HOW TO PROPERLY ASSEMBLE NPT PIPES & FITTINGS.

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About the Author

Don Oldiges is the Technical Director at Jet Lube LLC, focusing strongly on producing the highest quality valve lubricants, anti-seize, production and drilling compounds, thread and high-temp sealants, anaerobics, penetrants, and cleaners and degreasers for more than 35 years. He is a specialist in developing complex greases and testing frictional properties of a broad range of products and threaded connection designs.

Assembly of NPT Piping

NPT stands for National Pipe Taper — pipe and fittings have a tapered thread profile.

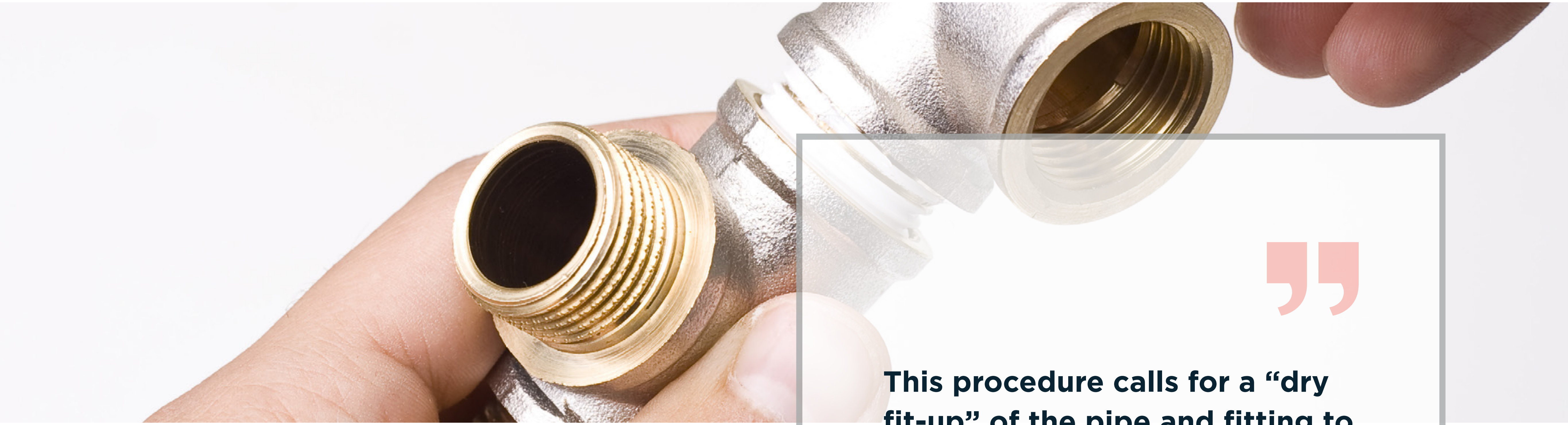
The tapered thread seals using an interference fit between the male and female threads. NPT fittings should never bottom out in assembly. By hand assembly only, the pipe or fitting should only screw in part way before jamming. If an NPT pipe or fitting screws all the way into the female port without binding, the threads are either incorrectly tapped, worn out, or the tapers are grossly mismatched.

Within this specification, only specific Line Classes are permitted use of threaded piping, with some permitting up to NPT 2. ASME Standard B1.20.1 Pipe Threads, General Purpose identifies the required thread length engagement for hand tight plus wrench tight positions during assembly.

It is important to understand that torque is not the appropriate assembly technique (i.e., "Tight is not right") for NPT assembly, but rather thread engagement by the number of turns. Torque is not an appropriate method to makeup connections due to the differences in thread surface roughness, variance in threads and taper, lubricity of thread compounds, and other factors.

Fit to Hand Tight - FTHT

Fit to Hand Tight (FTHT) is commonly referenced in threaded piping assembly as the hand tightened position, without compound or tape applied. Table 11 below identifies the intended thread engagement in hand tight and wrench makeup for NPT 1/8” to 6”.



This procedure calls for a “dry fit-up” of the pipe and fitting to the L1 position during assembly.

Step One:

From the position of FTHT the technician should count the remaining threads on the pipe, as well as mark the pipe and fitting on the axis of the pipe, to establish dry fit position.

Step Two:

Following application of thread compounds and/or tape, the pipe connection should be returned to the hand tight position then further tightened by wrench the additional turns as prescribed in the ASME Standard for proper thread engagement.

ASME Standard

For threaded piping 1/8” to 2”, these sizes are to engage an additional three threads in wrench makeup beyond hand tight fit-up.

Table 11 includes partial data extracted from ASME Standard B1.20.1 Pipe Threads, identifying standard hand tight and wrench makeup data (length and thread count) for NPT 1/8” to 6” threaded piping.

Engaging the connection from hand tight to the required additional three turns can grind down the tape on the threaded flanks to sub-micron thickness, where it may lose suitability for galling resistance, but the remaining material extruded into the helical void helps to ensure sealability.

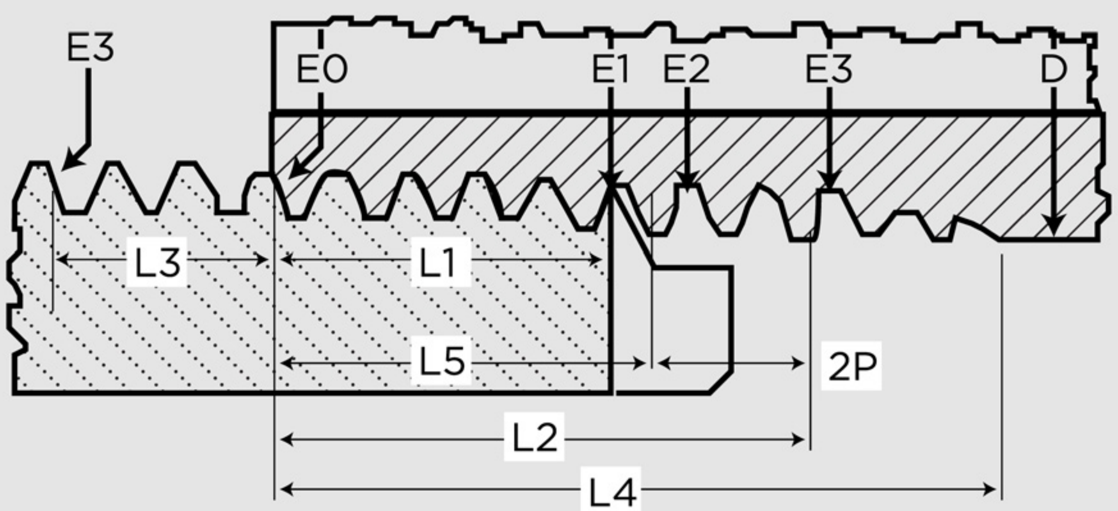


Table 11 Basic Dimensions of National Pipe Tapered threads

NPS	Pipe OD	TPI	Length of Effective Thread External **L2**	Hand Engagement plus Wrench Makeup Lengths – not necessarily equal to length of effective Thread			
				Hand Tightened Engagement Length **L1**	Wrench Makeup Length **L3**	Hand Tight Threads	**Wrench Makeup Threads**
1/8”	0.405	27	0.2639	0.1615	0.1111	4.36	**3**
1/4”	0.540	18	0.4018	0.2278	0.1667	4.10	**3**
3/8”	0.675	18	0.4078	0.2400	0.1667	4.32	**3**
1/2”	0.840	14	0.5337	0.320	0.2143	4.48	**3**
3/4”	1.050	14	0.5457	0.339	0.2143	4.75	**3**
1”	1.315	11.5	0.6828	0.400	0.2609	4.60	**3**
1-1/4”	1.660	11.5	0.7068	0.420	0.2609	4.83	**3**
1-1/2”	1.900	11.5	0.7235	0.420	0.2609	4.83	**3**
2”	2.375	11.5	0.7565	0.436	0.2609	5.01	**3**
3”	3-1/2”	8	1.2000	0.766	0.2500	6.13	2
4”	4-1/2“	8	1.3000	0.844	0.2500	6.75	2
6”	6-5/8”	8	1.5125	0.958	0.2500	7.66	2

Pipe Thread Compounds

Reaching for the nearest pipe joint sealing material can lead to serious problems, including leaks, pipe system damage, contamination, and facility downtime.
As the name suggests, pipe sealants, also known as pipe joint compounds, seal threaded pipe fittings and block the leak path along the threads. Thread sealants have two primary functions: first, to lubricate, and second, to provide sufficient filler to “dam the thread clearances” where it is applied, thereby sealing the connection and preventing leakage from internal pressure.

There are three basic types of pipe sealants used today, PTFE (Teflon) tape, pipe dope, and anaerobic resin compounds. The experience of the technician and the availability of the product dictate which one is used. Each type has properties for optimum sealability. Each provides its own advantages and disadvantages.

The constraints of each product depend on the service, the properties of the pipe material, properties of the fluid being sealed, service temperature and pressure, and outside influences such as vibration. The application determines the sealant. Tape, if not properly used, does not seal - it lubricates. Dope can harden and become brittle, while anaerobic products must be compatible with the piping materials.

PTFE (Teflon) Tape

Teflon (trade name) tape is no longer manufactured by DuPont and should only be referred to as PTFE (Polytetrafluoroethylene) tape.

The purpose of this non-sticking tape is to serve as a lubricant and sealant when threaded parts of a piping system are being assembled. The inherent slipperiness of the material makes assembly easier. PTFE tape has applications for use on its own or used in conjunction with other sealants. See discussion on assembly later on.

Strictly speaking, PTFE tape provides a mass to clog up the thread path, but it does not adhere to the surfaces as a true sealant should. During installation, the tape must be carefully wrapped in the direction of the threads or it unravels and tears. The advantage of PTFE in higher temperature sealing applications is the higher coefficient of linear expansion, allowing it to expand with the pipe, ensuring a better seal when properly wrapped.

PTFE tape manufactured by Jet-Lube for application in oil and gas is available in 3 mil thickness, and the 4 mil thickness with a nickel-filler for applications in stainless steel piping systems. It is important that the product be equivalent/conform to Military Specifications – CID A-A 58092 (formerly MIL-T-27730A) and have a density of 1.2 g/cm3 for the non-nickel-filled tape. For the nickel-filled tape, similar thickness and stretch properties to CID A-A 58092 are required. PTFE tape is generally limited to an operating range of -240°C (-400°F) to +260°C (+500°F). Above 315°F (600°F), PTFE tends to break down and becomes very corrosive.

Jet-Lube brand Petro-Tape™ in 3-mil thickness has been tested for threaded pipe connections not exceeding NPT 3 and 13,800 kPa (2,000 psi). The 4-mil Petro-Tape™ Nickel is grey in color with a higher 10,000 psi rating to a maximum NPT 2 connection.

Advantages: PTFE tape can be applied quickly with no mess. It supplies sufficient lubrication to enable pipe system components to be easily assembled without damage to the threads. The product is easy to carry, store, and has an indefinite shelf life. Additionally, it is nearly inert to all services and not as prone to wash-out from the threads as typical thread sealants.

Disadvantages: PTFE tape does not adhere to thread flanks and does not always provide a secure seal. Because the tape is thin and fragile, it is prone to tearing when pipes are being assembled and tightened. Bits of torn tape can migrate into a fluid system, clogging valves, screens, and filters. Tape may be dislodged during pipe adjustments, allowing leak paths to form. PTFE tape can deteriorate when exposed to sunlight or high chlorine exposure. Under contact pressures above 35,000 psi it loses its anti-galling and lubricating properties. This is not typically an issue on schedule 40 pipe but could be with schedule 80.

Recommended uses: Widely used in plumbing, this material is adequate for assembling standard threaded water pipes and fittings as well as preferred for gasoline or high solvency and oxygen services. PTFE tape offers some resistance to vibration and should be avoided in high-pressure systems.

Pipe Dope, Thread Compound, and Thread Sealants

Pipe dope has been used in industrial applications for decades. Certain grades of pipe thread compounds rely on a solvent carrier and harden when the solvent evaporates. The resulting seal adheres to all plastic and metal pipes and effectively blocks leak paths.

Because it may contain solvents, pipe dope can have a tendency to shrink over time as the solvent evaporates. This condition creates the potential for the dope to pull away from the thread walls or crack, allowing leaks to develop. Pipe dope is usually applied to thread compounds with a brush or spatula.

The non-hardening thread compound relies solely on the boundary lubricants in the composition to affect the seal by damming the helical void and provides higher film strength to reduce galling by ensuring proper lubrication and lower assembly torque to reach the proper engagement.

Advantages: Pipe dopes are inexpensive, effective, and relatively easy to use. Their chemical composition is typically compatible with all pipe materials, including plastic on the solvent-free products. Hard-setting pipe dopes harden quickly and produce a moderate-to-strong seal. There are many different varieties of thread compound so proper selection is important. The compositions provide a stronger film strength than PTFE tapes and have a greater resistance to galling during engagement or disengagement. Under higher contact pressures they typically provide lower torque than PTFE. Once tape tears, direct metal-to-metal contact begins and can increase the potential for galling.

Disadvantages: Solvent-based pipe dopes can lose their effectiveness as a result of heat aging. When the seal shrinks and cracks, leaks can develop. This possibility is especially likely with systems where significant vibration occurs. Pipe dopes may lack sufficient resistance to solvents.

Recommended uses: Solvent-based pipe dopes provide an adequate seal in applications where high temperatures and pressures are not expected. Pipe dopes offer minimal resistance to vibration. They are acceptable when the installation of a piping system may require adjustment of components more than a few minutes after assembly.

Anaerobic Resin Compounds

Anaerobic compounds use different cure chemistry than solvent-based pipe dopes and generally do not contain solvents. The cure begins when the sealant is confined within the threads of the metal pipe connection and air is excluded.

Without solvent present, the cured material does not shrink or crack, and maintains its sealing properties even after heat aging as it forms a plastic-like structure. Because of their chemistry, anaerobic compounds exhibit excellent temperature and solvent/chemical resistance.

Advantages: Anaerobic compounds fill the voids between pipe threads, creating a seal. The compounds cure slowly, providing additional time to make adjustments to pipe system components without damaging the seal. Once cured, the compounds form a strong seal that resists temperature, pressure, solvents, and vibration. Because they are largely free of solid fillers they work where thread clearances are very small.

While some sealants produce bonds that make disassembly difficult, joints sealed with anaerobic products can be taken apart with standard hand tools or heated to 400°F for easier breakout. Many anaerobic thread sealants contain PTFE or similar lubricants, which aid assembly and reduce the potential for damage to pipe components.

Disadvantages: Because of their chemical composition, the compatibility of anaerobic compounds with plastic pipe and fittings should be verified before use. The curing mechanism requires an active metal surface to initiate the cure. A primer such as copper naphthenate in a solvent carrier is often available for less active surfaces. Although these compounds cure sufficiently for many immediate uses, a 24-hr period should be allowed before activating high-pressure systems or allowing significant shock or vibration. Anaerobic resins can be difficult to remove from clothing.

Recommended uses: This class of sealants provide the strongest, longest-lasting bond available. They are recommended for temperatures up to 300°F, pressures up to 10,000 psi, and where vibration is present. These sealants are ideal when installers need to make minor adjustments to a piping system.

Using PTFE Tape Alone

Jet-Lube brand (or approved substitute) has been identified in Table 1 as the preferred selection of PTFE tape. An equivalent product of equal or better chemical makeup and properties may be used. PTFE tape intended for use in hydrocarbon and associated process services must be certified or conform to the requirements of Military Specification – CID A-A-58092 (formerly MIL-T-27730A) and be of a minimum density of 1.2 g/cm^3 (sp. gr. 1.2) and recommended minimum thickness of 3 mil. Jet-Lube Petro-Tape is available in 3-mil and 4-mil thicknesses. The 3-mil product is for general applications. The 4-mil product is specific to stainless steel NPT pipe assembly and does not require thread compound application.

Instructions:

1. Ensure threads are clean before application of tape.

2. Secure the tape to the pipe threads wrapping clockwise (i.e., in the direction of the pipe thread) so that tape does not peel off during engagement into the female threads, stretching it approximately 20% to ensure the tape is secure. Only wrap tape 2-3 times on smaller diameter connections (i.e., ≤ NPT 2) so as not to over-apply, causing the tape to be rolled off threads during engagement. Larger diameter connections (> NPT 2), often require additional wraps from 4-8 depending on size. Follow manufacturer's guidelines.

a. Excessive use of tape increases the chance for the tape to be introduced to the process and potentially cause issues with instrumentation equipment in the future (i.e., turbine meters and gas analyzers specifically).

3. Complete the assembly by wrenching back to the FTHT position, plus the required additional threads.

As long as 2-3 wraps of the tape are properly secured to the male threads and the connection is engaged to the required threads (i.e., 2-3 turns) beyond FTHT, there should be no leaks. This however, would be with tapes that conform to MIL T-27730. There are many tapes less than 1 mil thick. Do not use these tapes in NPT pipe applications.

Using PTFE Tape in Combination with Compound

A common practice in Canada and other parts of the world is to use PTFE tape and thread compound "in combination" to join threaded pipe connections.

When applying PTFE tape in conjunction with thread compound, the following is a recommended practice.

1. Ensure threads are clean before application of tape and thread compound.

2. If using PTFE tape in combination with compound, secure the tape (3 mil) first to the pipe threads wrapping clockwise (i.e., in the direction of the pipe thread) so that tape does not peel off during engagement into the female threads, stretching it approximately 20% to ensure the tape is secure. Only wrap tape 2-3 times so as not to over-apply, causing the tape to be rolled off threads during engagement. Do not cover bottom two threads, leaving space for the thread sealing compound to adhere.

a. Excessive use of tape increases the chance for the tape to be introduced to the process and potentially cause issues with instrumentation equipment in the future (i.e., turbine meters and gas analyzers specifically).

3. Apply thread compound, filling root to crest of the first two threads, and only to the MNPT(Male) connection. The bare metal provides a coarse enough surface for the thread compound to adhere.

4. Complete the assembly by wrenching back to the FTHT position plus the required additional threads.

5. If using compound without PTFE tape, eliminate step 2, apply compound to the MNPT connection threads filling root to crest with no voids. On more galling-prone alloys, a thin film may also be applied to the FNPT(Female) threads to reduce shear loss during engagement.

6. Complete the assembly by wrenching back to the FTHT position plus the required additional threads.

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