SUCKER ROD CONNECTION FAILURES – WHY THEY OCCUR & WHAT TO DO ABOUT THEM

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ABSTRACT

Sucker rod connection failures seem to be a problem to some operators, while others do not seem to have the same problems. The connection should be the strongest link in the sucker rod string while the rod body should see more failures. There are three main classifications for the connection failures. These are: manufacturing discontinuities or defects, mechanical damage (including handling and make-up procedures), and loss of displacement (LOD). This paper will: discuss the API industry connection, discuss the three failure classification areas, and provide many example pictures of the failure causes Additionally, recommendations will be provided on how to prevent future connection failures.

INTRODUCTION

Failures of the sucker rod connections may occur for a variety of reasons. However, the cross-sectional area and design of the pin undercut along with the cross-sectional area of the coupling show these locations should have a larger area than the corresponding rod body. When these areas are coupled with the pin prestress that should be locked into the connection by properly applying the correct circumferential displacement (CD)[1], then, theoretically, any failures in the rod string normally should occur in the rod body. But, yet, a number of operators continue to be plagued by downhole connection failures.

This paper will discuss the potential reasons for rod string connection failures and provide three main categories for classification of these failures. These categories are: manufacturing defects, mechanical damage (including handling and make-up procedures) and loss of displacement (LOD) or loss of the pin prestress.

MANUFACTURING DISCONTINUITIES OR DEFECTS

Connection failures due to manufacturing discontinuities or possibly defects normally do not occur unless there is something inherently wrong with the original steel. While surface discontinuities should be caught at the manufacturer's facilities, near subsurface or deeper in the thickness of the rod or coupling may be very difficult to detect until these imperfections contribute to a failure. A variety of example manufacturing discontinuities or defects is shown in Figures 1 and 2 .

There may be little that can be done to prevent these unless increased visual inspection or even volumetric inspection of the steel is conducted. However, routinely conducting these increased inspections may add to the time and cost of manufacture which ultimately will be passed on to the end user.

MECHANICAL DAMAGE

Figures 3 through 14 provide a number of connection failures due to mechanical related problems. Some of these problems may be related to impacts or hammering on the connection or the coupling. Some of these failures may be due to improper lubrication and/or improper alignment and starting the pin thread in the coupling causing galling. Some of these types of failures may be due to excessive torsion during make-up which may yield the pin or coupling and may even deform of mushroom the coupling or split the coupling.

These failures usually are due to improper installation and make-up procedures. The remedies typically can be addressed by properly training the workover crews to:

- Properly clean, lubricate, and stab the pin into the coupling,
- Apply the correct amount of CD (not too little and not too much),
- Do not hammer or impact the connection or the coupling, especially to break the connection to unscrew the pin and coupling

LOSS OF DISPLACEMENT (LOD)

The final category for connection failures is related to the loss of displacement (LOD) or pin prestress that was applied when the sucker rod pin and the coupling were properly made up on the surface before running into the well. Figures 15 to 18 provide a few examples of these failures. This classification also may be called loss of circumferential displacement (LOCD) or even loss of pin prestress (LOPPS). This causes of this problem vary and it is probably the most difficult problem to address. However, it is important to understand this problem and the impact on the downhole failures since this is probably the reason most connection have failures.

Attempts have been made to prevent this problem by properly training the workover rig operators, having a witness/ inspector/ consultant at the well watching that all connections are properly made up and ran into the well, and even developing specialty thread forms or connections which may not solve the problem and may even have less fatigue life than the normal API threaded connection. Additionally, a number of service companies are attempting to record and automate the sucker rod connection make-up and break-out operations in an attempt to diminish the failures. However, all of these may be only solving symptoms of the problems without solving the root cause. As can be seen in figure 19, these types of failures are normally related to well operating practices.

Once the connection is properly made up on the surface, it is run downhole. It should be noted that no well fluids are squirted into the connection before the sucker rod pin and the coupling have the proper CD applied. But, many times, when the rod string is pulled, principally due to a connection failure, the rig crew or observers at the well will see fluid squirt out of the connection. Where did these fluids come from?

Somehow, produced fluids have to be pumped into the connection downhole. But, if the connection has proper pin prestress so that increased fatigue life is provided to the pin and coupling, how do these fluids get into the connection? They have to be "pumped" in due to the action of the applied rod string loads allowing the pin and the coupling to separate and the higher pressure fluid downhole is pressed into the connection.

No matter how much training is done, no matter how many witnesses watch the rig crew and connection make-up, and no matter what automation or specially connectors are used, if the operating practices allow the connection to loosen under operation, there ultimately will be a failure.

The problem after that is how to solve the failure. Many times the crew will pull the failed rod string with two or three rods connected together to speed up the removal and re-installation time. Normally, if there is a downhole connection failure, while the crew is breaking out and unscrewing the couplings, they will find the liquid "stored" in the connections many rods both above and below the actual depth or location of the actual failure. This is normally expected since the downhole operating practices will cause many of the connections to loosen. Then the weakest link or actually the highest stressed and probably looses connection will ultimately fail.

Then the normal operating practice is to run back in with a replacement rod while running back the rods in the derrick the way they were pulled (normally in doubles or triples). However, while the rods that were broken and unscrewed would be cleaned, dried, relubricated, and properly made up, it is normally the practice not to unscrew every connection to clean, dry out any produced fluids that may have been "stored," relubricate and properly remake up the connections in between.

This is probably the main reason why once a well starts having connection failures, it will continue to have failures. Since many of the other connections are rerun without proper make-up procedures, these pre-loosened connections then will continue to have corrosion occur from the untreated produced fluids. Also, the applied stressed will continue to cause other connection failures since it is probably believed that all the other connections were still properly made up and it was only the one connection that failed had problem (normally believed a poor originally made up connection, mechanical damage and/or a manufacturing discontinuity).

These repeat well failures could be solved if the rig crew notes the depth they start seeing fluid squirt out of the connection and they segregate the rods from this point down to the pump from the rest of the rods in the well. Then when the rods are rerun, all the segregated rods should have each connection broken, threads dried, new lubricant properly applied and then the connection remade with proper CD. It is only by removing the cause of the potential repeat failures will extended life be obtained or adequate life be obtained for the rods string.

Hopefully, this procedure will help solve repeat connection failures in a rod string. But, it will not solve the original reason for the connections to become loose and the loss of displacement occur. The downhole operating practices will need to be reviewed to see if any of the potential reasons or causes for the LOD listed in Figure 19 can be prevented in the future. This may mean practices may have to change and the belief that the operating company had in their practices may become clouded. It is only after finding out the original root cause for the connection failure problem can the solution be found.

CONCLUSIONS & RECOMMENDATIONS

1. There are many reasons for sucker rod connection failures to occur.
2. Manufacturing discontinuities or defects, mechanical damage, handling, lubricating, and make-up procedures should be easily addressed.
3. Loss of pin prestress or loss of circumferential displacement, or preferably, loss of displacement (LOD) is probably the most difficult cause of failure to address; but, it is probably the major reason for connection failures.
4. Connection failures are like cancer and can quick spread causing other connection failures unless LOD can be addressed.
5. If a downhole connection failed by LOD, unless all the other affected connections are broken, cleaned, relubricated and properly remade, there will continue to be other connection failures.
6. Since the downhole sucker rod connection should be "fluid free," the rig crew should note at what depth, during pulling, fluid comes out of any rod connection.
7. All rods from this depth to the bottom of the well or when fluids no longer were obtained when the rods were pulled, should be segregated in the derrick.
8. During re-running, these connections should be completely unscrewed, inspected and any corroded rod pins and/or couplings should be removed and replace with new equipment.
9. The remaining rods and couplings should be cleaned, properly lubricated, then properly made-up, using the correct CD cards recommended by the rod manufacturer.
10. The original reason for the first connection failure should be properly analyzed to determine the root cause and then proper steps should be applied to try to prevent these failures from occuring.

REFERENCES

1. Stevens, R. and Hein, N.W., "Circumferential Displacement - Partial History of the Industry Practice," SWPSC 2010, Lubbock, TX.

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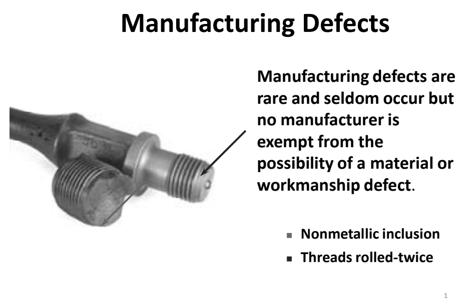


Figure 1 - Manufacturing Discontinuities or Defects

Figure 2-Other Example Manufacturing Discontinuities or Defects

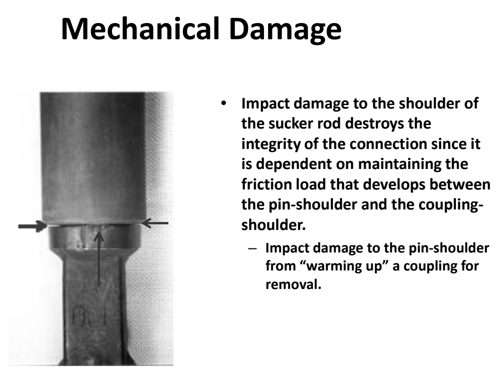


Figure 3 - Example Impact Mechanical Damage

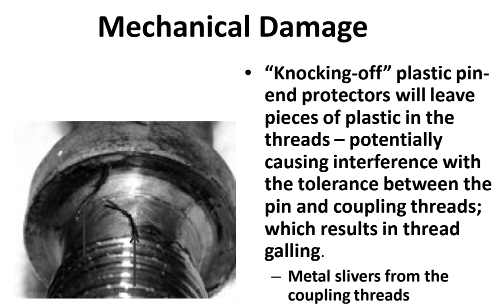


Figure 4 - Damage from Knocking Off Protectors

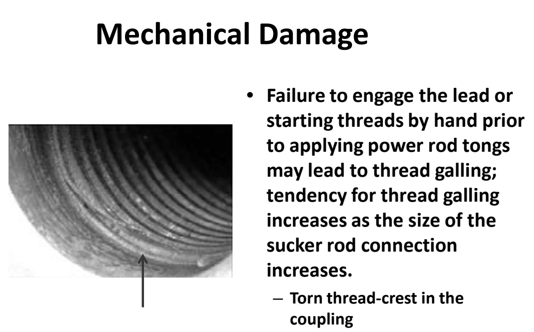
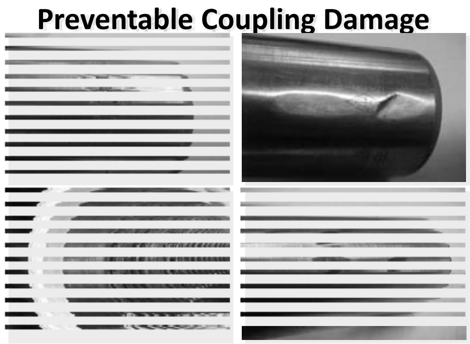


Figure 5 - Damage from Improper Start

Figure 6 - Coupling Impact Damage



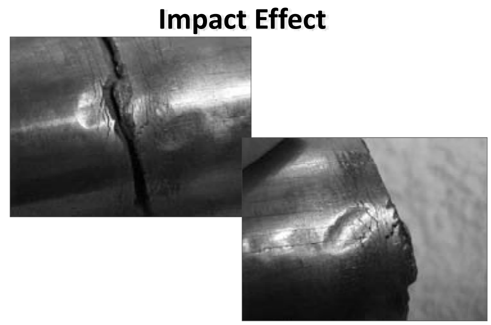
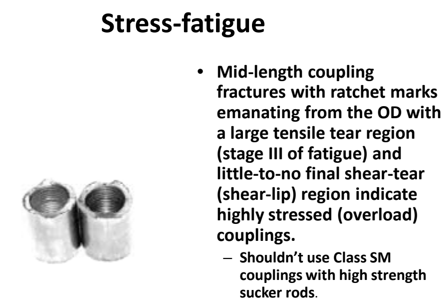


Figure 7 - Other, Typical Mechanical Damage

Figure 8 - Other Impact Damage Normally Seen



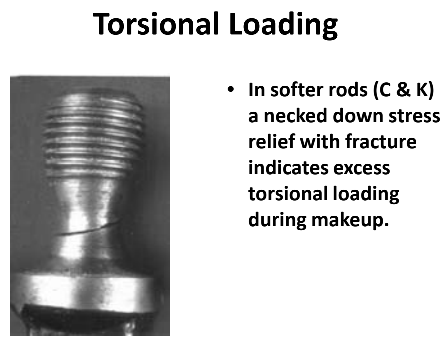
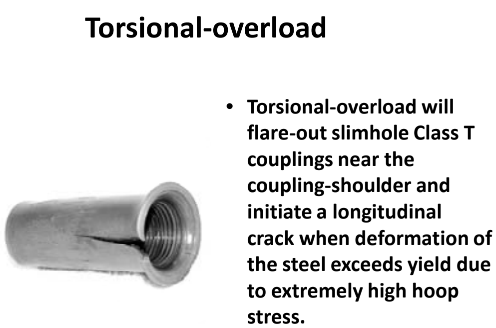


Figure 9 - Damage To Couplings

Figure 10-Pin Damage Due To Excessive Makeup Torsion



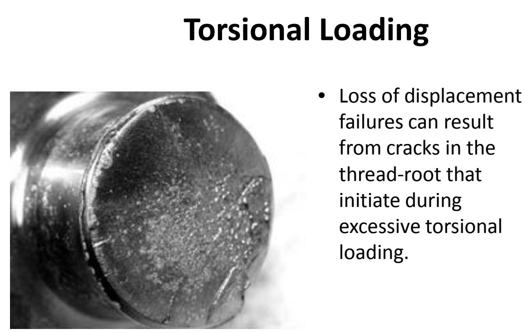


Figure 11 - Coupling Damage Due To Excessive Torsion

Figure 12 - Excessive Torsion Damage

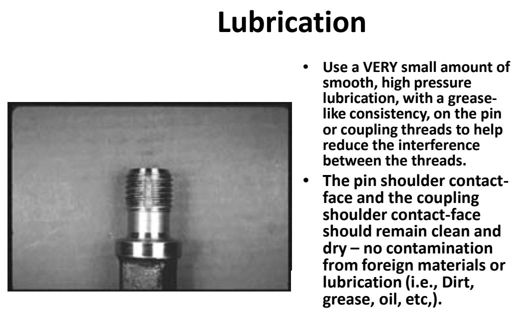


Figure 13 - Improper Lubrication Damage

Figure 14 - Galling Damage

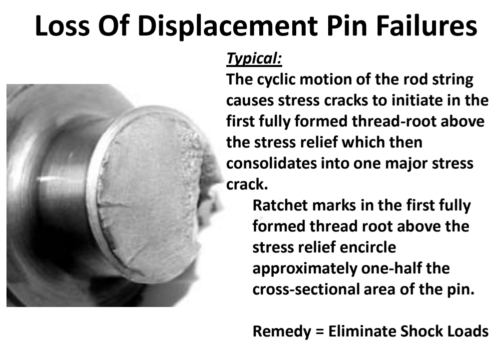


Figure 15 - Loss Of Displacement Failure

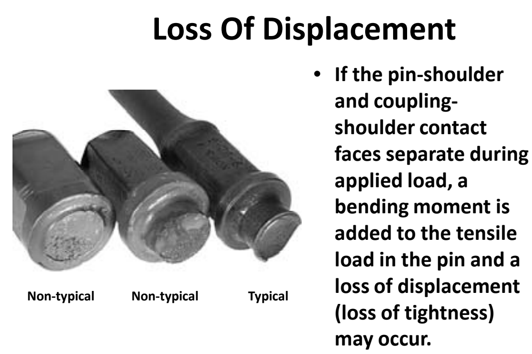


Figure 16 - Examples Of LOD Failures

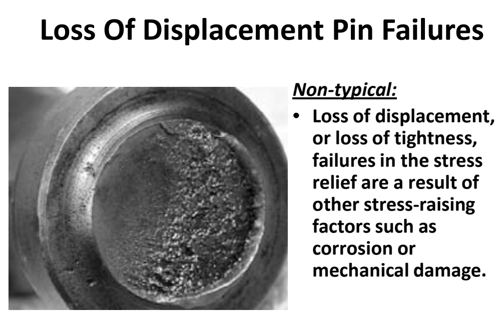


Figure 17 -. LOD Non-Typical Failure

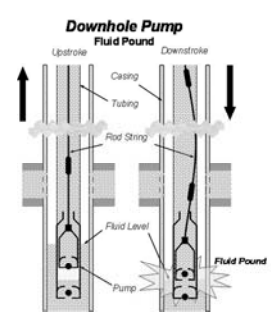
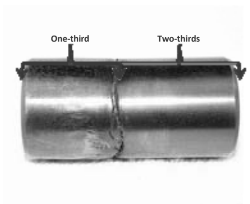


Figure 18 - LOD Due To Excessive Pumping, Rod Buckling Or Fluid Pound

Possible LOD Failure Cause



- Poor design.
- End-of-life.
- Poor makeup practices.
- Reconditioning.
- Shock loads (i.e., partial pump fillage, stuck or sticking pump plungers, tagging, etc.)
- Unanchored or improperly anchored tubing.
- Well bore deviation.
- Over-pumping wells.
- Prior failures.
- Operating practices for pump off/ down. (Norm's pickle jar example)

Figure 19 - Possible LOD Causes & Remedies