched fluids. These fluids if not properly monitored may be another recipe for getting stuck with the drill string especially with downhole BHA.

Stuck pipe is hence a result of two major causes; formation challenges and drilling practice challenges. Whichever the cause, stuck pipe present an undesirable hole condition with great consequence to drilling cost. Most stuck pipes are a result of formation cavings, differential sticking, wall cakes, pressured formation, poor tripping practice, severe doglegs, swelling shale, bridging, keyseating and pack off from poor hole cleaning. Stuck pipes have to be recovered from hole for the drilling to continue. The process of recovering the stuck pipe is known as fishing. Several methods and approaches are available for fishing. However, these approaches apply differently depending on the type of fish in hole. The choice of the fishing procedure highly determines the success of a fishing operation. Poor selection of fishing method is a recipe to well abandonment and or high fishing costs and project completion time.

Stuck pipe and fishing operations have no well-defined model or approach to finding solution to such challenges, in geothermal drilling, stuck pipe and fishing challenges are enormous. This is due to the nature of geothermal formation which are predominantly weak, altered and generally prone to sloughing. Exploration and production drilling in the Olkaria geothermal field dates back to 1982. The drilling industry in Kenya is as old as the Olkaria geothermal field. Olkaria has documented several fishing challenges that cost valuable time and money. No written literature exists to solve this stalemate. It is for this reason that this paper seeks to develop a solution model and assist in improving the stuck pipe and fishing management.

2. COMMON CAUSES OF STUCK PIPE

2.1 Hole Pack off

Drilled cuttings fall back and settle on bottom burying the downhole BHA and getting stuck. This is usually due to insufficient cutting slip velocity. Poor hole-cleaning, poor mud properties and pump failure are major contributors.

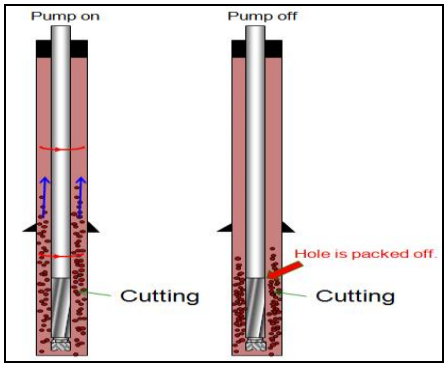

Figure 1: Hole pack-off stuck pipe

2.2 Unconsolidated formation

When drilling into unconsolidated formations such as gravel, sand and pea, the bond between particles are weak, particles in the formations will separate and fall down hole packing off the BHA and the stuck pipe arises.

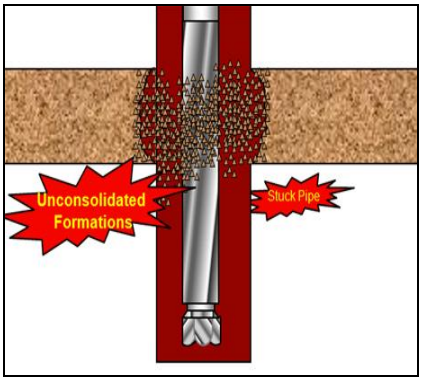

Figure 2: Stuck pipe due to unconsolidated formation

2.3 Naturally fractured formations

While drilling into naturally fractured formations, pieces of formations fall down in the annulus and stuck drill string.

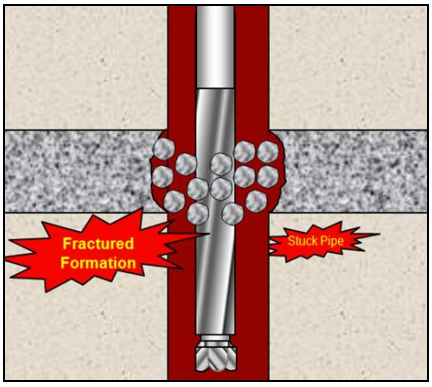

Figure 3: Stuck pipe due to naturally fractured formations

2.4 Junk lost in hole

Junk from the surface drops into the wellbore causing stuck pipe. It could be happened due to several factors as poor housekeeping on the rig floor, rotary table not covered, surface/down hole equipment failure.

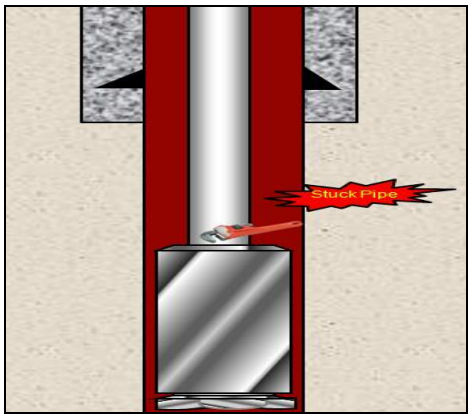

Figure 4: Stuck pipe due to junk lost in hole

2.5 Differential sticking

One of the most causes of pipe stuck. Happens when there is differential pressure (overbalance pressure) pushing a drill string into filter cake of a permeable formation.

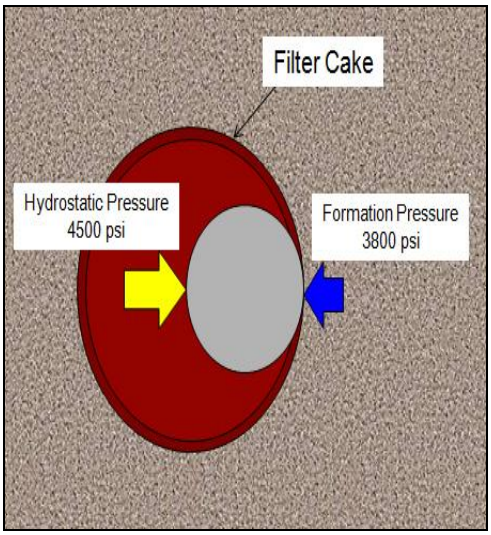

Figure 5: Stuck pipe due to differential sticking

2.6 Drilling with Limber BHA

The well is drilled with limber BHA. When stiff BHA precedes a the limber BHA, the stiff BHA is unable to pass through the existing hole profile due to excessive dog leg and thereby getting stuck.

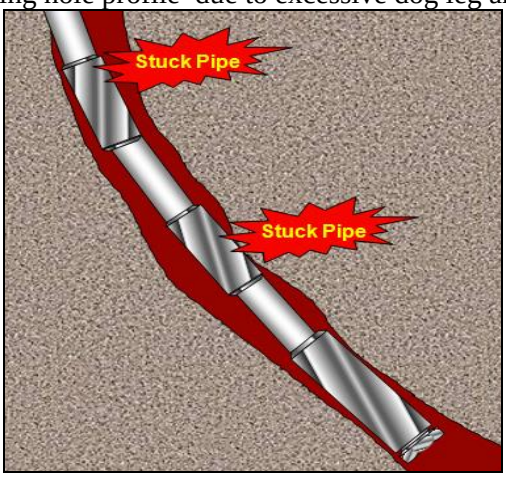

Figure 6: Stuck pipe due to stiff BHA preceding limber BHA

3. STUCK PIPE FREEING MODEL

Whenever a drill pipes gets stuck. The drill string is either in the following four conditions:

1. Tripping in hole
2. Pulling out of hole
3. Rotating and drilling
4. Static conditions

The flow charts in the following pages present best diagnostic models for each of the four cases above. Once the exact nature of fish has been identified, a more cost effective decision model will be developed to ensure the correct decision on fishing attempt, side track or abandonment is reached.

3.1 Stuck pipe while rotating the drill string

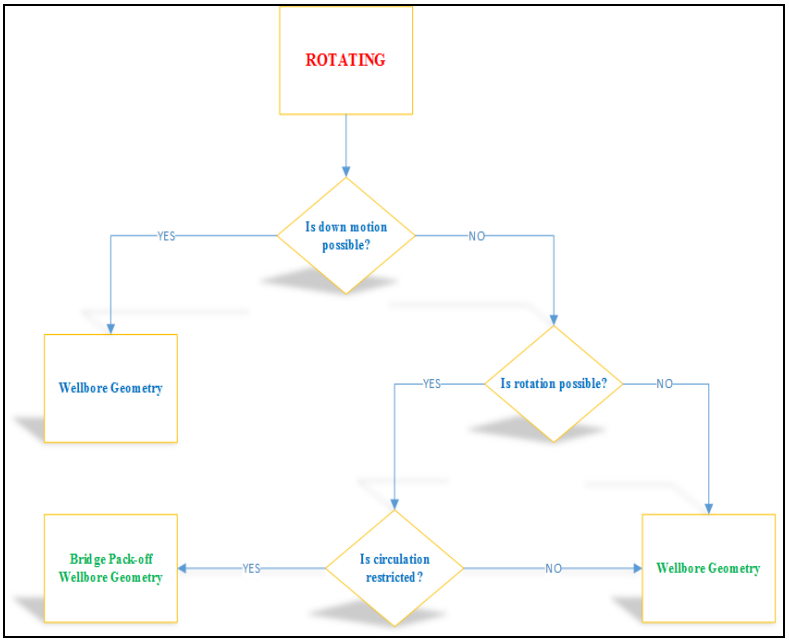

Figure 7: Stuck pipe while rotating the drill string

3.2 Stuck pipe while tripping in hole

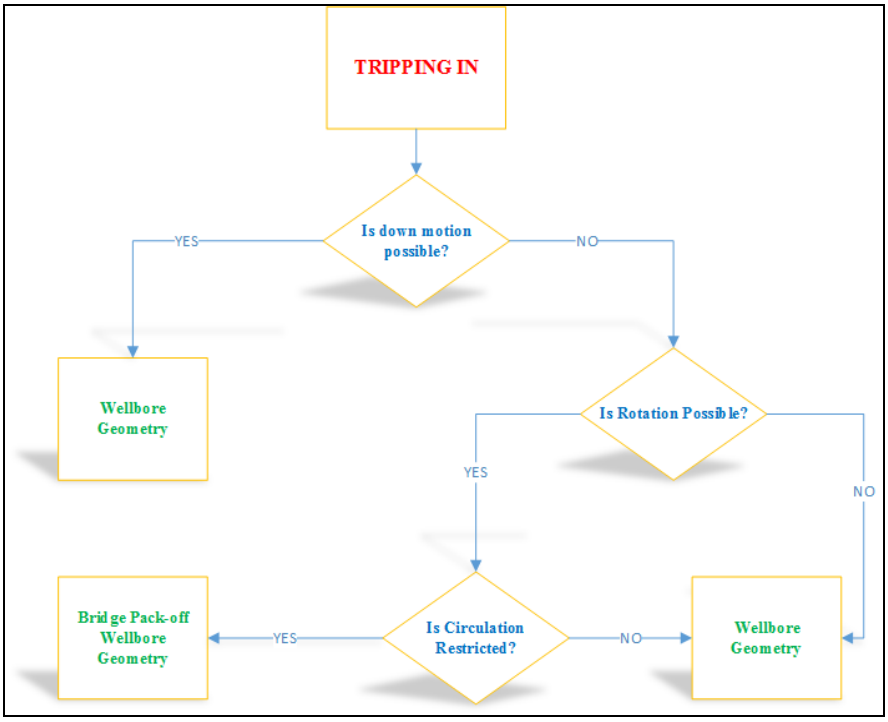

Figure 8**:** Stuck pipe while tripping in hole

3.3 Stuck pipe while tripping out of hole

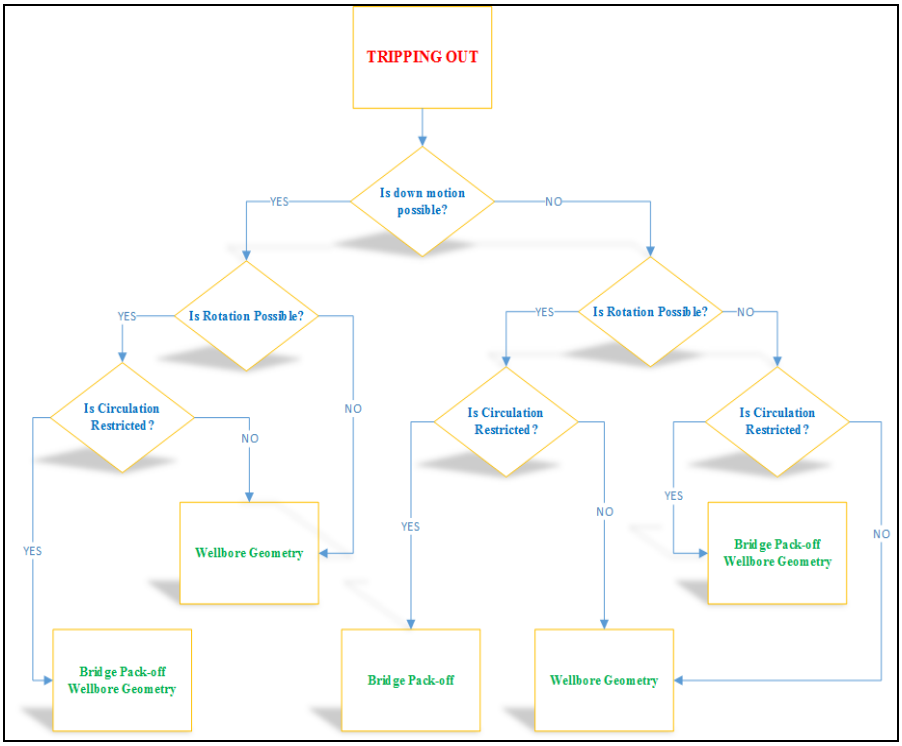

Figure 9: Stuck pipe while tripping out of hole

3.4 Stuck pipe while drill string is stationary

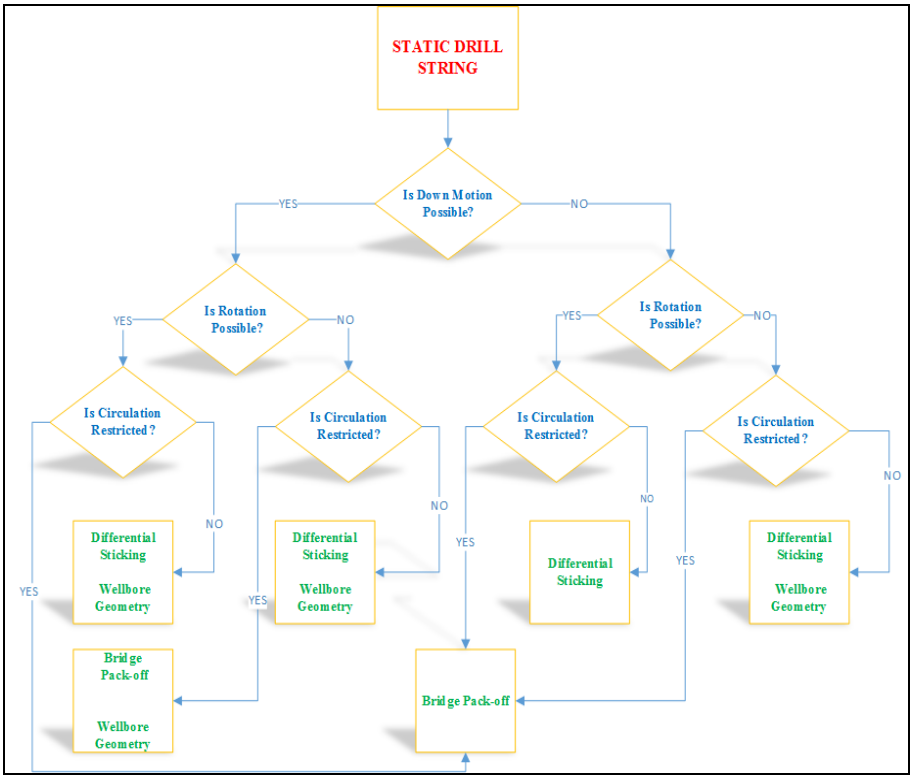

Figure 10: Stuck pipe while string is stationary

4. PIPE FREEING MECHANISMS

A complete diagnosis of the four conditions of drill string will generate primarily three forms of sticking as described below.

4.1 Hole pack-off

If the stuck pipe is caused by pack-off or bridging, proceed as follows

a. Circulate with low flow rate (300-400 psi pumping pressure . high flow rate worsens the stuck pipe situation
b. If the pack–off is while moving up or static , jar down with maximum trip load and torque may be applied to the drill string while jarring down
c. If the pack-off occurs while moving down, jar up with maximum trip load
d. To free the string, jarring operation may take long over 10 hours. Patience is required

After the string is freed proceed as

a. Increase flow rate and circulate to clean wellbore at maximum allowable flow rate.
b. Reciprocate sand rotate while circulating
c. Increase flow rate and circulate to clean wellbore at maximum allowable flow rate. Flow rate must be more than cutting slip velocity in order to transport cuttings effectively.
d. Reciprocate and rotate while circulating to improve hole cleaning ability. Work the drill string with full stand if possible.
e. Ensure that the wellbore is clean prior to continuing the operation. You can see from the sale shaker whether the hole is clean or not.
f. Sweep may be utilized to improve hole-cleaning.
g. Back ream or make a short trip through the area where causes the stuck pipe issue.

4.2 Differential sticking

If the stuck pipe is caused by differential sticking, proceed as follows:

a. Apply maximum flow rate as much as you can.
b. Apply maximum torque in the drill string and work down torque to stuck depth. Torque in the string will improve chance of free the pipe.
c. Slack off weight of string to maximum sit down weight.
d. Jar down with maximum trip load. Torque may be applied with jarring down with caution. The chance of freeing the pipe by jarring down is more than jarring up. Please be patient when a hydraulic jar trips because it may take around 5 minutes each circle.

After the string becomes free, proceed as follows:

a. Circulate at maximum allowable flow rate. Flow rate must be more than cutting slip velocity in order to transport cuttings effectively.
b. Reciprocate and work pipe while cleaning the hole. Ensure that you can work pipe with full stand or joint while circulating.
c. Condition mud prior to drilling ahead because if you still drill with poor mud properties, the differential sticking will be re-occurred.

4.4 Well bore geometry sticking

If the stuck pipe is caused by wellbore geometry, proceed as follows:

a. If the drill string gets stuck while moving up, jar down with maximum trip load and torque can be applied into drill string while jarring down. Be caution while applying torque, do not exceed make up torque.
b. On the other hand, if the drill string gets stuck while moving down, jar up with maximum trip load. DO NOT apply torque in the drill string while jarring up.
c. Flow rate must be reduced while attempting to free the drill string. Do not use high flow rate because it will make the stuck situation became worse and you will not be able to free the pipe forever.
d. To free the string, jarring operation may take long time so please be patient.
e. If a formation you get stuck is limestone or chalk, acid can be spotted to dissolve cuttings around the pipe.
f. If the drill string is stuck in a salt formation, spotting fresh water is another choice to clear the salt in the annulus.
g. Please always seriously consider regarding well control prior to spotting light weight stuff (acid or fresh water) around the drill string. You must ensure that you are still over balance formation pressure otherwise you will be dealing with well control too.

After the string becomes free, proceed as follows:

a. Increase flow rate and circulate to clean wellbore. Flow rate must be more than cutting slip velocity in order to transport cuttings effectively.
b. Reciprocate and work pipe while cleaning the hole.
c. Ensure that the wellbore is clean prior to continuing the operation.
d. Back ream or make a short trip the section that causes the problem.

5. SOLUTION (DECISION) MODEL

The decision on which way to go after stuck-pipe diagnosis is determined by how successful the initial attempts to free the string have proved. However, there is only up to a limit of time and cost that we can continue making fishing attempts. Figure 7 presents a flow chat on how to approach a stuck pipe scenario and what decision to make at what time.

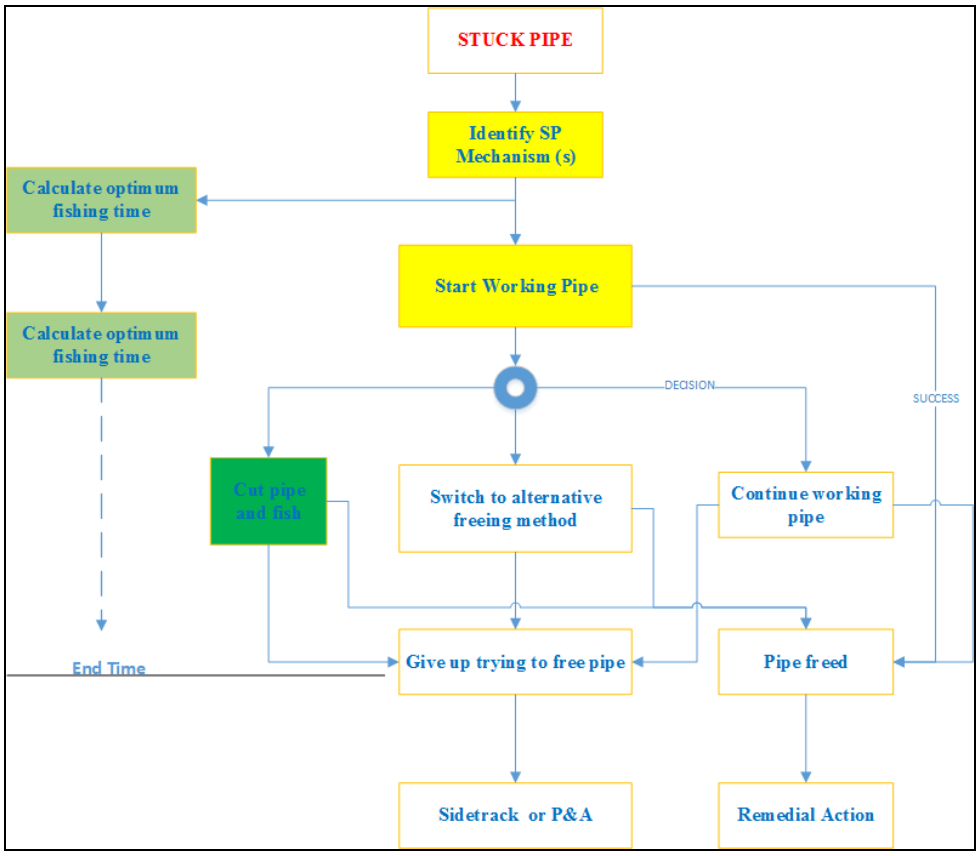

Figure 11: Solution (decision) model for stuck pipe

Stuck pipe and fishing is inevitable in drilling. The fishing practice adopted in overcoming stuck pipe scenario has a resultant cost and time element. To reduce non-productive time, a solution model must be adopted to prioritize and select the most appropriate method and tools. The above procedure is therefore suitable for fishing best results in fishing and stuck pipe problems.

References

Bourgoyne, A.T., Millheim, K.K., Chenevert , M.E. et al. 1986. Applied Drilling Engineering. Richardson, Texas: Textbook Series, SPE

Muhammad A. Muqeem, SPE, Alexander E. Weekse, SPE, Ali A. Al-Hajji, SPE, Saudi Aramco: Stuck Pipe Best Practices - A Challenging Approach to Reducing Stuck Pipe Costs, 160845-MS