Techniques for Breaking Free

Prevention of stuck pipe is far more economic than even the best of freeing procedures. But when prevention fails, the operator must move swiftly to select the most effective treatment. Here are some basics of unsticking pipe—from pills to jarring to fishing—that may help speed that decision.

Freeing stuck pipe involves finding the right combination of gentle persuasion and brute force. Gentle persuasion involves changing downhole conditions to reduce sticking so the pipe comes free on its own or is more responsive to force. And force is used when the hole’s grip on the pipe cannot be coaxed loose and must be overcome by a greater force.

Force is delivered by pulling on the pipe, slacking off or applying and holding torque. Stuck pipe can also be banged free with a jar—an impact device installed in the drillstring that delivers a blow up, down or both to free the pipe (see “Jars, Jarring and Jar Placement,” page 52). Repeatedly opening and closing the head valve in the mud pump several times causes pressure surges in the mud flow that may also vibrate and shake the pipe free.

The tools of persuasion are spotting fluids, hole conditioning and changes in hydrostatic pressure. A spotting fluid is a volume, or “pill,” of fluid containing lubricants and surfactants pumped downhole and placed in the annulus opposite the interval of pipe held by the wellbore, the stuck point.1 Diesel oil products prove successful half the time and are used most commonly, but environmental agencies have recently encouraged use of less toxic mineral oils.2

Some major oil companies have abandoned diesel altogether. Regardless of which base is used, spotting fluids contain additives that enable them to act as both a lubricant to help slide pipe around bends and through tight spots, and as a surfactant to weaken cohesion between the mudcake and pipe. Occasionally, in carbonate formations a pill of 15 to 25% by volume mud acid is used to partially dissolve hole bridges, cuttings or sloughed formation.

Hole conditioning once stuck involves increasing mud flow rate or changing mud properties (such as density, solids and pH) to enhance solids removal, such as a cuttings bed in a high-angle well or a plugged interval. Reduction in hydrostatic pressure is used mainly to free differentially stuck pipe. This can be achieved by lowering mud weight or the level of mud in the annulus if well conditions permit—no risk of gas inflow and good hole stability. An alternative is to "U-tube" the drillpipe and annulus, leading to drainage of the annulus and, more elaborately, backing off and installing a drillstem test (DST) tool (see “Freeing Stuck Pipe: An Overview of Two Techniques,” next page). An increase in hydrostatic pressure, by raising mud weight, is used to treat sticking in unconsolidated, mobile or geopressed formations.

(continued on page 30)

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<table>
<thead>
<tr>
<th>Type of Sticking</th>
<th>Identifying Features</th>
<th>Elf Recommendations</th>
<th>BP Recommendations</th>
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| Differential sticking | • Sticking occurs when drillstring is stationary  
• Drillstring cannot be rotated or moved up or down—or if drillstring can be moved, high overpull at connections and while tripping, and high torque right after a connection.  
• Generally no significant pressure variations in circulation  
• Porous and impermeable zones present in the openhole interval. May be a depleted zone. | 1. Stop or reduce circulation to lower effective mud weight at stuck point. Pull with maximum allowable force. Start jarring at once at maximum force. Jer upward for first hour then both ways. Try rotating. Make elongation measurements while varying pipe tension to estimate location of stuck point.  
2. As soon as possible, add surfactant slug while working drillstring. Be sure to give the additive time to work before washing out the slug.  
3. If previous attempts fail, hole is stable and there is no risk of gas inflow: (a) back off as deep as possible, (b) run in with a DST tool and screw into fish. Open tester for 1 minute; do not flow well. This relieves differential pressure on formation under no-flow condition. | 1. Start working the pipe immediately. If the bit is off bottom, slump the pipe with right-hand torque held in it. If the bit is on bottom, pull to the maximum immediately and jar. Apply right-hand torque to try to get movement to the stuck point.  
2. If first attempts fail, work the pipe in both directions until alternative action can be taken.  
3. Consider all aspects of well control before lowering hydrostatic pressure. In choosing how to lower pressure, remember the degree of control and speed of the pressure reduction. Pressure reduction is most effective if the drillstring is in compression.  
4. Locate the stuck point to ensure the pill is of sufficient volume to cover the stuck point. Fluid should 0.2 ppg heavier than the mud to ensure that it stays in place. Put the pipe into compression, slacking off 10,000 lb below the weight of the pipe and apply a half turn of right-hand torque for every 300 m [1000 ft] of pipe above the suspected stuck point. Every 5 minutes release torque and pack up the 10,000 lb. Leave a reserve volume of pill inside the drillpipe and every 30 minutes slowly pump half a barrel to move more pill into the hole. Work the pipe up and down at regular intervals. Allow 12 hours of soaking time; >40 hours is often considered excessive.  
5. The U-tube method is an alternative requiring careful well control. |
| Mechanical sticking | • Key seat  
• 1st drill collar or stabilizer caught at a specific depth only when tripping out  
• Free passage at suspected key seat depth when running in  
• Stuck point corresponds to dogleg  
• Tight hole will occur at the same depth on trips. | Never pull strongly; try moving down with torque. Jar down. Spot a highly lubricating slug. If unsuccessful, back off as close to stuck point as possible. Run in with jarring string of outside diameter small enough to enter the key seat on running in. If 2 to 3 hours of jarring is unsuccessful, spot lubricant and continue jarring. If differential sticking occurs, back off to the pipe above key seat. Hold fish with spear to prevent it falling and washerover. | Work the pipe down. When the pipe can be worked down and rotated, but cannot be pulled past the key seat, slowly rotate the string with minimum tension. It is hoped this will work the collars and stabilizers past the key seat. |
| Fallen objects | • Difficult to identify specifically. | Vibrate pipe with mud pump while moving in direction opposite that when the pipe stuck. Usually jar down. Set lubricant and continue. | Work the string and jar in both directions. Increase forces gradually. Work string upward and jar upward. Apply maximum forces from the start. |
| Undergauge hole | Commonly caused by lack of precautions while running in the hole, such as:  
• Drillstring too rigid compared with previous string.  
• New bit larger diameter than worn bit  
• A cast solid bit is run after a tricone bit. | Emphasize jarring; use same procedures as for fallen objects. | Work string upward and jar upward. Apply maximum forces from the start. |
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<tr>
<td>Massive (plastic) salt</td>
<td>• Rapid penetration</td>
<td>Restore circulation by backing off as low as possible and treating mud (supersaturated saltwater plug, 350 kg/m&lt;sup&gt;2&lt;/sup&gt;). Washover is a last resort.</td>
<td>A freshwater pill will often dissolve salt at the stuck point, which is usually in the BHA. Hold maximum pull on the pipe while spotting the pill. Spot a pill large enough to cover the BHA with 20 barrels left in the drillstring. In oil-base mud, place an unweighted spacer containing water and detergent ahead of the pill. If the pipe is not freed in 2 hours, spot a second pill. Well control considerations are paramount.</td>
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<tr>
<td>Sloughing shales/reactive formations</td>
<td>• Rapid penetration followed by large volume of cuttings at shale shakers</td>
<td>Circulate a high viscosity, low filtrate mud. Gradual hole cleaning is most effective—inject several plugs of increasing viscosity. During cleaning, work drillstring gently. If unsuccessful, spot a high viscosity plug, back off as low as possible and run in a jarring string. Be careful not to lose circulation.</td>
<td>Concentrate on establishing full circulation and working the string downward. Rotation may help disturb the material packing off the annulus. Gradually increase freeing forces to the maximum. If circulation is established, increasing mud weight may be beneficial.</td>
</tr>
<tr>
<td>Poor hole cleaning</td>
<td>• Excessive overpull during connections and trips</td>
<td></td>
<td>1. Attempt to establish circulation. Concentrate on downward working and apply forces gradually.</td>
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<tr>
<td></td>
<td>• Erratic and increasing torque while drilling</td>
<td></td>
<td>2. Once circulation is established, attempt to disturb cuttings/cavities. In low-angle holes, use weighted, high viscosity pills (for example, in 12½/8-inch hole at 8200 feet, use 50 bbl at 13.3 ppg).</td>
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<td></td>
<td>• Increase in pump pressure and pump pressure spikes as hole momentarily bridges</td>
<td></td>
<td>3. In high-angle holes, once circulation is established, use low-viscosity pills to disturb cuttings beds followed by weighted pills to carry material out of the wellbore.</td>
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<tr>
<td></td>
<td>• Shaker screens clean and dry</td>
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<td>4. Once circulation is established, rotate string to further disturb cuttings.</td>
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<td></td>
<td>• Reduced overpull when pumping</td>
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<tr>
<td></td>
<td>• Reduced weight/torque transmission at the end of a joint; weight/torque transmission improves after connection</td>
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<tr>
<td></td>
<td>• High rate of penetration</td>
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<td></td>
<td>• Large annulus in conjunction with low flow rate.</td>
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<tr>
<td>Plastic flow shales</td>
<td>• Torque increase during drilling</td>
<td>If circulation is not possible, attempt restoration with maximum pressure. If necessary, pressure up annulus to push back shales. Attempt jaring. Alternatively, back off as low as possible and continue mud treatment. Case hole promptly.</td>
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<tr>
<td></td>
<td>• Overpull when pulling off bottom with mud pressure increase</td>
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<tr>
<td></td>
<td>• Plastic shales at shale shaker; cuttings recovery declining</td>
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<tr>
<td></td>
<td>• Mud solids increasing</td>
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<td>• Reaming required on running in</td>
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"Strategies excerpted from:


There is some semantic variation in naming the causes of stuck pipe—what Elf calls "plastic flow shales" is largely what BP calls "mobile formations," what Elf covers under "hole sloughing," BP divides into "reactive formation" and "poor hole cleaning." For this reason, there are blanks in the table. This does not mean that one company ignores a given problem, but rather that it does not address it as a separate entity.
**Force or Persuasion?**

The first step in deciding how to free stuck pipe is to identify the likely cause of sticking (see “Causes, Detection and Prevention,” page 13). This not only indicates the optimum remedial action, but also what actions might cause more harm than good. For instance, if the cause of sticking is key seating, jarring up may be ruled out because it can force the pipe more firmly into the key seat (below).

Sticking may be due to more than one cause. Pipe initially stuck mechanically may be stationary in the hole long enough to become differentially stuck as well. The strategy for freeing pipe stuck by more than one cause must be worked out promptly but carefully, since treatment of one cause of sticking may conflict with treatment of the other cause.

Techniques for freeing stuck pipe are largely uniform across the industry, but companies differ in which procedures they emphasize, the order in which they are used and the rate at which they increase force.

For the common case of differential sticking, Elf developed a decision flowchart (next page). A flowchart that addresses any type of sticking was developed by Texaco, based on a survey of its Gulf of Mexico wells (page 32). The purpose of the chart is not only to suggest freeing procedures most likely to work, but also to show when fishing is uneconomic and the well should be abandoned or side tracked.

Texaco developed a semiquantitative method, based on its Gulf of Mexico experience, for determining whether freeing pipe is cost-effective. In most cases, fishing should be performed only as long as its cost is less than that of sidetracking or abandonment. To determine the cost of fishing, the authors developed an index, called risked fishing cost, based on the time from onset of sticking to spotting the first pill, and the likelihood of freeing the pipe. This likelihood is based on historical data relating success of freeing pipe with hole angle, hole size and mud weight.

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**What Role for Jarring?**

The first pill can be spotted within about an hour of sticking if the fluid is already prepared and ready to be pumped. But usually it must be mixed and may not arrive at the stuck point for 6 to 10 hours from the onset of sticking. The forward-looking operator has installed drilling jars in the bottomhole assembly (BHA) and while waiting for spotting fluid usually works the pipe and starts jarring. This may not free the pipe but can help prevent further differential sticking.

Use of drilling jars varies widely. Some operators run a jar in every well, others limit jars to directional and deep wells. In general, jars are run when there is a significant risk of sticking, commonly associated with a depleted zone, a hole with heavy mud, or a hole known for excessive drag or cleaning problems. Among the major oil companies, running jars is considered inexpensive insurance, accounting for less than 1% of drilling cost.

How jarring fits in the initial stages of freeing pipe varies, as illustrated by different approaches used by two majors drilling in mobile formations in the Gulf of Mexico:

- **Operator 1:** At the first indication of increased drag, pull up the weight of the BHA and engage topdrive. When sticking occurs, start circulating and jarring.
- **Operator 2:** When pipe sticks, slack off the weight of the BHA. Apply and hold torque for up to 1 hour. If pipe is suspected to be partly packed off by mobile formations, it can sometimes be pumped free by gently increasing pump rate. Start jarring while spotting fluid is prepared.

Regardless of the strategy, once jarring begins it may require as few as 10 or as many as 50 or more impacts, and its success varies widely—30 to 90%. One major found that unsuccessful jarring is usually not due to mechanical failure of the jar, but to sticking of the jar or pipe above it. To reduce this likelihood, and to increase the effectiveness of jarring, some operators use a hydraulic jar in conjunction with a jar accelerator—a piston that slides in and out of a chamber filled with nitrogen or synthetic compressible fluid. The accelerator is placed in the string above the BHA and jar, generally in the heavy-weight drillpipe or at the junction of heavy-weight pipe and drill collars. During drilling it is closed, and

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3. Reference 2, Shivers and Domangue.
Work drillstring; jar up and down

Spot surfactant

NO  YES
Free string?

Risk of flowing well?

YES
Reduce hydrostatic pressure by circulating light mud or water with blowout preventor closed to maintain well control

NO
Decrease hydrostatic pressure

Free string?

NO
Back off

YES
Free string?

Jarring

NO
Free string?

NO
DST

NO
Washover; fishing

Free string?

YES
NO
SIDETRACK

Elk flowchart for treating differentially stuck pipe.

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extends when the driller pulls up to fire the jar. When the jar trips up, it accelerates the pipe only between the jar and accelerator, closing the accelerator (next page). This helps overcome problems of pipe drag above the jar and achieves a higher pipe velocity and therefore a greater peak force. This force can be increased several times by use of a jar accelerator.

An advantage of an accelerator is that it allows the driller to use only heavyweight drillpipe for jarring but, for a given BHA, achieve a higher impulse than with drill collars. Because it is less stiff, heavyweight drillpipe offers less drag than drill collars, and is therefore subject to less damping than an equal length of drill collars. Use of accelerators has become increasingly important in British Petroleum's (BP's) North American operations, which are moving away from use of drill collars in directional wells and toward lightweight drillpipe, which is less prone to sticking because of its small diameter and greater flexibility.

A common misconception is that the accelerator is working when the derrick rattles on jar firing. The opposite is true: if the accelerator is working, drag above the accelerator keeps most of the energy downhole, insulating the rig from shock. An operational consideration is that stroke length of the accelerator must be at least as long as that of the jar, to be sure the jar hits before the accelerator reaches the end of its travel.

**Stuck pipe strategy**

The duration of jarring, before deciding to fish, side track or abandon the hole, is ideally dictated mainly by economics. Jarring duration depends on many variables, including availability of fishing equipment, cost of operation, importance of the hole or of retrieving downhole equipment and indications that jarring may succeed or fail.

Jarring duration also varies by hydrocarbon province. In Africa and Europe, especially offshore, jarring for 24 to 48 hours is not uncommon. One major, however, finds that jars themselves usually do not work for more than 24 hours. Typically, the oil company stops jarring after several hours to assess the situation. If spotting fluid is an option, stopping jarring prevents needless wear until the fluid is in place. If spotting is

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Texaco's flowchart for treating stuck pipe, based on data collected in the Gulf of Mexico. RFC, the risked fishing cost, is the expected cost of freeing stuck pipe. TFI is the dimensionless Texaco freeing index (the higher the TFI, the better the chance of freeing stuck pipe), and $P_s$ is probability of the success of freeing stuck pipe. ESTL is the effective soaking time limit. Calculation of TFI and RFC is made statistically. A rule for use of the flowchart is that attempts to free stuck pipe should cease after 96 hours.

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not an option, then jarring is continued until the decision is made to sidetrack. In the North American midcontinent, Onyx Energy Company usually quits jarring if there is no sign of progress after spotting a lubricant and jarring for 4 to 6 hours. Occasionally, jarring may be carried out for 12 hours. Usually the operator calls for a backoff crew after jarring for 3 to 4 hours.

After attempting to free the pipe for a given time with soaking, drilling hardware or both, the operator usually decides to back off and side track or back off and run in with a fishing assembly (see “Backoff Basics,” page 48). Abandonment now is rarely an option for an operating group.

The choice between sidetracking and fishing is based on cost comparison. A handful of decision trees and formulas have been published. Two typical approaches are used by BP and Mobil to determine the length of time that is economic to fish. BP calculates economic fishing time as sidetracking cost times the probability of fishing success divided by the daily cost while fishing. Mobil’s formula is the same except instead of the cost of sidetracking, it uses “known hole costs,” which involve different inputs.

BP calculates sidetracking cost as the sum of the following costs: the fish lost in the hole, backing off (wireline unit, backoff shot plus rig time), setting a plug from which to kick off (rig time to run a cementing string, to set the plug, trip out, wait on cement, trip in to tag, test and dress the plug and pull out) and redrill time. The most difficult estimate is the probability of fishing success. BP uses local experience, guidelines from a company data base or the small amount of published data. In the Gulf of Mexico, a 50% success rate for fishing was reported by Mobil and a 33% rate by Texaco. A quantitative estimate of fishing success can be derived from Texaco’s dimensionless freeing index, which is reported to accurately predict the success of freeing pipe with fishing jags.

Also in the Gulf of Mexico, Exxon developed a “stickiness factor” that determines the likelihood of freeing stuck pipe. This factor increases with increasing hole angle, mud weight, length of openhole interval, American Petroleum Institute (API) fluid loss and BHA length. Since the factor also indicates the relative difficulty of freeing pipe, it can be used to evaluate the effectiveness of spotting fluids and fishing techniques.

5. Heavyweight drillpipe has thicker walls and longer tool joints than normal drillpipe and an integral wear pad in the middle.
12. Reference 2, Shivers and Domanguer. 
Fishing
The key to successful fishing is measuring the hole diameter, the inside diameter (ID) and outside diameter of all downhole hardware before it goes downhole. Experience and equipment specification sheets cannot be trusted—they are often wrong. Pitfalls in developing a fishing plan usually involve not having certain information, such as:

- The depth of the top of the fish. The fishing operator relies on the drilling crew to have carefully measured drillpipe lengths.
- BHA assembly dimensions. In the North Sea, this job is considered so important that one person is often assigned the sole task of measuring what goes in the hole.
- Time of sticking. This can be a problem if sticking occurs during a shift change, or in the small hours of the morning, when record-keeping may become lax.

A typical fishing string, from the bottom, includes an overshot grab to grip the fish and a guide to find it, a bumper sub, a hydraulic jar, three stands of drill collars, a stand of heavyweight drillpipe, a jar accelerator and standard drillpipe (below). As the fishing gear approaches the fish, circulation is slowed. Once engaged, 80,000 to 100,000 lb of pull are applied, often with jarring up. Pulling, jarring and circulation are maintained. Progress can be incremental but significant, and the fish can come free unpredictably after hours of trying. Patience is essential.

The most important safety point is to know the rig—the pulling capacity of the drawworks, cables and tools. Certain practices should be avoided, such as pulling left using chains during a back off. When the backoff charge fires, the sudden release of torque could spin the chain, endangering rigfloor personnel.

The past decade has seen a dramatic change in what constitutes openhole fishing. Time-honored but time-consuming techniques—catching stuck pipe, cutting it, milling the cut, washing over the fish and gripping it to pull out—are performed less often. To many operators, “fishing” usually constitutes nothing more than backing off and running in with fishing jars. When that fails, they side track.

Several forces have accounted for this change. On the economic side, cost analyses began to reveal that fishing is often less economic than sidetracking (next page). Sidetracking became economic mainly because technology emerged that can place a sidetracked well at the depth of the original well in about 36 hours after deciding to abandon the fish.

Another reason for the increased popularity of sidetracking is the uncertainty of fishing, whereas sidetracking, although risky, often involves fewer uncertainties. Lessons learned about sticking in the original hole...
can be applied to prevent sticking in the sidetracked hole.

Another reason for the decline in fishing is the increased use of undergauge stabilizers on every second or third drill collar to inhibit differential sticking. This makes fishing difficult and washover prohibitively expensive because the stabilizers have to be milled to accommodate the washover pipe.

The success of fishing at its simplest—backing off and running in with fishing jars—is strongly linked to its promptness. Texaco found that success declines sharply with time: in all but one of 14 attempts, the fish came free on the first jarring attempt. The second attempt had only a 7% success rate. All attempts after 96 hours failed.

Based on a study of 44 fishing jobs from 1970 to 1981, Mobil found that the probability of success declined from 75% the first day to zero by the eighth day. Mobil recommended 8 days (192 hours) as the limit for fishing operations, which includes a maximum of two days of soaking. Shell, in a 1984 study of its North Sea operations, recommended that fishing be abandoned if there was no progress after 36 hours.

These studies suggest that openhole fishing will continue to decline in duration and in number of jobs. But as long as drillers continue testing the limits of new technology and technique, there will always be an opportunity to find new ways to unstuck pipe. —JMK

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12. General works on fishing:


13. See reference 9, Keeler, Brinkmann and Taneja.

14. See reference 8, Schofield.

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Relative costs of unsticking pipe, calculated by Anadroll.