

Thread Sealing 101: Consider your options when choosing a method of sealing pipe joints

As featured in *Plant Services* magazine

By Robert Valitsky, Technical Communications Manager
Henkel Corporation

Liquid and gas leaks are serious business. Governments legislate against them, technical societies create standards to avoid them, manufacturers expend mighty efforts to prevent them and maintenance departments work continuously to correct them. More than a billion gallons of industrial fluids are wasted through leakage every year.

Beyond the value of lost fluids and gases, leaks affect toxicity, emissions, safety, contamination and personnel. There is also the expense of locating, diagnosing and repairing leaks in pipe systems. All together, this leakage costs the industry more than \$200,000 every day.

What causes leakage?

On the whole, most leaks can be traced to pipe joints. Threaded joints in piping systems are necessary evils. Pipe system designers seek to reduce the number of joints wherever possible, but without demountable joints, each repair would require the removal of massive pipe links.

Piping, in general, is manufactured to industry standards that specify exactly how threads should be cut or formed on pipes and fittings. The most common standard for commercially available pipe in the United States is known as National Pipe Thread or National Pipe Taper (NPT).

NPT fittings have 60-degree threads cut on a taper of $\frac{3}{4}$ inch per foot of length for both internal (female) and external (male) joints. The taper satisfies two conditions: ease-of-assembly and direct metal-to-metal contact. If pipe threads are cut straight, such as is the case for nuts and bolts, threads must be cut with exact precision to provide a leak-proof joint.

Other thread standards include: Dry Seal Standard Taper Pipe Thread (NPTF), American Standard Straight Thread – also known as National Coarse (NC) – and European series (straight female and tapered male fittings).

Thread Sealing 101: Consider your options when choosing a method of sealing pipe joints

As featured in *Plant Services* magazine articles

In a perfect world, straight thread pipes would be available for every situation because they allow the most metal-to-metal contact. However, straight thread fittings must be precision cut for each use, making them cost - and time - prohibitive in most cases.

Despite the standards created to maintain uniform fittings, tapered pipe threads are imprecise – an anomaly in the precise world of mechanical engineering. They are not cut to precise dimensions, nor can they be installed with specific torque. During the course of use and repair, threads become damaged and more vulnerable to leakage. But since it is the least expensive, tapered pipe threads are the most common. This means leaks are bound to occur from a number of causes.

Primary among causes is the fact that manufacturing tolerances lead to thread clearances. The area where the crest and the root of the thread meet forms a spiral leak path. No amount of tightening will eliminate this leak path. For the most part, thread sealing is an attempt to block this leak path that occurs naturally in pipe connections.

The leak path problem is multiplied when pipe and fitting threads are damaged during shipping or otherwise. One minor dent in a single thread can create or augment major leak paths.

And, since there are no torque specifications for most pipe joints, operators are left to judge for themselves how much force is necessary. Too much torque can crack or distort fittings; too little results in improper formatting of thread cling, excessive pressure, vibration, shock and inefficient sealing methods can lead to leaks and financial loss. Consideration of potential causes is important when installing a fitting, but sealing allows operators to control a fitting's potential to leak.

Sealing Options

The earliest attempts at creating leak-free pipe joints involved the use of joining compounds, such as white and red lead, litharge with glycerin and paint with hemp fibers. These were inefficient or had major side effects. For instance, the lead-based compounds provided a very good seal. However, the discovery of their toxic nature, both during application and in use, made them unsuitable. Nowadays, there are still a few methods commonly used to create a seal in pipe fittings.

Paints and dopes have been used for quite some time with varying measure of success. Paints and dopes rely on solvents to carry them and form solid seals. They contain ingredients such as crushed walnut shells and other fillers, shellac, oils and thinners.

Thread Sealing 101: Consider your options when choosing a method of sealing pipe joints

As featured in *Plant Services* magazine articles

When the solvent evaporates, the product dries to form a tough seal. The rigid, brittle nature of most of these sealants, however, causes them to crack, especially when used on dynamic joints such as those found in compressed air and hydraulic systems. Also, as the remaining solvent carrier evaporates over time, subsequent leakage can occur.

In many cases, pieces of these rigid cure sealants find their way into the systems they are meant to seal, resulting in blockages to ports or unseating valves in delicate hydraulic and pneumatic systems.

Yielding metal/dryseal is another version of tapered fittings used in critical sealing operations. The “dryseal” type of tapered fitting seals by deforming the crests of the threads as the fitting is wrenched tight. The metal “cold flows” and is forced into the roots of the opposite thread. Therefore, sealing takes place at the roots and crests, as well as on the flanks of the threads. This effectively eliminates the spiral leak paths at the crest and root areas of the threads.

However, galling may occur during assembly. Galling occurs when threads cold weld together and later rip apart, creating small scratch-like leak paths. A lubricating sealant reduces the associated friction and prevents galling of the threads.

Extremely high stress points are developed at the thread crests and roots on the dryseal fitting. Over-tightening may create cracks in the mating fitting or housing at these points. As with any over-torqued fittings, cracks may not be visible initially, but could appear later as fatigue failures or fluid seepage. Nonetheless, properly installed dryseal joints can be effective up to 98 percent of the time.

The confined **O-ring** is one form of a trapped elastomer used to seal joints. It can be effective, but is prone to sloppy assembly. Damaged thread or pinched rings can contribute to leakage. The O-ring is only recommended in high-pressure fluid power systems where the extra cost is justified more easily and freedom from contamination is desirable.

Teflon tape can be classified as a tripped elastomer as well. Like imprecise tapered pip threads, it too is an anomaly in the precise world of mechanical engineering. Although it is not a sealant, it was adopted for thread sealing because of its anti-friction lubricity, which allows more turns to be taken on a tapered fitting. Many Teflon tape joints serve well. However, tape is often banned in hydraulic and pneumatic systems because of its tendency to shred and contaminate sensitive areas. Its increased lubricity has also been known to induce over-torquing.

Thread Sealing 101: Consider your options when choosing a method of sealing pipe joints

As featured in *Plant Services* magazine articles

Latex-based sealants, another trapped elastomer, are pre-applied acrylic latex-based sealant supplied by fitting makers. Applied to the male threads of tapered pipe fittings, this material forms a yieldable interface for thread variables and plugs leak paths. Treated parts are reusable four or five times, as with O-rings. Disadvantages of this method include the difficulty of replacing a worn seal, incompressibility and the lack of locking ability.

Anaerobic thread sealing adhesives, sometimes called “machinery adhesives,” are anaerobic resin compounds that develop strength by curing. They are forgiving of tolerances, tool marks and even slight misalignment. In addition, they cure in the absence of air, remaining liquid until the fitting is assembled. Many contain Teflon or similar lubricant fillers that aid assembly and eliminate galling or other component assembly problems. The very slow cure speed of the adhesive allows for adjustment to fittings during system assembly, without breaking the seal in the threads.

Once cured, anaerobic sealants lock fittings, preventing loosening from vibration. Unlike the tape and hard setting sealants replaced by anaerobic materials, machinery adhesives won't contaminate lines and valves in hydraulic and pneumatic systems.

Precautions with anaerobics

Anaerobic thread sealants provide a reliable seal for pipe fittings, but only when installed properly. Because of their wide range of strengths, select the correct grade of anaerobic thread carefully for the proper locking strength or ease of disassembly.

Check for large cracks in fittings that can result in low strength or sealing due to poor or no cure. Do not adjust fittings after the thread sealant has fully cured, or apply high pressures to the piping system before the sealant has fully cured.

If using anaerobic sealant on active metals, such as copper and brass, be sure not to let the sealant set for too long before tightening the fittings. Active metals speed the curing mechanism and delays may cause procuring in the threads, leading to difficult assembly. Apply a curing primer where a sealant is used on inactive metals to ensure a proper seal. And because contaminated threads can lead to a low cure or allow a leak path, always be sure threads are clean before assembly.

Thread Sealing 101: Consider your options when choosing a method of sealing pipe joints

As featured in *Plant Services* magazine articles