Common Causes of Failure in Sucker Rod Strings

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Our attitude in approaching any problem has a great deal to do with our success in solving it. If we were to get a flat every time we drove into our driveway, we would gain little by asking the manufacturer of the punctured tires to replace them. If we recognized the tacks, nails and broken glass in the driveway as the source of our difficulty, not the quality of the tires, and cleaned up the driveway, our tire maintenance problem would be solved.

So it is with sucker rod strings. If we recognize that **environment** usually has more to do with sucker rod string life than built-in quality, we will more effectively control our maintenance costs. For practical considerations, the "built-in quality" of all manufacturers' sucker rods vary within very narrow limits. Of much more importance is the understanding of the many causes of sucker rod string failures and the understanding of the means and methods of correcting them. Before we censure the quality of the rods, let us "clean up our driveways".

Over 90 per cent of all sucker rod string failures can be categorized into four principal classes: corrosion, improper joint make-up, improper operating and running procedures, and improper string design. Most of the material covered by this paper is well recognized and well understood, but too often overlooked or neglected.

CORROSION

Corrosion is undoubtedly the number one enemy of sucker rod string life, as well as all other oil field equipment. It is a subject which requires far greater consideration than can be covered in this paper. Suffice it to say, if rods fail because of corrosion, the services of a corrosion consultant are required. It is worthwhile observing, however, that no two wells are identical. They may be pumping with the same type of equipment, under seemingly identical conditions in the same field, from the same depths and formations, but like the leaves on an oak tree, no two are identical—similar, yes, but not identical. Each well, when trouble develops, needs individual attention. Furthermore, well conditions can and do change with time. An inhibitor program which may have been adequate a year ago may not be effective today. The writer knows of one instance where 7-1/2 parts per million inhibitor completely controlled corrosion eight months before a check was made. At the time of the check, it was found that 20 ppm were required. Incidentally, 20 ppm is a rule-of-thumb average dosage. To determine the parts per million, use this formula:

$$PPM = \frac{\text{Gallons Inhibitor Per Day}}{0.042 \times BFPD/1000}$$

Anaerobic sulphate-reducing bacteria can be very troublesome. The writer knows of one case in a waterflood where only one well had corrosion problems. It developed, upon careful investigation, that it had been inoculated with bacteria when second-hand tubing had been run in. Remember that ordinary inhibitors are not effective against bacteria; it takes a bactericide.

Finally, if the rod string shows any evidence of corrosion, fight corrosion first; don't assume the rods are at fault without definite proof.

IMPROPER JOINT MAKE-UP

Before API adopted the under-cut or stress-relieved pin, joint trouble largely consisted of broken pins. Cause for these broken pins was charged to insufficiently tightened joints, and rightly so. Now that we have the under-cut pins, pin failure has been greatly reduced if not practically eliminated. However, we still have joint troubles in the form of broken couplings; this trouble too, can be charged to insufficiently tightened joints. To understand why this is true, let us review the nature of the sucker rod joint, its thread form and the forces acting on it.[1]

Sucker rod threads are straight threads, not tapered threads as on pipe, tubing and casing. Consequently when rod joints are tightened, they tighten on the shoulder faces and not at the roots or bottom of the threads as in pipe, tubing and casing joints. As the tightening force is increased, the pressure or load at the shoulder faces increases, and since steel stretches under load in much the same manner as a rubber band, the pin in the undercut section between the shoulder and the threads stretches a proportional amount.

In the well, the load on the rod string tends to pull the joints apart, thus reducing the load at the shoulder faces which was produced by the tightening mentioned above. If the joints have not been tightened enough, the rod string load will reduce the load at the shoulder faces to zero and the faces will separate. When this happens the pin can bend and fluid will seep into the joints. Proper tightness, therefore, must be great enough to prevent this separation but not so great that it stretches the pin to a point where it is pulled out of shape or even pulled apart, which has happened with hydraulic tongs which were not properly set.

Well fluid in the joints due to looseness and consequent separation as described above will rust and corrode both the coupling and pin threads. Since corrosion decreases the fatigue endurance level of steel drastically, couplings will crack at the roots of the threads and will fail much faster and under much lighter loads than they will if well fluid is kept out of the joints. This also explains why pin shoulder faces and coupling faces must be free from nicks and gouges even with proper tightness. Such defects permit fluid to seep into the joint in spite of proper face pressure. Hammering joints can ruin these faces even when they are not hit directly. Contact faces with defects cannot effect a seal against fluid intrusion.

Fluid in the joints and the resulting corrosion, will also freeze the joints making them hard to break out. A properly made-up joint, free of inside corrosion, will break out at about 75 per cent of the make-up torque. A 50-50 mixture of 40-grade motor oil and inhibitor in each coupling helps to reduce this corrosion and prevent this joint from freezing. Inhibitor pellets have been suggested which might be good with the 40-grade oil as lubricant but don't use heavy pipe compound.

Power tongs, obviously, are the only positive way we have of consistently controlling torque. They do a good job and a very necessary one, particularly on heavily loaded strings, **but only if they are properly maintained and are delivering the torque they are expected to deliver;** If they are in bad condition or improperly set, we would be much better off to tighten the joints by hand.

API sets out the recommended torques to be used in tightening the various sizes and grades of sucker rods.[2] This is shown in Table 1. These figures should be used as maximums, being certain not to drop lower than 10 per cent of these figures, particularly on heavily loaded string. API now has a task group making studies to determine values for rotational displacement

TABLE I

SUCKER ROD JOINT
MAKE-UP TORQUE

	Make-up Torque, ft -lb	
Rod Size	For 35,000 psi Rod Stress	Over 35,000 psi Rod Stress
1/2"	110	121
5/8"	220	242
3/4"	350	385
7/8"	520	572
1"	800	880
1-1/8"	1, 100	1,210

TABLE II

	Displacement--"D" *	
Rod Size	35,000 psi Rods	Over 35,000 psi Rods
5/8"	7/16"	1/2"
3/4"	1/2"	9/16"
7/8"	9/16"	5/8"
1"	9/16"	5/8"
1-1/8"		

* Deduct 1/16" for Oversize Couplings.

from the hand-tight position. This is illustrated in Fig. 1. This is an excellent method for getting a quick check in the field, of power tong output. Lacking a better method of calibrating tongs accurately, it has also been used for this purpose.[3] Table 2 gives the values we have used for a number of years. We have been assured they are not far from the values the Task Group expects to recommend.

To eliminate or mimimize coupling breakage, hard break-out and sucker rod joint trouble, generally, following the above suggestions will be worth the trouble.

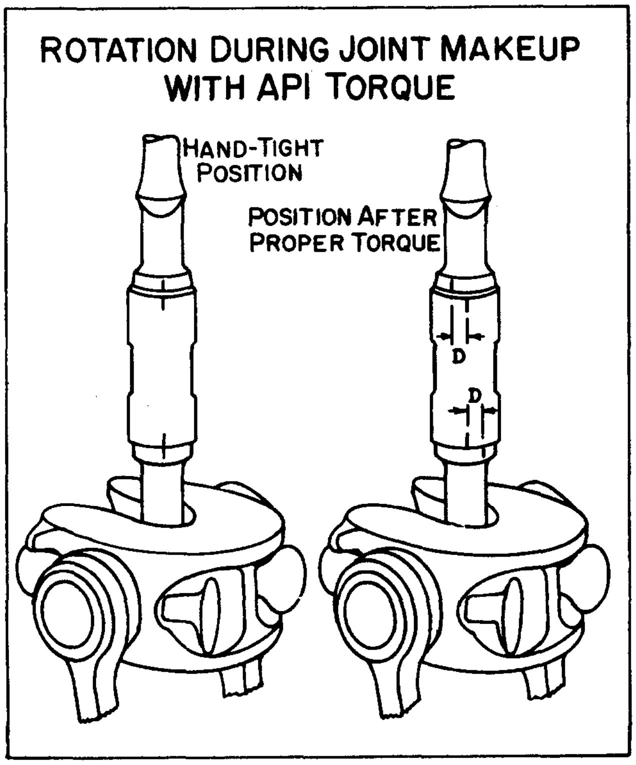

FIGURE 1

IMPROPER OPERATING AND RUNNING PROCEDURES

The previously mentioned API "Recommended Practice for Care and Handling of Sucker Rods"[2] sets out excellent rules and practices for running and operating sucker rod strings. For purposes of this paper a complete review of this bulletin is not within our scope. Rather, we will re-emphasize several of the recommendations which are commonly neglected but which deserve much more attention. The numbers used here are the same numbers used in the API bulletin.

2. Care should be taken not to bend or nick the rods in handling. I have seen rod packages opened in the field with an axe. Several rods were seriously nicked. "Preserve the surface" certainly applies to sucker rods.
4. Thread protectors should be removed in the derrick, not on the ground or in the racks. Rods in storage should be equipped with thread protectors if the rods are worth saving.
19. Rods should be individually tailed into the derrick or mast.
22. Cross threading can occur much more easily when using power tongs. Great care should be used to avoid cross threading. Making up the first full round by hand is recommended.
25. In making up rod joints by hand, **four** hard snaps by an experienced rod wrencher is earnestly recommended.
26. Use power tongs, properly calibrated and in good condition in running rods.
27. Make certain all threads are clean, undamaged, well oiled and have a free-running fit to shoulder contact.
28. Make certain that power tongs are in good condition before running rods. If there is any question about this, use the rotational displacement procedure mentioned above.
33. Rods should be carefully examined for any type of damage each time they are run, if it is intended to reuse them. This practice can save many a pulling job.
35. Do not lay down rods in doubles and certainly not in triples. If a derrick or mast is not used, always lay down in singles. This may seem time consuming and costly at the time, but it will pay off in the long run even if only in having each joint properly made up in rerunning.

In addition to the above, it is also recommended that "RP 11BR" be required reading for all personnel involved with sucker rod running, pulling, handling and storage, and not on a single time basis.

As far as improper operating practices are concerned, the most common is the practice of allowing rod strings to pound fluid. It is often argued that it is necessary to pound fluid in some wells to produce the fluid. This may be true to some extent, and if so, it may be a matter of economics. In this case, don't blame the sucker rods if trouble results. The writer has taken many dynamometer cards which showed a 6000 lb to 8000 lb drop-off due to fluid pound on the downstroke. Imagine what results when a three to four ton wallop hits the end of that long, slender string of rods. It bends rods as far as the tubing will permit; it creates instantaneous extremely high stresses which cannot be measured; it promotes stress corrosion cracking; and it causes joints to unscrew, to mention just a few of the ill effects of pounding fluid.

A short fast stroke is often used where a longer slower stroke would do better. The long slow stroke results in fewer load reversals which normally means longer rod life. It also results in lower peak loads and a smaller range of load, all of which contribute to longer rod life. Of course there are times and conditions where a longer slower stroke is not advisable such as when it would result in overloading the torque capacity of the gear box or those unusual cases where more fluid can be produced with a short fast stroke. Generally, however, the long slow stroke will be found to be advantageous. This is a matter for the man who designs the rod string, as well as being a matter of experience.

IMPROPER STRING DESIGN

This subject, too, cannot be adequately covered here. It deserves textbook treatment. However, for the purposes of this paper we will mention a few items of design which have proved helpful.

Tapered strings are used to keep rod stress within acceptable limits. Often strings are tapered in such a manner that the lower, smaller sections are operated at the maximum allowable stress level. This results in a string with more of the smaller rods than otherwise and less investment. The preferable taper is designed so that stresses at the top of each section are approximately equal. Such design results in more cost but lower stress in the smaller rods, and will normally result in longer string life and lower pulling costs. Also, since the smaller rod at a transition point is subjected to more bending moment than the larger rod at this point, 2-1/2 per cent more of the larger rods than equal stresses dictate has proved to be good design. Also, use two-way tapers where practical; don't go to three-way tapers to save money. The larger rods will last longer. Don't use 5/8-in. rods in 2-1/2 in. tubing; there is too much room for bending. On deep wells where four-way tapers appear to be desirable, taper the tubing as well as the rods.

Often on deep wells or in any well where bending of the lower part of the string occurs for any reason, it is advisable to "stabilize" the string. This is done by inserting 200 ft or 300 ft of larger, heavy rods just above the pump. Sometimes 1-1/2 in. polished rods are used but this presents elevator difficulties. These heavier rods help the string to fall and resist bending much more effectively than the smaller rods. J. C. Slonneger once made the remark to the writer that the ideal way to taper sucker rod strings would be the reverse of the way we now do it, that is, with the larger rods at the bottom and the smaller rods on top.[4] This remark, of course, was made in jest; but it does have a semblance of logic to it and serves to illustrate the principle of the "stabilized" string just described.

Whether or not neglecting to take into account the effect of synchronous pumping speeds would constitute improper design of sucker rod strings, is a controversial question. Some operators disregard this effect entirely. Others claim to have eliminated otherwise unexplained failures by moving to a non-synchronous speed. The fact remains, however, that the shape of dynamometer cards is clearly affected by synchronous speeds. It is the writer's feeling that on deep, heavily loaded strings, pumping at synchronous speeds can have an adverse effect. On lightly loaded strings, such speeds can conceivably be helpful in increasing effective plunger travel.

A year ago, this writer had the privilege of presenting a paper at The Southwestern Petroleum Short Course which developed formulas and methods of calculating synchronous speeds.[5] This paper up-dates methods developed in 1937 by Mr. J. C. Slonneger and in addition, presents greatly simplified means for calculating these speeds for tapered strings. We recommend that this paper be considered. On those deep, heavily loaded strings, a consideration of synchronous speeds could be significant.

The writer feels that a careful observance of the recommendations given above can pay big dividends. Even a well-studied design, careful selection of rod material, and well-advised operating methods will go for naught if rods are nicked with an axe and corrosion is allowed to run rampant.

REFERENCES

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