

ISO and NPT Pipe Threads

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Issue	Reason for Revision	Author	Checked/ Approved
01 : 08/09	1 st issue in new format for standards. Replaces engineering standard 7.30-1, issue 1, 24.2.78.	TJB	MC
02 : 04/11	Number changed in accordance with new company document numbering policy. Standards presented as a table in Appendix 1.	TJB	MC
03 : 01/12	Revision history table revised to include checked/approved initials.	TJB	MC
Table 1 Revision History			

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1. Introduction

When coupling pipes together and attaching pipes to components, screwed fittings are often used as opposed to compression couplings or soldered or welded connections.

The **British Standard Pipe thread (BSP thread)** is a family of standard screw threads that has been adopted internationally, by the ISO (International Organization for Standardisation), for interconnecting and sealing pipe ends by the mating of an external (male) thread with an internal (female) thread. In America, the **National Pipe Thread (NPT)** has been adopted by ANSI (American National Standards Institute).

This guide provides details of these pipe threads, including dimensions, code designations and reference information.

2. Thread Types

Two types of pipe threads are distinguished:

- **Parallel ('straight') thread** whose diameter remains constant along the length of the thread. The threaded section does not provide any sealing function other than some labyrinth seal effect, which may not be enough to satisfy either functional or code requirements. With parallel pipe threads, the seal is usually provided by an 'O' ring or gasket seated between the shoulder of the male pipe section and an interior surface on the female part.
- **Tapered thread** whose diameter increases or decreases along the length of the thread. A tapered thread is used in plumbing installations for the delivery of gases or fluids under pressure. The seal depends upon the labyrinth seal created by the threads; upon a positive seal between the threads created by the deformation of the threads when they are tightened to the proper torque; and on the presence of a sealing coating, such as thread seal tape (e.g. "Teflon" tape) or a liquid or paste pipe sealant (e.g. "Loctite 577" thread sealant). Tapered thread joints typically do not include an 'O' ring or gasket.

Especially precise or fine threads are known as "dry fit" or "dry seal" meaning that no sealant is required for a gas-tight seal. Such threads are needed where the sealant would contaminate or react with the media inside the piping, e.g., piping for oxygen service.

Due to the taper (cone) of the thread, when tapered threads are cut by a tap or a die, the amount of material being cut increases as the length of the thread is increased, and the force required to cut the thread therefore increases. It is therefore common to use powered thread cutting tools when producing tapered threads on pipes with diameters greater than one inch.

Pipe threads used in hydraulic circuits can be divided into two types:

- **Fastening threads** – are pipe threads where pressure-tight joints are not made on the threads. Both threads are parallel and sealing is affected by compression of a soft material onto the external thread, or a flat gasket.
- **Jointing threads** – are pipe threads where pressure-tight joints are made on the threads. The mating of the male and female threads forms the seal. They always use a taper male thread, but can have either parallel or taper female threads. The sealing effect is improved by using a jointing compound. (In Europe, taper female pipe threads are not commonly used.)

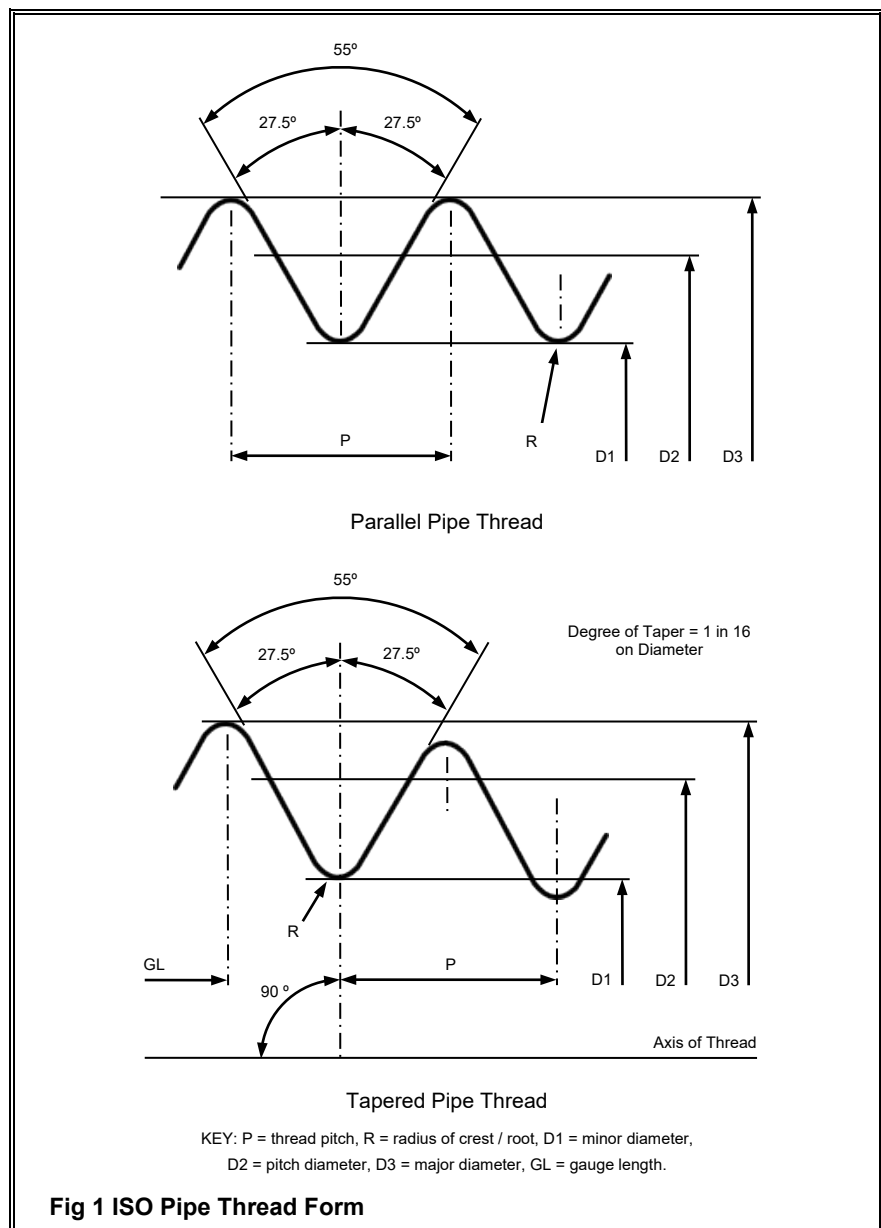
3. ISO Pipe Thread

3.1. ISO Pipe Thread Form

The form of the ISO pipe thread is as follows:

- Symmetrical V-thread in which the angle between the flanks is 55° (measured in an axial plane).
- One-sixth of this sharp V is truncated at the top and the bottom.
- The threads are rounded equally at crests and roots by circular arcs ending tangentially with the flanks.
- The theoretical depth of the thread is $0.64 \times$ the nominal pitch.

Fig 1 shows the thread forms for both parallel and tapered threads. Dimensions are given in Table 2 and Table 3.



3.2. ISO Pipe Thread Dimensions

Various thread sizes are listed and defined within the standards for pipe threads, ranging from 1/16 to 6. The size number was originally based on the inner diameter, measured in inches (1 inch = 25.4 mm), of a steel tube for which the thread was intended, but is now simply a size reference number in the modern metric version of the standards.

3.2.1. ISO Parallel Pipe Thread Dimensions

Table 2 gives dimensions of the standard range of parallel pipe threads. The thread form is shown in Fig 1 and described in 3.1 ISO Pipe Thread Form.

Thread Size	Threads Per 25.4 mm	Pitch P (mm)	Radius R (mm)	Minor Diameter D1 (mm)	Pitch Diameter D2 (mm)	Major Diameter D3 (mm)
1/16	28	0.907	0.125	6.561	7.142	7.723
1/8	28	0.907	0.125	8.566	9.147	9.728
1/4	19	1.337	0.184	11.445	12.301	13.157
3/8	19	1.337	0.184	14.950	15.806	16.662
1/2	14	1.814	0.249	18.631	19.793	20.955
5/8	14	1.814	0.249	20.587	21.749	22.911
3/4	14	1.814	0.249	24.117	25.279	26.411
7/8	14	1.814	0.249	27.877	29.039	30.201
1	11	2.309	0.317	30.291	31.770	33.249
1 1/8	11	2.309	0.317	34.939	36.418	37.897
1 1/4	11	2.309	0.317	36.952	40.431	41.910
1 1/2	11	2.309	0.317	44.845	46.324	47.803
1 3/4	11	2.309	0.317	50.788	52.267	53.746
2	11	2.309	0.317	56.656	58.135	59.614
2 1/4	11	2.309	0.317	62.752	64.231	65.710
2 1/2	11	2.309	0.317	72.226	73.705	75.184
2 3/4	11	2.309	0.317	78.576	80.055	81.534
3	11	2.309	0.317	84.926	86.405	87.884
3 1/2	11	2.309	0.317	97.370	98.851	100.83
4	11	2.309	0.317	110.072	111.551	113.03
4 1/2	11	2.309	0.317	122.772	124.251	125.73
5	11	2.309	0.317	135.472	136.951	138.43
5 1/2	11	2.309	0.317	148.172	149.651	151.13
6	11	2.309	0.317	160.872	162.351	163.83

Table 2 ISO Parallel Pipe Thread Dimensions

3.2.2. ISO Tapered Pipe Thread Dimensions

Table 3 gives dimensions of the standard range of tapered pipe threads. The thread form is shown in Fig 1.

Thread Size	Threads Per 25.4 mm	Pitch P (mm)	Radius R (mm)	Minor Diameter D1 (mm)	Pitch Diameter D2 (mm)	Nominal Gauge Length GL (mm)	Major Diameter D3 (mm)
1/16	28	0.907	0.125	6.561	7.142	4	7.723
1/8	28	0.907	0.125	8.566	9.147	4	9.728
1/4	19	1.337	0.184	11.445	12.301	6	13.157
3/8	19	1.337	0.184	14.950	15.806	6.4	16.662
1/2	14	1.814	0.249	18.631	19.793	8.2	20.955
3/4	14	1.814	0.249	24.117	25.279	9.5	26.411
1	11	2.309	0.317	30.291	31.770	10.4	33.249
1 1/4	11	2.309	0.317	36.952	40.431	12.7	41.910
1 1/2	11	2.309	0.317	44.845	46.324	12.7	47.803
2	11	2.309	0.317	56.656	58.135	15.9	59.614
2 1/2	11	2.309	0.317	72.226	73.705	17.5	75.184
3	11	2.309	0.317	84.926	86.405	20.6	87.884
4	11	2.309	0.317	110.072	111.551	25.4	113.03
5	11	2.309	0.317	135.472	136.951	28.6	138.43
6	11	2.309	0.317	160.872	162.351	28.6	163.83

The Major Diameter is measured at the Nominal Gauge Length from the small end of the thread.

Table 3 ISO Tapered Pipe Thread Dimensions

3.3. Additional Terminology

The following terms may be encountered on ISO pipe thread dimension tables. Most are applicable only to taper thread assemblies.

- **Accommodation Length** – Distance from the face of the internal thread to the first obstruction which the externally threaded component will encounter on tightening;
- **Assembly Length (Fitting Allowance)** - Useful thread beyond the gauge plane on an external thread required to provide an assembly with an internal thread at the upper limit of tolerance. This includes the wrenching allowance;
- **Complete Thread** – The thread which is full formed at both crest and root;
- **Crest** – The radius formed at the top of the thread;
- **Gauge Length** – On external threads the distance from the gauge plane to the small end of the thread;
- **Gauge Plane** – Plane on taper threads, which is perpendicular to the thread axis, at which the major cone has gauge diameter;

- **Major Cone** – Imaginary cone on a taper thread which touches the crest of all external threads or the roots of all internal threads;
- **Root** – Radius formed at the bottom of the thread;
- **Useful Tread** – All thread excluding washout thread;
- **Washout Thread** – Thread which is not full formed at the root;
- **Wrenching Length (Wrenching Allowance)** – Useful thread length provided to accommodate the relative movement when wrenching from the hand tight position to the fully tightened position.

3.4. ISO Pipe Thread Designations

The designation code for identifying an ISO pipe thread is made up of the following:

- The words "Pipe Thread";
- The document number of the standard (e.g., "ISO 278" or "EN 10226");
- The pipe thread type designation letter (refer to Table 4);
- The thread size (refer to Table 2 and Table 3).

Threads are normally right-hand. For left-hand threads, the letters "LH" are appended.

Designation Symbol	Thread Type	Example
G	Parallel thread (formally BSPP - British Standard Pipe Parallel thread)	-
GA	Parallel thread to class A tolerance	-
GB	Parallel thread to class B tolerance	-
R	External taper thread (formally BSPT - British Standard Pipe Taper thread)	-
R _p	Internal parallel thread	Pipe Thread EN 10226 R _p 3/4 LH (LH denotes a left-hand thread)
R _c	Internal taper thread	Pipe Thread ISO 228 R _c 3/4
R _s	External parallel thread	Pipe Thread EN 10226 G 3/4
R _L	Longscrew thread	Pipe Thread BS 21 R _L 3/4
Table 4 ISO Pipe Thread Designation Letters		

The terminology for the use of **G** and **R** originated from Germany (G for Gas, as it was originally designed for use on gas pipes, and R for Rohr, meaning pipe).

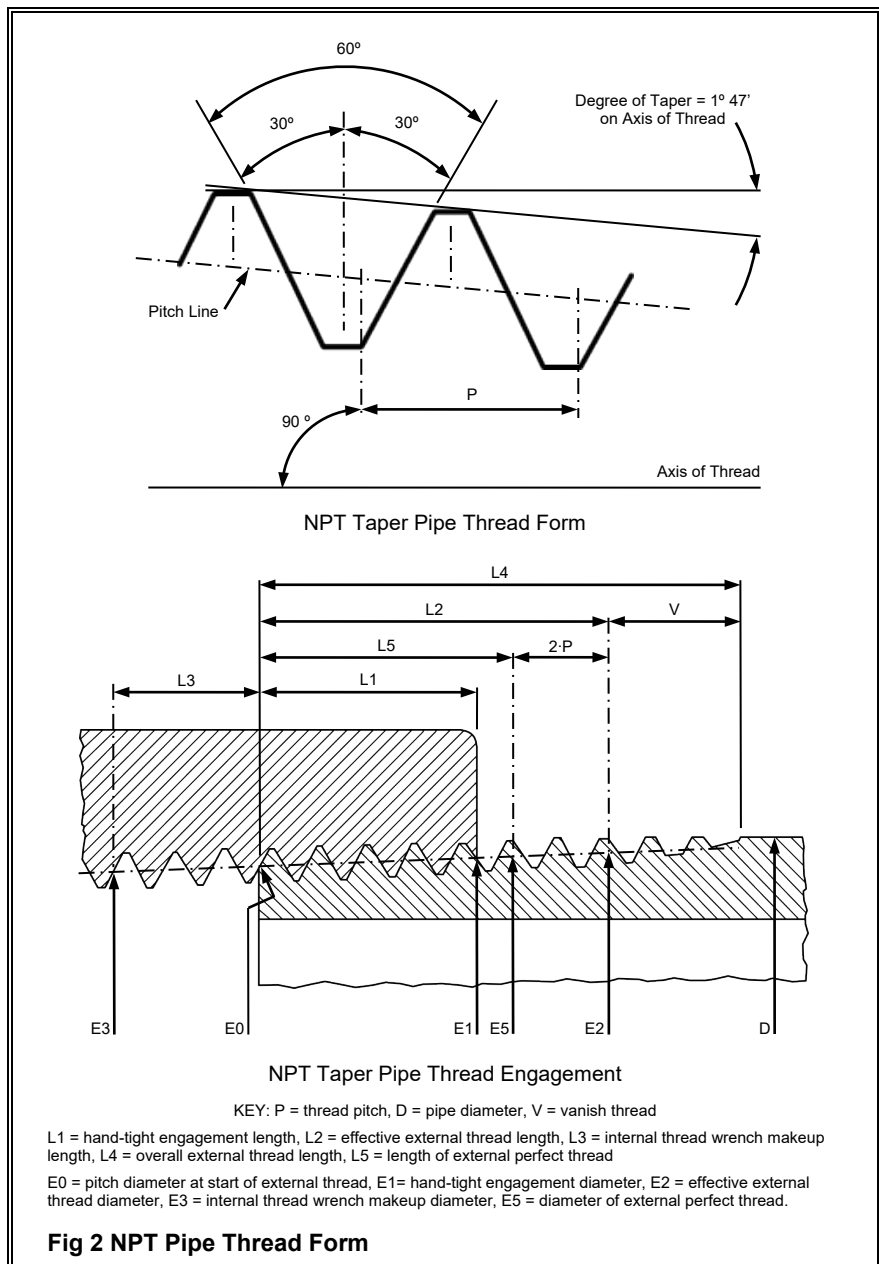
4. NPT Taper Pipe Thread

4.1. NPT Tapered Pipe Thread Form

The form of the NPT pipe thread is as follows:

- Symmetrical V-thread in which the angle between the flanks is 60° (measured in an axial plane).
- One-sixth of this sharp V is truncated at the top and the bottom.
- The threads are finished equally at crests and roots by flats ending tangentially with the flanks.
- The theoretical depth of the thread is $0.8 \times$ the nominal pitch.

Fig 1 shows the thread form for a NPT tapered thread. Dimensions are given in Table 5.



4.2. NPT Tapered Pipe Thread Dimensions

Various thread sizes are listed and defined within the standards for pipe threads, ranging from 1/16 to 24 inch. Commonly-used sizes are 1/8, 1/4, 3/8, 1/2, 3/4, 1, 1 1/4, 1 1/2, and 2 inch, with the larger sizes being used less frequently as other methods of pipe joining are more practical at 3 inches and above for most applications.

Table 5 gives dimensions of the NPT tapered pipe threads. The thread form is shown in Fig 2 and described in 4.1 NPT Tapered Pipe Thread Form.

Nominal Pipe Size	Outside Diameter of Pipe D (in)	Threads per inch	Pitch P (in)	Vanish Thread V (in)	Pitch Diameter at Beginning of Ext. Thread E0 (in)	Hand-tight Engagement	
						Length ¹ L1 (in)	Diameter ² E1 (in)
1/16	0.313	27	0.03704	0.1285	0.27118	0.160	0.28118
1/8	0.405	27	0.03704	0.1285	0.36351	0.162	0.37360
1/4	0.540	18	0.05556	0.1928	0.47739	0.228	0.49163
3/8	0.675	18	0.05556	0.1928	0.61201	0.240	0.62701
1/2	0.840	14	0.07143	0.2478	0.75843	0.320	0.77843
3/4	1.050	14	0.07143	0.2478	0.96768	0.339	0.98887
1	1.315	11.5	0.08696	0.3017	1.21363	0.400	1.23863
1 1/4	1.660	11.5	0.08696	0.3017	1.55713	0.420	1.58338
1 1/2	1.900	11.5	0.08696	0.3017	1.79609	0.420	1.82234
2	2.375	11.5	0.08696	0.3017	2.26902	0.436	2.29627
2 1/2	2.875	8	0.12500	0.4337	2.71953	0.682	2.76216
3	3.500	8	0.12500	0.4337	3.34062	0.766	3.38850
3 1/2	4.000	8	0.12500	0.4337	3.83750	0.821	3.88881
4	4.500	8	0.12500	0.4337	4.33438	0.844	4.38712
5	5.563	8	0.12500	0.4337	5.39073	0.937	5.44929
6	6.625	8	0.12500	0.4337	6.44609	0.958	6.50597
8	8.625	8	0.12500	0.4337	8.43359	1.063	8.50003
10	10.750	8	0.12500	0.4337	10.54531	1.210	10.62094
12	12.750	8	0.12500	0.4337	12.53281	1.360	12.61781
14	14.000	8	0.12500	0.4337	13.77500	1.562	13.87262
16	16.000	8	0.12500	0.4337	15.76250	1.812	18.57575
18	18.000	8	0.12500	0.4337	17.75000	2.000	17.87500
20	20.000	8	0.12500	0.4337	19.73750	2.125	19.87031
24	24.000	8	0.12500	0.4337	23.71250	2.375	23.86094

Table 5 NPT Tapered Pipe Thread Dimensions

Nominal Pipe Size	Effective Thread, External		Wrench Make-up Length for Internal Thread		Overall Length of External Thread ⁴ L4 (in)	Nominal Complete External Threads ⁵	
	Length ³ L2 (in)	Diameter E2 (in)	Length L3 (in)	Diameter E3 (in)		Length L5 (in)	Diameter E5 (in)
1/16	0.2611	0.28750	0.1111	0.26424	0.3896	0.1870	0.28287
1/8	0.2639	0.38000	0.1111	0.35656	0.3924	0.1898	0.37537
1/4	0.4018	0.50250	0.1667	0.46697	0.5946	0.2907	0.49556
3/8	0.4078	0.63750	0.1667	0.60160	0.6006	0.2967	0.63056
1/2	0.5337	0.79179	0.2143	0.74504	0.7815	0.3909	0.78286
3/4	0.5457	1.00179	0.2143	0.95429	0.7935	0.4029	0.99286
1	0.6828	1.25630	0.2609	1.19733	0.9845	0.5089	1.24543
1 1/4	0.7068	1.60130	0.2609	1.54083	1.0085	0.5329	1.59043
1 1/2	0.7235	1.84130	0.2609	1.77978	1.0252	0.5496	1.83043
2	0.7565	2.31630	0.2609	2.25272	1.0582	0.5826	2.30543
2 1/2	1.1375	2.79062	0.2500	2.70391	1.5712	0.8875	2.77500
3	1.2000	3.41562	0.2500	3.32500	1.6337	0.9500	3.40000
3 1/2	1.2500	3.91562	0.2500	3.82188	1.6837	1.0000	3.90000
4	1.3000	4.41562	0.2500	4.31875	1.7337	1.0500	4.40000
5	1.4063	5.47862	0.2500	5.37511	1.8400	1.1563	5.46300
6	1.5125	6.54062	0.2500	6.43047	1.9462	1.2625	6.52500
8	1.7125	8.54062	0.2500	8.41797	2.1462	1.4625	8.52500
10	1.9250	10.66562	0.2500	10.52969	2.3587	1.6750	10.65000
12	2.1250	12.66562	0.2500	12.51719	2.5587	1.8750	12.65000
14	2.2500	13.91562	0.2500	13.75938	2.6837	2.0000	13.90000
16	2.4500	15.91562	0.2500	15.74688	2.8837	2.2000	15.90000
18	2.6500	17.91562	0.2500	17.73438	3.0837	2.4000	17.90000
20	2.8500	19.91562	0.2500	19.72188	3.2837	2.6000	19.90000
24	3.2500	23.91562	0.2500	23.69688	3.6837	3.0000	23.90000

The basic dimensions are given in inches to four or five decimal place. While this implies a greater deal of precision than is ordinarily attained, these dimensions form the basis if gauge dimensions and are so expressed for the purpose of eliminating errors in calculations.

¹ Also length of thin ring gauge and length from gauging notch to small end of plug gauge.

² Also pitch diameter at gauging notch.

³ Also length of plug gauge.

⁴ Reference dimension only.

⁵ The length L5 from the end of the pipe determines the plane beyond which the thread form is incomplete at the crest. The next two threads are complete at the root. At this plane the cone formed by the crests of the thread intersects the cylinder forming the external surface of the pipe. $L5 = L2 - 2P$.

Table 4 (continued) NPT Tapered Pipe Thread Dimensions

4.3. NPT Pipe Thread Variations

NPT threads are often referred to as MPT, MNPT, or NPT(M) for male external threads; and FPT, FNPT, or NPT(F) for female (internal) threads. An equivalent designation is MIP (male iron pipe) and FIP (female iron pipe). Also the terms NPS and NPSM are sometimes used to designate a parallel, instead of taper, thread (this should not be confused with NPS meaning Nominal Pipe Size).

NPT taper threads allow a seal to be formed when the correct torque is applied as the flanks of the threads compress against each other. However a clearance remains between the crests and roots of the threads, resulting in a leakage around this spiral. This means that NPT fittings must be made leak-free with the aid of thread seal tape or a liquid or paste pipe sealant. Note that the use of tape or sealant will also help to limit corrosion on the threads, which otherwise can make future disassembly nearly impossible.)

A semi-compatible variant called National Pipe Thread Tapered Fine (NPTF), also called Dryseal American National Standard Taper Pipe Thread, is designed to provide a more leak-free seal without the use of thread seal tape or a liquid or paste pipe sealant. NPTF threads are the same basic shape but with crest and root heights adjusted for an interference fit, eliminating the spiral leakage path.

5. Compatibility

Threads to ISO 7 standard are not interchangeable with threads to ISO 228 standard.

Also, ISO threads are not interchangeable with NPT threads. Even though they look similar ISO threads have a 55° taper angle versus 60° for NPT and the pitch and root and crest configurations are also different.

6. References for Further Information

Publication Number	Title
BS 21 ¹	Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads (metric dimensions).
BS EN 10226-1 ²	Pipe threads where pressure-tight joints are made on the threads. Part 1: Taper external threads and parallel internal threads. Dimensions, tolerances and designation.
BS EN 10226-2	Pipe threads where pressure-tight joints are made on the threads. Part 2: Taper external threads and taper internal threads. Dimensions, tolerances and designation.
BS EN 10226-3	Pipe threads where pressure-tight joints are made on the threads. Part 3: Verification by means of limit gauges.
BS EN ISO 228-1	Pipe threads where pressure-tight joints are not made on the threads. Part 1: Dimensions, tolerances and designation.
BS EN ISO 228-2	Pipe threads where pressure-tight joints are not made on the threads. Part 2: Verification by means of limit gauges.
ISO 7-1	Pipe threads where pressure-tight joints are made on the threads. Part 1: Dimensions, tolerances and designation.
ISO 7-2	Pipe threads where pressure-tight joints are made on the threads. Part 2: Verification by means of limit gauges.
ISO 228-1	Pipe threads where pressure-tight joints are not made on the threads. Part 1: Dimensions, tolerances and designation.
ISO 228-2	Pipe threads where pressure-tight joints are not made on the threads. Part 2: Verification by means of limit gauges.
ANSI B 1.20.1	NPT American Taper Pipe Thread.
ANSI B 1.20.3	NPTF American Taper Pipe Thread.
<p>¹This standard has been part superseded and is applicable only for long screw threads and internal taper / external taper thread combinations.</p> <p>²This standard part supersedes BS 21.</p> <p>Revision numbers and/or issue dates correct at date of issue. The latest revision of a document or its applicable replacement where it has been superseded shall apply.</p> <p>Table 6 List of Standards</p>	