ROD AND TUBING INSPECTION
OPTIONS AND IDEAS TO LOWER OPERATING COSTS

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INTRODUCTION

Applying the best operating practices can lead to very low tubing and rod failure rates. However, less than optimum tubing and rod life is common in many areas. Approximately 50% of rod pumped well pulling repair operations and 60% of the costs are associated with rod and tubing failures. The cost of replacing a string of tubing can be over four times the cost of the pulling unit time required to replace one joint. Individual rod replacement versus replacing an entire string has similar economics. Conversely, pulling unit time associated with multiple failures can easily exceed the cost of a new string of tubing or rods. Proper application of tubing and rod inspection can reduce operating costs of rod pumped wells. This paper will review rod and tubing inspection options. Guidelines will be presented regarding when to apply the different inspection options. The guidelines were developed from experience with Permian Basin rod pumped wells with seating nipple depths averaging 3000' to 6000'. Fluid volumes vary from less than 50 BFPD to over 700 BFPD.

SUMMARY

Wellhead inspection of tubing should be the starting point for reducing tubing leak frequency. Based on inspection results, an operator may be able to identify trends. The trends may allow an operator to reduce well head inspection and move to a program of rotating tubing and or laying down sections of tubing when tubing leaks occur.

Rod inspection can reduce overall rod repair costs.

TUBING LEAKS

What do you do if you have a tubing leak? It seems the only practice common to all operators is removing the joint of tubing that has a leak. In many areas it is standard operating procedure to replace the one bad joint and return the well to pumping. This practice has the lowest cost for that operation. Any additional work done will add cost to the operation. However, experience indicates in many cases one leaking joint is an indication that other joints will also fail. There are several alternatives that can be considered to reduce the chance of a repeat failure. Listed below are several options and some of the advantages and disadvantages of each option. The options are listed from least expensive operation to most expensive. The option you choose can have a dramatic impact on future costs.

One caveat is that the options listed below are intended as a guide for tubing failures in rod pumped wells located in joints above the pump joint. The causes of a failure in the bottom joint or pump joint are usually different than the rest of the string. Controlling bottom joint failures, which can be over 50% of the tubing leaks, is critical. Cutting and examining failures is an effective method of identifying the root cause of the failure and eliminating bottom joint failures. Typical fixes include use of plastic lined joint, poly lined joint, upgraded metallurgy, guided rods immediately above the pump, top hold down pump, or non-metallic top guide on a bottom hold down pump.

Repair Options

Replace one joint and return the well to pumping

Advantages:

- Lowest cost option -- less rig time and minimal tubing replacement costs
- Returns the well to production in the least time
- Only one joint of tubing to handle from yard to well site

Disadvantages:

- High chance of additional tubing leaks and thus additional repair costs
- Do not know the condition of the remaining tubing or get information that can identify the root cause of the problem.

Replace one joint and rotate some tubing so that better tubing is relocated to the problem area. There are multiple ways to rotate tubing. Moving joints from the top to the bottom and shifting the remaining tubing up in the string is a good option. Can rotate one joint to as much as 50% of the string. One caution is to insure that a good joint is in the slips.

Advantages:

- Low cost -- minimal extra rig time and minimal tubing replacement costs
- Very likely to extend life of tubing between failures
- Can be very successful if tubing leaks are in a section less than 30% of the string length. Rod wear typically happens in the lower section of a tubing string where compression forces are greatest. Corrosion rates may also be higher in the lower sections of tubing. Most importantly, hydrostatic pressure that causes the leak increases with depth. Moving thinner wall tubing up in the string will move the joints to a location with less hydrostatic pressure and thus less chance for leak.
- Returns the well to production in less time than inspection
- Only one joint of tubing to handle from yard to well site

Disadvantages:

- Eventually a full rotational cycle will be completed and tubing will need to be inspected or replaced. CAUTION: Getting a thin walled joint set in the slips can result in a tubing part.
- Do not know the condition of the tubing. The tubing moving to the area around leak may be worse than the tubing being moved from this location.
- Pulling unit crews need specific instructions. Inconsistent practices or inaccurate record keeping can lead to the bad section being rotated back to the problem area (usually near the bottom) and lead to more leaks.
- Rotating tubing with poor record keeping followed by a wellhead inspection can lead to mis-diagnosing the location of the root cause of problems. An inspection might indicate severe rod wear and lead to installation of rod guides. However, if tubing was rotated in the past and the original location of the tubing is not known, you do not know where in the string the wear occurred.

Lay down a section of tubing above and below the leak and replace it with new tubing. A likely addition to this option is collecting the laid down tubing and eventually inspecting the tubing in a yard, and reusing tubing that has remaining life.

Advantages:

- Very likely to extend life of tubing between failures
- Overall tubing inspection costs are lower than hydro-testing or a well head inspection.
- Good tubing can be salvaged with a yard inspection

Disadvantages:

- Do not know the condition of the tubing to determine if too much or too little tubing is being laid down.
- Do not get information that might lead to solving the root cause of the tubing leak.
- Does not require as detailed record keeping as when tubing is rotated.

Hydro-test (Pressure test) tubing and replace joints that fail during hydro-testing -- Estimated cost of $.12 to $.18 per foot

Advantages:

- May be less cost than other well head inspection methods.
- Easily identifies leaks
- Identifies collar leaks that other inspection methods cannot do

Disadvantages:

- Do not know the condition of the remaining tubing.
- Experience indicates that hydro-testing is not an effective way to identify joints that are likely to fail. Repeat failures after hydro-testing are frequent.
- Do not know how many replacement joints are needed until the last joint is tested going in the hole. Thus quite often new tubing is installed at the top rather than at the bottom where the best quality tubing is usually needed.
- Do not get information that might lead to solving the root cause of the tubing leak.

Internal caliper inspection -- Estimated cost of $.20 to $.25 per foot

Advantages:

- Should eliminate most potential bad tubing from the well and is very likely to extend the time before the next failure.
- Usually less cost than an electromagnetic inspection (EMI)
- Identifies location and type of problem (corrosion or rod wear) and thus allows solutions to the root cause of the problem to be identified. Strategic placing of rod guides, modifying pumping conditions, or improving corrosion control programs are solutions that can reduce reoccurring failures.
- Tubing can be graded yellow, blue and green and then run back in the hole with the highest quality tubing in the most difficult conditions, usually near the bottom of the string.
- Less tubing (than some options) needs to be hauled to location since only the rejected joints need to be replaced.
- Less area goes uninspected in the internal areas around the collars.
- One rule of thumb is that if the value of the reusable tubing exceeds the cost of the inspection operation, the inspection was an economical investment.

Disadvantages:

- A 24 pin caliper is usually a less accurate internal inspection than the EMI process
- No external inspection other than unit crew's visual inspection
- Pulling unit time is increased because of rig up and down of the inspection equipment and the time to sort tubing.

Wellhead electromagnetic inspection (EMI) of tubing as it is pulled from the well -- Estimated cost of $.25 to $.32 per foot

Advantages:

- Eliminates nearly all potential bad tubing from the well and is very likely to extend the time before the next failure.
- Identifies location and type of problem (corrosion or rod wear) and thus allows solutions to the root cause of the problem to be identified. Strategic placing of rod guides, modifying pumping conditions, or improving corrosion control programs are solutions that can reduce reoccurring failures.
- Tubing can be graded yellow, blue and green and then run back in the hole with the highest quality tubing in the most difficult conditions, usually near the bottom of the string.
- Less tubing (than some options) needs to be hauled to location since only the rejected joints need to be replaced.
- Most consider EMI the most accurate well head inspection method
- One rule of thumb is that if the value of the reusable tubing exceeds the cost of the inspection operation, the inspection was an economical investment.

Disadvantages:

- May be the highest cost per foot for inspection.
- Pulling unit time is increased because of rig up and down of the inspection equipment and the time to sort tubing.

Lay down the entire string and replace with new tubing. A likely addition to this option is collecting the laid down tubing and eventually inspecting the tubing in a yard, and reusing tubing that has remaining life. Basic inspection cost may be as low as $.15 per foot, but usually costs average over $.30 per foot due to cleaning, thread repairs, straightening, and trucking.

Advantages:

- Eliminates all potential bad tubing from the well and thus is the most likely case to extend the time before the next failure.
- Cost to inspect tubing in the yard including extra trucking charges may be less than cost to inspect at well sites due to volume discounts.

Disadvantages:

- Typically when inspection occurs, multiple wells are inspected. Thus you do not learn the condition of the tubing in each well and cannot identify solutions that could reduce future tubing leak frequency.
- High cost in replacement tubing -- offset by tubing salvaged during yard inspection process.

Economic Examples

Replace one joint with each failure versus inspect tubing and replace bad joints -- Two year life cycle costs, 6000 foot depth, rod wear and corrosion are problems.

- Option 1: Replace one joint and return the well to pumping. Costs average $3000 per tubing leak (Pulling unit time, equipment rentals, pump repairs, tubing anchor repairs, tubing loading costs, etc.). Experience indicates that three tubing leaks can be expected in the two year period, bringing the total cost to $9000. If several joints of tubing are not replaced, additional failures are likely.

- Option 2: Wellhead electromagnetic or caliper inspection of tubing as it is pulled from the well. Basic pulling cost will be increased to $3500, inspection costs of $2000, and estimated tubing replacement costs of $3500, bringing the total costs to $9000.

- Conclusion: Inspection is better than replacing only one joint. Estimated total cost of both operations is similar. However, an estimated 6 days down time would be eliminated and tubing would probably be in good condition to provide additional failure free pumping time if a wellhead inspection is done with the first failure.

Yard Inspection versus well head inspection -- 6000 foot depth, rod wear and corrosion are problems, estimate that 1500' of tubing will be junked.

- Option 1: Yard inspection. Pulling costs would be similar and will be ignored. Eventual tubing replacement costs similar in each case. A full string of tubing would be needed for the well, but that cost would be offset by the salvaged tubing. Yard inspection costs estimated at $1500 plus trucking.

- Option 2: Well head inspection. Well head inspection costs of $2000 and estimated tubing replacement costs similar to cost of replacement minus salvage in option 1.

- Conclusion: Wellhead inspection is better than yard inspection. Cost of wellhead inspection may be slightly higher depending on trucking costs, but information gained will help identify the root cause of the problem. Also data from multiple wells could lead to lower cost program of laying down only the joints in well-established problem areas and thus reduce total inspection costs.

Wellhead inspection versus laying down a section of tubing above and below the leak and replacing it with new tubing. In addition, the laid down tubing would be collected and inspected in a yard, and good tubing reused. 6000' depth, rod wear and corrosion are problems.

- Option 1: Well head inspection. Pulling costs would be similar and will be ignored. Well head inspection costs of $2000. Less tubing replacement cost on a well by well basis (only replace joints that do not meet criteria), but long term tubing replacement costs similar.

- Option 2: Inspection costs estimated at $500. This is lower than well head inspection due to only a section of the tubing that is laid down is inspected. In the typical 6000' well, 2000' of tubing might be laid down, but only 1500' would be rejected if inspected. The remaining 500' can be returned to the field for use.

- Conclusion: Wellhead inspection is best initially. In fields where tubing problem trends are well established from wellhead inspection, laying down a section of tubing and sending it in for yard inspection is a lower cost option. However, this program is only successful in areas where detailed records are kept on tubing repair and replacement.

Tubing Repair Conclusions:

- In most rod pumped wells, some tubing will need to be replaced eventually.
- Look at the failed pieces in each well, but especially cut all bottom joint failures to determine the root cause of the failure. Treat bottom joint failures separately from failures above the bottom joint. If you have a predominant bottom joint failure problem, you may be wasting money on inspection of tubing.
- Each well is different. Using only one option will not yield the most economical solution for all fields or even all wells in one field. Reviewing well records and trends in the area is key to determining the best practice in each well. A mix of some of the above practices properly applied has the best chance of minimizing operating costs. A combination of tubing rotation, laying down historical problem sections and doing yard based inspection, and well head tubing inspection appears to be the most cost effective practice in a well-managed program with first class record keeping.
- If tubing conditions are unknown, operators have inaccurate well records regarding tubing rotation, you have inexperienced personnel making decisions, or have well conditions that vary greatly from well to well, well site inspection (caliper or electromagnetic) is the most cost effective way to reduce failures. Delaying inspection past the first or second tubing failure increases total pulling unit dollars spent during the well's life cycle and only delays the cost of tubing replacement. Identifying what tubing needs replacement through wellhead inspection reduces repeat failures and allows other remedial measures to be taken to prevent the conditions that led to the failure.
- If well conditions and operating practices are well established and prior well site inspections have identified a section of the tubing string that is most likely the problem area, laying down the problem section of tubing for yard inspection is a very cost effective way to manage tubing life.
- Understanding well conditions and managing what tubing can be rerun and how the tubing should be rerun can substantially reduce tubing cost over the life of a well. ARCO Permian is using green band tubing successfully in the upper section of 6000' wells. Our experience is that most tubing failures are leaks rather than parts. Leaks are dependent on a combination of metal loss and hydrostatic pressure or more simply, depth.
- Tubing inventory management (record keeping) in the hole, in the derrick and on the ground is important to reducing operating costs.

ROD REPAIR OPTIONS

There are few options associated with rod repair operations. Well site inspections are limited to visual inspection by the well service crew or others who visit the well site. Properly trained crews can identify very pitted rods, but it is difficult for crews to identify rods with minor pitting or filled pits. When a rod parts, you can replace one or more rods up to the entire string. Well failure history and the visual inspection are the primary guides to determining how many rods to replace.

A typical procedure is to replace only one rod with the first failure in a taper if the rods appear in good condition. On the second or third failure, all of the taper (or all rods in the well if the failures have been in multiple tapers) is laid down.

Many companies are supplementing this procedure with the addition of electromagnetic rod inspection of the laid down rods. The cost to inspect a rod is 20% to 35% of the cost of a new rod. Experience indicates that the value of returned rods that meet inspection guidelines will exceed the cost of inspection. A growing consensus is that inspected rods that were used in corrosive service (most of the Permian Basin) have similar failure rates as new uninspected rods. The fact that most rod failures occur due to combination of corrosion and fatigue or wear and fatigue rather than only fatigue supports the similar failure rates between new and inspected rods. With the addition of visual rough cut sorting by the pulling unit crew to separate poor quality rods from good quality rods, inspection costs can be minimized and salvage value of the rods can be maximized.

Rod Repair Conclusions

Inspecting rods that have been laid down and reusing the good rods will lower rod purchase costs and should not change rod failure rates. Tracking two items to determine if your program is economical is recommended. Monitor if the value of rods returned is exceeding your inspection cost and if you are getting acceptable run times from inspected rods.

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