CARE AND HANDLING OF DRILL STEMS

WELDON M. ROGERS
AMF Tuboscope, Inc.

INTRODUCTION

Shortages of drill pipe have hit the industry hard for the past few years. Not only has there been a lack of availability of pipe, but costs to replace discarded strings and strings for new rigs have risen sharply. Therefore, the subject of proper care and handling of drill stems becomes increasingly more important. Owners and users must get maximum life with a minimum of problems for their drill strings. Much has been done to increase the life of drill strings, but much more can be accomplished with a broader understanding and practical approach to proper care of drill stems.

Although the subject of care and handling of drill stems is not new to the industry, it must be recognized that new people enter the industry every day. How well they are trained and acquainted with possible drill stem problems and the proper care of drill stems will have a direct effect upon the life of a drill string. Therefore, one of the most important steps in proper care and handling of drill stems should be to assure that all personnel associated with using and handling of drill stems are knowledgeable as to why drill strings deteriorate.

Most drill pipe degradation, including tool joints, can be categorized into four broad groups: fatigue, corrosion, mechanical damage, and wear.

FATIGUE

Failure due to fatigue breaks is generally recognized as the most common cause of drill pipe failure. Fatigue has been defined as the reaction ultimately leading to fracturing in metal which is subjected to repeated application of load or reversal of stresses. Stress reversals are a routine factor to be contended with while drilling. Highest stress reversals seem to be localized near the upset run out on either end of the tube body. As a result, the majority of failures occur a few inches away from the tool joints in the pipe body.

High stress reversals are also known to occur in the transition zone of pipe positioned just above the drill collars at the bottom of the drill string. Other high stress reversals occur in areas where the hole is deviated or where similar hole conditions exist.

Usually a surface imperfection such as corrosion pitting or a similar notch gives rise to premature formation of fatigue cracking, (Fig. 1).

FIG. 1 –EXAMPLE OF DRILL PIPE - FATIQUE CRACKS

Crack development usually progresses to a point where internal mud pressure bursts through the thin remaining wall beneath the crack tip, resulting in a pump-out. Often, an alert drilling crew detects this condition by observing a reduction in mud pressure. As a result, usually the entire drill string can be withdrawn from the well with little more than lost time.

On the other hand, crack development in association with torque on the pipe frequently results in a twist-off that leaves a portion of drill string in the hole. At this point, damage, lost time, and expenses can become very great.

CORROSION

In the past, corrosion was probably the principal factor affecting degradation of used drill pipe. Results taken from used drill pipe inspections performed in 1964 indicate 7763 lengths or 32.5 % of the pipe downgraded into restricted use categories (Table 1.) The majority of this pipe was downgraded because of excessive pitting damage.

TABLE 1—USED DRILL PIPE INSPECTION RESULTS

Year	Lengths Inspected	Classification #2	#3	#4
1964	23,920	16,157	5,061	2,702
		67.5%	21.2%	11.3%
1974	23,784	23,249	418	117
		98%	2%	- - -

Corrosion pitting (Fig. 2) was a widespread problem creating notches on the inside surface of the drill pipe. Notches, combined with repeated stress reversals, commonly result in fatigue cracking; in this case, the notch formed by the corrosion pitting damage. With inside surface pitting, fatigue crack development is expected to progress from the inside surface outward.

Much practical work has been done for at least the past 10 - 12 years to reduce the corrosion damage problem. Improved inhibitors have been developed, and, recently, oxygen scavenging equipment has begun to gain wide acceptance. One of the most significant factors reducing corrosion damage has been the broad scale use of specially designed plastic coatings applied to the inside surface of drill pipe.

Broad use of plastic coatings began about 1963 and has gained such wide acceptance to the point

FIG. 2—EXAMPLE OF DRILL PIPE - CORROSION PITTING

that estimates indicate approximately 70% of drill pipe in sizes 4-1/2 and 5 in. OD are coated. The estimates are based on 1974 industry figures. Obviously, coatings of this nature must be capable of withstanding bending stresses, internal abrasion, corrosion attack, heat and other conditions.

Coatings must also be able to remain intact for many thousands of feet and thousands of hours of drilling service. Coatings remaining in good condition continue to work while the pipe is in downhole service or while it is racked and subject to atmospheric conditions.

Reduction of pitting damage and resulting surface notches has significantly effected a reduction in downgraded drill pipe during inspections (Table 2.) An analysis of inspections performed in 1974 indicate a sizable reduction in the number of lengths classified into categories set up for restricted use pipe. Compare the 1974 results with the 1964 results. In the 1974 analysis, a large percentage of the downgraded material resulted from mechanical damage and wear. Obviously, corrosion control including plastic coating, has retarded the development of corrosion/fatigue cracking, particularly those cracks developing from the inside pipe surface. It is generally thought that the application of plastic coatings nearly doubles the life expectancy of drill pipe strings as compared to the life expectancy of uncoated pipe a few years ago.

MECHANICAL DAMAGE

Mechanical damage often is evidenced by outside surface cuts, gouges, mashes, slip area crushing, hammer marks and other similar anomalies (Fig. 3). Quite often such anomalies introduce a notch or abrupt change in the surface of the tube which, in combination with stress reversals, result in fatigue crack development. As a result, where once the majority of fatigue cracking originated on the inside surface of the pipe, the major incidence of fatigue cracking now appears to have shifted to the outside surface. Most mechanical damage is introduced by poor handling and operating practices. Well-organized and repeated training sessions would reduce this problem. Training should include all rig operating personnel plus others who are required to handle pipe.

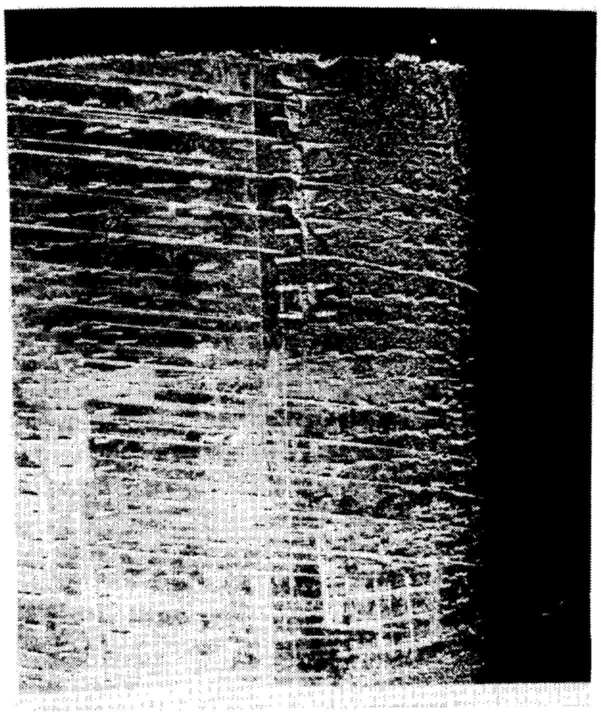

FIG. 3 EXAMPLE OF DRILL PIPE - SLIP AND MECHANICAL DAMAGE

WEAR

Usually, wear is evidenced by broad area reduction in body wall thickness where the outside surface of the pipe comes in contact with the wall of the wellbore (Fig. 4). Abrasive wear mostly affects the cross sectional area of the tube which, in turn, has an effect upon the tensile capacity of the tube in question. Depending upon the pattern, wear can also affect collapse resistance and occasionally aid in fatigue crack development.

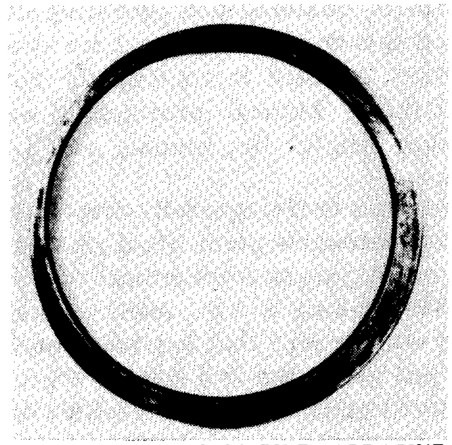

FIG. 4—EXAMPLE OF DRILL PIPE - ABRASIVE WEAR

Usually, abrasive wear in the tube body is located near the center third of the pipe length. The tool joints, to a degree, hold end zones of the tube away from contact with the wellbore but allow the center of the tube to make contact. If the pipe is maintained in a reasonably straight condition, the wear pattern is usually in a more or less even distribution around the tube circumference. However, if pipe is used in a crooked condition, the major wear pattern is often located on one side of the tube circumference. The worse the crooked condition, the worse the wear.

TOOL JOINTS

Obviously, the usability of a length of drill pipe also depends on the condition of the pipe connections. Tool joints are subjected to similar factors of degradation as the tube body — mechanical damage, wear, fatigue and, to a lesser degree, corrosion.

Examination of damaged tool joints indicates that a large percentage of the problem stems from mishandling and lack of proper care and maintenance. Many strings of drill pipe are run without the tool joint threads and shoulder having been properly cleaned and lubricated; a process that should be continually attended to. Some damage is caused during transportation and storage when exposed threads and shoulders are abused. Thread protectors should be installed when drill pipe is picked up, laid down, transported or stored. Other damage occurs while tripping the pipe into or out of the hole when tool joints are misstabbed and improperly torqued.

WHAT TO DO?

1. Train and retrain personnel in the proper procedures of handling and operating downhole drilling equipment. Sources of aid are available to the industry to assist in training rig crews. The IADC Drilling Manual provides a wealth of information helpful for training and operating purposes.

2. Hold stress levels, especially stress reversals, at the lowest reasonable point. Hold rpm's as low as possible but stay away from critical rotary speeds.

3. While making a trip, make a practice of changing out the pipe that has been running in a position just above the drill collars. Move at least one or more lengths up-hole. Or possibly on critical wells, lay down one or more lengths for inspection before reusing.

4. Use proper grade of steel for the environment. Some high strength steels are more notch sensitive than lower strength steels, especially if put into a hydrogen sulfide environment.

5. Continue development and use of corrosion mitigation materials and equipment. Although much has been accomplished in this area, as the critical nature of drilling becomes more intense, constant attention to corrosion problems is required.

6. Keep mud pH under control. Generally, lower pH factors are thought to contribute to corrosion problems and shorten the fatigue life of the drill string. Many users consider a mud pH of less than 9.5 as detrimental.

7. Develop better pipe handling equipment for use on the rig and for transportation and storage. For example, semiautomatic pipe spinners used while tripping in and out of the hole could reduce some mechanical damage caused by spinning chains.

8. Pay attention to tool joint conditions; clean and properly lubricate threads and shoulders regularly. Install thread protectors when the pipe is not in use downhole.

9. Wash out the inside of drill pipe with fresh water when it is being laid down. Do this even with plastic-coated drill pipe; it is an inexpensive process when compared to the cost of pipe.

10. Keep drill pipe as straight as possible. This will reduce wear on the pipe and tool joints.

11. Hardface tool joints where permitted. Good quality hardfacing on the box tool joint and on drill collars increases the life expectancy of those products. Much investigation has been performed lately regarding possible casing damage resulting from hardfaced tool joints. Investigation results are encouraging and indicate possible broader acceptance of the use of hardfaced tool joints.

12. Reface tool joint and collar connection as required, but do not remove excessive material which would adversely affect the standoff factor. Study groups are working on the development of good guidelines regarding this need.

13. Protect the plastic coatings inside the drill pipe. Often, personnel are observed putting objects such as steel bars, cables, and similar items inside the pipe. This practice could damage the coating and reduce the effectiveness.

14. Use good, qualified inspection services that are designed to evaluate the multiple conditions that can exist in a length of drill pipe. Usually, different processes are required to evaluate different conditions. For example, a process sensitive to detection of pitting and fatigue cracking is often not sensitive to detection and evaluation of wear. Evaluation of tool joint conditions may require additional services not normally included in routine drill pipe inspection services. Particular attention should be focused upon detection of fatigue cracking in the upset fade-out zone at each end of the tube. This zone is critical from a failure standpoint and is often difficult to evaluate.

15. Establish inspection classification standards which fit the local needs of drilling operations. API and IADC groups have established inspection and classification guidelines which can be found in section B6 of the IADC Drilling Manual and in API RP7G publication. The API-IADC guidelines are gaining increased acceptance.

Table 2 compiles data taken from recent inspections using the API-IADC guidelines. A similarity exists between the standards and results as shown in Tables 1 and 2.

TABLE 2—USED DRILL PIPE INSPECTION RESULTS
API - IADC Guidelines

Lengths Inspected	Premium	CLASSIFICATION #2	#3	#4	Cracked
5,712	4,281	1,320	42	--	69
	75%	23%	1%	--	1%