English version

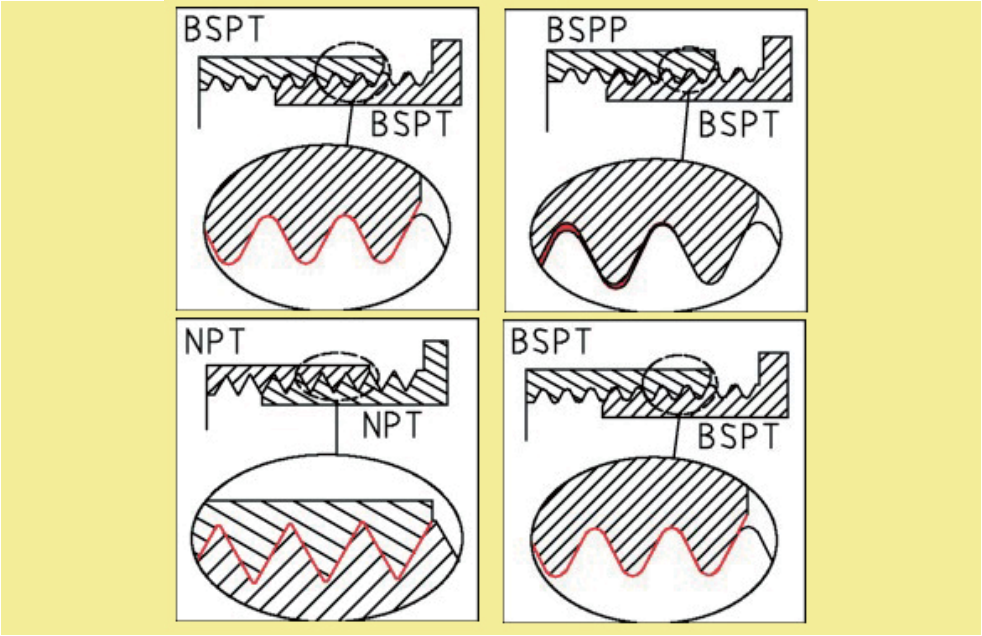
ULTIMHEAT® MUSEUM

Jacques Jumeau

Technology of components used in heating.

Chapter 32

Main pipe connection systems



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Main systems used in small diameter pipes for mounting thermostats, pressure switches, flow sensors, level sensors, temperature sensors, immersion heaters and instrumentation

Summary

- Threaded joints with sealing on the thread:
They assemblies are composed of a tapered male thread and a tapered or parallel female thread. The sealing effect is improved by using a grouting product.

- Threaded joints without sealing on the thread:
These are assemblies where male and female parts have parallel threads and where the seal is made by compressing a joint, metal surfaces or deformable metal parts

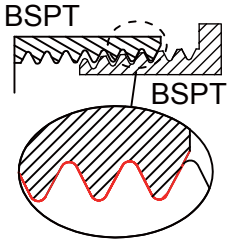
- Quick joints without threads:
These are assemblies where male and female parts have a gasket seat, which is compressed by the assembly without using a thread

-Usual problems

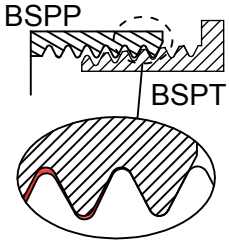
1st section: Threaded joints with sealing on the thread

1-1: Sealing on the thread, definitions and variants

In this technique, the oldest one, the pipe threads must provide a mechanical strength but also a hydraulic seal. This sealing is achieved by the shapes of the threads, by eliminating the clearance between the male and female parts, by the use of tapered threads, and by the possible use of grout between the two to avoid spiral leakage. along the threads. Two variants exist:



First Variant: Assemblies of male tapered threads on female tapered threads (example BSPT on BSPT)

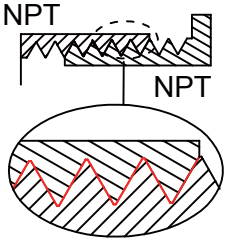


Second variant: Assemblies of male tapered threads on female parallel threads (example BSPT on BSPP)

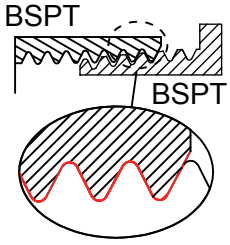
1-2: Sealing of tapered male threads on female tapered thread

1-2-1 Assembling a tapered male thread with a tapered female thread (NPT with NPT or BSPT with BSPT), with sealant.

In practice, because of thread shapes and tolerances, standard NPT and BSP threads cannot guarantee water tightness without the use of a sealant such as Teflon tape or pipe sealant. The shape of the NPT thread is however more appropriate than that of the BSPT thread to prevent spiral leakage due to the clearance between the male and female parts at the head and foot of the thread. This disadvantage of the BSPT threads, however, can be easily solved by a sealant.



The shape of the crest of the NPT thread is triangular



The shape of the BSP crest is rounded or truncated

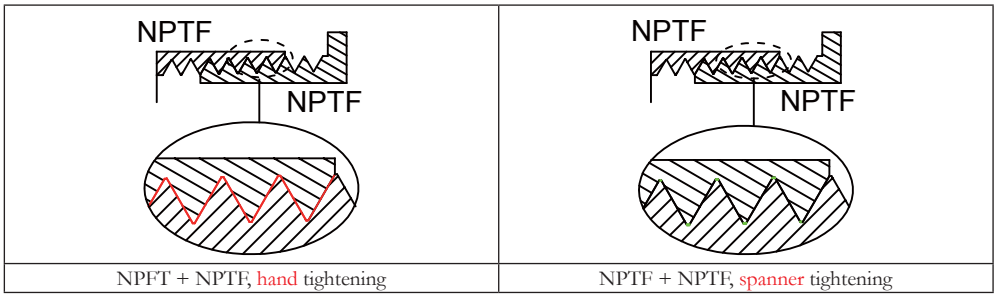
In both types of threads (BSP and NPT), the taper is 1/16, or 6.25% (Originally, this ratio 1/16 corresponded to the ratio between 3/4 of an inch and a foot). Because of this conicity, a tapered male thread can be screwed only a certain length on a parallel thread before locking.

The standards specify this length as the hand tightening length. A general rule is to

tighten by hand then then give one or two turns with a spanner but this tightening depends on the sealant used. The standards give the minimum lengths of threads that need to be in contact, but in practice the lengths of threads are often shorter.

1-2-2 Assembling a tapered male thread with a tapered female thread without sealant on the thread, (NPTF + NPTF) also called Dryseal

A number of variations of the NPT thread have been introduced to solve the spiral leakage problem and are known as "Dryseal" threads (See SAE J476). The best known is the NPTF (F for "Fuel" gasoline). In the NPTF, the design of the male and female thread heads and bottoms was done so that the crest crushes or moves material into the bottom of the thread when tightening. The tight fit between the thread head of one and the bottom of the thread results in a tight junction, not subject to spiral leakage. The ridges of both the male and female portions are in contact with the bottom of the thread before the flanks of the thread touch each other. After a tightening of a turn with a spanner, we can see that the flanks of the nets are touching and that the material of the crests has matted in the bottom of threads.



NPFT + NPTF, hand tightening	NPTF + NPTF, spanner tightening

1-3: Sealing of tapered male threads with parallel threads

1-3-1 Jointing a tapered male thread with a parallel female thread (BSPT + BSPP or NPT + NPSC), with sealant.

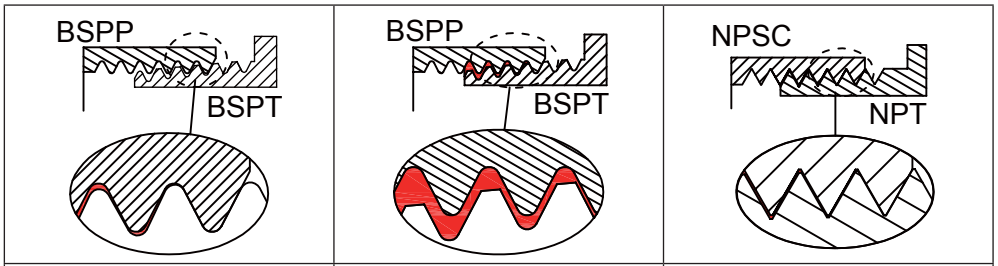
This solution is not considered as the best, but is the most widely used in Europe. In this assembly, the pressure-tightness is achieved by compression of the threads due to tightening. This compression occurs in the first turns of the parallel internal thread. When the tightening is done, the materials of the male and female threads deform one into the other. It is this deformation which theoretically guarantees the tightness

However, despite the standards created to guarantee the size and shape of threads, taper and parallel threads and threads are not accurate and leaks can occur.

The area where the ridge and the bottom of the thread meet can form a spiral leak path that will pass through the first threads where the seal is expected to be achieved, and no tightening can eliminate it.

A general rule is to tighten by hand then then give one or two turns with a spanner but this tightening depends on the sealant used.

The standards give the minimum lengths of threads that need to be in contact, but in practice the lengths of threads are often shorter.



BSPP female with male BSPT	BSPP female with BSPT male with truncated thread	NPT male with female NPSC

Important Note : The ISO 228 standard (Standard defining parallel threads type BSPP) which deals with assemblies where the seal is not made in the thread has defined a truncated male thread with no rounded head of thread. Many builders mistakenly use this form of thread to produce tapered male threads. This form

of truncated thread head causes a much larger spiral leak than the rounded shape, thereby reducing the maximum operating pressure and in extreme cases causing leaks that are impossible to seal.

1-3-2 Assembling a tapered male thread with a parallel female thread (NPTF + NPSF), without sealant, also called Dryseal

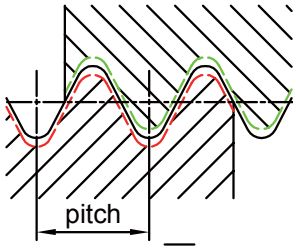
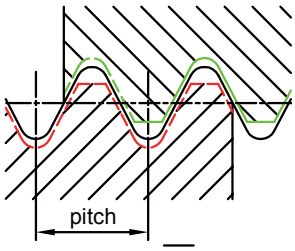
It is the combination of a male NPTF thread with a parallel female variant of the "Dryseal" thread named NPSCF (National Pipe Straight Fuel). It is used to make a satisfactory mechanical connection and a hydraulic seal. (for information, because little used)

2nd section:
Threaded joints with sealing not made on the thread

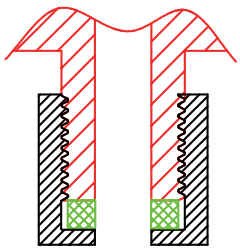
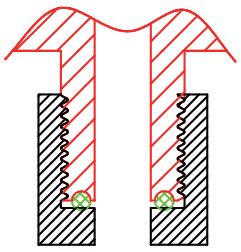
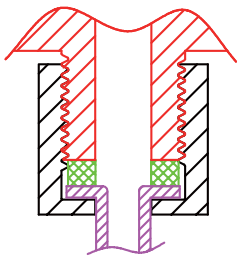
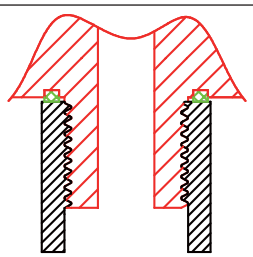
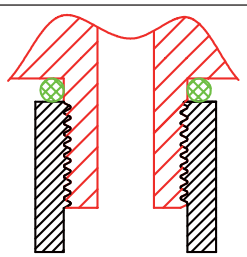
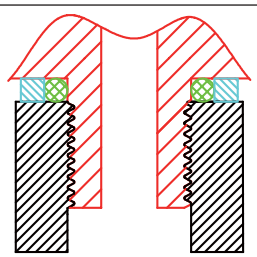
There are dozens of solutions for sealing piping out of threads. Many have been developed over the past two decades, particularly by fitting manufacturers. We will describe the most important methods, and cite the corresponding standards.

The most commonly used is the ISO 228 standard, which deals with pipe joints without sealing on the thread, but only describe Whitworth threads, tolerances and thread shapes, without providing any indication of how to achieve the sealing.

The threads of the assembled parts are most often those defined by ISO 228 (BSPP, with rounded or truncated threads, which has two classes of tolerances: A and B), but also NPT, NPSC, and more rarely, UNF and metric. It is necessary to refer to the specific standards of each of these pipe jointing systems.

	
BSPP female with full thread male BSPP (according to ISO 228)	BSPP female with truncated thread male BSPP (according to ISO228)

2-1 Sealing by gasket between opposite faces

		
Internal flat gasket: the seal is made by compressing a fiber, elastomer or metal gasket. This solution is preferred for mounting pressure measuring devices	Assembly with internal gasket (Flat or O-Ring) inside a groove made on male part. This solution limits the excessive compression of the joint	Assembly with internal flat gasket on a lip, with mobile nut. System often used in conventional plumbing to connect a copper tube.
		
Rigid external flat gasket: sealing is achieved by compressing a fiber or metal gasket. Solution often used on immersion heater	Elastomeric O-ring tightening on a groove or un-threaded part of the male fitting. Often used on the small diameter thermowells of temperature sensors and thermostats	Flat elastomeric gasket or O-ring tightening on un-threaded part of the male fitting, with external metal ring keeping the seal in place and avoiding excessive compression

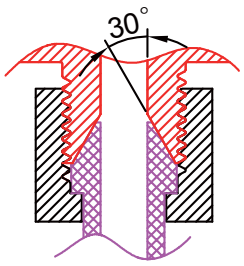
Size of gaskets

Flat seals can be used for inside or outside mounting in cylindrical threaded joints. Table of recommended dimensional values (Threads with ISO 228 and ISO 10226 dimensions, tightening torques provided for metal fittings only).

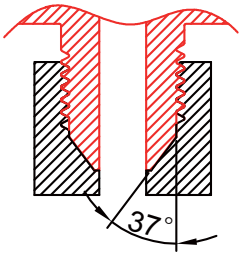
Size (Inch)	Old french nominal size	Internal assembly				External assembly			
		Gasket diameter (mm)		Tightening torque (N.m)		Gasket diameter (mm)		Tightening torque (N.m)	
		Inside	Outside	Fiber	NBR	Inside	Outside	Fiber	NBR
1/8	5-10	8.4	11.9	11	7	9.8	13.6	14	10
1/4	8-13	11.5	15.2	16	11	13.2	17.4	20	14
3/8	12-17	15	19	21	15	16.7	21.2	26	19
1/2	15-21	18.7	23	28	20	21	25.8	36	25
3/4	20-27	24.2	29.2	42	29	26.5	32	50	35
1	26-34	30.3	35.7	56	39	33.3	39.2	68	47
1-1/4	33-42	39	45.8	91	63	42	49	100	70
1-1/2	40-49	44.9	52	108	76	47.8	55	116	81
2	50-60	56.7	63	118	83	59.6	67	147	103

2-2 Sealing by metal cone.

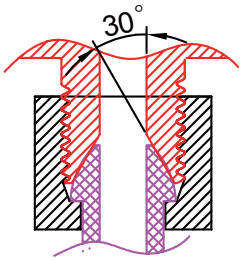
These seals are used when high pressures are reached, or when for sanitary reasons or chemical or thermal resistance of elastomer or fiber gaskets are not possible.



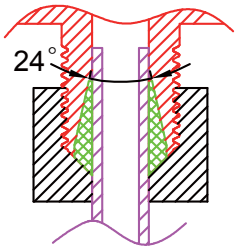
Cone on cone sealing, cone angle 30°



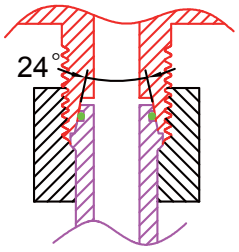
Cone on cone sealing, cone angle 37°



Spherical sealing on cone, cone angle 30°



Cone on cone sealing with attached double cone metal gasket, 24° cone angle

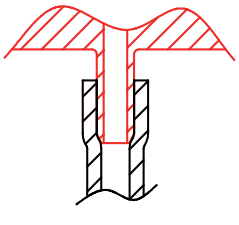


Cone on cone sealing with O-ring or metal gasket in groove, cone angle 24°

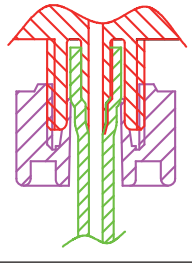
3rd section:
Pipes jointing without thread

3-1 Sealing by deformation of flexible tube:

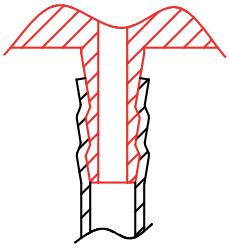
Simple and economical solutions for connections subject to low pressures (less than 1 bar).



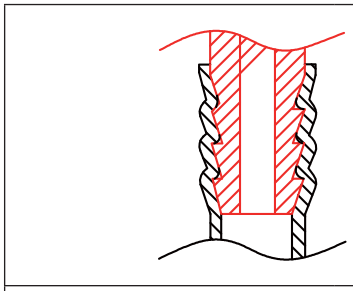
Smooth spout



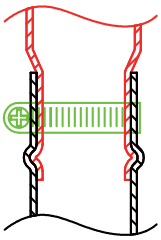
Smooth spout+ locking nut



Grooved spout

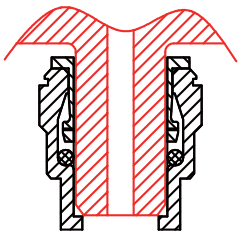


Barbed spout

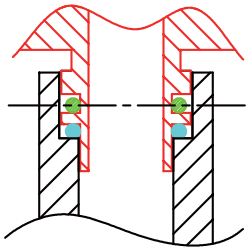


Grooved spout with hose clamp for large diameter tube

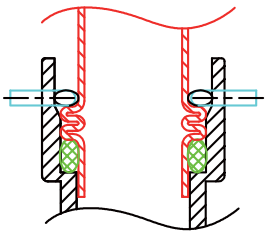
3-2-Joints so-called "quick couplers", most often used in large series applications



Quick coupling style “pressurized air”, locking by claws



Quick connector with double groove, clip lock



Quick connector with double groove, on deformed copper tube, clip lock

4th section:
Common problems of pipes jointing

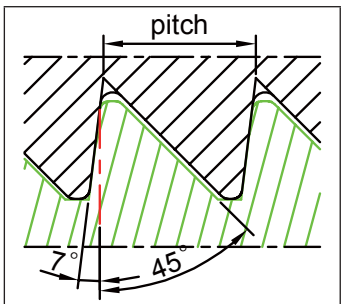
4-1 Problems linked to the use of molded plastic threaded joints

4-1-1 Dimensional Differences of Threads

Originally, pipe threads were designed to be made of machined metal. In the injected plastic parts, deformations of the plastic and the molding shrinkage make it difficult to achieve watertight joint threads.
For this reason, the use of a sealant is recommended on all plastic pipe threads.

4-1-2 Excessive tightening

The major difference between plastics and metals is the behavior of polymers under permanent load.
Indeed, plastic parts continue to deform if they are subjected to a constant load, and this deformation is called creep. In addition, the creep of plastics increases with temperature.
It is in the tapered threads that the permanent stress is the strongest, because the angle of taper of 6.25% exerts a significant constraint on the diameter. It is therefore necessary to greatly reduce the tightening torques of plastic tapered joints.
The deformations on parallel threads are less important because the stress is lower. However these fittings tend to loosen due to the change in diameter due to the 60° or 55° angles of the threads.
If the tightening torque, the temperature or the pressure are too high, these deformations will occur and will inevitably lead to leaks or breakage of the part in a more or less long time.



Buttress thread for plastic fittings used on spas and pools

There is a form of threading adapted to the stress that can be subjected to the plastic nuts and which limits the creep, it is the 7°/45° asymmetrical threading whose flank which undergoes the pressure of the clamping is almost perpendicular to the tube. The most used version of this asymmetrical thread is the "American National Standard Inch Buttress Screw Thread" (Ainsi B1-9-1973). In particular, it is used almost universally in pump and heaters for spas and pool heaters, which are connected to PVC pipes. (Usual diameters 2.5 "- 8 and 3" - 8)

4-1-3 Corrosion of plastic threads

A particular corrosion phenomena can occur when plastic threads are connected to metal pipes.
Chemical etching can occur when the sealants used on the thread are inadequate. In particular, anaerobic pastes and mastics should be avoided as they have generally been designed to fill metal thread leaks. These products may contain chemicals that attack plastics. Therefore, Teflon sealant, in paste or tape is the best choice for plastic threads.

4-2 Connection errors between threads with similar dimensions (metal or plastic).

The BSPT thread with a thread angle of 55° and a taper of 1/16 is not interchangeable with the NPT thread which has a thread angle of 60° and the same taper. The nominal diameters are close and it is not easy for the naked eye to see a difference. In addition, in the nominal size of 1/2 "and 3/4" they both have the same pitch of 14 threads per inch. As a result, they are often confused.

4-2-1 Error # 1: NPT Male in Female BSPP

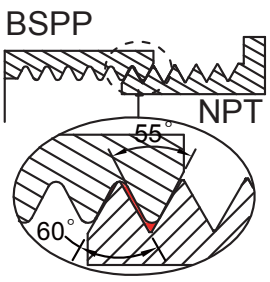
In the nominal sizes 1/16", 1/8", 1/4" and 3/8" the pitch is different, which causes a quick lock during assembly.
Because of the smaller diameter of the BSPP and the difference in pitch, the NTP screws up only a few turns before it locks and the assembly is not waterproof.

4-2-2 Error # 2a: Male NPT in Female BSPT

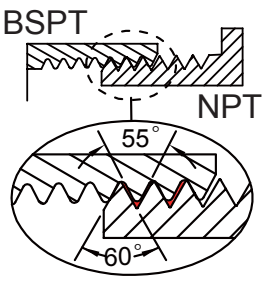
Because the BSPT has a larger diameter, it will allow the NTP to screw more, but the pitch difference and angle differences of the threads cause spiral leakage.

Error # 2b: NPT male in BSPT female in 1/2"and 3/4" sizes

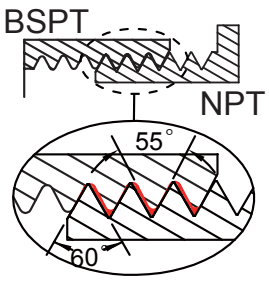
In the particular case of the nominal dimensions 1/2 "and 3/4" the pitch is identical and the assembly will be relatively good, but the difference in angle of the thread will cause a spiral leakage along the thread. It is possible in this particular case to make a tight assembly using a suitable sealant.



Error # 1: Male NPT in female BSPP



Error # 2a: Male NPT in female BSPT



Error # 2b: NPT in BSPT in ½"or ¾" sizes

4-3 Angular Positioning Problems

When two threaded parts are connected to each other, and in particular when this connection is made by compressing a flexible or rigid joint, or by tightening a conical male thread on a female thread conical or cylindrical, it is not possible to predict in advance what will be the relative angular positioning of the two parts, since this positioning will be given by the moment when the seal is waterproof. Some solutions:

Systems with sealing on the thread	Systems with elastomeric flat gasket	Systems with low compressible flat gasket (fiber or copper)	Systems with metal-to-metal sealing
- Use coated polyamide wires: positioning can be adjusted to 90 to 180°	- Use a compressible seal with a thickness of at least 3 times the pitch (eg 6 mm for ½ ") allows adjustment to +/- 180°, but reduces the pressure resistance. A thickness of 1.5 times the pitch, in 80 Shore hardness allows in general a trimming on 90°	- Use a swivel nut - Make a first assembly with manual tightening, estimate the position with complete tightening (which will generally be between 90° and 180° extra), if this estimated position does not correspond to that desired, change the seal for a different thickness. For this type of adjustment, it is necessary to have 4 sets of joints of different thickness, the step between each thickness being equal to ¼ of the pitch. For example for a ½ "thread (1.814 pitch, it will be necessary to have 2, 2.5, 3 and 3.5 mm seals	- Use a swivel nut