Pipe Cutoff

Pipe cutoff downhole is required for a variety of reasons. The methods used in pipe cutoff have evolved from basic explosive methods to a full spectrum of methods to fit most applications. The success and reliability of pipe cutting depends significantly on the well conditions and the selection and deployment of the cutter.

Traditional solutions usually involve mechanical, chemical or explosive cutters. Successful application of cutters requires putting the pipe in tension before the shot and selection of a tool diameter that results in optimum standoff. Common mistakes are removal of the tool centralizers and improper choice of the tool (using a tool that is "close" to the optimum size rather than one that is the right size). Most tubing cuts are made with the chemical cutters or mechanical cutters, while casing cuts may be more common with explosive cutters. Success with the cutters run about 75% when the tubulars can be placed in tension, while the success falls sharply (to about 25%) when the tubulars cannot be placed in tension (e.g., tailpipe below a packer). Chemical cutters leave a slightly jagged, but unflared cut looking up while the explosive cutters often leave a ½" flare on the outside rim of the tubular. Problems common to both these tools are in getting the near gauge tools to the zone to be cut; a problem especially apparent in cutting damaged strings or strings with heavy deposits. A second problem, more common with the explosive cutter, is damage to the outside string from the cutter charge.

Chemical Cutter – The chemical cutter operates by spraying bromine tri fluoride through small ports in a copper alloy tool body. The rough-edged, but unflared tubing cut is made within milliseconds as the bromine tetra fluoride reacts with the steel.

When the cutter is correctly sized and depth control is good, the overlapping spray of reactant severs the pipe. If the tool is not exactly centered, a coating or scale partly covers the tubing inside surface, or the spray pattern is interrupted during the cut, only a partial cut will be made. Because the body tensile strength of tubing is usually far greater than the pull force that can be delivered by most rigs, an incomplete chemical cut will not reliably separate if more than about 20% of the steel body remains. In the 4-1/2" tubing cut shown in the following photo, an over-pull of 55,000 lb was not sufficient to separate the pipe after the cutter was fired.

The tool body port size and condition influences tubing cut efficiency. Some chemical cutters are reused, thus the port size may be larger than optimum. Larger ports result in an inefficient spray pattern and a poor cut.

There are several critical factors for a chemical cutter. The success depends more on the service technician than any other single factor.

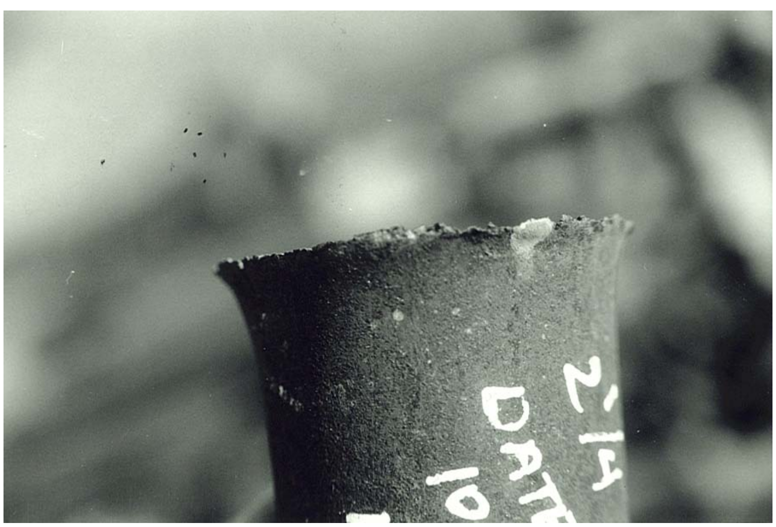
1. The steel to be cut should be free of scale, oil, wax, plastic or other coatings. Many of the coatings are resistant to the cutter fluid and can result in partial or no cut.
2. The tool should be centralized and anchored. Any movement of the tool during spraying of the cutter fluid smears the fluid impact and dilutes the effectiveness of the cut.
3. Movement of fluid around the cutter during the cut decreases the chances of success. Chemical cutting depends on a focused application of the cutting fluid. Fluid surges during the cutting can and have defeated the operation of the tool. The well has to be fully dead (no flow for a few hours), before the cut is made for best performance.
4. High external pressure reduces the effectiveness of any nozzle device through back pressure effect on the exiting fluid.
5. Cutting in mud or other dense fluid is detrimental for cutter success. The heavy or viscous fluids defeats pin-point (jetting) application of the cutting fluid.
6. Selection of the optimum diameter of cutter is one of the most critical operations. Efficiency of the cut depends heavily upon the distance between the nozzle and the wall of the tubing. If the cutter is too small due to tool availability or restrictions in the tubing string, the cutter will not cut the tubing.
7. Application of tension is usually needed to finish the separation of the pipe. Usually, only 90 to 95% of the pipe wall body is cut during the firing of the cutter in the best of cases; the remainder of the tube body must be yielded by application of an axial stress (tension) by the rig.

Typical applied tension to separate the pipe is usuall between 20,000 and 50,000 lb. If effective tension cannot be applied (dogleg section or horizontal well), another type of cutter should be found.

8. Higher strength alloys (e.g., chrome), chemically resistant alloys, thick pipe and coatings on the inside surface of the pipe are challenges to a chemical cutter. High alloy (above S-135), high chrome and nickel content steels, and thick wall pipe should usually not be attempted with a chemical cutter unless all sizing, temperature and pressure conditions can be met.
9. The cutter should be placed to avoid the coupling and profiles or other jewelry.
10. Deep tubing cuts (cut depth greater than 15,000 ft) are not usually successful. Pressure and temperature may be reasons.
11. On reused cutters, the nozzles wash out slightly, and later cuts are much poorer (less focus of the fluid) than the first cut. Use a new cutter section, with gauge nozzle diameter, for best results.

Some operators place some 000 and 0000 steel wool in the cutter cavity to "activate" the cutter fluid. This use may not be widespread, but field tests appear to work better than plain cutters (no steel wool),

Shaped Charge Cutter – These are linear shaped charge formed into a circle. The cutters work by focusing a ultra-high pressure, directed, explosive pulse against the pipe wall. The cutter is a close relation to a perforating charge and are unaffected by most coatings. The draw back to an explosive cutter is the flare produced at the cut area by the detonation.



Early cutters produced large flares (20% pipe diameter growth or more) and broken sections of pipe. Later cutters (last few years) have been re-engineered to produce less than a 10% flare and no ribbons or splits.

Prior to fishing operations with an overshot tool, any flare must be dressed off.

Critical Factors:

1. Selection of the optimum diameter of cutter is very important to successful application. Efficiency of the cut depends heavily upon the distance between the base of the charge and the wall of the tubing. If the cutter is too small due to cutter availability or restrictions in the tubing string, the cutter will cut only one side of the tubing.

2. The tool should be centralized if possible. This may not be quite as critical as with a chemical cutter, but will still affect performance.

3. Application of tension is usually needed to finish the separation of the pipe. Usually, only 80 to 95% of the pipe wall body is cut during the firing of the explosive cutter; the remainder of the tube body must be yielded by tension. If effective tension cannot be applied (dogleg section or horizontal well), another cutter should be found.

4. Higher strength alloys, chemically resistant alloys, thick pipe and coatings on the inside surface of the pipe are challenges. High alloy (above S-135), high chrome alloys, high nickel alloys and thick wall pipe should usually not be attempted with an explosive cutter.

5. The cutter should be placed to avoid the coupling.

6. High temperatures may create problems with explosive cutters. High temperature cutters can be made but the one-of-a-kind designs lack the power of RDX or HMX cutters and the reliability of the application-proven designs.

7. The strings outside the tubing to be cut may be damaged by an explosive cutter.

The chance of a successful first cut on pipe above the packer is the same as with a chemical cutter: 75%, with 50% of the failures resolved by a second attempt. When tension cannot be pulled into the pipe (i.e., below the packer), the chance of success on the cut is about 25%.

Split Shot or linear shaped charges – The Split Shot device (from Owen Tool in Ft. Worth) is an unusual cutter with good potential for cutting where restrictions prevent a larger cutter from being deployed. It is a linear piece of shaped charge that can be run through restrictions and still make effective cuts in the coupling. The cutter is a straight tube with the linear charge running lengthwise. The tool is placed in the collar or tool joint and shot through the pipe and the coupling, weakening the connection sufficiently to allow pulling out at 5,000 to 10,000 lb.

tensile force. Joints shot in this way often “jump” out with minimum application of over-pull when shot in most API thread connections.

The charge strip is held in a magnetically decentralized tool and is run on wireline. The advantage of the tool is its smaller diameter (1-11/16” and smaller) that will pass many obstructions. Tube tension during cutting is still recommended. The tool is best suited to upper pipe recovery operations in tubing without hook-wall threads. The split coupling may hamper fishing operations on the lower tubing.

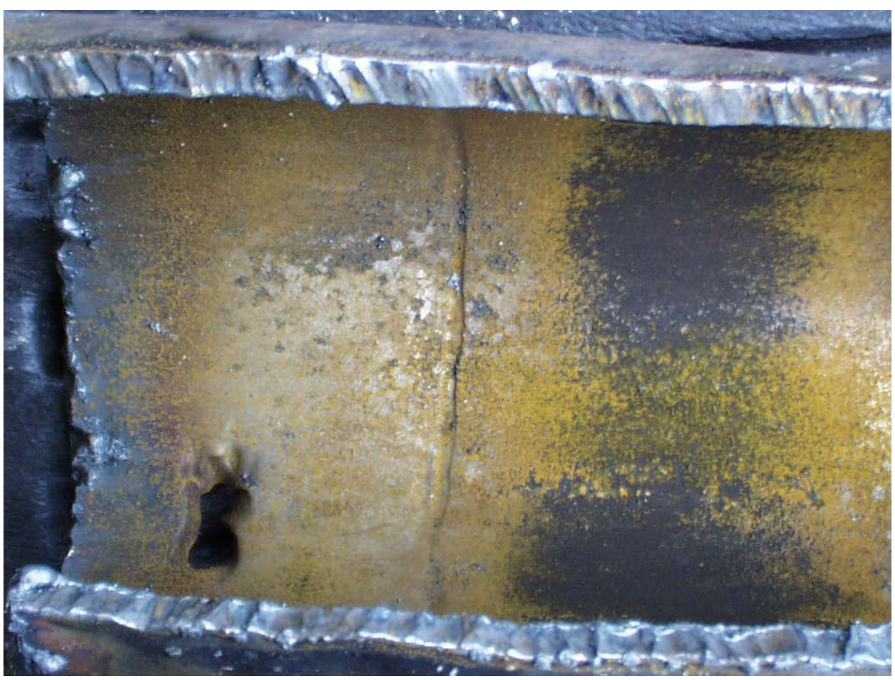
Critical Factors:

1. The tool is only effective if shot in the coupling. Accurate depth control (within inches) is a must. The failures of the tool have principally been linked to problems in depth control. The tool can be made longer on request: a minimum length of 18” is suggested. Reliability is directly proportional to depth control accuracy.
2. Couplings with hook-wall threads are not good candidates for the cutter.
3. Time-at-temperature limitations of explosive powders apply.
4. The problems involved with fishing a split coupling must be understood before application.

When shooting with the pipe in tension (above the packer) and accurate depth control, the field reliability is about 90%.

Abrasive Cut-off – The development of abrasive cut-off tools is an outgrowth of the abrasive perforating process that uses a sand and fluid slurry directed at the tubular and pumped at high rates. Tubular cut-off requires a rotating nozzle on coiled tubing or rotating the workover tubing. The mechanism can be used to cut nearly any weight or grade of tubular. The cut produced by abrasives is usually smooth with no flare. Cutting times of a few minutes at surface and about double to triple that time in the well (function of backpressure).

Drawbacks are need for a fluid supply path (coiled or jointed tubing) and potential damage to the strings beyond the first pipe. If the abrasive cutter tool fails to rotate or if pumping of abrasive continues beyond the severing of the tubing, severe casing damage can result as shown in the test piece of 7" casing on the following photo. In this test, the cutter failed to rotate on one test (note the hole in the 7") and rotated for 20 seconds after the 3-1/2" S-135 drill pipe was severed (note the groove in the 7").



Critical Factors:

1. Although the proper standoff from the nozzle to the tubular wall is important, a cut can be made with several inches of clearance.
2. The tool must be anchored. If the tool can move, a large section of the pipe can be thinned without making a clean cut.
3. The tool head must rotate to provide a complete cut. If the tool stalls or is rotated too long with abrasive applied to the cut, then a hole or groove can be cut through tubing and casing.
4. Back pressure increases the time needed to make the cut. Experimental application of the tool in 3-1/2”, 13 lb./ft, S-135 DP has resulted in average cut times of 3 minutes at surface conditions (about half the time needed downhole).
5. Sufficient solids must be pumped to achieve cutting. Solids may be of various types, including sand, calcium carbonate and other materials.

Radial Cutting Torch – The tool sprays a thermite derivative (burns at 5000F) from shaped nozzles at the wall of the tube. This device is used for higher alloy tubing or cuts in jewelry. No success numbers are available, but the tool has achieved significant reliability gains in the past several years.   As shown in the following photograph, application of an over lapping nozzle pattern of the material is critical for a successful cut.

The impacted surfaces are melted. Incomplete cuts and misfires have been the major drawback, but some successes in chrome pipe have been recorded. The cutter has few limitations, however, outside casing strings may be damaged by application of the cutter.

Critical Factors:

1. Nozzle condition. Reuse of nozzles is not suggested due to wear.
2. Nozzle to pipe wall clearance is critical to successful application of the tool.
3. Crossflow and flow from outside to inside the cut surface may be detrimental if it disperses the thermite dispersion during the cut.

Mechanical cutters – These mill-like devices, rotated by tubing or downhole motors are often slow in cutting heavy wall or high alloy pipe. Tubing cut times are 20 minutes to 6 or more hours for cutters driven by small motors, depending on the tubing size, weight, grade and depth of cut.

Critical Factors:

1. Anchoring the tool is required for a successful cut.
2. Good hydraulics are essential at the tool since cutting arms are pumped out and cuttings are removed by the flow.
3. Higher alloy pipes may be more difficult to cut with a mechanical cutter.

Colliders– These are gross explosive tools meant to shatter or break drill collars and stabilizers. They operate by focusing a pressure surge produced by two advancing (and opposing) fronts of high explosive. Although seldom used in normal tubulars, they are one of the few mechanisms of cutting the heaviest wall tools in a drilling BHA

This overview of pipe cutoff methods is an educational tool only and does not imply design criteria for successful application of any cutoff device.

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