

Instruction  
Hardware Engineering

No. LMS 6-4

Subject: Pipe Threads

APPROVED BY Manager, Hardware Engineering

STATUS Maintenance Revision

PURPOSE Establishes requirements for the manufacture and inspection of pipe threads. L-3 Communications Corporation, Link Simulation & Training Division (hereafter referred to as Link) personnel shall follow the requirements of this instruction when manufacturing and inspecting pipe threads.

AFFECTED FUNCTIONS Hardware Engineering  
Manufacturing

REFERENCES ANSI B94.11M-79 Twist Drills Straight Shank and Taper Shank  
Combined Drills and Countersinks  
MIL-P-7105 Pipe Threads, Taper, Aeronautical National  
Form, Symbol ANPT, General Requirements  
for

DEFINITIONS None

#### INSTRUCTION

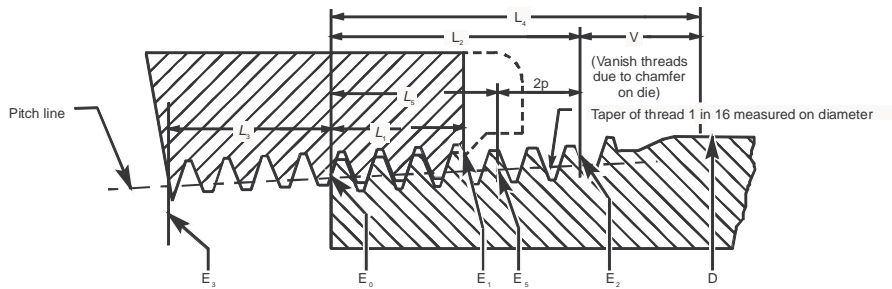
##### 1. Requirements

CAUTION	
The nominal sizes used to identify pipe sizes and pipe threads are very different from the actual outside dimensions of the pipe. Therefore, caution must be used in determining the amount of metal required for machining an external pipe thread or the size of the hole required to accept such a thread. The amount of this difference can be seen from the following examples:	
<u>Nominal Pipe Size</u>	<u>Actual OD of Pipe</u>
1/16	5/16
1/2	27/32
1	1 5/16
2	2 3/8

1.1 Standard dimensions. The standard dimensions to be used for the four types of pipe threads which may be called out on engineering drawings are noted in the following paragraphs.

- a. American National Standard Taper Pipe Thread (NPT). The dimensions for this series of pipe threads, which are considered standard at Raytheon, shall be in accordance with Table I.

**Table I Basic Dimensions of American National Standard Taper Pipe Thread, NPT<sup>1</sup>**



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For all dimensions, see corresponding reference letters in Table I.

Angle between sizes of thread is 60 degrees. Taper thread on diameter is 3/4 inch per foot. Angle of taper with centerline is 1\_ 47'.

The basic maximum thread height of the truncated thread is .8 x pitch of thread. The crest and root are truncated a minimum of .033 x pitch for all pitches.

Nominal Pipe Size	OD of Pipe (D)	Threads/In. (n)	Pitch of Thread (P)	Pitch Dia. at Beginning of External Thread (E <sub>0</sub> )	Handtight Engagement			Effective Thread-External		
					Length <sup>2</sup> (L <sub>1</sub> )		Dia <sup>3</sup> (E <sub>1</sub> )	Length <sup>4</sup> (L <sub>2</sub> )		Dia (E <sub>2</sub> )
					Inch	Threads		Inch	Threads	
1	2	3	4	5	6	7	8	9	10	11
1/16	.312	27	.03704	.27118	.160	4.32	.28118	.2611	7.05	.28750
1/8	.405	27	.03704	.36351	.1615	4.36	.37360	.2639	7.12	.38000
1/4	.540	18	.05556	.47739	.2278	4.10	.49163	.4018	7.23	.50250
3/8	.675	18	.05556	.61201	.240	4.32	.62701	.4078	7.34	.63750
1/2	.840	14	.07143	.75843	.320	4.48	.77843	.5337	7.47	.79179
3/4	1.050	14	.07143	.96768	.339	4.75	.98887	.5457	7.64	1.00179
1	1.315	11.5	.08696	1.21363	.400	4.60	1.23863	.6828	7.85	1.25630
1-1/4	1.660	11.5	.08696	1.55713	.420	4.83	1.58338	.7068	8.13	1.60130
1-1/2	1.900	11.5	.08696	1.79609	.420	4.83	1.82234	.7235	8.32	1.84130
2	2.375	11.5	.08696	2.26902	.436	5.01	2.29627	.7565	8.70	2.31630
2-1/2	2.875	8	.12500	2.71953	.682	5.46	2.76216	1.1375	9.10	2.79062
3	3.500	8	.12500	3.34062	.766	6.13	3.38850	1.2000	9.60	3.41562
3-1/2	4.000	8	.12500	3.83750	.821	6.57	3.88881	1.2500	10.00	3.91562
4	4.500	8	.12500	4.33438	.844	6.75	4.38712	1.3000	10.40	4.41562

**Table I Basic Dimensions of American National Standard  
Taper Pipe Thread, NPT<sup>1</sup> (Cont.)**

Nominal Pipe Size	Length, $L_1$ Plane to $L_2$ Plane External Thread ( $L_2 - L_1$ )		Wrench Makeup Length for Internal Thread <sup>7</sup>			Vanish Thread (V)		Overall <sup>8</sup> Length External Thread ( $L_4$ )	Nominal Complete External Threads <sup>5</sup>		Height of Thread ( $h$ )	Increase in Dia./ Thread (.0625/ $n$ )	Basic <sup>6</sup> Minor Dia. at Small End of Pipe ( $K_0$ )
			Length ( $L_3$ )		Dia. ( $E_3$ )				Length ( $L_5$ )	Dia. ( $E_5$ )			
	In.	Thread	In.	Thread		In.	Thread						
<b>1</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>	<b>17</b>	<b>18</b>	<b>19</b>	<b>20</b>	<b>21</b>	<b>22</b>	<b>23</b>	<b>24</b>
1/16	.1011	2.73	.1111	3	.26424	.1285	3.47	.3896	.1870	.28287	.02963	.00231	.2416
1/8	.1024	2.76	.1111	3	.35656	.1285	3.47	.3924	.1898	.37537	.02963	.00231	.3339
1/4	.1740	3.13	.1667	3	.46697	.1928	3.47	.5946	.2907	.49556	.04444	.00347	.4329
3/8	.1678	3.02	.1667	3	.60160	.1928	3.47	.6006	.2967	.63056	.04444	.00347	.5676
1/2	.2137	2.99	.2143	3	.74504	.2478	3.47	.7815	.3909	.78286	.05714	.00446	.7013
3/4	.2067	2.89	.2143	3	.95429	.2478	3.47	.7935	.4029	.99286	.05714	.00446	.9105
1	.2828	3.25	.2609	3	1.19733	.3017	3.47	.9845	.5089	1.24543	.06957	.00543	1.1441
1-1/4	.2868	3.30	.2609	3	1.54083	.3017	3.47	1.0085	.5329	1.59043	.06957	.00543	1.4876
1-1/2	.3035	3.49	.2609	3	1.77978	.3017	3.47	1.0252	.5496	1.83043	.06957	.00543	1.7265
2	.3205	3.69	.2609	3	2.25272	.3017	3.47	1.0582	.5826	2.30543	.06957	.00543	2.1995
2-1/2	.4555	3.64	.2500	2	2.70391	.4337	3.47	1.5712	.8875	2.77500	.10000	.00781	2.6195
3	.4340	3.47	.2500	2	3.32500	.4337	3.47	1.6337	.9500	3.40000	.10000	.00781	3.2406
3-1/2	.4290	3.43	.2500	2	3.82188	.4337	3.47	1.6837	1.0000	3.90000	.10000	.00781	3.7375
4	.4560	3.65	.2500	2	4.31875	.4337	3.47	1.7337	1.0500	4.40000	.10000	.00781	4.2344

NOTES:

- The basic dimensions of the American National Standard Taper Pipe Thread are given in inches to four or five decimal places. While this implies a greater degree of precision than ordinarily attained, these dimensions are the basis of gage dimensions and are so expressed for the purpose of eliminating errors in computations.
- Also length of thin ring gage and length from gaging notch to small end of plug gage.
- Also pitch diameter at gaging notch (handtight plane).
- Also length of plug gage.
- The length  $L_5$  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,  
 $L_5 = L_2 - 2p$ .
- Given as information for use in selecting tap drills.
- Military Specification MIL-P-7105 gives the wrench makeup as three threads for sizes 3 and smaller. The E3 dimensions are as follows:  
  
Nominal pipe size 2-1/2 = 2.69609 and size 3 = 3.31719, sizes 2 and smaller same as above, col 16.
- Reference dimension.

- b. Free-fitting mechanical joints for fixtures (NPSM). This straight pipe thread series shall be in accordance with Table II.

**Table II Dimensions of External and Internal Straight Pipe Threads for  
Fixtures, NPSM**

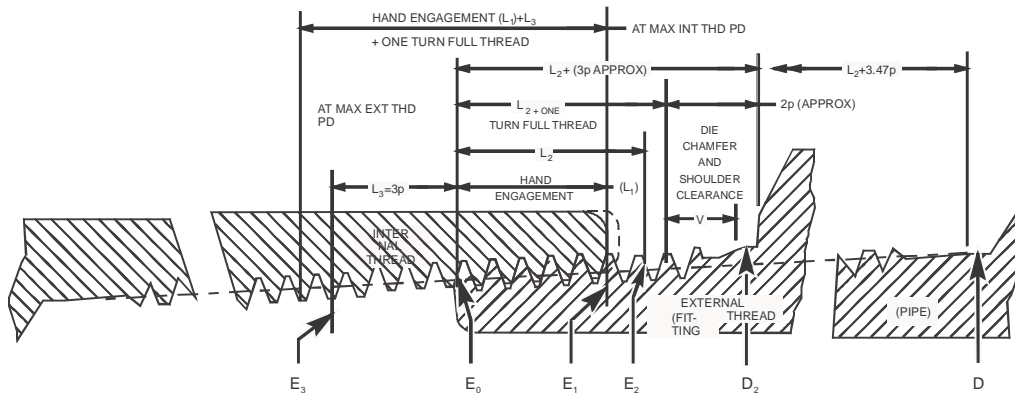
Nom. Pipe Size	OD of Pipe (D)	Threads per In.	Allowance	External Thread, Class 2A				Internal Thread, Class 2B			
				Major Diameter		Pitch Diameter		Major Diameter		Pitch Diameter	
				Maxi-mum	Mini-mum	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum	Maxi-mum <sup>1</sup>	Mini-mum
1	2	3	4	5	6	7	8	9	10	11	12
1/8	.405	27	.0011	.397	.390	.3725	.3689	.358	.364	.3736	.3783
1/4	.540	18	.0013	.526	.517	.4903	.4859	.468	.481	.4916	.4974
3/8	.675	18	.0014	.662	.653	.6256	.6211	.603	.612	.6270	.6329
1/2	.840	14	.0015	.823	.813	.7769	.7718	.747	.759	.7784	.7851
3/4	1.050	14	.0016	1.034	1.024	.9873	.9820	.958	.970	.9889	.9958
1	1.315	11.5	.0017	1.293	1.281	1.2369	1.2311	1.201	1.211	1.2386	1.2462
1 1/4	1.660	11.5	.0018	1.638	1.626	1.5816	1.5756	1.546	1.555	1.5834	1.5912
1 1/2	1.900	11.5	.0018	1.877	1.865	1.8205	1.8144	1.785	1.794	1.8223	1.8302
2	2.375	11.5	.0019	2.351	2.339	2.2944	2.2882	2.259	2.268	2.2963	2.3044
2 1/2	2.875	8	.0022	2.841	2.826	2.7600	2.7526	2.708	2.727	2.7622	2.7720
3	3.500	8	.0023	3.467	3.452	3.3862	3.3786	3.334	3.353	3.3885	3.3984
3 1/2	4.000	8	.0023	3.968	3.953	3.8865	3.8788	3.835	3.848	3.8888	3.8988
4	4.500	8	.0023	4.466	4.451	4.3848	4.3771	4.333	4.346	4.3871	4.3971
5	5.563	8	.0024	5.528	5.513	5.4469	5.4390	5.395	5.408	5.4493	5.4598
6	6.625	8	.0024	6.585	6.570	6.5036	6.4955	6.452	6.464	6.5060	6.5165

NOTES:

- Column 11 is the same as the pitch diameter at the large end of internal thread  $E_1$ , *Basic*. (See Table I, column 8.)
- NPSM threads are of United screw thread form to Classes 2A/2B tolerances, having the minimum pitch diameter of the internal thread basic and equal to  $E_1$  of NPT threads.
- The minor diameters of external threads and major diameters of internal threads are those as produced by commercial straight pipe dies and commercial ground straight pipe taps. The major diameter of the external thread has been calculated on the basis of a truncation of  $.10825p$ , and the minor diameter of the internal thread has been calculated on the basis of a truncation of  $.21651p$ , to provide no interference at crest and root when product is gaged.

- c. Dryseal, American Standard Taper Pipe Thread (NPTF). This series of threads differs from NPT, as their purpose is to seal pressure joints without the necessity of using sealing compound and shall be in accordance with Table III.

Table III Basic Dimensions For NPTF Threads



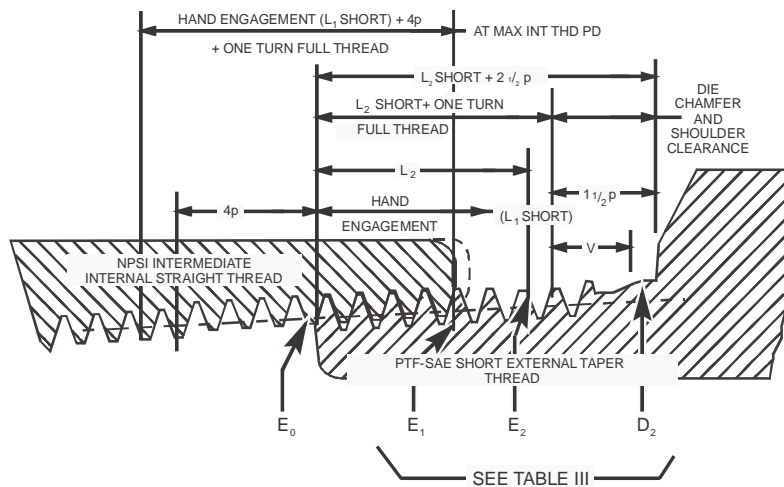
Size	Pitch (p)	PD at Small End of Ext. Thread ( $E_0$ )	PD at Large End of Int. Thread ( $E_1$ )	PD at Large End of Ext. Thread ( $E_2$ )	PD at Small End of Int. Thread ( $E_3$ )	Hand Engagement ( $L_1$ )		Length of Full Thread ( $L_2$ ) <sup>1</sup>		Vanish Thds V Plus Full Thd Tol Plus Shoulder Clearance ( $V + 1.5p$ )		Shoulder Length [ $L_2 + (3p$ Approx)]		External Thread for Draw ( $L_2 - L_1$ )		Internal Basic Full Thread Length ( $L_1 + L_3$ ) <sup>2</sup>		OD of Fitting ( $D_2$ )	OD of Fitting (D)
		Inch	Inch	Inch	Inch	Inch	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd	Inch
1/16	.03704	.27118	.28118	.28750	.2642	.1600	4.32	.2611	7.05	.1139	3.075	.3750	.1011	2.73	.2711	7.32	.315	.3125	
1/8	.03704	.36351	.37360	.38000	.3566	.1615	4.36	.2639	7.12	.1112	3.072	.3750	.1024	2.76	.2726	7.36	.407	.4050	
1/4	.05556	.47739	.49163	.50250	.4670	.2278	4.10	.4018	7.23	.1607	2.892	.5625	.1740	3.13	.3945	7.10	.546	.5400	
3/8	.05556	.61201	.62701	.63750	.6016	.2400	4.32	.4078	7.34	.1547	2.791	.5625	.1678	3.02	.4067	7.32	.681	.6750	
1/2	.07143	.75843	.77843	.79179	.7451	.3200	4.48	.5337	7.47	.2163	3.028	.7500	.2137	2.99	.5343	7.48	.850	.8400	
3/4	.07143	.96768	.98887	1.00179	.9543	.3390	4.75	.5457	7.64	.2043	2.860	.7500	.2067	2.89	.5533	7.75	1.060	1.0500	
1	.08696	1.21363	1.23863	1.25630	1.1973	.4000	4.60	.6828	7.85	.2547	2.929	.9375	.2828	3.25	.6609	7.60	1.327	1.3150	
1-1/4	.08696	1.55713	1.58338	1.60130	1.5408	.4200	4.83	.7068	8.13	.2620	3.013	.9688	.2868	3.30	.6809	7.83	1.672	1.6600	
1-1/2	.08696	1.79609	1.82234	1.84130	1.7798	.4200	4.83	.7235	8.32	.2765	3.180	1.0000	.3035	3.49	.6809	7.83	1.912	1.9000	
2	.08696	2.26902	2.29627	2.31630	2.2527	.4360	5.01	.7565	8.70	.2747	3.159	1.0312	.3205	3.69	.6969	8.01	2.387	2.3750	
2-1/2	.12500	2.71953	2.76216	2.79062	2.6961	.6820	5.46	1.1375	9.10	.3781	3.025	1.5156	.4555	3.64	1.0570	8.46	2.893	2.8750	
3	.12500	3.34062	3.38850	3.41562	3.3172	.7660	6.13	1.2000	9.60	.3781	3.025	1.5781	.4340	3.47	1.1410	9.13	3.518	3.5000	

NOTES:

- External thread tabulated full thread lengths include chamfers not exceeding one pitch (thread) length.
- Internal thread tabulated full thread lengths do not include countersink beyond the intersection of the pitch line and the chamfer cone.

- d. PTF-SAE Short. External threads of this type conform in all respects with NPTF threads, except that the thread length has been shortened by eliminating one thread from the small (entering) end. These threads are designed for applications where clearance is not sufficient for the full thread length of NPTF threads or for economy of material, where the full thread length is not necessary. PTF-SAE SHORT external threads are intended for assembly with NPSI threads, but may also be assembled with NPTF internal threads. They are not designed for, and at extreme tolerance limits may not assemble with, PTF-SAE SHORT internal or NPSF threads. This type of thread shall be in accordance with Table IV.

**Table IV Basic Dimensions For PTP-SAE Short, External Threads**



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Size	Pitch (p)		PD at Small End of Ext. Thread (E <sub>0</sub> )		(L <sub>1</sub> )		Hand Engagement (L <sub>1</sub> Short)		Length of Full Thread (L <sub>2</sub> Short) <sup>1</sup>		Vanish Thds V Plus Full Thd Tol Plus Shoulder Clearance (V + 1.5p)		Minimum Shoulder Length (L <sub>2</sub> Short + 2.5p)		External Thread for Draw (L <sub>2</sub> Short - L <sub>1</sub> Short)		Length of Internal Full Thread (L <sub>1</sub> Short + 4p) <sup>2</sup>	
	Inch	Inch	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd
1/16	.03704	.27349	.1600	4.32	.1230	3.32	.2241	6.05	.0926	2.50	.3167	.1011	2.73	.2711	7.32			
1/8	.03704	.36582	.1615	4.36	.1244	3.36	.2268	6.12	.0926	2.50	.3194	.1024	2.76	.2726	7.36			
1/4	.05556	.48086	.2278	4.10	.1722	3.10	.3462	6.23	.1389	2.50	.4851	.1740	3.13	.3945	7.10			
3/8	.05556	.61548	.2400	4.32	.1844	3.32	.3522	6.34	.1389	2.50	.4911	.1678	3.02	.4067	7.32			
1/2	.07143	.76289	.3200	4.48	.2486	3.48	.4623	6.47	.1786	2.50	.6409	.2137	2.99	.5343	7.48			
3/4	.07143	.97214	.3390	4.75	.2676	3.75	.4743	6.64	.1786	2.50	.6528	.2067	2.89	.5533	7.75			
1	.08696	1.21906	.4000	4.60	.3130	3.60	.5958	6.85	.2174	2.50	.8132	.2828	3.25	.6609	7.60			

**Table IV Basic Dimensions For PTP-SAE Short, External Threads (Cont.)**

Size	Pitch (p)	PD at Small End of Ext. Thread (E <sub>0</sub> )	(L <sub>1</sub> )		Hand Engagement (L <sub>1</sub> Short)		Length of Full Thread (L <sub>2</sub> Short) <sup>1</sup>		Vanish Thds V Plus Full Thd Tol Plus Shoulder Clearance (V + 1.5p)		Minimum Shoulder Length (L <sub>2</sub> Short + 2.5p)	External Thread for Draw (L <sub>2</sub> Short- L <sub>1</sub> Short)		Length of Internal Full Thread (L <sub>1</sub> Short + 4p) <sup>2</sup>	
	Inch	Inch	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Thd	Inch	Inch	Thd	Inch	Thd
1-1/4	.08696	1.56256	.4200	4.83	.3330	3.83	.6198	7.13	.2174	2.50	.8372	.2868	3.30	.6809	7.83
1-1/2	.08696	1.80152	.4200	4.83	.3330	3.83	.6365	7.32	.2174	2.50	.8539	.3035	3.49	.6809	7.83
2	.08696	2.27445	.4360	5.01	.3490	4.01	.6695	7.70	.2174	2.50	.8869	.3205	3.69	.6969	8.01
2-1/2	.12500	2.72734	.6820	5.46	.5570	4.46	1.0125	8.10	.3125	2.50	1.3250	.4555	3.64	1.0570	8.46
3	.12500	3.34844	.7660	6.13	.6410	5.13	1.0750	8.60	.3125	2.50	1.3875	.4340	3.47	1.1410	9.13

**NOTES:**

1. External thread tabulated full thread lengths include chamfers not exceeding one pitch (thread) length.
  2. Internal thread tabulated full thread lengths do not include countersink beyond the intersection of the pitch line and the chamfer cone.
- 1.2 Drill sizes for internal threads. Table V identifies the recommended drill size to be used for the various sizes of internal pipe threads.

**Table V Suggested Twist Drill Diameters For Drilled Hole Sizes For Pipe Threads**

Nominal Pipe Size	Outside Diameter of Pipe	Taper Thread				Straight Pipe Thread <sup>1</sup> (NPSC) <sup>2</sup>	
		With use of Reamer		Without use of Reamer		Fractional Equivalent	Decimal Equivalent
		Fractional Equivalent	Decimal Equivalent	Fractional Equivalent	Decimal Equivalent		
1/16	.3125		.234 <sup>1</sup>		.242 <sup>1</sup>	1/4	.250 <sup>1</sup>
1/8	.405	21/64	.328 <sup>1</sup>		.332 <sup>1</sup>	11/32	.344 <sup>1</sup>
1/4	.540	27/64	.422 <sup>1</sup>	7/16	.438 <sup>1</sup>	7/16	.438 <sup>1</sup>
3/8	.675	9/16	.562 <sup>1</sup>	9/16	.562 <sup>1</sup>	37/64	.578 <sup>1</sup>
1/2	.840	11/16	.688 <sup>1</sup>	45/64	.703 <sup>1</sup>	23/32	.719 <sup>1</sup>
3/4	1.050	57/64	.891 <sup>1</sup>	29/32	.906 <sup>1</sup>	59/64	.922 <sup>1</sup>
1	1.315	1 1/8	1.125 <sup>1</sup>	1 9/64	1.141 <sup>1</sup>	1 5/32	1.156 <sup>1</sup>
1 1/4	1.660	1 15/32	1.469	1 31/64	1.484	1 1/2	1.500
1 1/2	1.900	1 45/64	1.703	1 23/32	1.719	1 3/4	1.750
2	2.375	2 11/64	2.172	2 13/16	2.188	2 7/32	2.219
2 1/2	2.875	2 37/64	2.578	2 39/64	2.609	2 21/32	2.656

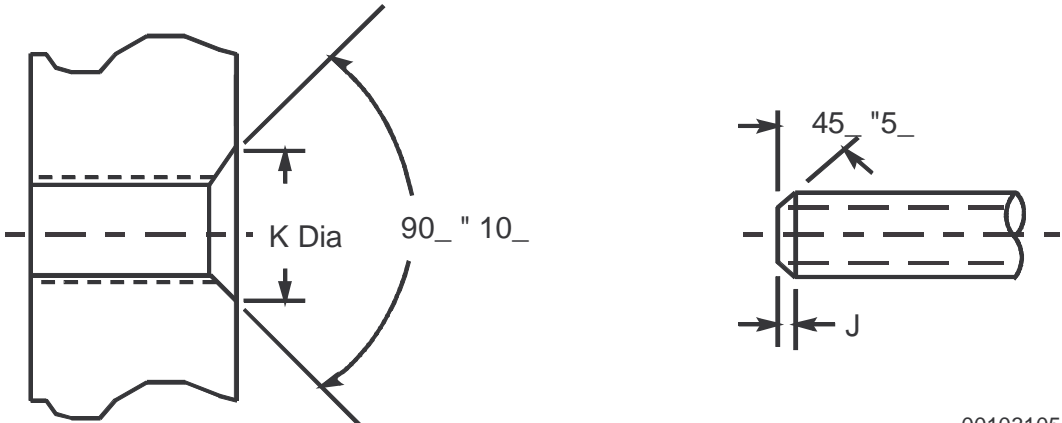
General Note: The use of twist drills of the diameters listed will not assure completely formed threads over the entire L<sub>1</sub> length.

**NOTES:**

1. American National Standard twist drill sizes in accordance with ANSI B94.11, applicable to commercial threads only.
2. Twist drill diameters for NPSM, NPSL, and NPSH threads may be larger to suit the increased internal minor diameters established for these threads.

- 1.3 Chamfers and countersinks. Unless otherwise specified on the drawing, all external and internal pipe threads shall be chamfered or countersunk in accordance with Table VI.
- 1.4 Burrs. Break all sharp corners and remove all hanging burrs and slivers which might become dislodged under usage.

**Table VI Chamfers And Countersinks of Pipe Threads**



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PIPE SIZE	CHAMFER J <sup>+0.016</sup> / <sub>-.000</sub>	COUNTERSINK Dia K <sup>+0.016</sup> / <sub>-.000</sub>
1/16	.030 - .050	.312
1/8	.030 - .050	.406
1/4	.040 - .070	.562
3/8	.040 - .070	.687
1/2	.050 - .080	.875
3/4	.050 - .080	1.062
1	.060 - .090	1.312
1 1/4	.060 - .090	1.641
1 1/2	.060 - .090	1.906
2	.060 - .090	2.500
2 1/2	.080 - .110	2.906
3	.080 - .110	3.531

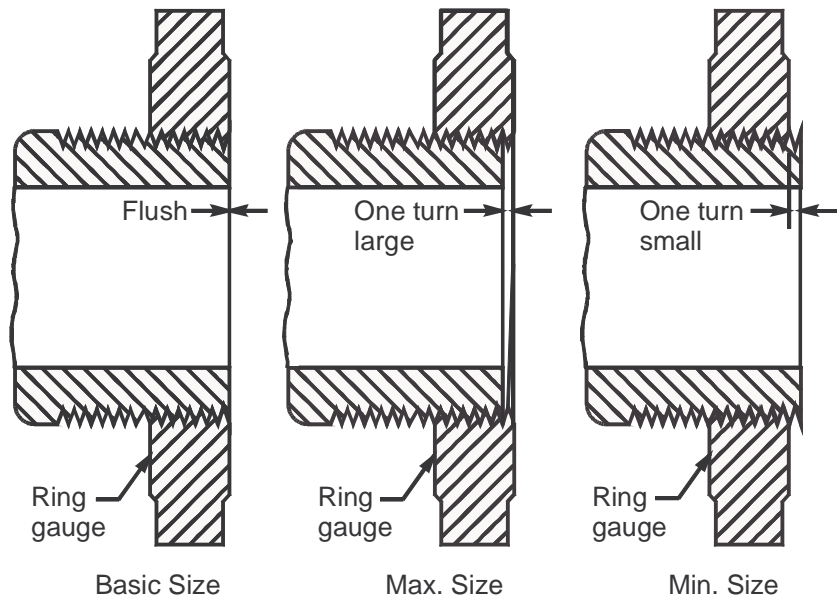


2. Quality Assurance Requirements

- 2.1 Inspection of threads. Inspection of threaded parts shall be performed by the Quality Assurance Organization using standard ring gauges, thread plug gauges, thread micrometers, or other accepted methods. All threaded parts shall be visually inspected for burrs, completeness of thread, and excessive surface roughness.

Gauging of taper pipe threads.

- a. Gauging external taper threads. In gauging external taper threads, the ring gauge is screwed hand tight on the pipe or external thread. (See Figure 1.) The thread is within the permissible tolerance when the gauging face of the working ring gauge is not more than one turn, large or small, from being flush with the end of the thread, as indicated in Figure 1.

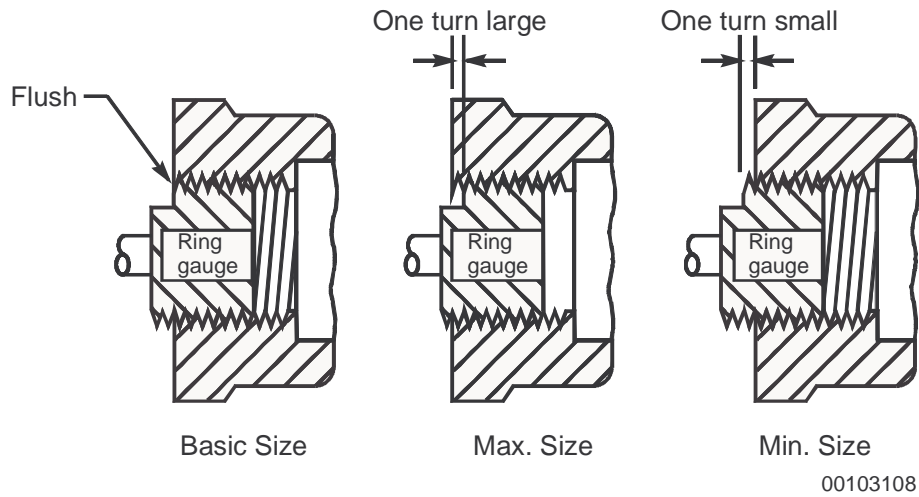


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**Figure 1 Gauging External Taper Thread With Ring Gauge**

- b. Gauging internal taper threads. In gauging internal taper threads, the plug gauge is screwed hand tight into the fitting or coupling. The thread is within the permissible tolerance when the gauging notch of the

working plug gauge is not more than 1 turn, large or small, from being flush with the end of the thread, as indicated in Figure 2.



**Figure 2 Gauging Internal Taper Threads**

3. Preparation For Delivery (Not Applicable)