Economics of Used Tubing Inspection

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Considering today's high operating costs most producers are constantly in search of ways to save money. Downhole production tubing represents one of the more sizable investments that the operator will make when putting a well on production. Often the costs involving the tubing string does not end with that original investment. During the service life of tubing, it is subjected to various environments and stresses which result in degradation of the integrity of the material. Tubing frequently fails in service due to development of various types of defects, such as those found in Fig. 1. This necessitates the investment of more monies in workovers and material replacement. While the well is down, the producer suffers with loss of production.

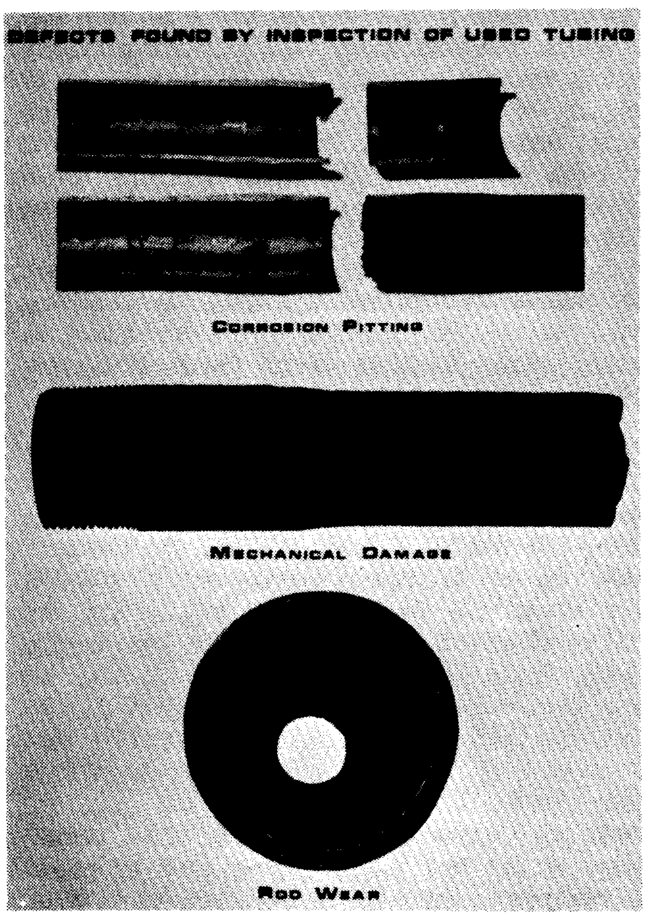

FIGURE 1

A few years ago, most producing companies would, after a pattern of failures developed, discard entire tubing strings from service and replace them with new materials. Of course, the profit expense squeeze was not as great then as it is today. Today's new pipe replacement costs are considerably higher than yesterday or a few years ago. Continuing that practice of replacement, the operator often finds himself having to invest premium dollars in pipe and rod strings when the money could be put to better use elsewhere or channeled into profits.

Many producing companies have found that by using a properly administered nondestructive testing program, they can take advantage of several money saving benefits. By periodically inspecting their used materials, they have been able to save by:

1. ***Reducing new pipe purchases.*** Inspection results, covering a number of years, have indicated that over 67 percent of the used material is suitable for further service downhole. Much of the downgraded material is suitable for limited service in shallow wells or flow lines.
2. ***Drastically reducing pulling jobs caused by premature pipe failures.*** Inspection will separate out lengths that are often run back downhole, which would otherwise fail in a short length of time.
3. ***Reducing lost production as a result of premature failures and pulling jobs.***

A well-administered inspection program can also aid the producer by providing valuable information concerning the effect of corrosion protection practices such as the use of inhibitors and plastic coatings. A large number of wells are abandoned each year, sometimes causing a surplus of pipe and rods. Often the true condition of that material is not evident. Therefore, inspection would also enable the producer to cull out lengths no longer usable and reduce the cost of warehousing defective materials. It also aids in increasing the market value of surplus stocks by assuring the quality of this material if it is to be sold.

One of the major producing companies has had a well-administered inspection program for several years. The savings resulting from these inspections have been quite substantial. Figure 2 illustrates an analysis of data taken over a five-year period involving the inspection of used tubing. During the period, this particular user inspected 12,224 lengths of tubing ranging in size from 2-3/8-in. OD to 3-1/2-in. OD. If he had followed past practices of discarding the entire string of tubing after a pattern of failures developed, the estimated cost outlay would equal $368,000. Of course, he could sell the discarded material as scrap, recapturing a small portion of the cost; thereby, reducing his total outlay to $318,000.

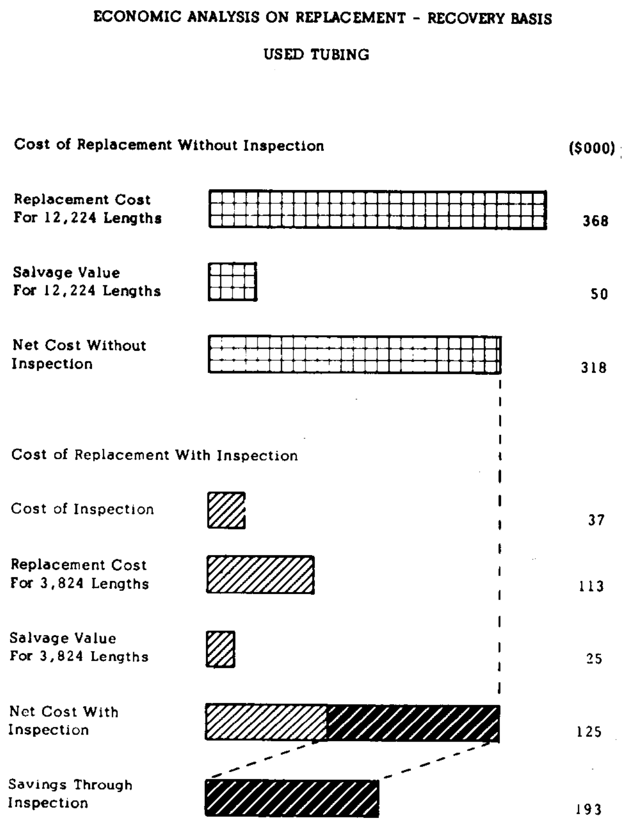

FIGURE 2

In this case, he used inspection services to his advantage to significantly reduce the outlay for new pipe. Through inspection, he was able to separate into groups the material which was reusable downhole and suitable for various depths and conditions. In this analysis, the cost of inspecting the 12,224 lengths equaled $37,000. Since only 3824 lengths were classified into categories not intended for reuse downhole, his cost outlay for replacing those lengths equals $113,000. He can further reduce that cost by selling the non-reusable material for scrap, estimated at $25,000. A combination of the cost of inspection, cost of replacing the scrap material, and recapturing of outlay by selling the scrap equals $125,000. This results in a net savings of $193,000 when compared to the cost of replacing all of the pipe strings when discarded.

If the producer had elected to reuse the material without inspection, he could have expected continued failures resulting in pulling costs and lost production. It would be difficult to estimate the cost of lost production, but it would surely be a significant figure. On the other hand, one can make meaningful estimates as to possible failures and the cost of pulling the wells. The pipe is usually classified into four separate groups with the two top groups normally re-used somewhere downhole, depending on conditions. The remaining two lower groups contain extensive defects and are more likely to fail in downhole service. For instance, the lowest group (No. 5) would normally contain defects affecting over 50 percent of the pipe bodywall thickness. The next group (No. 4) would normally contain defects affecting from 31 percent to 50 percent of the pipe bodywall thickness. One would certainly expect the majority of failures to occur in the lowest group (No. 5) which contains the most severe defects; however, some failures could result from the defects in the No. 4 group. By establishing a possible failure rate for each of the two lowest groups, we can compute the savings effected by a reduction in pulling costs resulting from fewer premature failures.

Figure 3 illustrates the costs and savings when computed on a premature failure elimination basis. Assuming that 10 percent of the lengths falling into the No. 4 group will fail, the producer could expect to spend approximately $122,000. This amount is determined by multiplying the number of lengths which fail (153) by the average pulling costs ($800.00). The pipe containing the most severe defects would be expected to fail more frequently. Therefore, if we estimate that 50 percent of the pipe falling into the No. 5 group would fail, the cost to the producer would be approximately $233,000. The combination of the two should give a good indication of workover costs for these particular wells. The total of the two categories represented in this estimate would equal a cost of $355,000.

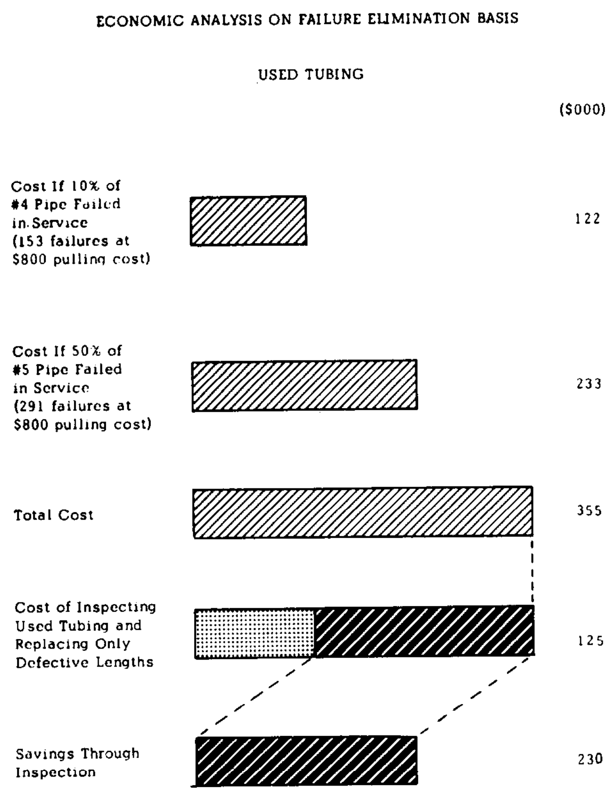

FIGURE 3

In this case, the pipe was inspected and it was only necessary to replace the lengths no longer usable downhole. Referring back to Fig. 2, we find that the cost of inspecting, plus the cost of replacing the lengths, minus the price obtained by selling the scrap equaled $125,000. Taking that figure from the cost of continually pulling the wells, we find a net savings of $230,000 in the premature failure elimination basis.

Therefore, money which can be channeled into profit improvement can be saved by reducing the number of failures that occur as well as reducing the amount of pipe to be purchased.

HOW THE INSPECTIONS ARE PERFORMED

Several methods can be employed to inspect used tubing. However, none of these methods, used alone, are normally capable of disclosing all the defect variations which develop in used tubing. A combination of methods generally provides much more complete information. The majority of known practical testing methods used today can be grouped into five broad categories:

1. electromagnetic
2. radiological
3. mechanical
4. ultrasonic
5. visual

Electromagnetic Methods

Used tubing is a material on which a combination of all five methods are often employed. For example, the electromagnetic flux leakage method (Fig. 4) is used to detect transverse and three-dimensional defects, such as corrosion pitting on the inside and outside surfaces of the pipe. When a piece of pipe is magnetized with a direct current flux field, patterns of magnetic flux lines are established in and through the metal of the bodywall. Smooth, uniform metal provides a smooth uniform flux field. When the metal is not smooth or has a break, the flux pattern is altered, creating a bridge pattern of flux lines over and around the defect. The height and characteristics of this bridge can be correlated to the depth and characteristic of the break in the metal. Electromagnetic transducers are employed to detect the disturbance in the flux pattern created by the defect. The signal is then amplified and recorded on a permanent strip chart providing a record of the location and severity of the defect.

Radiological Methods

The gamma ray method may be employed to detect a loss of bodywall as the result of sucker rod wear on the inside surface of the tubing. A radioactive source is used to project a gamma ray radiation beam directly through the pipe and out the opposite side where it is measured by a detector unit. While rotating the system around the circumference of the pipe, changes in the intensity of the beam, caused by variations in bodywall thickness resulting from sucker rod wear or erosion, are detected and recorded on the same strip chart with the electromagnetic system. See Fig. 5.

Mechanical Methods

Damage such as mashes and bends can be located by mechanical methods, such as passing a drift mandrel (sizing bar) through the ID of the pipe. In most cases, drift mandrels are used which conform to API specifications for specific sizes and weights of pipe. Damage caused by mashes and sharp bends will block free passage of the mandrel through the pipe.

Ultrasonic Methods

Ultrasonic systems are frequently used to veri-

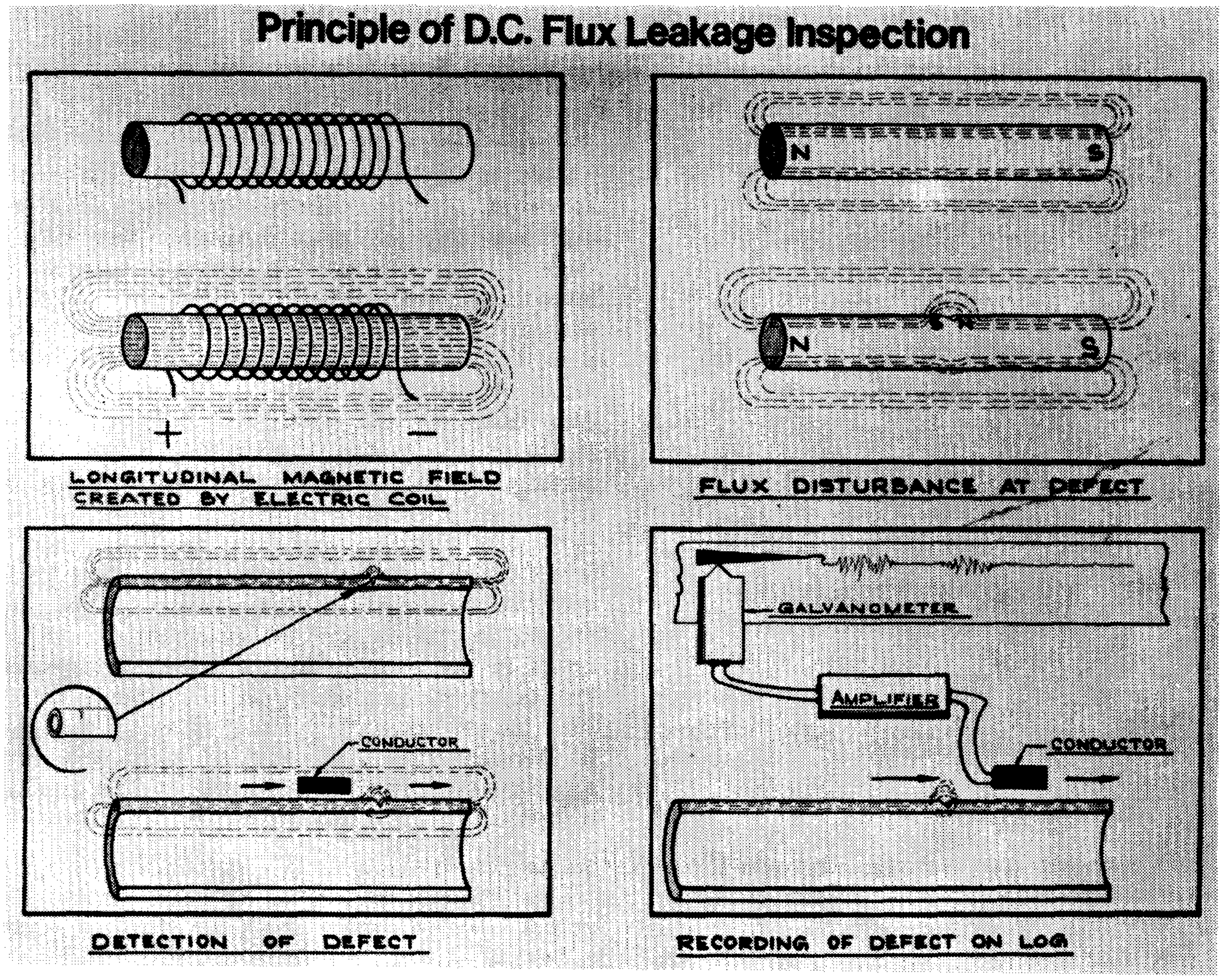

FIGURE 4

fy certain conditions, such as remaining bodywall thickness in so called "gray areas" near the breakover points between classification groups. Utilizing this method, ultrasonic compression sound waves enter the pipe wall perpendicular to the surface of the wall and are reflected by its outer and inner surfaces. The round trip time of the sound waves reflecting from the outer and inner surfaces indicates remaining wall thickness.

Visual Methods

Visual methods are used to examine the condition of threaded areas, couplings, and upsets. Preceding this examination, threads should be cleaned free of old thread lubricants, mud, scale, or other foreign material. Properly cleaned, damaged threads can be easily detected by visual observation.

Combining the above methods into a service enables the inspector to detect the various types of defects commonly found in used tubing. More important, the pipe can be classified according to its usability and color coded according to its classification. According to his needs, each user of this service, can establish the upper and lower limits for grouping the pipe into classifications. On an average, the producer can expect over 67 percent of the pipe to be returned to service downhole.

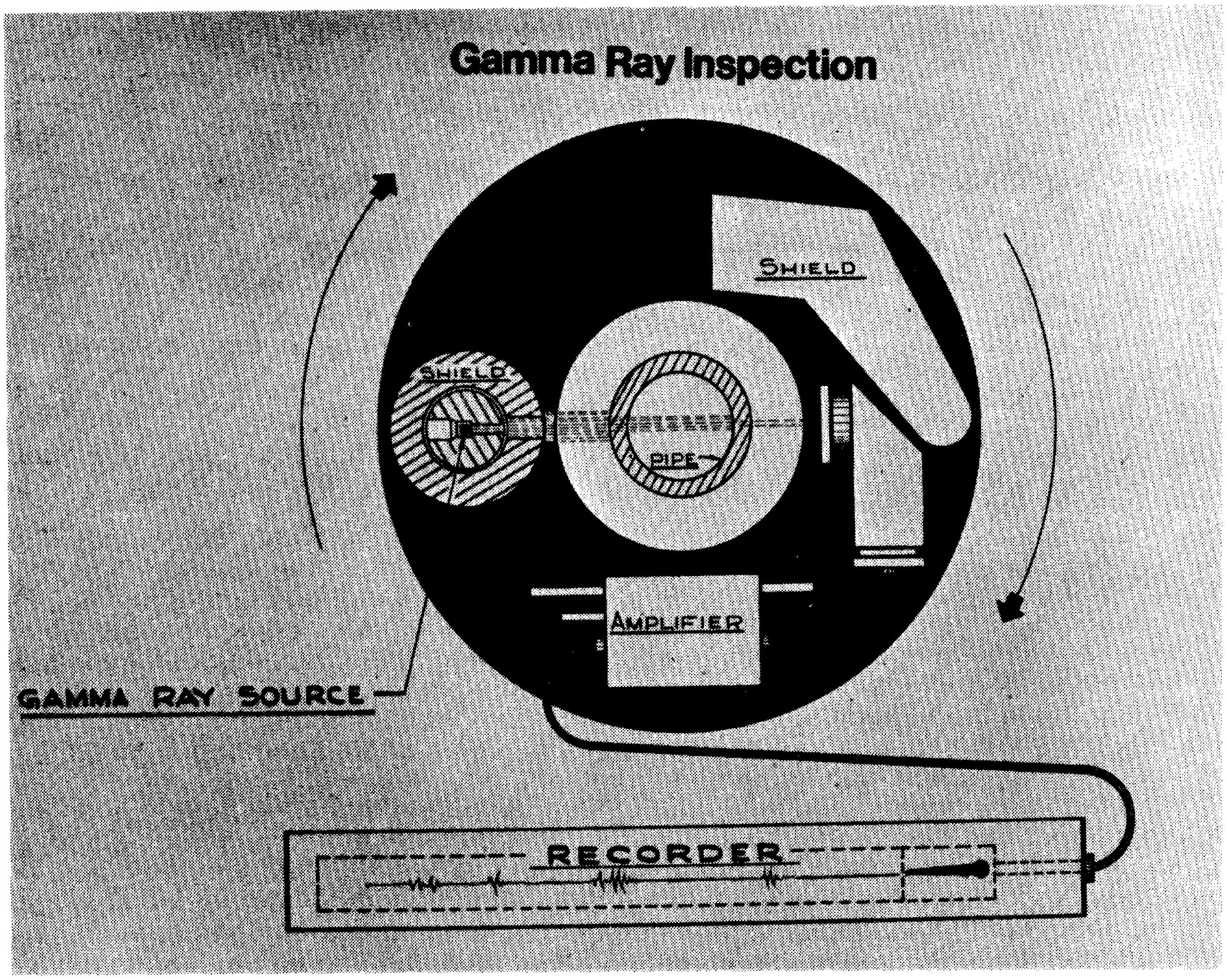

FIGURE 5

ACKNOWLEDGMENT

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