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FOCUS

Visual Testing of Pipe Threads

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As an oil well is drilled, the casing and tubing threads must undergo visual testing before the downhole tubular structure can be assembled. In the oil well drilling industry, tubular products such as these are referred to as *oil country tubular goods*.

The term *casing* applies to the many strings of pipe that are used to line the well during and after drilling. This pipe protects the hole from formation collapse and prevents the exchange of fluids between the formation and well bore. The casing strings are a permanent part of the well and many are cemented into the formation.

The *tubing* string is the production string, the pipe through which the oil or gas is brought to the surface. From time to time, it may be removed and replaced.

Thread Functions

The threads on both tubing and casing are required to perform two functions: seal the connection to prevent leaks and support the weight of the string as it is lowered into the well.

Extensive service data for older connections and design testing for new connections help predict the capabilities of properly manufactured and undamaged threaded connections. Inspectors visually testing threads are looking for manufacturing errors, damage caused by handling and corrosion that would affect the ability of the connection to seal.[1] The second function of a visual test is to detect any discontinuity that would interfere with the ability of the connection to be properly "made up," that is, screwed together.

Types of Seal

There are three types of seals used on oil field tubing and casing:

- interference sealing threads,
- gasket seals and
- metal to metal seals.

Interference Sealing Threads. The interference sealing threads use a tapered connection that is made up two or more turns beyond hand tight. This power tight makeup forces the mating surfaces together under pressure. Figure 1 shows the profile of a typical interference sealing thread. Thread lubricant (a heavy grease) is used to close the gap between the root and crest of the mating threads.[2] The smallness of the gap and the length of the thread helical make an effective seal.

Gasket Seals. Gasket seals use a ring of resilient material somewhere in the connection. The ring is ductile enough to form itself to the shape of the mating piece. This type of seal is always used with at least one other seal.

Metal to Metal Seals. Metal to metal seals are considered the premium seals in the oil field. The machined

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surface of the pin connection forms a seal around a mating machined surface in the box connection.

These three types of seals are used either alone or in combination in the various connections used in oil country tubular goods.

Inspection Criteria

American Petroleum Institute (API) round and buttress threads are public property and are governed by API SPEC 5B, where the inspection guidelines are very well defined.[3] Additionally there are over a hundred thread designs used on oil country tubular goods that are proprietary. That is, the design is owned by someone and in many cases, patented. For these non-API threads, the inspection criteria may be confidential. The third party inspector of these connections can only examine the threads and set aside any suspect thread for the manufacturer's evaluation. The inspector must be familiar with the published literature on non-API connections in order to recognize any deviation from normal.

Inspection

Before inspection, the threads must be cleaned with solvents and brushes. The waste materials must be captured for proper disposal. During cleaning, the inspector should begin his inspection of the threads. Any obvious imperfections should be marked as soon as they are found.

A critical consideration throughout the threaded area, regardless of the type of connection, is that there are no protrusions on the thread surfaces that could score the mating surface. If the surface has a protrusion, the pressure of makeup will be concentrated in the high spot causing friction and galling, instead of being distributed across the broad surface. Minor repair of high spots with a hand file may be permitted with the pipe owner's permission. If the protrusion cannot be repaired the connection is rejected.

Thread form is critical to the load strength and sealing ability of the threads. Because most machining errors are not detectable without the aid of a profile gage, each connection

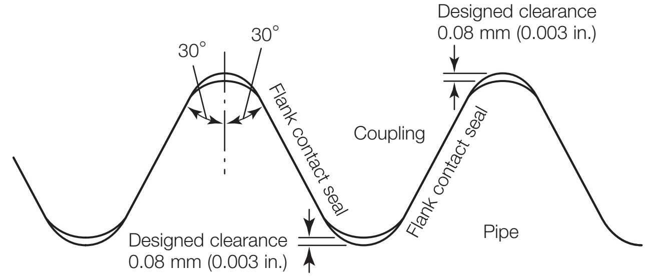

Figure 1. API round thread profile.

must be checked with a precision profile gage (Fig. 2). Light between the profile gage and the connection indicates a thread form error. Improper thread form is cause for rejection. Profile gages are also used to verify that repaired protrusions have been sufficiently repaired.

Imperfection Criteria for Pin Threads

The pin thread of API threads have four distinct areas with different criteria for each, Fig. 3a shows the areas on a round thread, buttress threads areas are similar.

Pin Sealing Area Criteria

The threads toward the end of the pipe are the sealing threads. This area is referred to as the *minimum length full crested threads (L_c).* The L_c length is a specified length. Tables in API SPEC 5B give the distance from the end of the pipe to the end of the L_c area for each size connection. The L_c thread must be free of visible tears, cuts, grinds, shoulders or any other anomaly that breaks the continuity of the threads. All threads in the L_c must have full crests on round threads. Buttress threads are allowed some non full crested threads. Any potential leak path in the L_c area as well as not meeting any of the above criteria would cause the connection to be rejected. The L_c threads are allowed superficial discoloration, but that is the limit of discontinuities allowed.

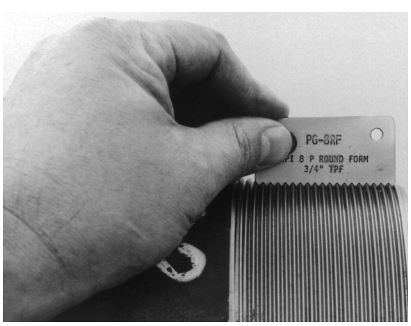

Figure 2. Profile gage on round threads.

Pin Nonsealing Threads Criteria

The threads between the end of the L_c area and the vanish point of the threads are not considered as sealing threads so they are allowed to have imperfections that could be considered to be leak paths. The manufacturer may repair threads in this area by grinding within API specified limits. The most critical factor in this area is that there be no protrusions on the thread flanks that will remove the protective coating or score the mating surfaces.

Chamfer Criteria

The chamfer area on the end of the pipe is beveled to provide a place for the thread to start. This bevel must be present for 360° around the pipe face and the starting thread must run out on the chamfer.[3] This design minimizes the risk of damage while making the connections on the drilling rig floor. If a ridge were present and folded over, it would result in galling during makeup.

If the starting thread is not continuous, that is, if a portion of the groove is missing, this condition in itself is acceptable but may be a sign that the pipe and thread axis are misaligned.[4] There are tolerances for angular and axial alignment and this condition must be evaluated. The chamfer smoothness is not critical since it does not contribute to the thread function after it provides a place to start makeup.

Pin Face Criteria

The fourth and final area where threads are critical is the pipe end. The ends must be free of burrs on the inside and outside.[5] Freedom from burrs is actually important to the entire threaded area because burrs might be dislodged during makeup. If they become dislodged they could interfere with makeup and promote galling. Burrs on the inside of the face are of concern because they may damage tools and equipment used for surveys or other functions during drilling.

Coupling Threads

There are three areas on the coupling threads (Fig. 3b). The area on the coupling referred to as the *perfect thread length* must meet the same criteria as the L_c area on the pin. The perfect thread length on the coupling starts with the first threads at the end of the coupling and continues to the plane located near the made-up position of the first full thread of the pin threads. The length of this area provides the pin thread a properly formed mating thread throughout its travel during makeup. A mirror is required when inspecting couplings in order to view the flanks facing the center of the coupling. The repair of minor anomalies in the coupling threads is normally not practical because of curvature of the

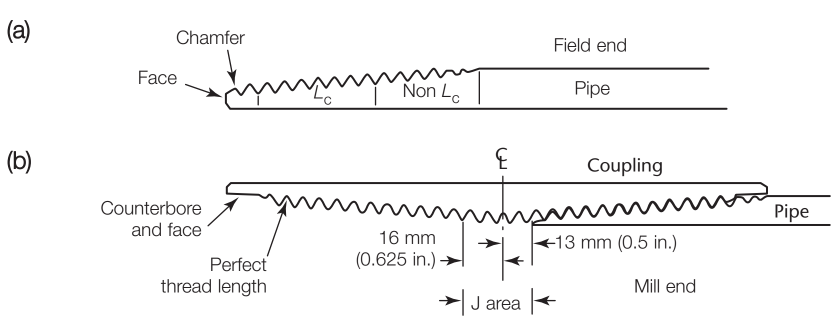

Figure 3. Round thread areas: (a) pin, (b) coupling.

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Focus continued from p 3

connection. Additionally couplings have a zinc, tin or metallic phosphate coating to improve corrosion resistance, antigalling and sealing ability and repairs would damage this coating.

The second coupling area, those threads in the center of the coupling, are required only to be present. These threads are considered acceptable if the thread root is present all the way to the center. Seams, laps or cracks in the coupling threads are always considered rejectable but are not normally found by visual testing alone because of the coating applied to the internal threads. While cutting the second end, the thread cutter may cut beyond the center of the coupling. This condition is acceptable unless the cutting extends into the perfect thread area.

The counter bore and face is the other area of the coupling. The diameter of the recess shall be sufficient to prevent cutting ghost thread roots on the surface of the recess.[2] Also, there should be no burrs (Fig. 4) or protrusions in the counter bore area that could damage the pipe threads during stabbing at the rig site.

The criteria for pin and coupling are summarized in Table 1 for round and buttress threads.

Presence of Makeup Triangle

The visual thread inspector checks for the presence of the makeup triangle (a manufacturer's stamp indicating where makeup should stop) on buttress threads and round threads larger than 400 mm (16 in.). The lack of a triangle is not normally cause for rejection, but the customer should be notified since the triangle is used to aid proper makeup on the rig floor. The thread area stops at the apex of the makeup triangle.

Makeup Connections

The completely tightened makeup is also checked visually during a visual thread test. The pin thread face should be made up to 13 mm (0.5 in.) from the center of the coupling (Fig. 5) for most pipe. The center of the coupling can usually be visually located. By counting threads between the center of the coupling and the face of the pin on the opposite side, the distance can be quite accurately estimated. Further evaluation by measurement may be required for classification if visual evaluation shows a significant error.

Shoulders

API round threads are designed to run out at the pipe surface. Excessive metal, machined for threading but in fact not threaded, where the thread stops on the outside surface of the pipe is referred to as a shoulder.[6] If the shoulder goes all the way around the connection, it indicates that either the pipe is too big or the thread is too small.

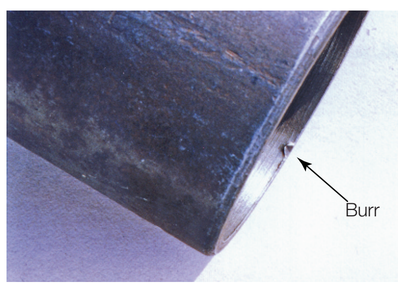

Figure 4. Burr on end of coupling.

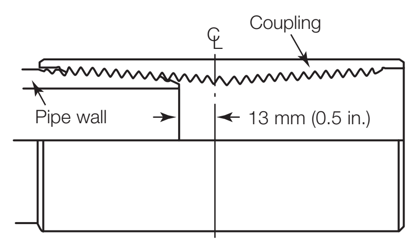

Figure 5. Connection makeup.

Table 1. Criteria for visual testing of API round and buttress threads.[3] Anomalies described below are considered defects.

Area	Anomalies	Applies to
Pin face	knife edge	round and buttress
	burrs	round and buttress
Chamfer	feather edge	round and buttress
	burrs	round and buttress
	chamfer not present for full 360 degrees around pipe	round and buttress
	starting thread not running out on chamfer	round and buttress
Pin, L_c area	any imperfection that will cause a leak path	round and buttress
	any imperfection that causes distortion of thread form	round and buttress
	non full crested threads	round
	no more than two non full crested threads no longer than 25 percent of circumference	buttress
Pin, not L_c area	any imperfection that causes distortion of thread form	round and buttress
	other imperfection cannot extend beyond root of thread or 12.5 percent of wall thickness	round and buttress
Coupling	threads not extending to center of coupling except beyond the perfect thread length	round and buttress
	metal protrusion	round and buttress
	any imperfection that will cause leak path except beyond perfect thread length	round and buttress
	non full crested threads except beyond perfect thread length	round and buttress
Coupling face and counterbore	any metal protrusion that would prevent proper makeup	round and buttress

Further investigation is required to determine which of these conditions exists. A small thread size is a serious condition because makeup and sealing depend on both thread members being the proper size.

An angular alignment problem may be indicated by shoulders on only one side for round threads. Angular misalignment (hooked threads) would cause makeup problems in the field.

Conclusion

Visual inspection of threads in oil wells has specific requirements and an understanding of these requirements along with careful attention to detail are needed for successful inspections.

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