

# **Adhesives Retain with Confidence: Anaerobic adhesives greatly improve the reliability of cylindrical assemblies**

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Most machinery contains cylindrical parts that must be shaft mounted or “retained.” Faced with a typical shaft-hub assembly problem, engineers can choose among several mounting methods, all of which have advantages and disadvantages. But no mechanical fitting alone is stronger or can provide more protection against leakage and corrosions that one bonded with an anaerobic retaining compound.

Maintenance, repairs, and operations (MRO) managers are starting to realize that although some mechanical retaining methods may be effective in specific situations, all could benefit or even be effectively replaced by the use of an anaerobic retaining compound.

## **Interference Fits**

Probably the most common mechanical method of retaining is interference fitting. Interference fits achieve their holding power from the high interfacial pressure caused by mechanical interference. This radial contact pressure is translated into torque or axial load capacity by the friction between mating surfaces. The level of interference will determine the joint strength.

Interference fits can be assembled by two basic methods – press and shrink fitting. In press fitting, a hub is forced to stretch elastically over a shaft that is larger than its bore. Shrink fitting is the assembly of a shaft and hub with a significant interference by heating the hub, chilling the shaft, or both.

The force required to make a press fit is generally at least as high as that required to disassemble the fit. And with press fitting, there is a risk of bending, shearing, and galling, especially when shafts less than 25 mm are forced into relatively thick, rigid hubs. Also, stretching thin hubs too much may expand them beyond their yield, resulting in a lower strength than the estimated value for the fit.

A shrink fit requires the application of a considerable amount of heat to the female component. Often, this assembly method is limited due to the temperature limitation of the materials used. The technique is generally feasible only on diameters larger than 40 mm.

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Interference fits typically have only 20-40% effective area contact due to surface irregularities. Therefore, engineers are always forced to use arbitrary coefficients to calculate hub pressures. Since the hub pressure is a function of the actual interference between the mating parts, the interference will fluctuate with the dimensional tolerances, causing hub pressure to vary. Thus, a calculation of the strength of an interference fit can be considered only a rough estimate of the capacity of the joint.

In interference fits, the presence of oxygen in the small voids along the joint interface and micro-movements of surface irregularities make these fits prone to fretting and corrosion, particularly in dynamically loaded assemblies.

### **Other assembly methods**

A handful of other assembly methods are commonly used in retaining, but they are all basically variations on the press - or slip-fitting theme. All of these conventional techniques require additional – sometimes precision – machining steps to produce the properly sized or shaped part. Since any machining allows for human error, machining tolerances are usually inexact. Failure of cylindrical assemblies is often linked to machining variances. Listed below are the most common retaining methods and their shortcomings:

**Knurled joint.** While the ridges of a knurled fit provide more surface contact than a smooth press fit, this method requires extra machining operations and may prove difficult in harder steels or work-hardened alloys. At any rate, this method is limited to low torque applications.

**Splines.** Like knurled fits, splines are costly to machine. They require close drive fit tolerances and broaching or milling of both the hub and the shaft.

**Brazed joint.** This method is complicated because it requires induction or furnace heating and, consequently, may distort parts in the process of assembly. It is also irreversible; it does not permit disassembly.

**Sliding fit.** The simple sliding fit requires additional milling, broaching, and threading operations and requires extra components.

**Set screw.** Although using set screws is advantageous where frequent disassembly is necessary, the joint's shear strength is limited in torque situations by the set screw itself and the hardness of the shaft.

**Pins.** Using pins requires drilling and reaming or taper reaming of both the hub and shaft. Alignment is necessary during assembly.

**Driven key.** The use of keys can provide a locking attribute to a cylindrical fit if machining tolerances are kept narrow. However, keys always add complication and expense to a joint. Internal and external milling is required, as well as alignment in assembly.

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**Slip fit with key.** The use of the key requires added machining operations and extra components. The nature of the slip fit permits backlash.

**Tapered shaft.** Much like the slip key fit, a tapered-shaft fit requires turning of tapers, threading, drilling, and extra components.

**Split hub.** The split hub requires special components, including the hub, but still delivers limited shear strength.

### **Retaining compounds**

Simply put, bonding assemblies with anaerobic retaining compounds permits easy machining tolerances and produces joints that are five times stronger than heavy press fits. Be aware that cleaning prior to bonding is necessary, and retaining compounds are not recommended if frequent disassembly is required.

To understand how retaining compounds provide extra strength and efficiency, one must be aware that when two metal surfaces are brought together as an assembly, there remains a microscopic “inner space” between them. The surfaces touch where there are raised surface areas, but even the most tightly fitted parts have empty spaces. This “inner space” is the source of such problems as vibration loosening, leakage, and corrosion. Therefore, the most efficient assemblies have the most surface-area contact.

Anaerobic adhesives are applied directly from a bottle or by brushing or wiping them onto a metal surface. The liquid flows into the surface irregularities that make up the inner space, allowing for 100% surface coverage in the assembly contact area. Upon assembly, the adhesive hardens - they harden only when deprived of air - creating thousands of small surface “keys” that increase the overall strength of the assembly. The cured adhesive film also seals the joint against fluids such as oil, gasoline, and water and protects against oxidation and corrosion.

Adhesive bonding allows manufacturers, as well as MRO professionals, to use slip fitted parts with relaxed machining tolerances, and it can reduce the size, weight, and number of parts required for assembly. In addition, combining the use of these adhesives with the more traditional fitting techniques, such as splines and interference fits, can produce some of the most reliable assemblies achievable.

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## **Anaerobics + Mechanical Retaining = Reliability**

Anaerobic adhesives have been used as thread lockers and sealants since the 1960's. More recently, anaerobic adhesives have been found to be very effective in increasing the strength and performance of joints where loads are traditionally transmitted by friction. For several reasons, the practice of retaining with anaerobics has become very popular for MRO:

- 1. Press fits can be eliminated** and slip fits can be used in some applications. This allows wider machining tolerances and possibly the elimination of secondary machining.
- 2. Knurls, keys, and splines can be eliminated** or their tolerances widened. This eliminates machining operations, reduces machining costs, and permits faster assembly. It also prevents backlash in splines and reduces wallowing or "chucking."
- 3. Dissimilar, low-strength materials can be joined** with press-fit strength. This simplifies designs, reduces material costs, and can solve problems caused by differential thermal expansion. Use of an anaerobic adhesive allows 100% sealing of the joint against fluid leakage, corrosion, and oxidation. It also can eliminate the need for static o-rings and seals.
- 4. Parts can be joined in a relaxed state.** This eliminates distortion and reduces premature failure due to fatigue.
- 5. Fits can be restored to worn assemblies.** This allows immediate return to service and eliminates expensive rework procedures.
- 6. Wider machining tolerances may be used.** Expensive machining for press fit keyways, splines, "D" shafts, and square shafts can be relaxed, and these assemblies can be joined with retaining adhesives.
- 7. Interface fits may be augmented.** Where design does not allow the elimination of press fits, these may be augmented with retaining adhesives. In these applications, strengths are doubled while fretting and leakage are eliminated. For cylinder sleeve retaining, tolerances can be relaxed to allow easier assembly.

Finally, MRO professionals who also wear "production hats" should be aware that OEMs can achieve higher production rates by using anaerobic adhesives in either hand or automated assembly and, thereby, eliminate machining steps. Pressing operations and expensive tooling can be eliminated. The size, weight, and number of parts required for assembly may be reduced.

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