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Part 3 of 6

1.25	1.5	1.75	2	2.5	3	3.5	4	5	6	8	10	12	
1.125	1.375	1.625	1.875	2.25	2.75	3.25	3.75	4.5	5.5	7	9	11	
1.375	1.625	1.875	2.25	2.75	3.25	3.75	4.5	5.5	7	9	11	13	
Pitch diameter tolerances													Threads per inch
in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	
---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	40
0.0028 .0035	0.0029 .0036	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	36
.0029 .0037	.0030 .0038	0.0031 .0038	0.0031 .0039	0.0032 .0040	0.0033 .0042	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	32
.0031 .0038	.0031 .0039	.0032 .0040	.0033 .0041	.0034 .0042	.0035 .0044	0.0036 .0045	0.0036 .0046	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	28
.0031 .0039	.0032 .0040	.0033 .0041	.0033 .0041	.0034 .0043	.0035 .0044	.0036 .0045	.0037 .0046	0.0038 .0048	0.0039 .0049	---------- ----------	---------- ----------	---------- ----------	27
.0033 .0041	.0033 .0042	.0034 .0042	.0035 .0043	.0036 .0045	.0037 .0046	.0037 .0047	.0038 .0048	.0040 .0050	.0041 .0051	---------- ----------	---------- ----------	---------- ----------	24
.0035 .0044	.0036 .0045	.0036 .0045	.0037 .0046	.0038 .0048	.0039 .0049	.0040 .0050	.0041 .0051	.0042 .0053	.0043 .0054	---------- ----------	---------- ----------	---------- ----------	20
.0036 .0046	.0037 .0047	.0038 .0047	.0039 .0048	.0040 .0050	.0041 .0051	.0041 .0052	.0042 .0053	.0044 .0054	.0045 .0056	0.0047 .0059	---------- ----------	---------- ----------	18
.0038 .0048	.0039 .0049	.0040 .0050	.0040 .0050	.0041 .0052	.0042 .0053	.0043 .0054	.0044 .0055	.0045 .0057	.0047 .0058	.0049 .0061	0.0050 .0063	---------- ----------	16
.0041 .0051	.0041 .0052	.0042 .0052	.0043 .0053	.0044 .0055	.0045 .0056	.0045 .0057	.0046 .0058	.0048 .0060	.0049 .0061	.0051 .0064	.0053 .0066	0.0054 .0068	14
.0043 .0054	.0044 .0055	.0045 .0056	.0045 .0057	.0046 .0058	.0047 .0059	.0048 .0060	.0049 .0061	.0050 .0063	.0052 .0065	.0054 .0067	.0055 .0069	.0057 .0071	12
.0047 .0059	.0048 .0060	.0048 .0061	.0049 .0061	.0050 .0063	.0051 .0064	.0052 .0065	.0053 .0066	.0054 .0068	.0055 .0069	.0057 .0072	.0059 .0074	.0061 .0076	10
.0052 .0065	.0053 .0066	.0054 .0067	.0054 .0068	.0055 .0069	.0056 .0070	.0057 .0071	.0058 .0072	.0059 .0074	.0061 .0076	.0063 .0078	.0064 .0080	.0066 .0082	8
---------- ----------	.0061 .0076	.0061 .0077	.0062 .0078	.0063 .0079	.0064 .0080	.0065 .0081	.0066 .0082	.0067 .0084	.0068 .0085	.0070 .0088	.0072 .0090	.0074 .0092	6
---------- ----------	---------- ----------	---------- ----------	.0076 .0095	.0077 .0096	.0078 .0097	.0079 .0098	.0079 .0099	.0081 .0101	.0082 .0102	.0084 .0105	.0086 .0107	.0087 .0109	4

LEGENDS

1. These values do not agree with and shall not be used in place of any tabulated values for the UNC, UNF, and 8UN thread series in table 2.21.
2. Class 3A tolerances in this table for 5 to 15 pitches are based on 9 pitches and are obtained by multiplying the class 2A (external thread) tolerences for 9 pitches taken to six decimal places by a factor of 0.75. (See table 2.19).
3. Class 3A tolerances in this table for 16 to 30 pitches are obtained by multiplying the class 2A (external thread) tolerances for 9 pitches taken to six decimal places by a factor of 0.9375 (obtained by multiplying the 0.75 factor by 1.25.) (See table 2.19.) For lengths of engagement not tabulated, see par. 7.3, p. 3.03.
4. Pitches listed are those used most commonly and are recommended. Where intermediate pitches are specified, the formula in par. 7.3, p. 3.03, should be applied.
5. Tolerances are tabulated only for combinations of diameter, pitch, and length of engagement which are considered to be generally used. For other combinations encountered, see Design of Special Threads in appendix A5.

3A P.D. TOLERANCES

TABLE 3.6. *Pitch diameter tolerances for internal threads of special diameters, pitches, and lengths of engagement, class 1B*

(UNS threads. See par. 7.3, p. 3.03; par. 10, p. 3.05.)

Tolerance based on diameter of →			0.0625	0.09375	0.125	0.1875	0.25	0.375	0.5	0.625	0.75	1
For diameter range Above →			0.0470	0.0781	0.1094	0.1562	0.2188	0.3125	0.4375	0.5625	0.6875	0.875
To and including →			0.0781	0.1094	0.1562	0.2188	0.3125	0.4375	0.5625	0.6875	0.875	1.125
Threads per inch	Length of engagement		Pitch diameter tolerances									
	Number of pitches	Inches										
			in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*
80	5 to 15	0.06 to 0.19	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	0.191 to 0.38	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
72	5 to 15	0.07 to 0.21	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	0.211 to 0.42	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
64	5 to 15	0.08 to 0.23	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	0.231 to 0.46	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
56	5 to 15	0.09 to 0.27	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	0.271 to 0.54	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
48	5 to 15	0.10 to 0.31	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	0.311 to 0.62	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
44	5 to 15	0.11 to 0.34	--------	0.0050	0.0051	0.0053	0.0055	0.0058	0.0060	0.0062	0.0063	0.0066
	16 to 30	0.341 to 0.68	--------	.0062	.0064	.0067	.0069	.0072	.0075	.0077	.0079	.0082
40	5 to 15	0.12 to 0.38	--------	--------	.0054	.0056	.0057	.0060	.0062	.0064	.0065	.0068
	16 to 30	0.381 to 0.76	--------	--------	.0067	.0070	.0072	.0075	.0078	.0080	.0082	.0085
36	5 to 15	0.14 to 0.42	--------	--------	.0056	.0058	.0060	.0063	.0065	.0066	.0068	.0071
	16 to 30	0.421 to 0.84	--------	--------	.0070	.0073	.0075	.0078	.0081	.0083	.0085	.0088
32	5 to 15	0.16 to 0.47	--------	--------	.0059	.0061	.0063	.0066	.0068	.0070	.0071	.0074
	16 to 30	0.471 to 0.94	--------	--------	.0074	.0077	.0079	.0082	.0085	.0087	.0089	.0092
28	5 to 15	0.18 to 0.54	--------	--------	--------	.0065	.0067	.0069	.0072	.0073	.0075	.0078
	16 to 30	0.541 to 1.08	--------	--------	--------	.0081	.0083	.0087	.0089	.0092	.0094	.0097
27	5 to 15	0.19 to 0.56	--------	--------	--------	.0066	.0068	.0070	.0073	.0074	.0076	.0079
	16 to 30	0.561 to 1.12	--------	--------	--------	.0083	.0085	.0088	.0091	.0093	.0095	.0098
24	5 to 15	0.21 to 0.62	--------	--------	--------	.0070	.0072	.0074	.0076	.0078	.0080	.0082
	16 to 30	0.621 to 1.24	--------	--------	--------	.0087	.0089	.0093	.0095	.0098	.0100	.0103
20	5 to 15	0.25 to 0.75	--------	--------	--------	--------	.0078	.0080	.0083	.0084	.0086	.0089
	16 to 30	0.751 to 1.50	--------	--------	--------	--------	.0097	.0101	.0103	.0105	.0107	.0111
18	5 to 15	0.28 to 0.83	--------	--------	--------	--------	--------	.0084	.0087	.0088	.0090	.0093
	16 to 30	0.831 to 1.66	--------	--------	--------	--------	--------	.0105	.0108	.0110	.0112	.0116
16	5 to 15	0.31 to 0.94	--------	--------	--------	--------	--------	.0089	.0091	.0093	.0095	.0097
	16 to 30	0.941 to 1.88	--------	--------	--------	--------	--------	.0111	.0114	.0116	.0118	.0122
14	5 to 15	0.36 to 1.07	--------	--------	--------	--------	--------	--------	.0097	.0099	.0100	.0103
	16 to 30	1.071 to 2.14	--------	--------	--------	--------	--------	--------	.0121	.0124	.0125	.0129
12	5 to 15	0.42 to 1.25	--------	--------	--------	--------	--------	--------	.0104	.0106	.0108	.0110
	16 to 30	1.251 to 2.50	--------	--------	--------	--------	--------	--------	.0130	.0133	.0135	.0138
10	5 to 15	0.50 to 1.50	--------	--------	--------	--------	--------	--------	--------	--------	.0117	.0120
	16 to 30	1.501 to 3.00	--------	--------	--------	--------	--------	--------	--------	--------	.0147	.0150
8	5 to 15	0.62 to 1.88	--------	--------	--------	--------	--------	--------	--------	--------	--------	.0133
	16 to 30	1.881 to 3.76	--------	--------	--------	--------	--------	--------	--------	--------	--------	.0167
6	5 to 15	0.83 to 2.50	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	2.501 to 5.00	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
4	5 to 15	1.25 to 3.75	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	3.751 to 7.50	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

1B P.D. TOLERANCES

1.25	1.5	1.75	2	2.5	3	3.5	4	5	6	8	10	12	
1.125	1.375	1.625	1.875	2.25	2.75	3.25	3.75	4.5	5.5	7	9	11	
1.375	1.625	1.875	2.25	2.75	3.25	3.75	4.5	5.5	7	9	11	13	
Pitch diameter tolerances													Threads per inch
in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	
---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	40
0.0073 .0091	0.0075 .0094	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	36
.0076 .0095	.0078 .0098	0.0080 .0100	0.0081 .0102	0.0084 .0105	0.0087 .0108	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	32
.0080 .0100	.0082 .0102	.0084 .0104	.0085 .0106	.0088 .0110	.0090 .0113	0.0093 .0116	0.0095 .0118	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	28
.0080 .0101	.0083 .0104	.0085 .0106	.0085 .0108	.0089 .0111	.0092 .0114	.0094 .0117	.0096 .0120	0.0099 .0124	0.0103 .0128	---------- ----------	---------- ----------	---------- ----------	27
.0085 .0106	.0087 .0108	.0088 .0110	.0090 .0112	.0093 .0116	.0095 .0119	.0097 .0122	.0100 .0124	.0103 .0129	.0106 .0133	---------- ----------	---------- ----------	---------- ----------	24
.0091 .0114	.0093 .0116	.0095 .0118	.0096 .0120	.0099 .0124	.0101 .0127	.0104 .0130	.0106 .0132	.0109 .0137	.0112 .0141	---------- ----------	---------- ----------	---------- ----------	20
.0095 .0118	.0097 .0121	.0099 .0123	.0100 .0125	.0103 .0129	.0105 .0132	.0108 .0135	.0110 .0137	.0113 .0142	.0116 .0146	0.0122 .0152	---------- ----------	---------- ----------	18
.0100 .0124	.0101 .0127	.0103 .0129	.0105 .0131	.0108 .0135	.0110 .0138	.0112 .0140	.0114 .0143	.0118 .0148	.0121 .0151	.0126 .0158	0.0131 .0164	---------- ----------	16
.0105 .0132	.0107 .0134	.0109 .0136	.0111 .0138	.0114 .0142	.0116 .0145	.0118 .0148	.0120 .0150	.0124 .0155	.0127 .0159	.0132 .0165	.0137 .0171	0.0141 .0176	14
.0113 .0141	.0115 .0143	.0116 .0145	.0118 .0147	.0121 .0151	.0123 .0154	.0126 .0157	.0128 .0159	.0131 .0164	.0134 .0168	.0140 .0175	.0144 .0180	.0148 .0185	12
.0122 .0153	.0124 .0155	.0126 .0158	.0128 .0160	.0130 .0163	.0133 .0166	.0135 .0169	.0137 .0172	.0141 .0176	.0144 .0180	.0149 .0187	.0154 .0192	.0158 .0197	10
.0136 .0170	.0138 .0172	.0139 .0174	.0141 .0176	.0144 .0180	.0146 .0183	.0149 .0186	.0151 .0188	.0154 .0193	.0157 .0197	.0163 .0203	.0167 .0209	.0171 .0214	8
---------- ----------	.0158 .0197	.0160 .0200	.0161 .0202	.0164 .0205	.0167 .0208	.0169 .0211	.0171 .0214	.0174 .0218	.0178 .0222	.0183 .0229	.0187 .0234	.0191 .0239	6
---------- ----------	---------- ----------	---------- ----------	.0197 .0246	.0200 .0250	.0202 .0253	.0204 .0255	.0206 .0258	.0210 .0262	.0213 .0266	.0218 .0273	.0223 .0279	.0227 .0284	4

LEGENDS

1. These values do not agree with and shall not be used in place of any tabulated values for the UNC, UNF, and 8UN thread series in table 2.21.
2. Class 1B (internal thread) tolerances in this table for 5 to 15 pitches are based on 9 pitches and are obtained by multiplying the class 2A (external thread) tolerances for 9 pitches taken to six decimal places by a factor of 1.95. (See table 2.19.)
3. Class 1B tolerances in this table for 16 to 30 pitches are obtained by multiplying the class 2A (external thread) tolerances for 9 pitches taken to six decimal places by a factor of 2.4375 (obtained by multiplying the 1.95 factor by 1.25.) (See table 2.19.) For lengths of engagement not tabulated, see par. 7.3, p. 3.03.
4. Pitches listed are those used most commonly and are recommended. Where intermediate pitches are specified, the formula in par. 7.3, p. 3.03, should be applied.
5. Tolerances are tabulated only for combinations of diameter, pitch, and length of engagement which are considered to be generally used. For other combinations encountered, see Design of Special Threads in appendix A5.

1B P.D. TOLERANCES

TABLE 3.7. *Pitch diameter tolerances for internal threads of special diameters, pitches, and lengths of engagement, class 2B*

(UNS threads. See par. 7.3, p. 3.03; par. 10, p. 3.05.)

Tolerance based on diameter of →			0.0625	0.09375	0.125	0.1875	0.25	0.375	0.5	0.625	0.75	1
For diameter range Above →			0.0470	0.0781	0.1094	0.1562	0.2188	0.3125	0.4375	0.5625	0.6875	0.875
To and including →			0.0781	0.1094	0.1562	0.2188	0.3125	0.4375	0.5625	0.6875	0.875	1.125
Threads per inch	Length of engagement		Pitch diameter tolerances									
	Number of pitches	Inches										
			in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*
80	5 to 15	0.06 to 0.19	0.0025	0.0026	0.0027	0.0028	0.0029	------	------	------	------	------
	16 to 30	0.191 to 0.38	.0031	.0032	.0033	.0035	.0037	------	------	------	------	------
72	5 to 15	0.07 to 0.21	.0026	.0027	.0028	.0029	.0030	0.0032	------	------	------	------
	16 to 30	0.211 to 0.42	.0032	.0034	.0035	.0037	.0038	.0040	------	------	------	------
64	5 to 15	0.08 to 0.23	.0027	.0028	.0029	.0031	.0032	.0034	0.0035	------	------	------
	16 to 30	0.231 to 0.46	.0034	.0035	.0037	.0038	.0040	.0042	.0044	------	------	------
56	5 to 15	0.09 to 0.27	------	.0030	.0031	.0032	.0033	.0035	.0037	0.0038	0.0039	------
	16 to 30	0.271 to 0.54	------	.0037	.0039	.0040	.0042	.0044	.0046	.0047	.0049	------
48	5 to 15	0.10 to 0.31	------	.0032	.0033	.0034	.0036	.0037	.0039	.0040	.0041	------
	16 to 30	0.311 to 0.62	------	.0040	.0041	.0043	.0044	.0047	.0048	.0050	.0051	------
44	5 to 15	0.11 to 0.34	------	.0033	.0034	.0036	.0037	.0039	.0040	.0041	.0042	0.0044
	16 to 30	0.341 to 0.68	------	.0042	.0043	.0045	.0046	.0048	.0050	.0051	.0053	.0055
40	5 to 15	0.12 to 0.38	------	------	.0036	.0037	.0038	.0040	.0041	.0043	.0044	.0045
	16 to 30	0.381 to 0.76	------	------	.0045	.0046	.0048	.0050	.0052	.0053	.0055	.0057
36	5 to 15	0.14 to 0.42	------	------	.0037	.0039	.0040	.0042	.0043	.0044	.0045	.0047
	16 to 30	0.421 to 0.84	------	------	.0047	.0049	.0050	.0052	.0054	.0055	.0057	.0059
32	5 to 15	0.16 to 0.47	------	------	.0030	.0041	.0042	.0044	.0045	.0046	.0047	.0049
	16 to 30	0.471 to 0.94	------	------	.0049	.0051	.0052	.0055	.0056	.0058	.0059	.0061
28	5 to 15	0.18 to 0.54	------	------	------	.0043	.0044	.0046	.0048	.0049	.0050	.0052
	16 to 30	0.541 to 1.08	------	------	------	.0054	.0056	.0058	.0060	.0061	.0062	.0065
27	5 to 15	0.19 to 0.56	------	------	------	.0044	.0045	.0047	.0048	.0050	.0051	.0052
	16 to 30	0.561 to 1.12	------	------	------	.0055	.0057	.0059	.0061	.0062	.0063	.0066
24	5 to 15	0.21 to 0.62	------	------	------	.0047	.0048	.0049	.0051	.0052	.0053	.0055
	16 to 30	0.621 to 1.24	------	------	------	.0058	.0060	.0062	.0064	.0065	.0066	.0069
20	5 to 15	0.25 to 0.75	------	------	------	------	.0052	.0054	.0055	.0056	.0057	.0059
	16 to 30	0.751 to 1.50	------	------	------	------	.0065	.0067	.0069	.0070	.0072	.0074
18	5 to 15	0.28 to 0.83	------	------	------	------	------	.0056	.0058	.0059	.0060	.0062
	16 to 30	0.831 to 1.66	------	------	------	------	------	.0070	.0072	.0074	.0075	.0077
16	5 to 15	0.31 to 0.94	------	------	------	------	------	.0059	.0061	.0062	.0063	.0065
	16 to 30	0.941 to 1.88	------	------	------	------	------	.0074	.0076	.0077	.0079	.0081
14	5 to 15	0.36 to 1.07	------	------	------	------	------	------	.0065	.0066	.0067	.0069
	16 to 30	1.071 to 2.14	------	------	------	------	------	------	.0081	.0082	.0084	.0086
12	5 to 15	0.42 to 1.25	------	------	------	------	------	------	.0070	.0071	.0072	.0074
	16 to 30	1.251 to 2.50	------	------	------	------	------	------	.0087	.0088	.0090	.0092
10	5 to 15	0.50 to 1.50	------	------	------	------	------	------	------	------	.0078	.0080
	16 to 30	1.501 to 3.00	------	------	------	------	------	------	------	------	.0098	.0100
8	5 to 15	0.62 to 1.88	------	------	------	------	------	------	------	------	------	.0089
	16 to 30	1.881 to 3.76	------	------	------	------	------	------	------	------	------	.0111
6	5 to 15	0.83 to 2.50	------	------	------	------	------	------	------	------	------	------
	16 to 30	2.501 to 5.00	------	------	------	------	------	------	------	------	------	------
4	5 to 15	1.25 to 3.75	------	------	------	------	------	------	------	------	------	------
	16 to 30	3.751 to 7.50	------	------	------	------	------	------	------	------	------	------

2B P.D. TOLERANCES

TABLE 3.7 *Pitch diameter tolerances for internal threads of special diameters, pitches, and lengths of engagement, class 2B*—Con

1.25 1.125 1.375	1.5 1.375 1.625	1.75 1.625 1.875	2 1.875 2.25	2.5 2.25 2.75	3 2.75 3.25	3.5 3.25 3.75	4 3.75 4.5	5 4.5 5.5	6 5.5 7	8 7 9	10 9 11	12 11 13	Threads per inch
Pitch diameter tolerances													
in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	
---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	40
0.0049 .0061	0.0050 .0062	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	36
.0051 .0063	.0052 .0065	0.0053 .0066	0.0054 .0068	0.0056 .0070	0.0058 .0072	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	32
.0053 .0067	.0055 .0068	.0056 .0070	.0057 .0071	.0059 .0073	.0060 .0075	0.0062 .0077	0.0063 .0079	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	28
.0053 .0067	.0055 .0069	.0056 .0071	.0057 .0072	.0059 .0074	.0061 .0076	.0063 .0078	.0064 .0080	0.0066 .0083	0.0068 .0085	---------- ----------	---------- ----------	---------- ----------	27
.0056 .0070	.0058 .0072	.0059 .0074	.0060 .0075	.0062 .0077	.0064 .0079	.0065 .0081	.0066 .0083	.0069 .0086	.0071 .0089	---------- ----------	---------- ----------	---------- ----------	24
.0061 .0076	.0062 .0077	.0063 .0079	.0064 .0080	.0066 .0083	.0068 .0085	.0069 .0086	.0070 .0088	.0073 .0091	.0075 .0094	---------- ----------	---------- ----------	---------- ----------	20
.0063 .0079	.0065 .0081	.0066 .0082	.0067 .0083	.0069 .0086	.0070 .0088	.0072 .0090	.0073 .0091	.0076 .0094	.0078 .0097	0.0081 .0101	---------- ----------	---------- ----------	18
.0066 .0083	.0068 .0085	.0069 .0086	.0070 .0087	.0072 .0090	.0073 .0092	.0075 .0094	.0076 .0095	.0079 .0098	.0081 .0101	.0084 .0105	0.0087 .0109	---------- ----------	16
.0070 .0088	.0072 .0089	.0073 .0091	.0074 .0092	.0076 .0095	.0077 .0097	.0079 .0099	.0080 .0100	.0083 .0103	.0085 .0106	.0088 .0110	.0091 .0114	0.0094 .0117	14
.0075 .0094	.0076 .0096	.0078 .0097	.0079 .0098	.0081 .0101	.0082 .0103	.0084 .0105	.0085 .0106	.0087 .0109	.0090 .0112	.0093 .0116	.0096 .0120	.0099 .0123	12
.0082 .0102	.0083 .0104	.0084 .0105	.0085 .0106	.0087 .0109	.0089 .0111	.0090 .0113	.0091 .0114	.0094 .0117	.0096 .0120	.0100 .0124	.0103 .0128	.0105 .0131	10
.0090 .0113	.0092 .0115	.0093 .0116	.0094 .0118	.0096 .0120	.0098 .0122	.0099 .0124	.0100 .0125	.0103 .0128	.0105 .0131	.0108 .0136	.0111 .0139	.0114 .0143	8
---------- ----------	.0105 .0132	.0106 .0133	.0108 .0134	.0109 .0137	.0111 .0139	.0113 .0141	.0114 .0142	.0116 .0145	.0118 .0148	.0122 .0152	.0125 .0156	.0128 .0159	6
---------- ----------	---------- ----------	---------- ----------	.0131 .0164	.0133 .0166	.0135 .0168	.0136 .0170	.0138 .0172	.0140 .0175	.0142 .0178	.0146 .0182	.0149 .0186	.0151 .0189	4

LEGENDS

1. These values do not agree with and shall not be used in place of any tabulated values for the UNC, UNF, and 8UN thread series in table 2.21.
2. Class 2B (internal thread) tolerances in this table for 5 to 15 pitches are based on 9 pitches and are obtained by multiplying the class 2A (external thread) tolerances for 9 pitches taken to six decimal places by a factor of 1.3. (See table 2.19.)
3. Class 2B tolerances in this table for 16 to 30 pitches are obtained by multiplying the class 2A (external thread) tolerances for 9 pitches taken to six decimal places by a factor of 1.625 (obtained by multiplying the 1.3 factor by 1.25.) (See table 2.19.) For lengths of engagement not tabulated, see par. 7.3, p. 3.03.
4. Pitches listed are those used most commonly and are recommended. Where intermediate pitches are specified, the formula in par. 7.3, p. 3.03, should be applied.
5. Tolerances are tabulated only for combinations of diameter, pitch, and length of engagement which are considered to be generally used. For other combinations encountered, see Design of Special Threads in appendix A5.

2B P.D. TOLERANCES

TABLE 3.8 *Pitch diameter tolerances for internal threads of special diameters, pitches, and lengths of engagement, class 3B*

(UNS threads. See par. 7.3, p. 3.03; par. 10, p. 3.05.)

Tolerance based on diameter of →			0.0625	0.09375	0.125	0.1875	0.25	0.375	0.5	0.625	0.75	1
For diameter range Above →			0.0470	0.0781	0.1094	0.1562	0.2188	0.3125	0.4375	0.5625	0.6875	0.875
To and including →			0.0781	0.1094	0.1562	0.2188	0.3125	0.4375	0.5625	0.6875	0.875	1.125
Threads per inch	Length of engagement		Pitch diameter tolerances									
	Number of pitches	Inches										
			in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*
80	5 to 15	0.06 to 0.19	0.0019	0.0019	0.0020	0.0021	0.0022	--------	--------	--------	--------	--------
	16 to 30	0.191 to 0.38	.0023	.0024	.0025	.0026	.0027	--------	--------	--------	--------	--------
72	5 to 15	0.07 to 0.21	.0019	.0020	.0021	.0022	.0023	0.0024	--------	--------	--------	--------
	16 to 30	0.211 to 0.42	.0024	.0025	.0026	.0027	.0029	.0030	--------	--------	--------	--------
64	5 to 15	0.08 to 0.23	.0020	.0021	.0022	.0023	.0024	.0025	0.0026	--------	--------	--------
	16 to 30	0.231 to 0.46	.0026	.0027	.0027	.0029	.0030	.0031	.0033	--------	--------	--------
56	5 to 15	0.09 to 0.27	--------	.0023	.0023	.0024	.0025	.0026	.0027	0.0028	0.0029	--------
	16 to 30	0.271 to 0.54	--------	.0028	.0029	.0030	.0031	.0033	.0034	.0035	.0036	--------
48	5 to 15	0.10 to 0.31	--------	.0024	.0025	.0026	.0027	.0028	.0029	.0030	.0031	--------
	16 to 30	0.311 to 0.62	--------	.0030	.0031	.0032	.0033	.0035	.0036	.0037	.0038	--------
44	5 to 15	0.11 to 0.34	--------	.0025	.0026	.0027	.0028	.0029	.0030	.0031	.0032	0.0033
	16 to 30	0.341 to 0.68	--------	.0031	.0032	.0033	.0034	.0036	.0037	.0039	.0040	.0041
40	5 to 15	0.12 to 0.38	--------	--------	.0027	.0028	.0029	.0030	.0031	.0032	.0033	.0034
	16 to 30	0.381 to 0.76	--------	--------	.0033	.0035	.0036	.0037	.0039	.0040	.0041	.0043
36	5 to 15	0.14 to 0.42	--------	--------	.0028	.0029	.0030	.0031	.0032	.0033	.0034	.0035
	16 to 30	0.421 to 0.84	--------	--------	.0035	.0036	.0037	.0039	.0040	.0042	.0043	.0044
32	5 to 15	0.16 to 0.47	--------	--------	.0030	.0031	.0031	.0033	.0034	.0035	.0036	.0037
	16 to 30	0.471 to 0.94	--------	--------	.0037	.0038	.0039	.0041	.0042	.0043	.0044	.0046
28	5 to 15	0.18 to 0.54	--------	--------	--------	.0033	.0033	.0035	.0036	.0037	.0037	.0039
	16 to 30	0.541 to 1.08	--------	--------	--------	.0041	.0042	.0043	.0045	.0046	.0047	.0048
27	5 to 15	0.19 to 0.56	--------	--------	--------	.0033	.0034	.0035	.0036	.0037	.0038	.0039
	16 to 30	0.561 to 1.12	--------	--------	--------	.0041	.0042	.0044	.0045	.0046	.0047	.0049
24	5 to 15	0.21 to 0.62	--------	--------	--------	.0035	.0036	.0037	.0038	.0039	.0040	.0041
	16 to 30	0.621 to 1.24	--------	--------	--------	.0044	.0045	.0046	.0048	.0049	.0050	.0051
20	5 to 15	0.25 to 0.75	--------	--------	--------	--------	.0039	.0040	.0041	.0042	.0043	.0044
	16 to 30	0.751 to 1.50	--------	--------	--------	--------	.0049	.0050	.0052	.0053	.0054	.0055
18	5 to 15	0.28 to 0.83	--------	--------	--------	--------	--------	.0042	.0043	.0044	.0045	.0046
	16 to 30	0.831 to 1.66	--------	--------	--------	--------	--------	.0053	.0054	.0055	.0056	.0058
16	5 to 15	0.31 to 0.94	--------	--------	--------	--------	--------	.0045	.0046	.0046	.0047	.0049
	16 to 30	0.941 to 1.88	--------	--------	--------	--------	--------	.0056	.0057	.0058	.0059	.0061
14	5 to 15	0.36 to 1.07	--------	--------	--------	--------	--------	--------	.0049	.0049	.0050	.0052
	16 to 30	1.071 to 2.14	--------	--------	--------	--------	--------	--------	.0061	.0062	.0063	.0064
12	5 to 15	0.42 to 1.25	--------	--------	--------	--------	--------	--------	.0052	.0053	.0054	.0055
	16 to 30	1.251 to 2.50	--------	--------	--------	--------	--------	--------	.0065	.0066	.0067	.0069
10	5 to 15	0.50 to 1.50	--------	--------	--------	--------	--------	--------	--------	--------	.0059	.0060
	16 to 30	1.501 to 3.00	--------	--------	--------	--------	--------	--------	--------	--------	.0073	.0075
8	5 to 15	0.62 to 1.88	--------	--------	--------	--------	--------	--------	--------	--------	--------	.0067
	16 to 30	1.881 to 3.76	--------	--------	--------	--------	--------	--------	--------	--------	--------	.0083
6	5 to 15	0.83 to 2.50	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	2.501 to 5.00	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
4	5 to 15	1.25 to 3.75	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	16 to 30	3.751 to 7.50	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

3B P.D. TOLERANCES

1.25	1.5	1.75	2	2.5	3	3.5	4	5	6	8	10	12	
1.125	1.375	1.625	1.875	2.25	2.75	3.25	3.75	4.5	5.5	7	9	11	
1.375	1.625	1.875	2.25	2.75	3.25	3.75	4.5	5.5	7	9	11	13	
Pitch diameter tolerances													Threads per inch
in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	
---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	40
0.0036 .0046	0.0037 .0047	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	36
.0038 .0048	.0039 .0049	0.0040 .0050	0.0041 .0051	0.0042 .0053	0.0043 .0054	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	32
.0040 .0050	.0041 .0051	.0042 .0052	.0043 .0053	.0044 .0055	.0045 .0057	0.0046 .0058	0.0047 .0059	---------- ----------	---------- ----------	---------- ----------	---------- ----------	---------- ----------	28
.0040 .0051	.0041 .0052	.0042 .0053	.0043 .0054	.0045 .0056	.0046 .0057	.0047 .0059	.0048 .0060	0.0050 .0062	0.0051 .0064	---------- ----------	---------- ----------	---------- ----------	27
.0042 .0053	.0043 .0054	.0044 .0055	.0045 .0056	.0046 .0058	.0048 .0060	.0049 .0061	.0050 .0062	.0052 .0064	.0053 .0066	---------- ----------	---------- ----------	---------- ----------	24
.0045 .0057	.0046 .0058	.0047 .0059	.0048 .0060	.0050 .0062	.0051 .0063	.0052 .0065	.0053 .0066	.0055 .0068	.0056 .0070	---------- ----------	---------- ----------	---------- ----------	
.0047 .0059	.0048 .0060	.0049 .0062	.0050 .0063	.0051 .0064	.0053 .0066	.0054 .0067	.0055 .0069	.0057 .0071	.0058 .0073	0.0061 .0076	---------- ----------	---------- ----------	18
.0050 .0062	.0051 .0063	.0052 .0065	.0052 .0066	.0054 .0067	.0055 .0069	.0056 .0070	.0057 .0072	.0059 .0074	.0061 .0076	.0063 .0079	0.0066 .0082	---------- ----------	16
.0053 .0066	.0054 .0067	.0055 .0068	.0055 .0069	.0057 .0071	.0058 .0072	.0059 .0074	.0060 .0075	.0062 .0077	.0063 .0079	.0066 .0083	.0068 .0086	0.0070 .0088	14
.0056 .0070	.0057 .0072	.0058 .0073	.0059 .0074	.0060 .0076	.0062 .0077	.0063 .0078	.0064 .0080	.0066 .0082	.0067 .0084	.0070 .0087	.0072 .0090	.0074 .0093	12
.0061 .0076	.0062 .0078	.0063 .0079	.0064 .0080	.0065 .0082	.0066 .0083	.0068 .0084	.0069 .0086	.0070 .0088	.0072 .0090	.0075 .0093	.0077 .0096	.0079 .0099	10
.0068 .0085	.0069 .0086	.0070 .0087	.0071 .0088	.0072 .0090	.0073 .0091	.0074 .0093	.0075 .0094	.0077 .0096	.0079 .0098	.0081 .0102	.0084 .0104	.0086 .0107	8
---------- ----------	.0079 .0099	.0080 .0100	.0081 .0101	.0082 .0103	.0083 .0104	.0084 .0106	.0085 .0107	.0087 .0109	.0089 .0111	.0091 .0114	.0094 .0117	.0096 .0120	6
---------- ----------	---------- ----------	---------- ----------	.0098 .0123	.0100 .0125	.0101 .0126	.0102 .0128	.0103 .0129	.0105 .0131	.0107 .0133	.0109 .0137	.0111 .0139	.0113 .0142	4

LEGENDS

1. These values do not agree with and shall not be used in place of any tabulated values for the UNC, UNF, and 8UN thread series in table 2.21.
2. Class 3B (internal thread) tolerances in this table for 5 to 15 pitches are based on 9 pitches and are obtained by multiplying the class 2A (external thread) tolerances for 9 pitches taken to six decimal places by a factor of 0.975. (See table 2.19.)
3. Class 3B tolerances in this table for 16 to 30 pitches are obtained by multiplying the class 2A (external thread) tolerances for 9 pitches taken to six decimal places by a factor of 1.21875 (obtained by multiplying the 0.975 factor by 1.25.) (See table 2.19.) For lengths of engagement not tabulated, see par. 7.3, p. 3.03.
4. Pitches listed are those used most commonly and are recommended. Where intermediate pitches are specified, the formula in par. 7.3, p. 3.03, should be applied.
5. Tolerances are tabulated only for combinations of diameter, pitch, and length of engagement which are considered to be generally used. For other combinations encountered, see Design of Special Threads in appendix A5.

3B P.D. TOLERANCES

TABLE 3.9. *Minor diameter tolerances for internal special screw threads, classes 1B and 2B*

(UNS threads, see par. 10, p. 3.05.)

Tolerance based on basic major diameter of →				0.060	0.073	0.086	0.099	0.112	0.125	0.138	0.164	0.190	0.216	
For diameter range Above →				0.053	0.066	0.079	0.092	0.105	0.118	0.131	0.151	0.177	0.203	All larger diameters
To and including →				0.066	0.079	0.092	0.105	0.118	0.131	0.151	0.177	0.203	0.233	
Threads per inch	Tolerance ratios	Length of engagement in terms of diameter[a] Above	to and including	1B, 2B			Minor diameter tolerances[b]				1B, 2B			
				in	in	in	in	in	in	in	in	in	in	in
80	0.5	0	0.33*D*	0.0035	0.0029	0.0025	0.0022	0.0020	0.0018	0.0017	0.0016	0.0016	0.0016	0.0016
	0.75	0.33*D*	0.67*D*	.0049	.0044	.0038	.0034	.0030	.0028	.0026	.0023	.0023	.0023	.0023
	1.0	0.67*D*	1.5*D*	.0049	.0049	.0049	.0045	.0040	.0037	.0034	.0031	.0031	.0031	.0031
	1.25	1.5*D*	3*D*	.0049	.0049	.0049	.0049	.0049	.0046	.0043	.0039	.0039	.0039	.0039
72	0.5	0	0.33*D*	.0039	.0033	.0029	.0026	.0023	.0021	.0020	.0017	.0017	.0017	.0017
	0.75	0.33*D*	0.67*D*	.0055	.0049	.0043	.0038	.0035	.0032	.0029	.0026	.0026	.0026	.0026
	1.0	0.67*D*	1.5*D*	.0055	.0055	.0055	.0051	.0046	.0042	.0039	.0034	.0034	.0034	.0034
	1.25	1.5*D*	3*D*	.0055	.0055	.0055	.0055	.0055	.0053	.0049	.0043	.0042	.0042	.0042
64	0.5	0	0.33*D*	.0045	.0038	.0033	.0029	.0027	.0024	.0023	.0020	.0019	.0019	.0019
	0.75	0.33*D*	0.67*D*	.0062	.0057	.0049	.0044	.0040	.0037	.0034	.0030	.0028	.0028	.0028
	1.0	0.67*D*	1.5*D*	.0062	.0062	.0062	.0059	.0053	.0049	.0045	.0040	.0038	.0038	.0038
	1.25	1.5*D*	3*D*	.0062	.0062	.0062	.0062	.0062	.0061	.0057	.0050	.0048	.0048	.0048
56	0.5	0	0.33*D*	--------	.0044	.0038	.0034	.0031	.0029	.0026	.0023	.0022	.0022	.0022
	0.75	0.33*D*	0.67*D*	--------	.0066	.0057	.0051	.0046	.0043	.0040	.0035	.0032	.0032	.0032
	1.0	0.67*D*	1.5*D*	--------	.0070	.0070	.0068	.0062	.0057	.0053	.0047	.0043	.0043	.0043
	1.25	1.5*D*	3*D*	--------	.0070	.0070	.0070	.0070	.0070	.0066	.0059	.0054	.0054	.0054
48	0.5	0	0.33*D*	--------	--------	.0045	.0040	.0037	.0034	.0032	.0028	.0025	.0025	.0025
	0.75	0.33*D*	0.67*D*	--------	--------	.0068	.0061	.0055	.0051	.0047	.0042	.0038	.0038	.0038
	1.0	0.67*D*	1.5*D*	--------	--------	.0082	.0081	.0074	.0068	.0063	.0056	.0051	.0050	.0050
	1.25	1.5*D*	3*D*	--------	--------	.0082	.0082	.0082	.0082	.0079	.0070	.0063	.0062	.0062
44	0.5	0	0.33*D*	--------	--------	.0050	.0044	.0040	.0037	.0035	.0031	.0028	.0028	.0028
	0.75	0.33*D*	0.67*D*	--------	--------	.0075	.0067	.0061	.0056	.0052	.0046	.0042	.0041	.0041
	1.0	0.67*D*	1.5*D*	--------	--------	.0090	.0089	.0081	.0075	.0070	.0062	.0056	.0055	.0055
	1.25	1.5*D*	3*D*	--------	--------	.0090	.0090	.0090	.0090	.0087	.0077	.0070	.0069	.0069
40	0.5	0	0.33*D*	--------	--------	--------	.0049	.0045	.0041	.0039	.0034	.0031	.0030	.0030
	0.75	0.33*D*	0.67*D*	--------	--------	--------	.0074	.0067	.0062	.0058	.0051	.0047	.0045	.0045
	1.0	0.67*D*	1.5*D*	--------	--------	--------	.0098	.0090	.0083	.0077	.0068	.0062	.0060	.0060
	1.25	1.5*D*	3*D*	--------	--------	--------	.0098	.0098	.0098	.0096	.0086	.0078	.0075	.0075
36	0.5	0	0.33*D*	--------	--------	--------	--------	.0050	.0046	.0043	.0038	.0035	.0033	.0033
	0.75	0.33*D*	0.67*D*	--------	--------	--------	--------	.0075	.0069	.0065	.0058	.0052	.0050	.0050
	1.0	0.67*D*	1.5*D*	--------	--------	--------	--------	.0100	.0093	.0086	.0077	.0070	.0066	.0066
	1.25	1.5*D*	3*D*	--------	--------	--------	--------	.0109	.0109	.0108	.0096	.0087	.0082	.0082
32	0.5	0	0.33*D*	--------	--------	--------	--------	--------	--------	.0049	.0043	.0039	.0037	.0037
	0.75	0.33*D*	0.67*D*	--------	--------	--------	--------	--------	--------	.0073	.0065	.0059	.0056	.0056
	1.0	0.67*D*	1.5*D*	--------	--------	--------	--------	--------	--------	.0098	.0087	.0079	.0074	.0074
	1.25	1.5*D*	3*D*	--------	--------	--------	--------	--------	--------	.0122	.0108	.0099	.0092	.0092
28	0.5	0	0.33*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0045	.0042	.0042
	0.75	0.33*D*	0.67*D*	← Tolerances in this range also apply to class 3B threads. →							--------	.0068	.0063	.0063
	1.0	0.67*D*	1.5*D*								--------	.0091	.0084	.0084
	1.25	1.5*D*	3*D*								--------	.0113	.0105	.0105
27	0.5	0	0.33*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0047	.0044	.0044
	0.75	0.33*D*	0.67*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0071	.0065	.0065
	1.0	0.67*D*	1.5*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0094	.0087	.0087
	1.25	1.5*D*	3*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0118	.0109	.0109
24	0.5	0	0.33*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0053	.0049	.0048
	0.75	0.33*D*	0.67*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0079	.0073	.0073
	1.0	0.67*D*	1.5*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0106	.0098	.0097
	1.25	1.5*D*	3*D*	--------	--------	--------	--------	--------	--------	--------	--------	.0132	.0122	.0121

Tolerance ratios	Length of engagement in terms of diameter Above	to and including	Minor diameter tolerances (Not applicable to diameters less than 0.25 in) 20 tpi	18 tpi	16 tpi	14 tpi	13 tpi	12 tpi	11 tpi	10 tpi	9 tpi	8 tpi	7 tpi	6 tpi	5 tpi	4.5 tpi	4 tpi
			in	in	in	in	in	in	in	in	in	in	in	in	in	in	in
0.5	0	0.33*D*	0.0058	0.0064	0.0070	0.0079	0.0085	0.0090	0.0097	0.0105	0.0114	0.0125	0.0138	0.0153	0.0170	0.0179	0.0188
0.75	0.33*D*	0.67*D*	0.0086	0.0095	0.0106	0.0118	0.0128	0.0135	0.0146	0.0158	0.0171	0.0188	0.0207	0.0230	0.0255	0.0268	0.0281
1.0	0.67*D*	1.5*D*	0.0115	0.0127	0.0141	0.0158	0.0170	0.0180	0.0194	0.0210	0.0228	0.0250	0.0276	0.0306	0.0340	0.0358	0.0375
1.25	1.5*D*	3*D*	0.0144	0.0159	0.0176	0.0198	0.0213	0.0225	0.0242	0.0262	0.0286	0.0312	0.0344	0.0382	0.0425	0.0448	0.0469

[a] Tolerances for lengths of engagement in terms of pitch should be selected from equivalent lengths of engagement in terms of diameter ranges.
If the minor diameter tolerance as selected from this table is less than the pitch diameter tolerance, use the latter. See Design of Special Threads in appendix A5.

TABLE 3.10. *Minor diameter tolerances for internal special screw threads, class 3B*

(UNS threads, see par. 10, p. 3.05.)

Tolerance based on basic major diameter of →					0.164	0.190	0.216	0.250	0.3125	0.375	0.4375	0.500	0.5625	0.625	0.6875	All larger diameters
For diameter range Above →				0.053	0.151	0.177	0.203	0.233	0.281	0.344	0.406	0.469	0.531	0.594	0.656	
To and including →				0.151	0.177	0.203	0.233	0.281	0.344	0.406	0.469	0.531	0.594	0.656	0.719	
Threads per inch	Tolerance ratios	Length of engagement in terms of diameter[a] Above	to and including	3B					Minor diameter tolerances[b]					3B		
				(c)	in	in	in	in	in	in	in	in	in	in	in	in
80	0.5	0	0.33*D*	--------	0.0015	0.0013	0.0013	0.0013	0.0013	--------	--------	--------	--------	--------	--------	--------
	0.75	0.33*D*	0.67*D*	--------	.0022	.0020	.0020	.0020	.0020	--------	--------	--------	--------	--------	--------	--------
	1.0	0.67*D*	1.5*D*	--------	.0030	.0027	.0026	.0026	.0026	--------	--------	--------	--------	--------	--------	--------
	1.25	1.5*D*	3*D*	--------	.0037	.0033	.0033	.0033	.0033	--------	--------	--------	--------	--------	--------	--------
72	0.5	0	0.33*D*	--------	.0017	.0015	.0015	.0015	.0015	0.0015	0.0015	--------	--------	--------	--------	--------
	0.75	0.33*D*	0.67*D*	--------	.0026	.0023	.0022	.0022	.0022	.0022	.0022	--------	--------	--------	--------	--------
	1.0	0.67*D*	1.5*D*	--------	.0034	.0031	.0029	.0029	.0029	.0029	.0029	--------	--------	--------	--------	--------
	1.25	1.5*D*	3*D*	--------	.0043	.0039	.0036	.0036	.0036	.0036	.0036	--------	--------	--------	--------	--------
64	0.5	0	0.33*D*	--------	.0020	.0018	.0016	.0016	.0016	.0016	.0016	0.0016	0.0016	--------	--------	--------
	0.75	0.33*D*	0.67*D*	--------	.0030	.0027	.0025	.0024	.0024	.0024	.0024	.0024	.0024	--------	--------	--------
	1.0	0.67*D*	1.5*D*	--------	.0040	.0036	.0033	.0032	.0032	.0032	.0032	.0032	.0032	--------	--------	--------
	1.25	1.5*D*	3*D*	--------	.0050	.0045	.0041	.0040	.0040	.0040	.0040	.0040	.0040	--------	--------	--------
56	0.5	0	0.33*D*	--------	.0023	.0021	.0019	.0018	.0018	.0018	.0018	.0018	.0018	0.0018	0.0018	0.0018
	0.75	0.33*D*	0.67*D*	--------	.0035	.0032	.0029	.0027	.0027	.0027	.0027	.0027	.0027	.0027	.0027	.0027
	1.0	0.67*D*	1.5*D*	--------	.0047	.0042	.0039	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036
	1.25	1.5*D*	3*D*	--------	.0059	.0053	.0049	.0045	.0045	.0045	.0045	.0045	.0045	.0045	.0045	.0045
48	0.5	0	0.33*D*	--------	.0028	.0025	.0023	.0021	.0021	.0021	.0021	.0021	.0021	.0021	.0021	.0021
	0.75	0.33*D*	0.67*D*	--------	.0042	.0038	.0035	.0032	.0031	.0031	.0031	.0031	.0031	.0031	.0031	.0031
	1.0	0.67*D*	1.5*D*	--------	.0056	.0051	.0047	.0043	.0041	.0041	.0041	.0041	.0041	.0041	.0041	.0041
	1.25	1.5*D*	3*D*	--------	.0070	.0063	.0059	.0054	.0052	.0052	.0052	.0052	.0052	.0052	.0052	.0052
44	0.5	0	0.33*D*	--------	.0031	.0028	.0026	.0024	.0022	.0022	.0022	.0022	.0022	.0022	.0022	.0022
	0.75	0.33*D*	0.67*D*	--------	.0046	.0042	.0039	.0036	.0033	.0033	.0033	.0033	.0033	.0033	.0033	.0033
	1.0	0.67*D*	1.5*D*	--------	.0062	.0056	.0052	.0047	.0045	.0045	.0045	.0045	.0045	.0045	.0045	.0045
	1.25	1.5*D*	3*D*	--------	.0077	.0070	.0065	.0059	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056
40	0.5	0	0.33*D*	--------	.0034	.0031	.0029	.0026	.0024	.0024	.0024	.0024	.0024	.0024	.0024	.0024
	0.75	0.33*D*	0.67*D*	--------	.0051	.0047	.0043	.0040	.0036	.0036	.0036	.0036	.0036	.0036	.0036	.0036
	1.0	0.67*D*	1.5*D*	--------	.0068	.0062	.0057	.0053	.0048	.0048	.0048	.0048	.0048	.0048	.0048	.0048
	1.25	1.5*D*	3*D*	--------	.0086	.0078	.0072	.0066	.0062	.0062	.0060	.0060	.0060	.0060	.0060	.0060
36	0.5	0	0.33*D*	--------	.0038	.0035	.0032	.0030	.0026	.0026	.0026	.0026	.0026	.0026	.0026	.0026
	0.75	0.33*D*	0.67*D*	--------	.0058	.0052	.0048	.0044	.0039	.0039	.0039	.0039	.0039	.0039	.0039	.0039
	1.0	0.67*D*	1.5*D*	--------	.0077	.0070	.0064	.0059	.0053	.0052	.0052	.0052	.0052	.0052	.0052	.0052
	1.25	1.5*D*	3*D*	--------	.0096	.0087	.0081	.0074	.0066	.0065	.0065	.0065	.0065	.0065	.0065	.0065
32	0.5	0	0.33*D*	--------	.0043	.0039	.0036	.0034	.0030	.0029	.0029	.0029	.0029	.0029	.0029	.0029
	0.75	0.33*D*	0.67*D*	--------	.0065	.0059	.0055	.0050	.0045	.0043	.0043	.0043	.0043	.0043	.0043	.0043
	1.0	0.67*D*	1.5*D*	--------	.0087	.0079	.0073	.0067	.0060	.0057	.0057	.0057	.0057	.0057	.0057	.0057
	1.25	1.5*D*	3*D*	--------	.0108	.0099	.0091	.0084	.0075	.0072	.0072	.0072	.0072	.0072	.0072	.0072
28	0.5	0	0.33*D*	--------	--------	.0045	.0042	.0039	.0034	.0032	.0032	.0032	.0032	.0032	.0032	.0032
	0.75	0.33*D*	0.67*D*	--------	--------	.0068	.0063	.0058	.0051	.0047	.0047	.0047	.0047	.0047	.0047	.0047
	1.0	0.67*D*	1.5*D*	--------	--------	.0091	.0084	.0077	.0069	.0063	.0063	.0063	.0063	.0063	.0063	.0063
	1.25	1.5*D*	3*D*	--------	--------	.0113	.0105	.0096	.0086	.0079	.0079	.0079	.0079	.0079	.0079	.0079
27	0.5	0	0.33*D*	--------	--------	.0047	.0044	.0040	.0036	.0032	.0032	.0032	.0032	.0032	.0032	.0032
	0.75	0.33*D*	0.67*D*	--------	--------	.0071	.0065	.0060	.0053	.0048	.0048	.0048	.0048	.0048	.0048	.0048
	1.0	0.67*D*	1.5*D*	--------	--------	.0094	.0087	.0080	.0071	.0065	.0065	.0065	.0065	.0065	.0065	.0065
	1.25	1.5*D*	3*D*	--------	--------	.0118	.0109	.0100	.0089	.0081	.0081	.0081	.0081	.0081	.0081	.0081
24	0.5	0	0.33*D*	--------	--------	.0053	.0049	.0045	.0040	.0037	.0035	.0035	.0035	.0035	.0035	.0035
	0.75	0.33*D*	0.67*D*	--------	--------	.0079	.0073	.0068	.0060	.0055	.0052	.0052	.0052	.0052	.0052	.0052
	1.0	0.67*D*	1.5*D*	--------	--------	.0106	.0098	.0090	.0080	.0073	.0070	.0070	.0070	.0070	.0070	.0070
	1.25	1.5*D*	3*D*	--------	--------	.0132	.0122	.0113	.0100	.0092	.0087	.0087	.0087	.0087	.0087	.0087
20	0.5	0	0.33*D*	--------	--------	--------	--------	.0054	.0048	.0044	.0041	.0039	.0039	.0039	.0039	.0039
	0.75	0.33*D*	0.67*D*	--------	--------	--------	--------	.0081	.0072	.0066	.0062	.0058	.0058	.0058	.0058	.0058
	1.0	0.67*D*	1.5*D*	--------	--------	--------	--------	.0108	.0096	.0088	.0082	.0078	.0078	.0078	.0078	.0078
	1.25	1.5*D*	3*D*	--------	--------	--------	--------	.0135	.0120	.0110	.0103	.0097	.0097	.0097	.0097	.0097
18	0.5	0	0.33*D*	--------	--------	--------	--------	--------	.0053	.0049	.0045	.0043	.0041	.0041	.0041	.0041
	0.75	0.33*D*	0.67*D*	--------	--------	--------	--------	--------	.0080	.0073	.0068	.0065	.0062	.0061	.0061	.0061
	1.0	0.67*D*	1.5*D*	--------	--------	--------	--------	--------	.0106	.0097	.0091	.0086	.0082	.0081	.0081	.0081
	1.25	1.5*D*	3*D*	--------	--------	--------	--------	--------	.0133	.0122	.0114	.0108	.0103	.0102	.0102	.0102
16	0.5	0	0.33*D*	--------	--------	--------	--------	--------	--------	.0054	.0051	.0048	.0046	.0044	.0043	.0043
	0.75	0.33*D*	0.67*D*	--------	--------	--------	--------	--------	--------	.0082	.0076	.0072	.0069	.0067	.0064	.0064
	1.0	0.67*D*	1.5*D*	--------	--------	--------	--------	--------	--------	.0109	.0102	.0096	.0092	.0089	.0086	.0085
	1.25	1.5*D*	3*D*	--------	--------	--------	--------	--------	--------	.0136	.0127	.0120	.0115	.0111	.0108	.0106

[a] Tolerances for lengths of engagement in terms of pitch should be selected from equivalent lengths of engagement in terms of diameter ranges.
[b] If the minor-diameter tolerance as selected from the table is less than pitch-diameter tolerance, use the latter. See Design of Special Threads in appendix A5.
[c] For 0.151 in diam sizes and smaller, tolerance values for all three classes are the same. For these smaller sizes, tolerance values are given in table 3.9.

TABLE 3.10. *Minor diameter tolerances for internal special screw threads, class 3B*—Continued

(UNS threads, see par. 10, p. 3.05.)

Tolerance based on basic major diameter of→				0.375	0.4375	0.500	0.5625	0.625	0.6875	0.750	0.8125	0.875	0.9375	All larger diameters
For diameter range Above →				0.344	0.406	0.469	0.531	0.594	0.656	0.719	0.781	0.844	0.906	
To and including →				0.406	0.469	0.531	0.594	0.656	0.719	0.781	0.844	0.906	0.969	
Threads per inch	Tolerance ratios	Length of engagement in terms of diameter[a] Above	to and including	3B			Minor diameter tolerances[b]					3B		
				in	in	in	in	in	in	in	in	in	in	in
14	0.5	0	0.33D	------	.0058	.0054	.0052	.0050	.0049	.0047	.0046	.0045	.0044	.0044
	0.75	0.33D	0.67D	------	.0086	.0082	.0078	.0075	.0073	.0071	.0069	.0068	.0067	.0066
	1.0	0.67D	1.5D	------	.0115	.0109	.0104	.0100	.0097	.0095	.0092	.0091	.0089	.0088
	1.25	1.5D	3D	------	.0144	.0136	.0130	.0125	.0122	.0118	.0116	.0113	.0111	.0110
13	0.5	0	0.33D	------	------	.0058	.0056	.0054	.0052	.0050	.0050	.0049	.0048	.0047
	0.75	0.33D	0.67D	------	------	.0087	.0083	.0080	.0078	.0076	.0074	.0073	.0071	.0070
	1.0	0.67D	1.5D	------	------	.0117	.0111	.0107	.0104	.0101	.0099	.0097	.0095	.0094
	1.25	1.5D	3D	------	------	.0146	.0139	.0134	.0130	.0126	.0124	.0122	.0119	.0118
12	0.5	0	0.33D	------	------	.0063	.0060	.0058	.0056	.0054	.0053	.0052	.0051	.0050
	0.75	0.33D	0.67D	------	------	.0094	.0090	.0087	.0084	.0082	.0080	.0078	.0077	.0075
	1.0	0.67D	1.5D	------	------	.0125	.0120	.0115	.0112	.0109	.0106	.0104	.0102	.0100
	1.25	1.5D	3D	------	------	.0157	.0150	.0144	.0140	.0136	.0133	.0130	.0128	.0125
11	0.5	0	0.33D	------	------	------	------	.0062	.0060	.0058	.0058	.0056	.0055	.0054
	0.75	0.33D	0.67D	------	------	------	------	.0094	.0091	.0088	.0086	.0084	.0082	.0082
	1.0	0.67D	1.5D	------	------	------	------	.0125	.0121	.0117	.0115	.0112	.0110	.0109
	1.25	1.5D	3D	------	------	------	------	.0156	.0151	.0146	.0144	.0140	.0138	.0136
10	0.5	0	0.33D	------	------	------	------	------	.0066	.0064	.0062	.0061	.0060	.0060
	0.75	0.33D	0.67D	------	------	------	------	------	.0099	.0096	.0093	.0092	.0090	.0090
	1.0	0.67D	1.5D	------	------	------	------	------	.0131	.0128	.0125	.0122	.0120	.0120
	1.25	1.5D	3D	------	------	------	------	------	.0164	.0160	.0156	.0153	.0150	.0150
9	0.5	0	0.33D	------	------	------	------	------	------	------	.0068	.0067	.0066	.0066
	0.75	0.33D	0.67D	------	------	------	------	------	------	------	.0103	.0100	.0100	.0100
	1.0	0.67D	1.5D	------	------	------	------	------	------	------	.0137	.0134	.0133	.0133
	1.25	1.5D	3D	------	------	------	------	------	------	------	.0171	.0168	.0166	.0166
8	0.5	0	0.33D	------	------	------	------	------	------	------	.0075	.0075	.0075	.0075
	0.75	0.33D	0.67D	------	------	------	------	------	------	------	.0112	.0112	.0112	.0112
	1.0	0.67D	1.5D	------	------	------	------	------	------	------	.0150	.0150	.0150	.0150
	1.25	1.5D	3D	------	------	------	------	------	------	------	.0188	.0188	.0188	.0188
7	0.5	0	0.33D	------	------	------	------	------	------	------	------	------	.0086	.0086
	0.75	0.33D	0.67D	------	------	------	------	------	------	------	------	------	.0129	.0129
	1.0	0.67D	1.5D	------	------	------	------	------	------	------	------	------	.0171	.0171
	1.25	1.5D	3D	------	------	------	------	------	------	------	------	------	.0214	.0214
6	0.5	0	0.33D	------	------	------	------	------	------	------	------	------	------	.0100
	0.75	0.33D	0.67D	------	------	------	------	------	------	------	------	------	------	.0150
	1.0	0.67D	1.5D	------	------	------	------	------	------	------	------	------	------	.0200
	1.25	1.5D	3D	------	------	------	------	------	------	------	------	------	------	.0250
5	0.5	0	0.33D	------	------	------	------	------	------	------	------	------	------	.0120
	0.75	0.33D	0.67D	------	------	------	------	------	------	------	------	------	------	.0180
	1.0	0.67D	1.5D	------	------	------	------	------	------	------	------	------	------	.0240
	1.25	1.5D	3D	------	------	------	------	------	------	------	------	------	------	.0300
4.5	0.5	0	0.33D	------	------	------	------	------	------	------	------	------	------	.0133
	0.75	0.33D	0.67D	------	------	------	------	------	------	------	------	------	------	.0200
	1.0	0.67D	1.5D	------	------	------	------	------	------	------	------	------	------	.0267
	1.25	1.5D	3D	------	------	------	------	------	------	------	------	------	------	.0333
4	0.5	0	0.33D	------	------	------	------	------	------	------	------	------	------	.0150
	0.75	0.33D	0.67D	------	------	------	------	------	------	------	------	------	------	.0225
	1.0	0.67D	1.5D	------	------	------	------	------	------	------	------	------	------	.0300
	1.25	1.5D	3D	------	------	------	------	------	------	------	------	------	------	.0375

See previous page for footnotes.

TABLE 3.11. *Consolidated method for the calculation of dimensions of special threads*

	External thread				Internal thread			
Thread element	Class 1A	Class 1AR	Class 2A	Class 3A	Class 1B	Class 2B	Class 3B	Thread element
Max major dia	Nominal size minus allowance			Nominal size	Nominal size			Min major dia
	Table 3.2	Tabulated on p. 3.03	Table 3.2					
Tolerance on major dia	Use values tabulated on p. 3.04 or compute in accordance with directions for designing special threads in appendix A5. APPLY MINUS.				$H/6(0.1667H)$, table 2.1, col. 8. APPLY PLUS.			Tolerance on major dia
Max pitch dia	Subtract $0.75H$, table 2.1, col. 14, from maximum major diameter shown above.				Subtract $0.75H$, table 2.1, col. 14, from minimum major diameter shown above.			Min pitch dia
Tolerance on pitch dia	Table 3.3 APPLY MINUS	Table 3.3 APPLY MINUS	Table 3.4 APPLY MINUS	Table 3.5 APPLY MINUS	Table 3.6 APPLY PLUS	Table 3.7 APPLY PLUS	Table 3.8 APPLY PLUS	Tolerance on pitch dia
Max minor dia	Subtract $17H/12(1.4167H)$, table 2.1, col. 18, from maximum major diameter. This is a reference dimension only.				Subtract $1.25H$, table 2.1, col. 17, from the basic major diameter and round off to the nearest 0.001 in for sizes 0.138 in and larger. For class 3B a cipher is added to yield four decimal places.			Min minor dia
Tolerance on minor dia	$H/12(0.0833H)$, table 2.1, col. 6. APPLY MINUS				For general applications use value for $0.67D$ to $1.5D$ length of engagement from table 3.9 or 3.10. For specific applications use values for applicable length of engagement or compute in accordance with directions for designing special threads in appendix A5. APPLY PLUS to four-place value of min minor diameter and round off for classes 1B and 2B values to the nearest 0.001 in for sizes 0.138 in and larger; class 3B values are to be rounded off to the nearest 0.0001 in.			Tolerance on minor dia

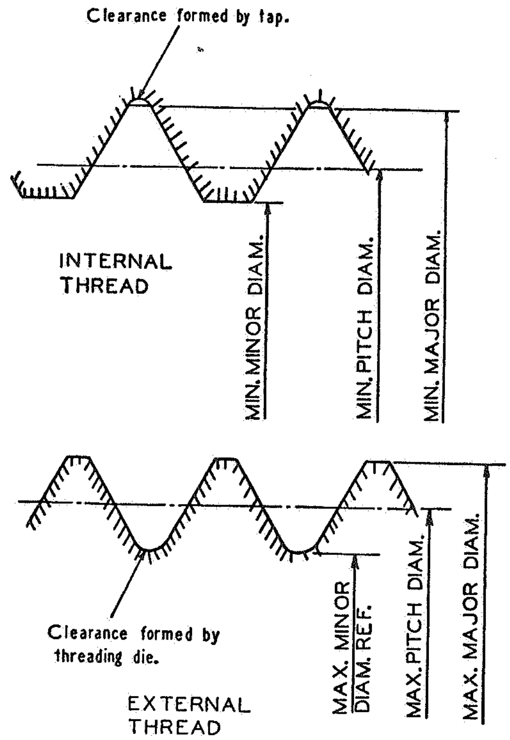

FIGURE 3.12. *Thread dimensions to be determined for a special thread.*

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UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

HANDBOOK H28

SCREW-THREAD STANDARDS

FOR FEDERAL SERVICES

SECTION 4

1969

CONTROLLED RADIUS ROOT SCREW THREADS UNJ SYMBOL

This section of Handbook H28 has not as yet been fully coordinated. As soon as coordination has been completed, it will be issued as a separate document.

Section 4 will be in general agreement with Military Specification MIL-S-8879, Screw Threads, Controlled Radius Root with Increased Minor Diameter; General Specification for.

Also in process of coordination is USAS B1.15 which is the industry standard for the UNJ thread.

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UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

HANDBOOK H28

SCREW-THREAD STANDARDS

FOR FEDERAL SERVICES

SECTION 5

1969

UNIFIED MINIATURE SCREW THREADS

CONTENTS

1. INTRODUCTION

This section is in general agreement with United States of America Standards Institute (USASI) Standard USA B1.10, Unified Miniature Screw Threads, published by The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017. The latest revision should be consulted when referring to this USA standard. As of date of issue of this part of H28, USA B1.10-1958 is the latest revision.

The thread sizes shown in this section are those endorsed by the American-British-Canadain Conference as the basis for a Unified standard among the inch-using countries.

This section presents a thread series known as Unified Miniature Screw Threads and is intended for general purpose fastening screws and similar uses in watches, instruments, and miniature mechanisms. The series covers a diameter range from 0.30 to 1.40 mm (0.0118 to 0.0551 in) and thus supplements the Unified thread series that begin at 0.060 in.

The 14 sizes are systematically distributed, providing a uniformly proportioned selection over the entire range. They are alternately separated into two categories. The primary sizes are selections made in the interest of simplification and are those to which it is recommended that usage be confined whenever the circumstances of design permit. For more restrictive conditions, the secondary sizes are available.

The diameter-pitch combinations have been determined to provide both maximum strength against stripping and optimum conditions for manufacture on an interchangeable basis.

The values of all dimensions are supplied in both metric and inch units. The standard being basically metric, only the metric values of the nominal diameters and pitches are rational. Consequently, metric units are stipulated for all formulas and the inch dimensions derived by conversion of the unrounded metric values, using the conversion factor 25.4 mm/in.

Use of this series is recommended on all new products in place of the many improvised and unsystematized sizes now in existence that have never arrived at broad acceptance nor recognition by any standardization bodies.

2. THREAD FORM

2.1. Basic Thread Form—The theoretical profile on which the design forms of the threads covered by this section are based is, except for one element, the Unified basic thread form as specified in section 2 and shown in figure 5.1. In exception is thread height, for which a basic value of $0.48p$ is used instead of

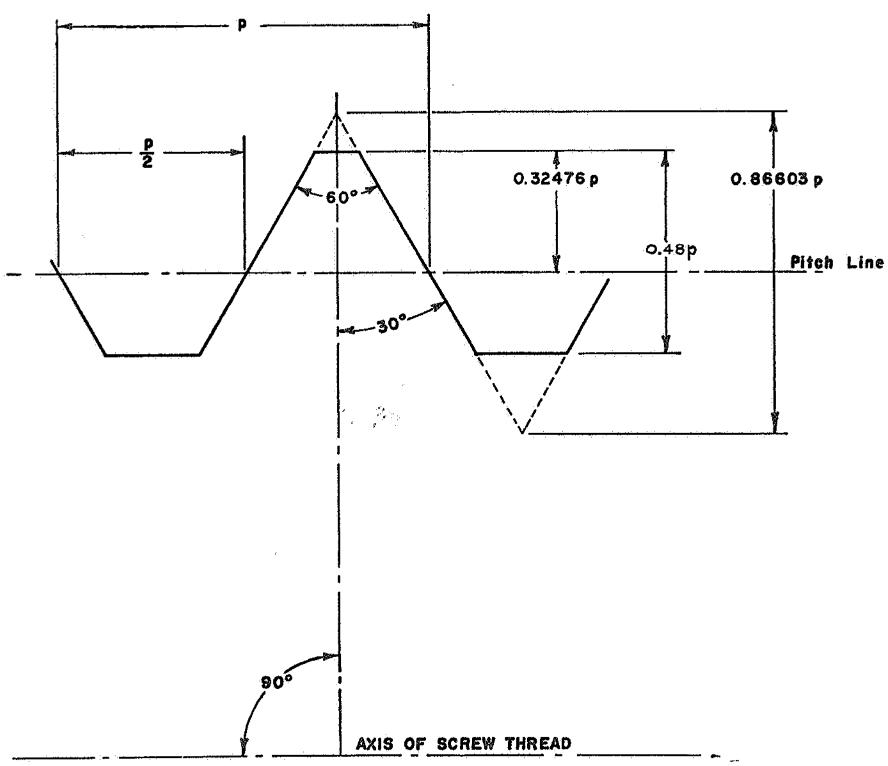

Figure 5.1. *Basic thread form, Unified Miniature threads, UNM.*

0.54127p $(=5H/8)$. Selection of this value is based on the extensive simplification that it affords throughout the calculations for this standard. Resulting coefficients in the formulas for many of the other thread dimensions derived from this property thereby become simple, finite multiples of the lowest common denominator (40) of the fractional equivalents of all but two of the metric pitches, thus yielding values for the majority of metric dimensions that are finite within the decimal place limits of the tables. Also, the calculation of inch equivalents from the terminal metric values is thereby simplified and discrepancies between the metric and inch tables kept to a minimum. This modification will not affect interchangeability with product made to any other standards retaining 0.54127p, as the resulting difference is negligible and completely offset by practical considerations in tapping, full internal thread heights being invariably avoided in these small sizes to escape excessive tap breakage.

2.2. Design Forms of Threads.—The design forms (maximum material condition) of external and internal Unified Miniature threads are shown in figure 5.2.

2.3. Basic Thread Data.—The formulas for the various features of the thread form are as follows:

Dimension	Symbol	Formula [a]
Basic thread form		
Angle of thread	2α	60°.
Half angle of thread	α	30°.
Pitch of thread	p	
No. of threads per inch	n	$25.4/p$.
Height of sharp-V thread	H	$0.866025p$.
Addendum of basic thread	h_{ab}	$0.32476p$.
Height of basic thread (Unified and ISO) [b].	h_b	$0.54127p$.
Height of basic thread (UNM series)	h_b	$0.48p$.
Design thread form		
Addendum of external thread	h_{as}	$0.32476p$.
Height of external thread	h_s	$0.56p$.
Flat at crest of external thread	F_{cs}	$0.125p$.
Radius at root of external thread	r_{rs}	$0.158p$ (approx.).
Depth of thread engagement	$h_e = h_b$	$0.48p$.
Height of internal thread	h_n	$0.516p$.
Flat at crest of internal thread	F_{cn}	$0.32074p$.
Radius at root of internal thread	r_{rn}	$0.072p$ (approx.).

[a] The formulas are applied to the metric values of p. Tabulated inch dimensions are derived from the unrounded metric dimensions.

[b] This item is listed for reference only. For the present standard all dependent details of thread form and dimensions are based on a height of 0.48p.

The corresponding thread data for the various standard pitches are shown in table 5.3. The formulas for basic and design thread sizes are as follows:

Dimension	Symbol	Formula
Major diameter, nominal and basic.	D	
Major diameter of external thread.	D_s	D.
Major diameter of internal thread.	D_n	$D - 2h_b + 2h_n = D + 0.072p$.
Pitch diameter, basic	E	$D - 2h_{ab} = D - 0.64952p$.
Pitch diameter of external thread.	E_s	E.
Pitch diameter of internal thread.	E_n	E.
Minor diameter, basic	K	$D - 2h_b = D - 0.96p$.
Minor diameter of external thread.	K_s	$D - 2h_s = D - 1.12p$.
Minor diameter of internal thread.	K_n	K.

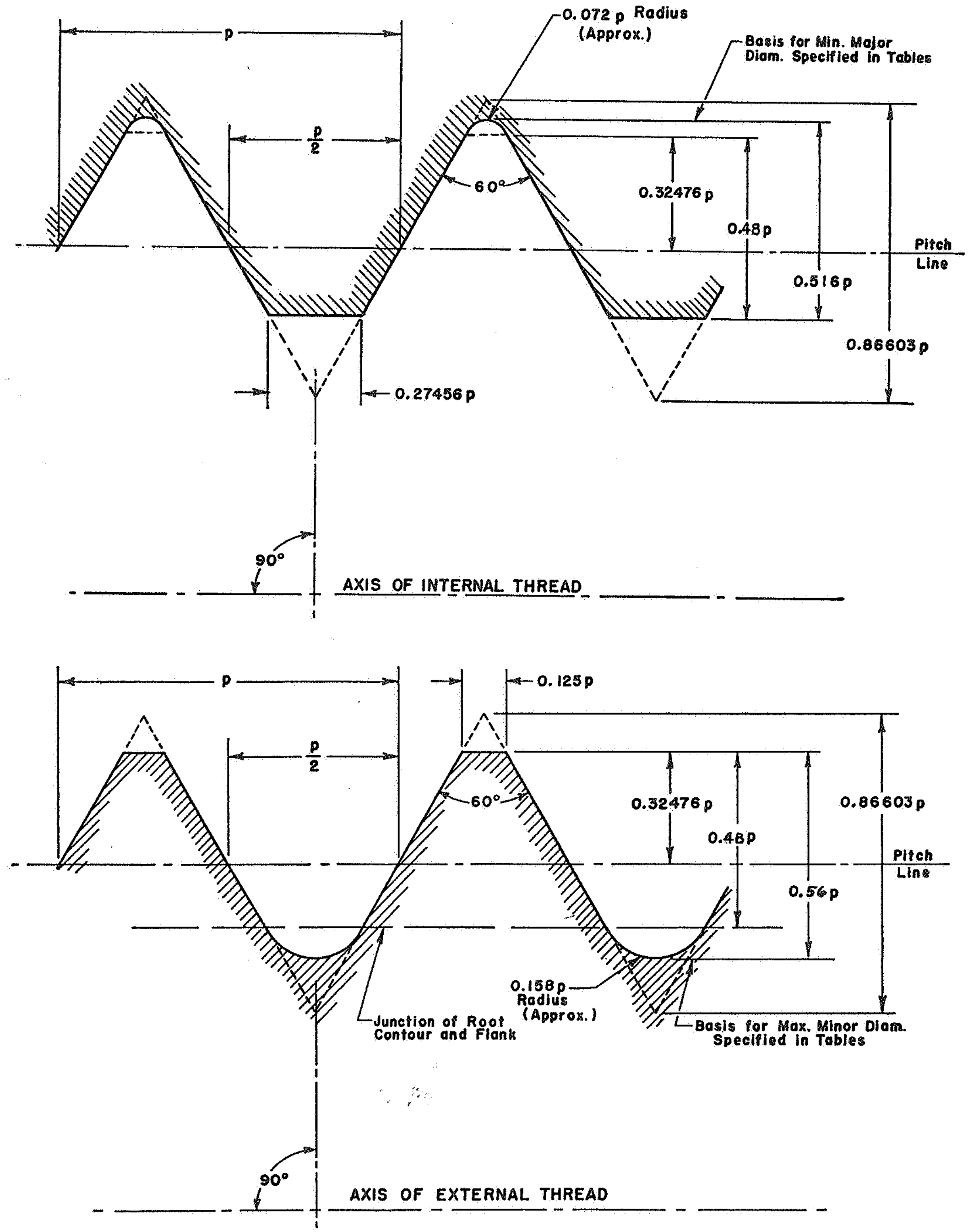

FIGURE 5.2. *Unified Miniature internal and external screw thread design forms (maximum-material condition).*

TABLE 5.3. *Thread form data, Unified Miniature screw threads, UNM*

Basic					External thread					Internal thread		
Threads per inch[a] n	Pitch, p	Height of sharp V thread, $H = 0.866025p$	Height, $h_b = 0.48p$	Addendum, $h_{ab} = h^a_s = 0.32476p$	Height, $h_s = 0.56p$	Flat at crest, $F_{cs} = 0.125p$	Radius at root, $r_{rs} = 0.158p$	Basis for minimum flat at root, $0.64p$	Min. flat at root, $F_{rs} = 0.136p$	Height, $h_n = 0.516p$	Flat at crest, $F_{cn} = 0.32074p$	Radius at root, $r_{rn} = 0.072p$
1	2	3	4	5	6	7	8	9	10	11	12	13
	mm	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*
	0.080	0.0693	0.0384	0.0260	0.045	0.0100	0.0126	0.0512	0.0109	0.0413	0.0257	0.0058
	.090	.0779	.0432	.0292	.050	.0112	.0142	.0576	.0122	.0464	.0289	.0065
	.100	.0866	.0480	.0325	.056	.0125	.0158	.0640	.0136	.0516	.0321	.0072
	.125	.1083	.0600	.0406	.070	.0156	.0198	.0800	.0170	.0645	.0401	.0090
	.150	.1299	.0720	.0487	.084	.0188	.0237	.0960	.0204	.0774	.0481	.0108
	.175	.1516	.0840	.0568	.098	.0219	.0277	.1120	.0238	.0903	.0561	.0126
	.200	.1732	.0960	.0650	.112	.0250	.0316	.1280	.0272	.1032	.0641	.0144
	.225	.1949	.1080	.0731	.126	.0281	.0356	.1440	.0306	.1161	.0722	.0162
	.250	.2165	.1200	.0812	.140	.0312	.0395	.1600	.0340	.1290	.0802	.0180
	.300	.2598	.1440	.0974	.168	.0375	.0474	.1920	.0408	.1548	.0962	.0216
	in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*
317 1/2	0.003150	0.00273	0.00151	0.00102	0.00176	0.00039	0.00050	0.00202	0.00043	0.00163	0.00101	0.00023
282 2/9	.003543	.00307	.00170	.00115	.00198	.00044	.00056	.00227	.00048	.00183	.00114	.00026
254	.003937	.00341	.00189	.00128	.00220	.00049	.00062	.00252	.00054	.00203	.00126	.00028
203 1/5	.004921	.00426	.00236	.00160	.00276	.00062	.00078	.00315	.00067	.00254	.00158	.00035
169 1/3	.005906	.00511	.00283	.00192	.00331	.00074	.00093	.00378	.00080	.00305	.00189	.00043
145 1/7	.006890	.00597	.00331	.00224	.00386	.00086	.00109	.00441	.00094	.00356	.00221	.00050
127	.007874	.00682	.00378	.00256	.00441	.00098	.00124	.00504	.00107	.00406	.00253	.00057
112 8/9	.008858	.00767	.00425	.00288	.00496	.00111	.00140	.00567	.00120	.00457	.00284	.00064
101 3/5	.009843	.00852	.00472	.00320	.00551	.00123	.00156	.00630	.00134	.00508	.00316	.00071
84 2/3	.011811	.01023	.00567	.00384	.00661	.00148	.00187	.00756	.00161	.00609	.00379	.00085

[a] In all subsequent tables these values are rounded to the nearest whole number.

TABLE 5.4. *Basic and design sizes, Unified Miniature thread series, UNM*

Size designation		Pitch, p	Basic major diameter, D	Basic pitch diameter, $E = D - 0.64952p$	Minor diameter external threads, $K_s = D - 1.12p$	Minor diameter internal threads, $K_n = K = D - 0.96p$	Major diameter internal threads, $D_n = D + 0.072p$	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 1.28p$
Primary	Secondary									
1	2	3	4	5	6	7	8	9		10
		mm	*mm*	*mm*	*mm*	*mm*	*mm*	*deg*	*min*	*mm*²
.30UNM		.080	0.300	0.248	0.210	0.223	0.306	5	52	0.0307
	.35UNM	.090	.350	.292	.250	.264	.356	5	37	.0433
.40UNM		.100	.400	.335	.288	.304	.407	5	26	.0581
	.45UNM	.100	.450	.385	.338	.354	.457	4	44	.0814
.50UNM		.125	.500	.419	.360	.380	.509	5	26	.0908
	.55UNM	.125	.550	.469	.410	.430	.559	4	51	.1195
.60UNM		.150	.600	.503	.432	.456	.611	5	26	.1307
	.70UNM	.175	.700	.586	.504	.532	.713	5	26	.1780
.80UNM		.200	.800	.670	.576	.608	.814	5	26	.232
	.90UNM	.225	.900	.754	.648	.684	.916	5	26	.294
1.00UNM		.250	1.000	.838	.720	.760	1.018	5	26	.363
	1.10UNM	.250	1.100	.938	.820	.860	1.118	4	51	.478
1.20UNM		.250	1.200	1.038	.920	.960	1.218	4	23	.608
	1.40UNM	.300	1.400	1.205	1.064	1.112	1.422	4	32	.811
		threads per inch	*in*	*in*	*in*	*in*	*in*	*deg*	*min*	*sq in* × 10^{-4}
.30UNM		318	0.0118	0.0098	0.0083	0.0088	0.0120	5	52	0.475
	.35UNM	282	.0138	.0115	.0098	.0104	.0140	5	37	.671
.40UNM		254	.0157	.0132	.0113	.0120	.0160	5	26	.901
	.45UNM	254	.0177	.0152	.0133	.0139	.0180	4	44	1.262
.50UNM		203	.0197	.0165	.0142	.0150	.0200	5	26	1.407
	.55UNM	203	.0217	.0185	.0161	.0169	.0220	4	51	1.852
.60UNM		169	.0236	.0198	.0170	.0180	.0240	5	26	2.03
	.70UNM	145	.0276	.0231	.0198	.0209	.0281	5	26	2.76
.80UNM		127	.0315	.0264	.0227	.0239	.0321	5	26	3.60
	.90UNM	113	.0354	.0297	.0255	.0269	.0361	5	26	4.56
1.00UNM		102	.0394	.0330	.0283	.0299	.0401	5	26	5.63
	1.10UNM	102	.0433	.0369	.0323	.0339	.0440	4	51	7.41
1.20UNM		102	.0472	.0409	.0362	.0378	.0480	4	23	9.43
	1.40UNM	85	.0551	.0474	.0419	.0438	.0560	4	32	12.57

TABLE 5.5. *Limits of size and tolerances, Unified Miniature thread series, UNM*

Size designation		Pitch	External threads								Internal threads							
			Major diameter limits			Pitch diameter limits			Minor diameter limits		Minor diameter limits			Pitch diameter limits			Major diameter limits	
Primary	Secondary		Max.	Min.	Tol.	Max.	Min.	Tol.	Max.[a]	Min.[b]	Min.	Max.	Tol.	Min.	Max.	Tol.	Min.[c]	Max.[b]
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
		mm	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*
.30UNM		0.080	0.300	0.284	0.016	0.248	0.234	0.014	0.210	0.189	0.223	0.260	0.037	0.248	0.262	0.014	0.306	0.327
	.35UNM	.090	.350	.333	.017	.292	.277	.015	.250	.228	.264	.305	.041	.292	.307	.015	.356	.380
.40UNM		.100	.400	.382	.018	.335	.319	.016	.288	.264	.304	.348	.044	.335	.351	.016	.407	.432
	.45UNM	.100	.450	.432	.018	.385	.369	.016	.338	.314	.354	.398	.044	.385	.401	.016	.457	.482
.50UNM		.125	.500	.479	.021	.419	.401	.018	.360	.332	.380	.432	.052	.419	.437	.018	.509	.538
	.55UNM	.125	.550	.529	.021	.469	.451	.018	.410	.382	.430	.482	.052	.469	.487	.018	.559	.588
.60UNM		.150	.600	.576	.024	.503	.483	.020	.432	.400	.456	.516	.060	.503	.523	.020	.611	.644
	.70UNM	.175	.700	.673	.027	.586	.564	.022	.504	.468	.532	.600	.068	.586	.608	.022	.713	.750
.80UNM		.200	.800	.770	.030	.670	.646	.024	.576	.536	.608	.684	.076	.670	.694	.024	.814	.856
	.90UNM	.225	.900	.867	.033	.754	.728	.026	.648	.604	.684	.768	.084	.754	.780	.026	.916	.962
1.00UNM		.250	1.000	.964	.036	.838	.810	.028	.720	.672	.760	.852	.092	.838	.866	.028	1.018	1.068
	1.10UNM	.250	1.100	1.064	.036	.938	.910	.028	.820	.772	.860	.952	.092	.938	.966	.028	1.118	1.168
1.20UNM		.250	1.200	1.164	.036	1.038	1.010	.028	.920	.872	.960	1.052	.092	1.038	1.066	.028	1.218	1.268
	1.40UNM	.300	1.400	1.358	.042	1.205	1.173	.032	1.064	1.008	1.112	1.220	.108	1.205	1.237	.032	1.422	1.480
		threads per in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*
.30UNM		318	0.0118	0.0112	0.0006	0.0098	0.0092	0.0006	0.0083	0.0074	0.0088	0.0102	0.0014	0.0098	0.0104	0.0006	0.0120	0.0129
	.35UNM	282	.0138	.0131	.0007	.0115	.0109	.0006	.0098	.0090	.0104	.0120	.0016	.0115	.0121	.0006	.0140	.0149
.40UNM		254	.0157	.0150	.0007	.0132	.0126	.0006	.0113	.0104	.0120	.0137	.0017	.0132	.0138	.0006	.0160	.0170
	.45UNM	254	.0177	.0170	.0007	.0152	.0145	.0007	.0133	.0124	.0139	.0157	.0018	.0152	.0158	.0006	.0180	.0190
.50UNM		203	.0197	.0189	.0008	.0165	.0158	.0007	.0142	.0131	.0150	.0170	.0020	.0165	.0172	.0007	.0200	.0212
	.55UNM	203	.0217	.0208	.0009	.0185	.0177	.0008	.0161	.0150	.0169	.0190	.0021	.0185	.0192	.0007	.0220	.0231
.60UNM		169	.0236	.0227	.0009	.0198	.0190	.0008	.0170	.0157	.0180	.0203	.0023	.0198	.0206	.0008	.0240	.0254
	.70UNM	145	.0276	.0265	.0011	.0231	.0222	.0009	.0198	.0184	.0209	.0236	.0027	.0231	.0240	.0009	.0281	.0295
.80UNM		127	.0315	.0303	.0012	.0264	.0254	.0010	.0227	.0211	.0239	.0269	.0030	.0264	.0273	.0009	.0321	.0337
	.90UNM	113	.0354	.0341	.0013	.0297	.0287	.0010	.0255	.0238	.0269	.0302	.0033	.0297	.0307	.0010	.0361	.0379
1.00UNM		102	.0394	.0380	.0014	.0330	.0319	.0011	.0283	.0265	.0299	.0335	.0036	.0330	.0341	.0011	.0401	.0420
	1.10UNM	102	.0433	.0419	.0014	.0369	.0358	.0011	.0323	.0304	.0339	.0375	.0036	.0369	.0380	.0011	.0440	.0460
1.20UNM		102	.0472	.0458	.0014	.0409	.0397	.0012	.0362	.0343	.0378	.0414	.0036	.0409	.0420	.0011	.0480	.0499
	1.40UNM	85	.0551	.0535	.0016	.0474	.0462	.0012	.0419	.0397	.0438	.0480	.0042	.0472	.0487	.0013	.0560	.0583

[a] This limit, in conjunction with root form shown in figure 5.2, is advocated for use when optical projection methods of gaging are employed. For mechanical gaging the minimum minor diameter of the internal thread is applied.

[b] This limit is provided for reference only. In practice, the form of the threading tool is relied upon for this limit. Control by gaging is not imposed.

[c] This limit is provided for reference only, and is not gaged. For gaging, the maximum major diameter of the external thread is applied.

NOTE.—Inch limits in this table have been determined by direct conversion of corresponding metric dimensions prior to rounding off. Inch tolerances are the differences between the inch limits and, consequently, differ in some instances by 0.0001 inch from the inch equivalent of the metric tolerance.

3. UNIFIED MINIATURE THREAD SERIES

The diameter-pitch combinations which constitute the Unified Miniature thread series, and the design sizes, are those shown in table 5.4. All threads are of the single (single-start) type.

4. CLASSIFICATION AND TOLERANCES

4.1. Classification.—There is established herein only one class of thread, with zero allowance on all diameters.

4.2. Tolerances.—All tolerances governing limits of size are based on functions of the pitch only and apply to lengths of engagement from 0.67 to 1.5 times the nominal diameter. (See note, table 5.5.) The limits of size resulting from the application of the specified tolerances are illustrated in figure 5.6. Length of engagement and nominal diameter have not been incorporated in any of the tolerance formulas in view of the following: (1) In the small thread sizes covered by this standard, lengths of engagement appreciably below or above the range covered by the formulas are seldom employed. (2) Functional fitness in these small sizes is dependent principally upon the properties of the thread rather than the size of the threaded member. (3) Total tolerances are too small to permit the imposition of minor order modifications.

Tolerances are tabulated in table 5.5 and are based on the following formulas:

	External thread[a]	Internal thread[b]
Major diameter	$0.12p + 0.006$	$0.168p + 0.008$[d]
Pitch diameter	$0.08p + 0.008$	$0.08p + 0.008$
Minor diameter	$0.16p + 0.008$[c]	$0.32p + 0.012$

NOTE: Metric units (millimeters) apply in these formulas. Inch tolerances are not derived by direct conversions of the metric values but are the differences between the rounded-off limits of size in inch units.

[a] Tolerances on external threads are applied to the design sizes in the *minus* direction.

[b] Tolerances on internal threads are applied to the design sizes in the *plus* direction.

[c] This formula is for reference only. In practice, the form of the threading tool is relied upon for controling the minimum minor diameter, and this limit is not gaged, except in confirming new tools.

[d] This formula is for reference only and is comprised of the pitch diameter tolerance and an extension of the thread form of $0.08p$ beyond the basic major diameter. In practice, this limit is applied to the threading tool (tap) and is not gaged on the product.

5. COATED THREADS

It is not within the scope of this standard to make recommendations for thicknesses of, or to specify limits for, coatings. However, it is obvious that in these small sizes any coatings applied must be kept thin because of the smallness of the threads. Generally, the coatings employed in practice are confined to those of the electroplated or oxide types and are limited to a flash thickness. For applications where these coatings are inadequate the product is usually made of a corrosion-resistant material, thereby avoiding the problems attendant to providing for heavier coatings. However, where coatings of a measurable thickness are required, it is essential that they be included within the maximum-material limits since no allowance is provided between these limits of the external and internal thread. In other words, the maximum material limits given in this standard apply to both uncoated and coated threads.

6. THREAD DESIGNATIONS

Screw threads of this series shall be designated on engineering drawings, in specifications, and on tools and gages (when space permits) by the size designations shown in columns 1 and 2 of table 5.4 in which the symbol UNM designates the Unified Miniature series. To these designations may be affixed, in parentheses, the inch equivalent of the basic major diameter, but this addition is optional. Thus, for example, the thread size identified by the designation .80UNM may also be designated .80UNM (.0315).

7. LIMITS OF SIZE

The limits of size of both external and internal threads, resulting from the application of the specified tolerances, are given in table 5.5 in both the metric and English systems and are illustrated in figure 5.6. For hole size limits before tapping, see appendix A3.

8. GAGES AND GAGING

The development of a gaging standard for Unified Miniature threads is anticipated after the accumulation of more experience with this standard. The following procedures are at present being successfully used by some producers:

1. Gaging Of External Threads.—The major diameter of the external thread is inspected by either contact gaging or optical projection. All other dimensions, such as pitch diameter, lead, thread form, and minor diameter are inspected by optical projection methods. There is presented in figure 5.7 an illustration of a chart which has been found very satisfactory for the optical projection method of

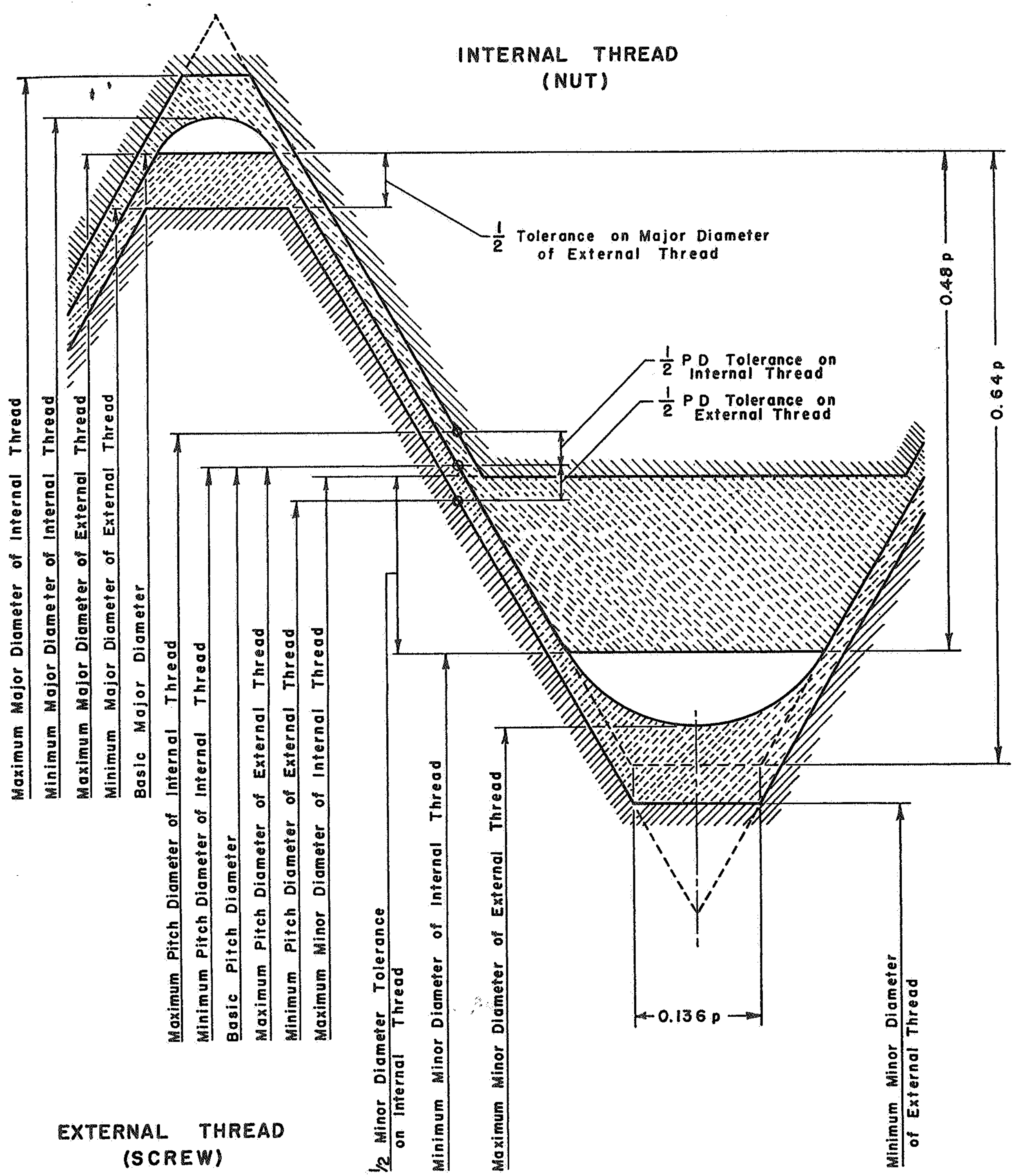

FIGURE 5.6. *Disposition of tolerances and crest clearances, Unified Miniature threads, UNM.*

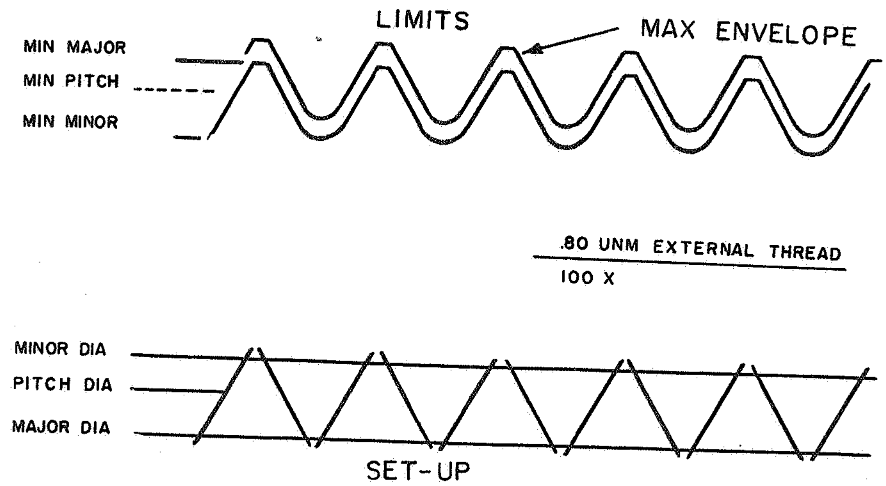

FIGURE 5.7. *Suggested chart for projection inspection of external Unified Miniature threads, UNM.*

inspection of external threads. Inspection at a magnification of 100 is recommended and at this scale the charts should be accurate to within ±0.01 in on all diameters and on pitches cumulatively up to five.

2. GAGING OF INTERNAL THREADS.—The minor diameter of the internal thread is gaged with GO and NOT GO plain cylindrical plug gages. All other elements are checked only for assembleability limits by means of a GO thread plug gage. For the minimum-material limit of the internal thread the accuracy and performance of the tap is relied upon. This implies that the major and pitch diameters of the tap do not exceed the maximum internal thread limits for these elements and disregards overcutting, which is rarely incurred because of the flexibility of these small taps and the manner in which they are generally fluted.

9. WIRE MEASUREMENT OF PITCH DIATETER

For information concerning the wire measurement of pitch diameter, see appendix A4.

UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

HANDBOOK H28

SCREW-THREAD STANDARDS

FOR FEDERAL SERVICES

SECTION 6

1969

GAGES AND GAGING FOR UNIFIED SCREW THREADS

CONTENTS

This section is in general agreement with United States of America Standards Institute (USASI) Standard USA B1.2 Gages and Gaging for Unified Screw Threads, published by The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017. The latest revision should be consulted when referring to this USA Standard. As of date of issue of this part of H28, USA B1.2–1966 is the latest revision.

A related standard is Commercial Standard CS8, Gage Blanks which is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The Industry standard for Gage Blanks is USA B47.1, published by The American Society of Mechanical Engineers. The latest revision should be consulted when referring to these standards. As of date of issue of this part of H28, CS8-61 and USA B47.1–1962 are the latest revisions.

1. INTRODUCTION

Gaging of screw threads is the process of investigating or determining the extent to which they conform dimensionally to prescribed limits of size. Dimensional gages are the means applied for that purpose.

This section for gages and gaging practice is supplementary to sections 2 and 3 and is intended to facilitate adherence to the limits of size specified therein without in any sense restricting the requirements more severely than those specified. Adherence to the gaging principles laid down, which have been tested by many years of practical use, will assure interchangeable assembly of product threads, the acceptance of satisfactory threads, and the rejection of threads that are outside of prescribed limitations.

This section covers gaging methods for final conformance and provides the essential specifications for the applicable gages required in line with the provisions of par. 5.1, p. 6.17.

It is not the intent to preclude the use of other gaging systems or dimensional control systems provided they are properly correlated by the user to this section and yield comparable results with respect to conformance within specified limits.

This section includes specifications for the following gages used for product inspection:

For Product Internal Thread:

(*a*) GO Thread Plug Gage for functional (virtual) diameter maximum-material limit.

(*b*) HI Thread Plug Gage for HI functional diameter minimum-material limit.

(*c*) GO and NOT GO Plain Plug Gages for minimum and maximum limits of the minor diameter.

For Product External Thread:

(*a*) GO Thread Ring Gage for functional (virtual) diameter maximum-material limit.

(*b*) LO Thread Ring Gage for LO functional diameter minimum-material limit.

(*c*) Indicating Thread Gages to establish numerical values for determining Functional Differential Reading for use in verifying conformance of the thread elements.

(*d*) LO Limit Thread Snap or Indicating Gages for LO minimum-material limit.

(*e*) GO and LO Thread Setting Plug Gages for (a) through (d) above.

(*f*) Plain Gages for minimum and maximum limits of the major diameter.

2. BASIC PRINCIPLES

2.1. Gage Classification.—The limits of size of the threads to be produced should be represented in: (1) Gages used in checking the threads as they are produced, known as "working gages"; (2) gages for use in the acceptance of the product, known as "inspection gages"; and (3) gages used to determine the accuracy of the two preceding classes of gages known as "master" and "setting gages."

2.2. Gages For Reference.—(*a*) *Master gage.*—The master gage is a thread plug gage which represents the physical dimensions of the basic size of the part. It clearly establishes the minimum size of the internal thread and the maximum size of the external thread at the point at which interference between mating parts begins when no allowance is provided. A master gage shall be accompanied by a record of its measurement.

(*b*) *Setting gage* (*check gage*).—*Threaded setting gages.*—A setting gage is a thread plug gage to which adjustable thread ring gages, thread snap gages, and other thread comparators are set to size. Threaded setting plug gages are of two standard designs which are designated as "basic-crest setting plugs" and "truncated setting plugs."

The basic-crest setting plug is one having a width of flat at the crest equal to $0.125p$. It is frequently used for setting thread snap gages and indicating type gages. See par. 5.2, p. 6.18.

The truncated setting plug of standard design, as shown in CS8 or B47.1, is similar to the basic-crest setting plug except that the crest of the thread is truncated for half the length of the gage, giving a full-form portion and a truncated portion, as specified in par. 4.6.3, p. 6.16. In setting thread gages to size, the truncated portion controls the pitch diameter, and the full-form portion assures that proper clearance is provided at the major diameter of the ring gage. Also, the use of the full-form portion in conjunction with the truncated portion checks, to some degree, the flank angle of the thread gage.

Plain cylindrical plug acceptance check gages.—GO and NOT GO plain cylindrical plug acceptance check gages are required to check the minor diameter limits of thread ring gages of the smaller sizes, after the gage has been properly set to the thread setting plug gage. Standard measuring equipment is usually employed in lieu of plain cylindrical plug gages for minor diameters larger than 0.375 in.

2.3. Limit Gages.—Limit gages are of two categories: (1) maximum-material-limit gages, designated GO gages and (2) minimum-material-limit gages, designated low limit (LO) gages for the functional diameter of external threads and high limit (HI) gages for internal threads.[1]

(*a*) *Maximum-material-limit or GO gages.*—The maximum-material-limit or GO gages, check or control the extent of the tolerance, as applied to a specific screw thread, in the direction of the limit of maximum material and represent the maximum limit of external threads and the minimum limit of internal threads. The ideal maximum-material-limit or GO gage is a threaded counterpart of the thread, made exactly to its prescribed maximum-material limits and, in length, equal to the length of engagement of the thread with its mating thread. Such gages would most nearly duplicate the assembly conditions of threads. They control the virtual diameter (or effective size) at the maximum-material limit. See par. 5.1, p. 6.17.

(*b*) *Minimum-material-limit or HI/LO gages.*—The minimum-material-limit gages control the ex-

[1] "HI" and "LO" gages were previously shown in H28 as "Not go" gages.

tent of the tolerance in the direction of the limit of minimum material and represent the minimum limit of external threads and the maximum limit of internal threads. The minimum-material pitch diameter limits are necessarily a limitation of the pitch diameter as a single thread element. Also, it is a principle of limit gaging that each element or dimension can be checked only singly by a minimum-material-limit gage. Accordingly, separate gages are required to check pitch, major, and minor diameters at minimum-material limits. That is, for external threads two gages are necessary: one to check the major diameter and another to check the pitch diameter; internal threads require a gage to check the pitch diameter and another to check the minor diameter. A third factor in minimum-material-limit gaging is nontechnical but of practical importance, namely, the economics of the gaging means and procedures, as thorough checking of a thread requires several individual gaging operations along and around the thread. It is not feasible, therefore, to establish an ideal gage design for gaging pitch diameter and approach that ideal closely in practice, as is done for maximum-material-limit gages.

As a result, two distinct gaging practices are widely used, as follows:

(1) The use of minimum-material-limit thread plug and ring gages provides a satisfactory means of gaging when proper functioning of the thread assembly only requires control of the virtual diameter (or effective size) of the threads at the minimum-material limits. The use of such gages is referred to as "virtual diameter (or effective size) gaging practice." See par. 5.1, p. 6.17.

(2) The use of minimum-material-limit thread snap or indicating gages conforming to the thread length requirements stated in paragraphs 4.4.2.2, p. 6.07, and 4.5.2.2, p. 6.12, controls to a close degree the pitch diameter at the minimum-material limit as a single element. Thus, without further checking, their use provides an economical means of control over such other variables as lead, uniformity of helix, flank angle, taper, roundness, and surface condition. The use of such gages, however, is referred to as "single element gaging practice." See par. 5.1, p. 6.17.

2.4. Final Conformance Gaging.—The object of final conformance gaging of product threads is to determine the extent they conform dimensionally to prescribed limits of size, and to segregate or reject product threads that are outside of prescribed limitations.

There are two general methods of approach to dimensional inspection of product threads, namely, inspection by attributes and inspection by variables.

Inspection by attributes involves the application of limit gages to assure that the product threads are within prescribed limits of size. Inspection by attributes forms the basis of final conformance gaging except as noted in the next paragraph.

Inspection by variables forms the basis of final conformance gaging where it is required by supplemental specifications that individual elements of product threads be controlled. Dimensional Inspection by variables is most useful in the control of manufacturing tools and processes and to collect manufacturing data for the analysis of product thread deviations. Inspection by variables involves the application of indicating gages or measuring instruments (optical, mechanical, pneumatic, or electrical) to determine the extent of deviations of product threads and their individual elements relative to prescribed limits.

2.5. Screw Thread Conformance.—Final dimensional acceptance of product threads shall be in accordance with the limits of size as determined by the final conformance gages outlined in par. 5.1, p. 6.17. It is important that the method of final conformance gaging be understood by both the producer and user. See par. 3.2, p. 6.04.

Thread plug gages are controlled by *direct* measuring methods. Thread ring, thread snap limit gages, and indicating thread gages are controlled by reference to the appropriate setting plugs.

2.6. Limitations Of Gaging.—Product threads accepted by a gage of one type may be verified by other types. It is possible, however, that parts which are near either rejection limit may be accepted by one type and rejected by another. Also, it is possible for two individual limit gages of the same type to be at the opposite extremes of the gage tolerances permitted, and borderline product threads accepted by one gage could be rejected by another. See under par. 3 which follows.

Large product external and internal threads may present additional problems for technical and economic reasons. In these instances, verification may be based on use of gages or measurement of thread elements. Various types of gages or measuring devices in addition to those defined in this section are available and acceptable when properly correlated to this section. It is essential to achieve agreement between producer and consumer with respect to method and equipment used.

2.7. Surveillance Of Gages.—Periodic rechecking and surveillance of gages is a necessary precaution to assure satisfactory product thread conformance.

2.8. Measurement Of Gages.

2.8.1. Determining Pitch Diameter.—The three-wire method of determining pitch diameter of thread plug gages is standard for gages in this section. Sizes of ring thread gages are determined by their fit on their respective setting plugs so measured. Other thread gages for product external threads are controlled by reference to appropriate setting plugs so measured. See appendix A4.

2.8.2. Standard Temperature.—The standard temperature used internationally for linear measurements is 68 °F (20 °C). Nominal dimensions of gages and product, as specified, and actual dimensions, as measured, shall be within specified limits at this temperature.

As product threads are frequently checked at temperatures which are not controlled, it is desirable that the coefficient of thermal expansion of gages be the same as that of the product on which they are used. Inasmuch as the majority of threaded product consists of iron or steel, and screw-thread gages are ordinarily made of hardened steel, this condition is usually fulfilled without special attention. When the materials of the product thread and the gage are dissimilar, the differing thermal coefficients can cause serious complications and must be taken into account.

2.8.3. Measuring Force for Wire Measurements of 60 Degree Threads.—In measuring the pitch diameter of screw thread gages by means of wires, the following measuring forces shall be used:

Threads per Inch	Measuring Force in Pounds (±10%)
20 or less	2.5
Above 20 to and including 40	1
Above 40 to and including 80	0.5

The thread wires should be calibrated by the procedure specified in appendix A4.

3. GAGING AND VERIFICATION OF PRODUCT THREADS

Gages are classified as to type and use, together with specific details of gaging practice applicable to each type, in the following paragraphs.

GO thread gages check the maximum-material size, to assure interchangeable assembly. HI and LO thread gages check the minimum-material size.

The thread form of GO thread gages corresponds to maximum product thread depth of engagement to assure clearance at the major diameter of the product internal thread or the minor diameter of the product external thread.

GO and NOT GO plain cylindrical plug gages, snap, or indicating gages, check the limits of size of the minor diameter of product internal threads and the major diameter of product external threads, respectively.

At the product thread maximum-material limit, the gages used for final conformance gaging are within the extreme limits of size of the product thread. At the product thread minimum-material limit the usual practice for gages used for final conformance gaging is to have the gage tolerance within the extreme limits of size of the product thread. However, to assure that usable product thread at the extreme limit of size (minimum-material limit) is not rejected, in border-line cases, the consumer may elect to use HI/LO gages having pitch diameter tolerances outside the product thread limits.

3.1. Use Of Gages.

3.1.1. Threaded and Plain Gages for Verification of Product Internal Threads:

Unless otherwise specified, all thread gages which directly check the product thread shall be *X* tolerance for all classes.

GO Thread Plug Gages. GO thread plug gages must enter the full threaded length of the product freely. The GO thread plug gage is a cumulative check of all thread elements except the minor diameter.

HI Thread Plug Gages. HI thread plug gages when applied to the product internal thread may engage only the end threads (which may not be representative of the complete thread). Entering threads on product are incomplete and permit gage to start. Starting threads on HI plugs are subject to greater wear than the remaining threads. Such wear in combination with the incomplete product threads permit further entry of the gage. Surveillance facilities ordinarily available in the field are often inadequate for fully determining such gage wear. Also, it is not practical to control nor limit the torque applied by operators, nor that utilized by a specific operator at various times and under varying conditions. For these reasons the following standard practice has been adopted with respect to permissible entry. Threads are acceptable when the HI thread plug gage is applied to the product internal thread if: (a) it does not enter, or if (b) all complete product threads can be entered, provided that a *definite* drag from contact with the product material results on or before the third turn of entry. The gage should not be forced after the drag is definite. Special requirements such as exceptionally thin or ductile material, or small number of threads, may necessitate modification of this practice.

GO and NOT GO Plain Plug Gages for Minor Diameter of Product Internal Thread. GO plain plug gages must completely enter the product internal thread to assure that the minor diameter does not exceed the maximum-material limit. NOT GO plain plug gages must not enter the product internal thread to provide adequate assurance that the minor diameter does not exceed the minimum-material limit.

3.1.2. Thread Setting Plug Gages.

GO and LO Truncated Setting Plugs. W tolerance truncated setting plugs are recommended for setting adjustable thread ring gages up to and including 6.25 inches nominal size and may be used for setting thread snap gages and indicating thread gages. Above 6.25 in. nominal size, the difference in feel between the full form and truncated sections in setting thread ring gages is insignificant, and the basic crest setting plug may be used.

When setting adjustable thread ring gages to size, the truncated portion of the setting plug controls the functional size, and the full form portion assures that adequate clearance is provided at the major diameter of the ring gage. The full form portion, in conjunction with the truncated portion, checks—to some degree—the half-angle accuracy of the gage. The same procedure may be applied to detect uneven angle wear of ring gages in use.

GO and LO Basic-crest (Full Form) Setting Plugs. W tolerance basic crest setting plugs are frequently used for setting thread snap limit gages and indicating thread gages. They may also be used for setting large adjustable thread ring gages, especially

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those above 6.25 inches nominal size. When they are so used it may be desirable to take a cast of the ring gage thread form to check the half-angle and profile. See par. 5.2.1.1, p. 6.18.

GO and NOT GO Plain Plug Acceptance Check Gages for Checking Minor Diameter of Thread Ring Gages. The GO plain plug gage is made to the minimum minor diameter specified for the thread ring gage (GO or LO), while the NOT GO gage is made to maximum minor diameter specified for the thread ring gage (GO or LO). After the adjustable thread ring gages have been set to the applicable thread setting plugs, the GO and NOT GO plain plug acceptance check gages are applied to check the minor diameter of the ring gage to assure that it is within the specified limits. An alternate method for checking minor diameter of thread ring gages is by the use of measuring equipment.

3.1.3. Threaded and Plain Ring, Snap, and Indicating Thread Gages for Verification of Product External Thread.

GO Thread Ring Gages. GO thread ring gages must be set to the applicable W tolerance setting plugs to assure they are within specified limits. The product thread must freely enter the GO thread ring gage for the entire length of the threaded portion. The GO thread ring gage is a cumulative check of all thread elements except the major diameter.

LO Thread Ring Gages. LO Thread ring gages must be set to the applicable W tolerance setting plugs to assure that they are within specified limits. LO thread ring gages when applied to the product external thread may engage only the end threads (which may not be representative of the complete product thread). Starting threads on LO rings are subject to greater wear than the remaining threads. Such wear in combination with the incomplete threads at the end of the product thread permit further entry in the gage. Surveillance facilities ordinarily available in the field are often inadequate for fully determining such gage wear. Also, it is not practical to control nor limit the torque applied by operators, nor that utilized by a specific operator at various times and under varying conditions. For these reasons the following standard practice has been adopted with respect to permissible entry. Threads are acceptable when the LO thread ring gage is applied to the product external thread if (a) it is not entered, or if (b) all complete product threads can be entered provided that a *definite* drag from contact with the product material results on or before the third turn of entry. The gage should not be forced after the drag is definite. Special requirements such as exceptionally thin or ductile material, small number of threads, etc., may necessitate modification of this practice.

LO Thread Snap Limit Gages or Indicating Thread Gages. LO thread snap limit gages (or indicating thread gages) check Class 3A product external thread LO minimum-material limit. The gages must be set to the applicable W tolerance setting plugs. The gage is then applied to the product thread at various points around the circumference and over the entire length of complete product thread. In applying the thread snap limit gage, threads are dimensionally acceptable when the gaging elements do not pass over the product thread or just pass over the product thread with perceptible drag from contact with the product material and the gage. Indicating thread gages provide a numerical value for the product thread size. Product external threads are dimensionally acceptable when the value derived in applying the gage (as described above) is not less than the specified minimum-material limit.

3.1.4. Check of Effect of Lead and Flank Angle Deviations on Product Thread. When this check is specified, there are two general methods available for the inspection procedures involved, as follows:

Direct Measurement of Deviations. The lead and flank angle of the product thread may be measured by means of available measuring equipment such as projection comparators, measuring microscopes, graduated cone points, lead measuring machines, helix variation measuring machines, and thread flank charting equipment. Formulas for obtaining the diameter equivalents of lead and flank angle deviations are given in subsection "Limits of size" in section 2. See also table 2.22 for such deviations equivalent to half the pitch diameter tolerances for Standard Unified Threads.

Differential gaging utilizing indicating thread gages with appropriate gaging elements as outlined under par. 5.4, p. 6.21, and par. 6, p. 6.27, may be used.

3.1.5. GO and NOT GO Plain Rings and Adjustable Snap Limit and Indicating Gages for Checking Major Diameter of Product External Thread. The GO gage must completely receive or pass over the major diameter of the product external thread to assure that the major diameter does not exceed the maximum-material limit. The NOT GO gage must not pass over the major diameter of the product external thread to assure that the major diameter is not less than the minimum-material limit.

3.2. Limitations.

Product threads accepted by a gage of one type may be verified by other types. It is possible, however, that parts which are near either rejection limit may be accepted by one type and rejected by another. Also, it is possible for two individual limit gages of the same type to be at the opposite extremes of the gage tolerances permitted and borderline product threads accepted by one gage could be rejected by another. In such instances (except when LO limit snap or indicating thread gages are specified) limit plug and ring thread gages that approximate as closely as practicable the extreme maximum-material product-limit and minimum-material product-limit shall be used to determine whether or not the product threads under inspection are within the specified limits of size.

Large product external and internal threads above 6.25 in. nominal size may present additional problems for technical and economic reasons. In these instances verification may be based on use of gages or measurement of thread elements. Various types of indicating thread gages are shown under par. 6, p. 6.27. Producer and user should agree on the method and equipment used.

3.3. Surveillance.

Gages are subject to wear and/or damage from normal usage. Periodic rechecking and surveillance is a necessary precaution to assure product thread conformance.

4. SPECIFICATIONS FOR GAGES

4.1. General Design.

The design of gages is specified herein only to the extent that it affects the results obtained in the gaging of product threads. Moreover, to serve their intended purposes satisfactorily, thread gages should be produced by the latest and best manufacturing techniques. The type of steel or wear-resistant material selected, together with the heat-treating and stabilization processes, should provide wear life and dimensional stability. Thread gaging elements should be precisely manufactured to assure adequate refinement of surface texture, prevention or eliminaton of amorphous or smear metal, and uniformity of thread form over the entire length of the gaging member. Precision lapping of thread flanks of thread plug and ring gages is a commonly used practice in manufacture.

4.2. Design Of Gage Blanks.

Designs of standard blanks for thread plug and ring gages, setting plug gages, plain cylindrical plug and ring gages, and plain snap gages have been developed by the American Gage Design Committee. The designs have proved satisfactory in many years of use and have been published in CS8 and B47.1, Gage Blanks. Also see tables 6.11 and 6.12.

GO gage blanks should theoretically approximate the length of engagement of the product thread with its mating thread, while HI/LO blanks may be shorter.

Where indicating thread gages are used, the length of GO gaging elements should approximate the length of the corresponding GO thread gage.

4 3. Specific Design Requirements.

4.3.1. Thread Form. The specifications for thread form of thread gages applicable to both external and internal threads are stated below for each particular type gage. These specifications for thread form apply over the entire circumference and threaded length of the gaging element.

4.3.2 Limits of Size. The specifications and format for tables of limits of size of thread gages and setting plugs are summarized in tables 6.6 and 6.7. Constants for the various standard thread pitches which are required to determine gage dimensions are tabulated in table 6.5.

4.3.3. Standard Gage Tolerances. Standard tolerances for thread plug and ring gages and thread setting plugs are: (1) W tolerances, shown in table 6.9, which represent the highest commercial grade of accuracy and workmanship, and are specified for truncated setting plugs; (2) X tolerances, shown in table 6.8 are larger than W tolerances.

4.3.3.1. Application of Tolerances. Thread Setting Plugs. Regardless of product thread class, all thread setting plugs for final conformance gaging shall be to W tolerances. For other than final conformance gaging, see par. 5.3.2, p. 6.20.

Thread Gages. Final conformance gages which directly check the product thread shall be to X tolerances for all classes unless otherwise specified.

4.3.3.2. Direction of Tolerances on Gages. At the maximum-material limit (GO), the dimensions of all gages used for final conformance gaging are within the extreme limits of size of the product thread. At the minimum-material limit (HI/LO), the usual practice for gages used for final conformance gaging, unless otherwise specified, is to have the gage tolerance within the extreme limits of size of the product thread. Dimensions for such gages are listed in columns 6 and 15 of table 6.19, p. 6.30, and col. 9 of table 6.20. However in order to assure that usable product thread at the extreme limit of size is not rejected, the consumer may elect to use (HI/LO) gages having pitch diameter tolerances outside of the product thread limit. Dimensions for such gages are listed in columns 7 and 16 of table 6.19, p. 6.30, and col. 10 of table 6.20.

Direction of Tolerances for Individual Gage Elements. The direction of tolerances for the individual elements of the various types of gages are specified in tables 6.6 and 6.7.

4.3.3.3. Tolerance on Lead (cumulative effect of progressive or erratic helix variation and thick-end or thin-end thread deviations) is specified as an allowable variation between any two threads not farther apart than the length of the standard taperlock or trilock gage as shown in CS8 or B47.1, Gage Blanks. In the case of setting plugs, the specified tolerance shall be applicable to the thread length in the mating ring gage or 9 pitches, whichever is smaller. *The tolerance on lead establishes the width of a zone, measured parallel to the axis of the thread, within which the actual helical path must lie for the specified length of the thread. Measurements will be taken from a fixed reference point located at the start of the first full thread to a sufficient number of positions along the entire helix to detect all types of lead deviations. The amounts that these positions deviate from their basic (theoretical) positions will be recorded with due respect to sign. The greatest deviation in each direction (+ and −) will be selected and the sum of their values, *disregarding sign*, shall not exceed the specified tolerance. If the deviations are all in one direction, the maximum

*NOTE: It has been customary in the past to specify tolerances on lead as plus or minus (±) values. Under the requirement established above, the width of the tolerance zone is the nominal tolerance value specified *regardless of sign*. In view of the preceding, the tolerance symbols, plus or minus, (±), should be omitted in referencing lead tolerances. The omission of the plus and minus does not change the total tolerance.

value governs conformance. In the case of truncated setting plugs, the lead deviations present on the full-form portion and the truncated portion of an individual gage shall not differ from each other by more than 0.0001 in. over any portion equivalent to the length of the thread ring gage, or nine pitches, whichever is smaller.

4.3.3.4. Tolerances on Half-Angle. Tolerances are specified for the half-angle rather than the included angle to assure that the bisector of the included angle will be perpendicular to the axis of the thread within proper limits. The equivalent of the deviation from the true thread form caused by such irregularities as convex or concave flanks, rounded crests, or slight projections on the thread form, shall not exceed the tolerance permitted on half-angle.

4.3.3.5. Interpretation of Tolerances. Tolerances on lead, half-angle, and pitch diameter are deviations which may be taken independently for each of these elements and may be taken to the full extent allowed by respective tabulated tolerances. The tabulated tolerance on any one element must not be exceeded even though deviations in the other two elements are smaller than the respective tabulated tolerances.

4.3.3.6. Tolerances for Plain Gages. Standard tolerances for plain plug gages for checking minor diameter of product internal threads and for gages for checking major diameter of product external threads are Z tolerances, as shown in table 6.10.

4.3.4. Identification. Each gage shall be plainly and permanently marked with the minimum marking essential for positive identification.

For multi-piece gages it may be desirable to identify individual components and handles or frames.

When it is impracticable to identify the gaging elements, due to size and/or lack of suitable space for marking, and they are packaged separately, it is suggested that identification be accomplished by a tag suitably attached or by marking the container.

4.4. Specifications For Gages Applicable To Product Internal Threads.

4.4.1. GO Thread Plug Gages.

4.4.1.1. Purpose. The GO thread plug gage checks the limit of tolerance of product internal thread in the direction of maximum material. The GO thread plug gage represents the minimum size limit of the product internal thread and its purpose is to achieve interchangeable assembly of maximum material mating parts. (See par. 4.4.3, p. 6.09, for gaging of minor diameter.) For gaging practice, see par. 3.1.1, p. 6.03.

4.4.1.2. Basic Design. Ideally, the maximum-material-limit or GO thread plug gage should be made to the prescribed maximum-material limit of the product internal thread, and, in length, be at least equal to the length of engagement of the mating product thread.

Gage Blanks. For practical and economic reasons, the design and lengths of the gaging members and handles have been standardized for various size ranges and pitches. (See CS8 or B47.1 and table 6.11.)

4.4.1.3. Thread Form. The specifications for thread form are stated in detail below and are summarized in table 6.6 and figure 6.1.

Thread Crests. The major diameter of the GO thread plug gage shall be the same as the minimum (basic) major diameter of the product internal thread, with a plus gage tolerance. The thread crests shall be flat in an axial section and parallel to the axis.

Thread Roots. The minor diameter of the GO thread plug gage shall be cleared beyond a $p/8$ width of flat either by an extension of the sides of the thread toward a sharp V or by an undercut no greater than $p/8$ maximum width and approximately central. (See fig. 6.1.)

Concentricity of Pitch and Major Cylinders. The pitch and major cylinders of GO thread plug gages should be concentric as stated hereafter. On thread plug gages, an eccentric condition produces an oversize effective major diameter, having a width of flat less than $p/8$, which may encroach on the minimum permissible limit for the root profile of the product internal thread. The permissible maximum effective major diameter, as determined by measurement of runout (total indicator variation) with respect to the pitch cylinder, shall not exceed the maximum major diameter specified.

Pitch Cylinder. The pitch cylinder shall be round and straight within the gage pitch diameter limits specified.

4.4.1.4. Lead and Half-Angle Deviations. Lead and half-angle deviations shall be within the limits specified. (See table 2.22.)

4.4.1.5. End Threads. The feather edge at both ends of the threaded section of the gaging member shall be removed. On pitches coarser than 28 threads per inch, not more than one complete turn of the end threads shall be removed to obtain a full thread form blunt start. See figure 6.4. On pitches 28 threads per inch and finer a 60° chamfer from the axis of the gage is acceptable in lieu of the blunt start.

4.4.1.6. Chip Grooves. Each GO thread plug gage, except in sizes No. 8(0.164) and smaller, shall be provided with a chip groove at the entering end. On reversible gages, a chip groove shall be provided at each end. Chip grooves are acceptable that are in accordance with commercial practice, such as a groove cut at an angle with the axis or a longitudinal groove cut parallel with the axis and extending the complete length of the gaging member. The groove shall be located circumferentially at the start of the full thread, and in all cases the depth shall extend below the root of the first full thread. The distance from the major diameter of the thread plug to the crest of the convolution rise in front of the chip groove, due to the radius of the convoluting tool, shall be a minimum of $H/2$ as shown in figure 6.4. The beginning of the first thread shall be of full form. The recommended widths for chip grooves are as follows:

Nominal diameter (inches)	Chip groove width (inches) Max	Min
.164 and smaller	No chip groove required	
Above .164 to and including .216	0.036	0.026
Above .216 to and including .375	0.052	0.042
Above .375 to and including .500	0.067	0.057
Above .500 to and including 1.000	0.083	0.067
Above 1.000 to and including 1.750	0.130	0.067
Above 1.750	0.193	0.067

4.4.1.7. Identification. The GO thread plug gage is basic and common to all classes of thread for any particular nominal size and series. Accordingly, it is recommended that the gage be identified by nominal size, threads per inch, series, and GO pitch diameter.

Example:

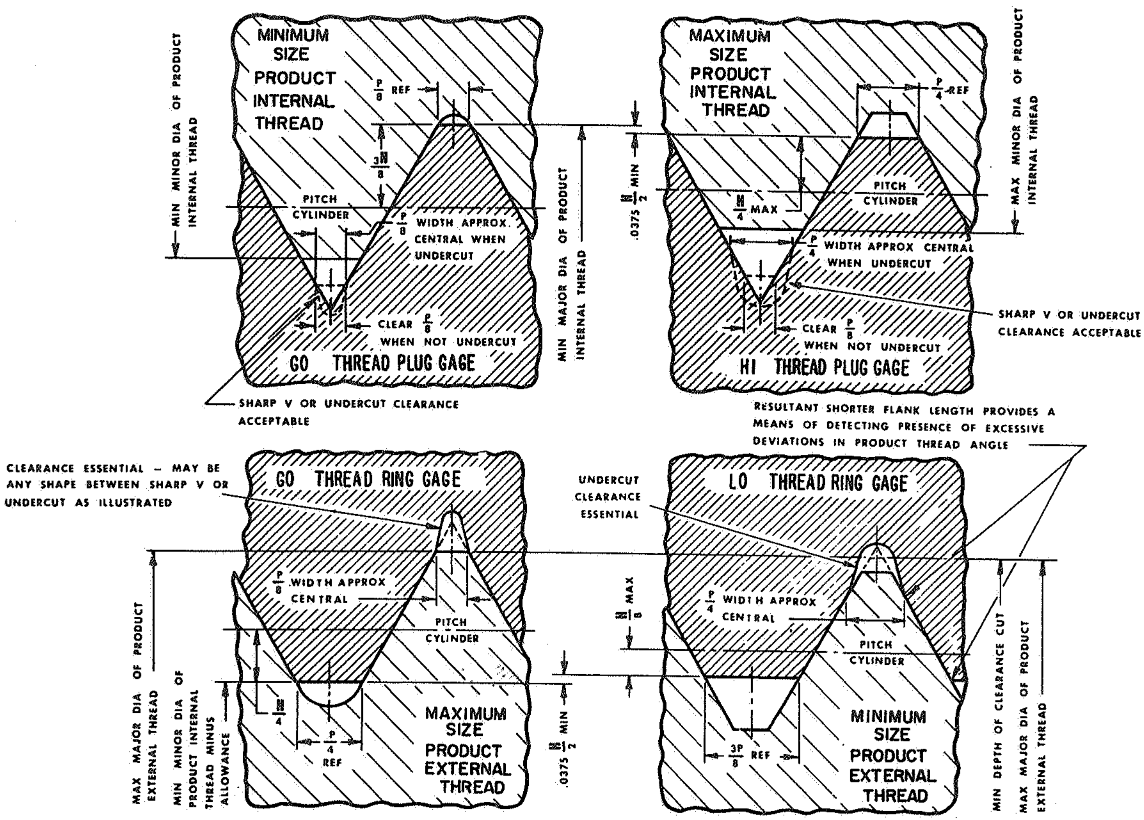
.250–20 (or 1/4–20) UNC GO PD .2175
.190–32 (or 10–32) UNF GO PD .1697

4.4.2. HI Thread Plug Gages.

4.4.2.1. Purpose. The HI thread plug gage checks the limit of tolerance of a product internal thread in the direction of minimum-material. The HI thread plug gage represents the maximum size limit of the product internal thread and provides a satisfactory method of gaging the functional diameter at the minimum-material limit. For gaging practice, see par. 3.1.1, p. 6.03.

4.4.2.2. Basic Design. In order that the HI thread plug gage may effectively check the minimum-material functional diameter, the half-angle contact should be reduced by truncating the major diameter and the length of the gaging element, where practical, should be less than that of the GO gage.

Gage Blanks. For practical and economic reasons the designs and lengths of the gaging members and handles have been standardized for various size



See paras. 4.4.1.3, 4.4.2.3, 4.5.1.3, 4.5.2.3 relative root clearance.

FIGURE 6.1. *Thread forms of gages for product external and internal threads.*

ranges and pitches. (See CS8 or B47.1 and table 6.11.)

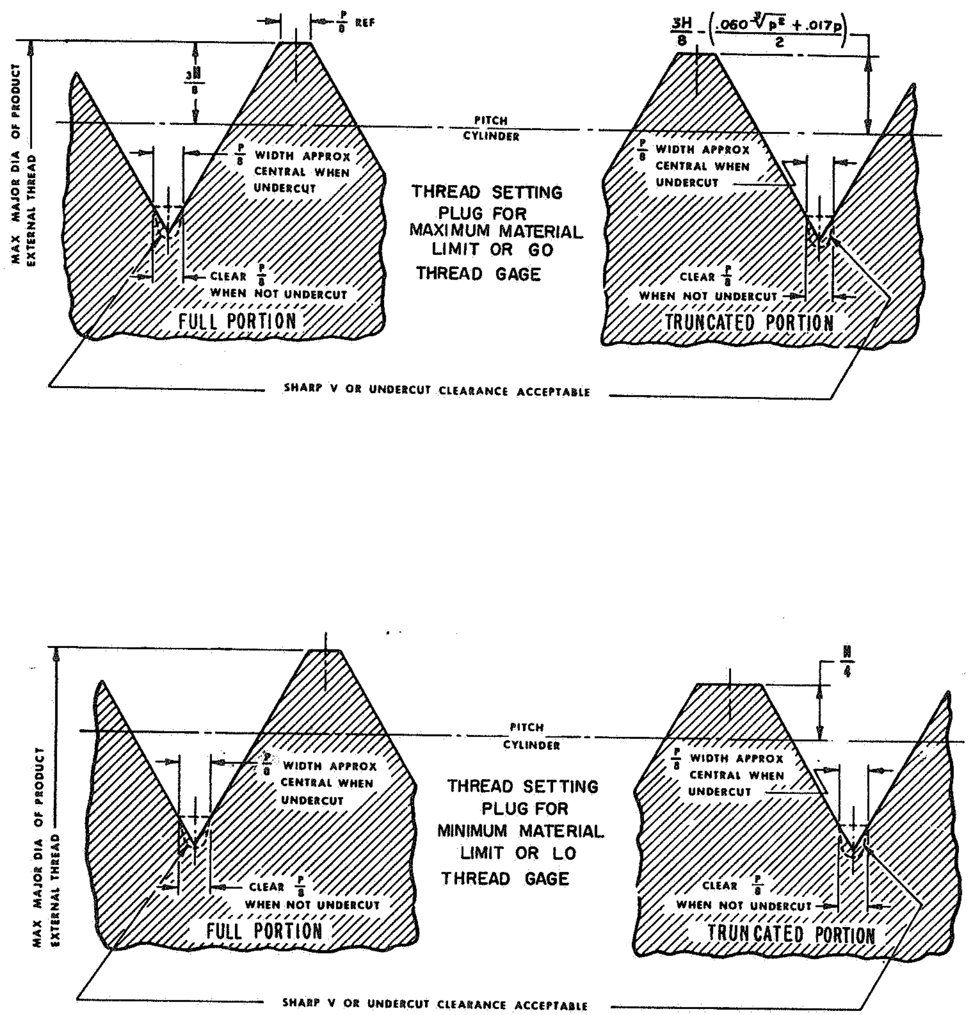
4.4.2.3. Thread Form. The specifications for thread form are stated in detail below and are summarized in table 6.6 and figure 6.1.

Thread Crests. The maximum major diameter of the HI thread plug gage shall be equal to the maximum pitch diameter of the product internal thread plus $H/2$ with the gage tolerance minus. This corresponds to a width of flat at the crest of the gage equal to $p/4$. However, the maximum major diameter of the HI thread plug gage shall not exceed the minimum major diameter of the product internal thread minus $0.0375H$ or $0.05h_b$. (See col. 16 of table 6.5.)

Thread Roots. The minor diameter of the HI thread plug gage shall be cleared beyond a $p/4$ width of flat by an extension toward a sharp V of the sides of the thread from the position corresponding to this approximate width or by an undercut to any dimension no wider than the width resulting from $p/8$ maximum width either side of and approximately central with the center line of the thread groove.

Concentricity of Pitch and Major Cylinders. The pitch and major cylinders of HI thread plug gages shall be concentric as stated hereafter. On thread plug gages an eccentric condition produces an oversize effective major diameter, having a width of flat less than $p/4$. The permissible maximum effective major diameter, as determined by measurements of runout (total indicator variation) with respect to the pitch cylinder, shall not exceed the maximum major diameter specified.

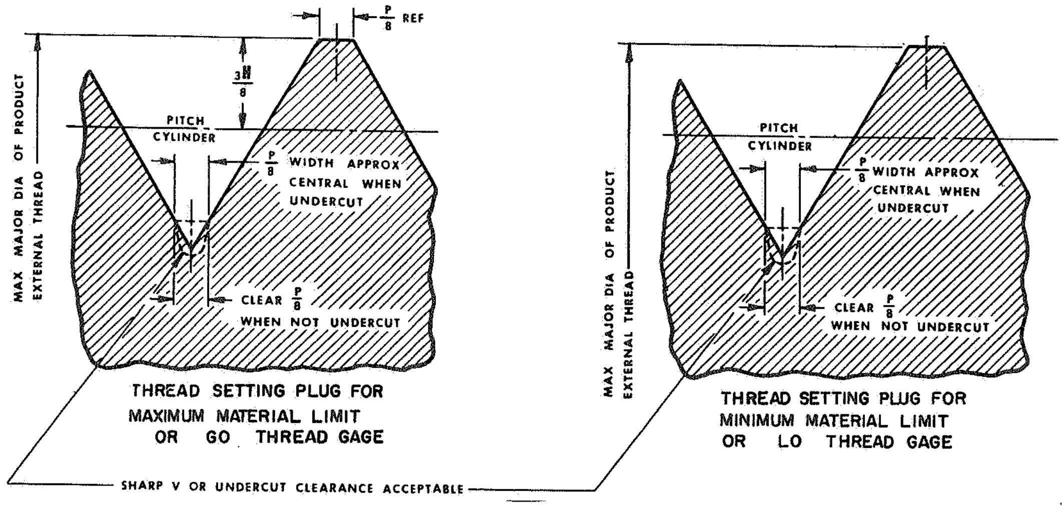
Pitch Cylinder. The pitch cylinder shall be round and straight within the gage pitch diameter limits specified.



See paras. 4.4.1.3, 4.4.2.3, 4.6.3.3 relative root clearance.

See col. 13 of table 6.7 relative crest of full portion of LO thread gage.

FIGURE 6.2. *Thread form of truncated thread setting plug gages.*



See paras. 4.4.1.2, 4.4.2.2, 4.6.3.3 relative root clearance.

See col. 13 of table 6.7 relative crest of LO thread gage.

FIGURE 6.3. *Thread forms of basic crest thread setting plug gages.*

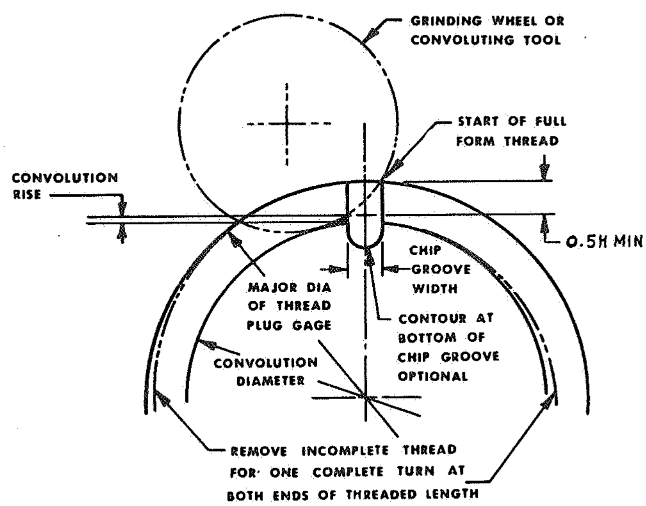


FIGURE 6.4. *Removal of partial thread and chip groove.*

4.4.2.4. Lead and Half-Angle Deviations. Lead and half-angle deviations shall be within the limits specified. See table 2.22.

4.4.2.5. End Threads. The feather edge at both ends of the threaded section of the gaging member shall be removed. On pitches coarser than 28 threads per inch, not more than one complete turn of the end threads shall be removed to obtain a full thread blunt start. On pitches 28 threads per inch and finer, a 60° chamfer from the axis of the gage is acceptable in lieu of the blunt start.

4.4.2.6. Identification. The HI thread plug gage should be marked with the nominal size, threads per inch, thread series, class, HI, and pitch diameter.

Example:

.250–20 UNC-2B HI PD .2224
.190–32 UNF-2B HI PD .1736

4.4.3. Plain Plug Gages for Minor Diameters.

4.4.3.1. Purpose and Basic Design. The GO and HI thread plug gages are cleared at the root and do not check the minor diameter of the product internal thread. Accordingly, GO and NOT GO plain plug gages are necessary to check the maximum-material and minimum-material limits at the minor diameter. For gaging practice, see par. 3.1.1, p. 6.03.

Gage Blanks. The designs of the gaging elements and handles have been standardized. (See CS8 or B47.1, Gage Blanks.)

TABLE 6.5. *Constants for computing thread gage dimensions*

Threads per inch, n	Pitch, p	$\frac{3}{4}p=$ $0.75p$	$p/4=$ $0.25p$	$p/8=$ $0.125p$	$0.067p$	$0.10048p$	$0.060\sqrt[3]{p^2}$	$0.017p$	$0.060\sqrt[3]{p^2}$ $+0.017p$	Height of sharp V-thread, $H=$ $0.866025p$	$\frac{3}{4}H=$ $0.649519p$	$H/2=$ $0.43301p$	$H/4=$ $0.21651p$	$0.13395H$ $=0.116p$ $=(2\times$ $0.058p)$	$0.0375H$ $=0.05h_b$ $=0.03248p$
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	in	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*
80	0.012500	0.00938	0.00312	0.00156	0.00084	0.00126	0.00323	0.00021	0.0034	0.010825	0.008119	0.00541	0.00271	0.00145	0.00041
72	.013889	.01042	.00347	.00174	.00093	.00140	.00347	.00024	.0037	.012028	.009021	.00601	.00301	.00161	.00045
64	.015625	.01172	.00391	.00195	.00105	.00157	.00375	.00027	.0040	.013532	.010149	.00677	.00338	.00181	.00051
56	.017857	.01339	.00446	.00223	.00120	.00179	.00410	.00030	.0044	.015465	.011599	.00773	.00387	.00207	.00058
48	.020833	.01562	.00521	.00260	.00140	.00209	.00454	.00035	.0049	.018042	.013532	.00902	.00451	.00242	.00068
44	.022727	.01705	.00568	.00284	.00152	.00228	.00482	.00039	.0052	.019682	.014762	.00984	.00492	.00264	.00074
40	.025000	.01875	.00625	.00312	.00168	.00251	.00513	.00042	.0056	.021651	.016238	.01083	.00541	.00290	.00081
36	.027778	.02083	.00694	.00347	.00186	.00279	.00550	.00047	.0060	.024056	.018042	.01203	.00601	.00322	.00090
32	.031250	.02344	.00781	.00391	.00209	.00314	.00595	.00053	.0065	.027063	.020297	.01353	.00677	.00362	.00101
28	.035714	.02679	.00893	.00446	.00239	.00359	.00651	.00061	.0071	.030929	.023197	.01546	.00773	.00414	.00116
27	.037037	.02778	.00926	.00463	.00248	.00372	.00667	.00063	.0073	.032075	.024056	.01604	.00802	.00430	.00120
24	.041667	.03125	.01042	.00521	.00279	.00419	.00721	.00071	.0079	.036084	.027063	.01804	.00902	.00483	.00135
20	.050000	.03750	.01250	.00625	.00335	.00502	.00814	.00085	.0090	.043301	.032476	.02165	.01083	.00580	.00162
18	.055556	.04167	.01389	.00694	.00372	.00558	.00874	.00094	.0097	.048113	.036084	.02406	.01203	.00644	.00180
16	.062500	.04688	.01562	.00781	.00419	.00628	.00945	.00106	.0105	.054127	.040595	.02706	.01353	.00725	.00203
14	.071429	.05357	.01786	.00893	.00479	.00718	.01033	.00121	.0115	.061859	.046394	.03093	.01546	.00829	.00232
13	.076923	.05769	.01923	.00962	.00515	.00773	.01085	.00131	.0122	.066617	.049963	.03331	.01665	.00892	.00250
12	.083333	.06250	.02083	.01042	.00558	.00837	.01145	.00142	.0129	.072169	.054127	.03608	.01804	.00967	.00271
11.5	.086957	.06522	.02174	.01087	.00583	.00874	.01178	.00148	.0133	.075307	.056480	.03765	.01883	.01009	.00282
11	.090909	.06818	.02273	.01136	.00609	.00913	.01213	.00155	.0137	.078730	.059047	.03936	.01968	.01055	.00295
10	.100000	.07500	.02500	.01250	.00670	.01005	.01293	.00170	.0146	.086603	.064952	.04330	.02165	.01160	.00325
9	.111111	.08333	.02778	.01389	.00744	.01116	.01387	.00189	.0158	.096225	.072169	.04811	.02406	.01289	.00361
8	.125000	.09375	.03125	.01562	.00838	.01256	.01500	.00212	.0171	.108253	.081190	.05413	.02706	.01450	.00406
7	.142857	.10714	.03571	.01786	.00957	.01435	.01640	.00243	.0188	.123718	.092788	.06186	.03093	.01657	.00464
6	.166667	.12500	.04167	.02083	.01117	.01675	.01817	.00283	.0210	.144338	.108253	.07217	.03608	.01933	.00541
5	.200000	.15000	.05000	.02500	.01340	.02010	.02052	.00340	.0239	.173205	.129904	.08660	.04330	.02320	.00650
4.5	.222222	.16667	.05556	.02778	.01489	.02233	.02201	.00378	.0258	.192450	.144338	.09623	.04811	.02578	.00722
4	.250000	.18750	.06250	.03125	.01675	.02512	.02381	.00425	.0281	.216506	.162380	.10825	.05413	.02900	.00812

4.4.3.2. Identification. The GO plain plug gage members for Unified threads are common to all classes of Unified threads, and as such should be marked with: Nominal size, threads per inch, thread designation, GO, and minor diameter.

Example:

.250–20 UNC GO .1960

The NOT GO plain plug gage members are not common to all classes, and should be marked with: Nominal size, threads per inch, thread designation, tolerance, class, NOT GO, and minor diameter. Example:

.250–20 UNC-3B NOT GO .2067.

4.5. SPECIFICATIONS FOR GAGES APPLICABLE TO PRODUCT EXTERNAL THREADS.

4.5.1. GO Thread Ring Gages.

4.5.1.1. Purpose. The GO thread ring gage checks the limit of tolerance of a product external thread in the direction of maximum material. The GO thread ring gage, when properly set on its respective thread setting plug, represents the maximum size limit of the product external thread and its purpose is to achieve interchangeable assembly of maximum material mating parts. For gaging practice, see par. 3.1.3, p. 6.04. See par. 4.5.5, p. 6.16, for gaging of major diameter.

4.5.1.2. Basic Design. Ideally, the maximum-material-limit or GO thread ring gage should be made to the prescribed maximum-material limit of the product external thread and, in length, equal to the length of engagement of the mating product thread.

Gage Blanks. For practical and economic reasons, the designs and thicknesses of thread ring gages have been standardized for various size ranges and pitches. (See CS8 or B47.1 and table 6.12.) The AGD (American Gage Design Standard) thread ring gage is adjustable to facilitate manufacturing and setting.

4.5.1.3. Thread Form. The specifications for thread form are stated in detail below and are summarized in table 6.6 and figure 6.1.

Thread Crests. The minor diameter of the GO thread ring gage shall be equal to the maximum pitch diameter of the product external thread minus $H/2$ with a minus gage tolerance. This corresponds to a width of flat of $p/4$. The thread crests shall be flat in an axial section and parallel to the axis.

Thread Roots. The major diameter of the GO thread ring gage shall be cleared by a clearance cut of substantially $p/8$ width and approximately central. The root clearance must be such that the maximum major diameter of the full form section of the thread setting plug gage is cleared after the gage has been properly set to size.

Concentricity of Pitch and Minor Cylinders. The pitch and minor cylinders of the GO thread ring gage shall be concentric as stated hereinafter. On thread ring gages an eccentric condition results in

TABLE 6.6. *Specifications and format for tables of limits of size of threaded and plain gages for Unified external and internal threads*

Nominal size and threads per inch	Series designation	Class	Gages for external threads								Gages for internal threads							Class	Series designation	Nominal size and threads per inch
			Thread gages					Plain gages for major diameter			Thread gages					Plain gages for minor diameter				
			GO		LO			GO	NOT GO *		GO		HI							
			Pitch diameter	Minor diameter	Pitch diameter		Minor diameter		Semi-finished	Unfinished hot-rolled material	Major diameter	Pitch diameter	Major diameter	Pitch diameter		GO	NOT GO*			
					Plus tol.gage	Minus tol.gage								Minus tol. gage	Plus tol. gage					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
			Max. pitch diameter of external thread. Gage tolerance minus. When wear allowance is required, subtract the applicable wear allowance from the max. pitch diameter and then apply the gage tolerance minus.	Max. pitch diameter of external thread minus 0.5*H*. Gage tolerance minus.	Min. pitch diameter of external thread. Gage tolerance plus.	Min. pitch diameter of external thread. Gage tolerance minus, (optional)	Min. pitch diameter of external thread minus 0.25*H* but not less than min. minor diameter of GO thread gage for external thread plus 0.0375*H* (=0.05h_b). Gage tolerance plus.	Max. major diameter of external thread. Gage tolerance minus.	Min. major diameter of external thread. Gage tolerance plus.	Min. major diameter of external thread of hot-rolled material in UNC-2A, and 8UN. Gage tolerance plus.	Min. major diameter of internal thread. Gage tolerance plus.	Min. pitch diameter of internal thread. Gage tolerance plus. When wear allowance is required, add the applicable wear allowance to the min. pitch diameter and then apply the gage tolerance plus.	Max. pitch diameter of internal thread plus 0.5*H* but not to exceed min. major diameter of GO thread gage for internal thread minus 0.0375*H* (=0.05h_b). Gage tolerance minus.	Max. pitch diameter of internal thread. Gage tolerance minus.	Max. pitch diameter of internal thread. Gage tolerance plus, (optional)	Min. minor diameter of internal thread. Gage tolerance plus.	Max. minor diameter of internal thread. Gage tolerance minus.			

* Plain minimum-material-limit gages retain the term NOT GO as customarily they are not permitted to enter or be entered by acceptable product.

NOTE: While the maximum diameters of Class 2A uncoated threads are less than basic by the amount of the allowance, the allowance may be used to accommodate additive finishes. It follows that unless specifically specified otherwise, for threads with additive finish, the maximum diameters of Class 2A may be exceeded by the amount of the allowance. In this event GO gages to basic pitch diameter would be applicable. Such gages are made to the same dimensions as listed in the tables for Class 3A threads.

TABLE 6.7. *Specifications and format for tables of limits of size of threaded setting plug gages for Unified, external threads*

Nominal size and threads per inch	Series designation	Class	Truncated setting plugs							Basic-crest setting plugs				
			Plug for GO			Plug for LO				Plug for GO		Plug for LO		
			Major diameter		Pitch diameter	Major diameter		Pitch diameter		Major diameter	Pitch diameter	Major diameter	Pitch diameter	
			Truncated	Full-form		Truncated	Full-form	Plus tol. gage.	Minus tol. gage.				Plus tol. gage	Minus tol. gage
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			Max. major diameter of external thread (=min. major diameter of full portion of GO setting plug, see col. 5) minus $(0.060\sqrt[3]{p^2}+0.017p)$. Gage tolerance minus.	Max. major diameter of external thread. Gage tolerance plus.	Max. pitch diameter of external thread. Gage tolerance minus. When wear allowance is required, subtract the applicable wear allowance from the max. pitch diameter and then apply the gage tolerance minus.	Min. pitch diameter of external thread plus $0.5H$. Gage tolerance minus.	Same as column 13.	Min. pitch diameter of external thread. Gage tolerance plus.	Min. pitch diameter of external thread. Gage tolerance minus (optional).	Max. major diameter of external thread. Gage tolerance plus.	Same as column 6.	Max. major diameter of external thread provided that, after applying the X major diameter tolerance, the max. major diameter of the gage corresponds to a truncation of not less than $0.067H$ or 0.0009 in., whichever is the greater. Gage tolerance plus. See par. 4.6.3.2, p. 000, and accompanying note.	Min. pitch diameter of external thread. Gage tolerance plus.	Min. pitch diameter of external thread. Gage tolerance minus (optional).

an undersize effective minor diameter having a width of flat less than $p/4$, which may encroach on the maximum permissible limit for the root profile of the product external thread. The permissible minimum effective minor diameter, as determined by measurements of runout (total indicator variation) with respect to the pitch cylinder, shall not be less than the specified minimum minor diameter minus the sum of the gage tolerances for the pitch and minor diameters.

Pitch Cylinder, Lead, and Half-Angle. Satisfactory conformance of these elements is normally determined by the setting of the thread ring gage to the applicable truncated setting plug gage.

4.5.1.4. End Threads. The feather edge at both ends of the thread ring gage shall be removed. On gages larger than 0.5 in. nominal size or on those having less than 20 threads per inch, from half to one pitch of the partially formed thread at each end shall be removed to obtain a full thread blunt start. On gages 0.5 in. nominal size and smaller or on those having 20 or more threads per inch, a 60° chamfer on the end threads from the axis of the gage to a depth of half to one pitch is acceptable in lieu of the blunt start.

4.5.1.5. Chip Grooves. GO thread ring gages of the adjustable type (AGD standard) do not require chip grooves as the adjusting slots serve this purpose.

4.5.1.6. Identification. The GO Thread Ring Gage for Class 3A is basic, and also is applicable for acceptance of Class 2A after coating. Accordingly, it is recommended that the gage be identified by nominal size, threads per inch, series, and GO pitch diameter. Example:

.250–20 UNC GO PD .2175.

The GO gages for Classes 1A and 2A are below basic size, having a common allowance. Accordingly, it is recommended that the gage be identified by nominal size, threads per inch, series, class, and GO pitch diameter. Example:

.250–20 UNC 1A-2A GO PD .2164.

4.5.2. LO Thread Ring Gages.

4.5.2.1. Purpose. The LO thread ring gage checks the limit of tolerance of a product external thread in the direction of minimum material. The LO thread ring gage when properly set on its respective set plug represents the minimum size limit of the product external thread and provides a satisfactory method of gaging the functional diameter at the minimum-material limit. For Gaging Practice, see par. 3.1.3, p. 6.04.

4.5.2.2. Basic Design. In order that the LO thread ring gage may effectively check the minimum-material functional diameter, the half-angle contact should be less than that of the GO gage and the length of the gaging element, where practical, should be less than that of the GO gage.

Gage Blanks. For practical and economic reasons, the thicknesses of thread ring gages have been standardized for various size ranges and pitches. (See CS8 or B47.1 and table 6.12.)

TABLE 6.8. *X Tolerances for GO, HI, and LO Thread Gages*

Threads per inch	Tolerance on lead [a]	Tolerance on half-angle of thread	Tolerance on major or minor diameters		Tolerance on pitch diameter			
			To and including 4 in dia	Above 4 in dia	To and including 1.5 in dia	Above 1.5 to 4 in dia	Above 4 to 8 in dia	Above 8 to 12 in dia [b]
1	2	3	4	5	6	7	8	9
	in	*deg min* ±	*in*	*in*	*in*	*in*	*in*	*in*
80	0.0002	0 30	0.0003	-------	0.0002	-------	-------	-------
72	.0002	0 30	.0003	-------	.0002	-------	-------	-------
64	.0002	0 30	.0004	-------	.0002	-------	-------	-------
56	.0002	0 30	.0004	-------	.0002	0.0003	-------	-------
48	.0002	0 30	.0004	-------	.0002	.0003	-------	-------
44	.0002	0 20	.0004	-------	.0002	.0003	-------	-------
40	.0002	0 20	.0004	-------	.0002	.0003	-------	-------
36	.0002	0 20	.0004	-------	.0002	.0003	-------	-------
32	.0003	0 15	.0005	0.0007	.0003	.0004	0.0005	0.0006
28	.0003	0 15	.0005	.0007	.0003	.0004	.0005	.0006
27	.0003	0 15	.0005	.0007	.0003	.0004	.0005	.0006
24	.0003	0 15	.0005	.0007	.0003	.0004	.0005	.0006
20	.0003	0 15	.0005	.0007	.0003	.0004	.0005	.0006
18	.0003	0 10	.0005	.0007	.0003	.0004	.0005	.0006
16	.0003	0 10	.0006	.0009	.0003	.0004	.0006	.0008
14	.0003	0 10	.0006	.0009	.0003	.0004	.0006	.0008
13	.0003	0 10	.0006	.0009	.0003	.0004	.0006	.0008
12	.0003	0 10	.0006	.0009	.0003	.0004	.0006	.0008
11.5	.0003	0 10	.0006	.0009	.0003	.0004	.0006	.0008
11	.0003	0 10	.0006	.0009	.0003	.0004	.0006	.0008
10	.0003	0 10	.0006	.0009	.0003	.0004	.0006	.0008
9	.0003	0 10	.0007	.0011	.0003	.0004	.0006	.0008
8	.0004	0 5	.0007	.0011	.0004	.0005	.0006	.0008
7	.0004	0 5	.0007	.0011	.0004	.0005	.0006	.0008
6	.0004	0 5	.0008	.0013	.0004	.0005	.0006	.0008
5	.0004	0 5	.0008	.0013	--------	.0005	.0006	.0008
4.5	.0004	0 5	.0008	.0013	--------	.0005	.0006	.0008
4	.0004	0 5	.0009	.0015	--------	.0005	.0006	.0008

[a] Allowable variation in lead between any two threads not farther apart than the length of the standard gage, shown in CS8 or B47.1.

It has been customary in the past to specify tolerances on lead as plus or minus (±) values. Under the requirement established above, the width of the tolerance zone is the nominal tolerance value specified *regardless of sign*. In view of the preceding, the tolerance symbols, plus or minus (±), should be removed in referencing lead tolerances. The omission of the plus and minus does not change the total tolerance.

[b] Above 12 in, the tolerance is directly proportional to the tolerance in column 9, in the ratio of the diameter to 12 in.

4.5.2.3. Thread Form. The specifications for thread form are stated in detail below and are summarized in table 6.6 and figure 6.1.

Thread Crests. The minimum minor diameter of the LO thread ring gage shall be equal to the minimum pitch diameter of the external thread minus $0.25H$. This corresponds to a width of flat at the crest of the gage equal to $0.375p$. However, the minimum minor diameter of the LO thread ring gage shall not be less than the minimum minor diameter of the GO thread ring gage plus $0.0375H$ or $0.05h_b$. See col. 16 of table 6.5. This requirement is necessary to assure that the minor diameter of the gage is not less than the minor diameter of the GO thread ring gage which may occur with a $0.375p$ flat on the LO ring thread crest when there is a pitch diameter allowance on the product external thread combined with a large pitch diameter tolerance.

Thread Roots. The major diameter of the LO thread ring gage shall be cleared by a clearance cut of substantially $0.25p$ width, approximately central. The LO thread ring gage shall clear the maximum major diameter of the product external thread or the maximum major diameter of the full-form portion of the truncated thread setting plug for the LO thread ring gage, whichever is the greater. Thus, contact of the thread gage can occur on the sides of the threads but not on the crest or root. Also, the effect of angle deviation on the fit of the gage with the product thread is minimized.

Concentricity of Pitch and Minor Diameter Cylinders. The pitch and minor cylinders of the LO thread ring gage shall be concentric as stated hereinafter. On thread ring gages, an eccentric condition results in an undersize effective minor diameter having a width of flat less than $0.375p$. The permissible minimum effective minor diameter as determined by runout (total indicator variation) with respect to the pitch cylinder shall not be less than the specified minimum minor diameter minus twice the sum of the gage tolerances for pitch and minor diameter.

Pitch Cylinder, Lead, and Half-Angle. Satisfactory conformance of these elements is normally determined by the setting of the thread ring gage to the applicable truncated setting plug gage.

4.5.2.4. End Threads. The feather edge at both ends of the thread ring gage shall be removed. On gages larger than 0.5 in. nominal size or on those having less than 20 threads per in., not more than one complete turn of the end threads shall be removed to obtain a full thread blunt start. On gages 0.5 in. nominal size and smaller or on those having 20 or more threads per inch, a 60° chamfer on the end threads from the axis of the gage, is acceptable in lieu of the blunt start.

4.5.2.5. Identification. The LO thread ring gage should be identified by nominal size, threads per inch, series, class, and LO pitch diameter. Example: .250–20 UNC 2A LO PD .2127.

4.5.3. Thread Snap Limit Gages or Indicating Thread Gages for LO Minimum-material limit.

4.5.3.1. Purpose. Thread snap limit gages or indicating thread gages having gaging elements as specified in par. 4.5.3.3, check Class 3A LO minimum-material limit. For gaging practices, see par. 3.1.3, p. 6.04.

4.5.3.2. Basic Design. The design is specified only to the extent that it affects the results obtained in gaging. Design details, etc., are optional and not included herein.

Thread snap limit gages are adjustable, and the gaging elements are adjusted and set to setting plugs and locked in proper position. Indicating thread gages are adjusted and set with reference to the applicable thread setting plugs.

4.5.3.3. Gaging Elements. The gaging elements should engage the thread over a length of approximately two pitches. The profile of the gaging element should be that of the LO thread ring gage.

4.5.3.4. Identification. Where practicable, the gaging elements should be marked with the minimum marking essential for identification. When space available for marking is inadequate and the gages

TABLE 6.9. *W Tolerances for GO, HI, and LO Thread Gages*

Threads per inch	Tolerance on lead[a]		Tolerance on half-angle of thread	Tolerance on major or minor diameters			Tolerance on pitch diameter				
	To and including 0.5 in dia	Above 0.5 in dia		To and including 0.5 in dia	Above 0.5 in. to 4 in. dia	Above 4 in. dia	To and including 0.5 in dia	Above 0.5 in. to 1.5 in dia	Above 1.5 in. to 4 in. dia	Above 4 in. to 8 in. dia	Above 8 in. to 12 in. dia[b]
1	2	3	4	5	6	7	8	9	10	11	12
	in	*in*	*deg min* ±	*in*	*in*	*in*	*in*	*in*	*in*	*in*	*in*
80	0.0001	0.00015	0 20	0.0003	0.0003	------------	0.0001	0.00015	------------	------------	------------
72	.0001	.00015	0 20	.0003	.0003	------------	.0001	.00015	------------	------------	------------
64	.0001	.00015	0 20	.0003	.0004	------------	.0001	.00015	------------	------------	------------
56	.0001	.00015	0 20	.0003	.0004	------------	.0001	.00015	0.0002	------------	------------
48	.0001	.00015	0 18	.0003	.0004	------------	.0001	.00015	.0002	------------	------------
44	.0001	.00015	0 15	.0003	.0004	------------	.0001	.00015	.0002	------------	------------
40	.0001	.00015	0 15	.0003	.0004	------------	.0001	.00015	.0002	------------	------------
36	.0001	.00015	0 12	.0003	.0004	------------	.0001	.00015	.0002	------------	------------
32	.0001	.00015	0 12	.0003	.0005	0.0007	.9001	.00015	.0002	0.00025	0.0003
28	.00015	.00015	0 8	.0005	.0005	.0007	.0001	.00015	.0002	.00025	.0003
27	.00015	.00015	0 8	.0005	.0005	.0007	.0001	.00015	.0002	.00025	.0003
24	.00015	.00015	0 8	.0005	.0005	.0007	.0001	.00015	.0002	.00025	.0003
20	.00015	.00015	0 8	.0005	.0005	.0007	.0001	.00015	.0002	.00025	.0003
18	.00015	.00015	0 8	.0006	.0005	.0007	.0001	.00015	.0002	.00025	.0003
16	.00015	.00015	0 8	.0006	.0006	.0009	.0001	.0002	.00025	.0003	.0004
14	.0002	.0002	0 6	.0006	.0006	.0009	.00015	.0002	.00025	.0003	.0004
13	.0002	.0002	0 6	.0006	.0006	.0009	.00015	.0002	.00025	.0003	.0004
12	.0002	.0002	0 6	.0006	.0006	.0009	.00015	.0002	.90025	.0003	.0004
11.5	.0002	.0002	0 6	.0006	.0006	.0009	.00015	.0002	.00025	.0003	.0004
11	.0002	.0002	0 6	.0006	.0006	0009	.00015	.0002	.00025	.0003	.0004
10	------------	.00025	0 6	------------	.0006	.0009	------------	.0002	.00025	.0003	.0004
9	------------	.00025	0 6	------------	.0007	.0011	------------	.0002	.00025	.0003	.0004
8	------------	.00025	0 5	------------	.0007	.0011	------------	.0002	.00025	.0003	.0004
7	------------	.0003	0 5	------------	.0007	.0011	------------	.0002	.00025	.0003	.0004
6	------------	.0003	0 5	------------	.0008	.0013	------------	.0002	.00025	.0003	.0004
5	------------	.0003	0 4	------------	.0008	.0013	------------	------------	.00025	.0003	.0004
4.5	------------	.0003	0 4	------------	.0008	.0013	------------	------------	.00025	.0003	.0004
4	------------	.0003	0 4	------------	.0009	.0015	------------	------------	.00025	.0003	.0004

[a] Allowable variation in lead between any 2 threads not farther apart than the length of the standard gage, shown in CS8 or B47.1.
It has been customary in the past to specify tolerances on lead as plus or minus (±) values. Under the requirement established above, the width of the tolerance zone is the nominal tolerance value specified *regardless of sign.* In view of the preceding, the tolerance symbols, plus or minus (±), should be removed in referencing lead tolerances. The omission of the plus and minus does not change the total tolerance.
[b] Above 12 inches the tolerance is directly proportional to the tolerance in column 12, in the ratio of the diameter to 12 inches.

TABLE 6.10. *Tolerances for Plain Gages*

Size range		Tolerances				
Above—	To and including—	XX	X	Y	Z	ZZ
1	2	3	4	5	6	7
in	*in*	*in*	*in*	*in*	*in*	*in*
0.029	0.825	0.00002	0.00004	0.00007	0.00010	0.00020
.825	1.510	.00003	.00006	.00009	.00012	.00024
1.510	2.510	.00004	.00008	.00012	.00016	.00032
2.510	4.510	.00005	.00010	.00015	.00020	.00040
4.510	6.510	.000065	.00013	.00019	.00025	.00050
6.510	9.010	.00008	.00016	.00024	.00032	.00064
9.010	12.010	.00010	.00020	.00030	.00040	.00080

TABLE 6.11. *Lengths of AGD taperlock and trilock thread plug gage blanks selected from CS8 or B47.1*

Thread sizes		Thread lengths					
Decimal range		Thread plug gages				Fine pitch instrument thread plug gages	
Above	To and including	GO			HI	GO	HI
1	2	3			4	5	6
in	*in*	*in*			*in*	*in*	*in*
0.059	0.105	0.25			0.1875	0.1875	0.125
.105	.150	.3125			.21875	0.21875	0.15625
.150	.240	.40625			.28125	0.28125	0.21875
.240	.365	.5			.3125	0.3125	0.25
.365	.510	.75			.375	.375	0.3125
.510	.825	.875			.5	0.5	0.375
.825	1.135	1			.625	0.625	0.4375
		12 tpi and finer		Coarser than 12 tpi			
1.135	1.510	1		1.25	.75	0.75	0.5
		7 tpi and Coarser	Finer than 7 tpi and Coarser than 16 tpi	16 tpi and finer			
1.510	2.010	1.875	1.25	0.875	.875	0.75	0.625
2.010	2.510	2	1.375	.875	.875	0.75	0.625
2.510	3.010	2.125	1.5	1	1	----------	----------
3.010	12.010	2.25	1.5	1	1	----------	----------

NOTE 1: For Trilock Plug Blanks above 0.760 to and including 1.510, see CS8 or B47.1.
NOTE 2: For Wire Type Plug Blanks in sizes below 0.760, see CS8 or B47.1.

TABLE 6.12. *Lengths of AGD thread ring gage blanks and total thread lengths of standard truncated setting plug gage blanks selected from CS8 or B47.1*

Thread sizes		Thread lengths Thread ring gages			Total thread lengths of truncated thread setting plugs		
Decimal range							
Above	To and including	Thin Ring	Thick Ring	Fine-pitch instrument ring	For thin ring	For thick ring	For fine-pitch instrument ring
1	2	3	4	5	6	7	8
0.059	0.090	0.09375	----------	----------	0.21875	----------	----------
.090	.150	.15625	----------	----------	.375	----------	----------
.150	.240	.1875	----------	----------	.40625	----------	----------
.240	.365	.34375	----------	.25	.75	----------	0.5625
.365	.510	.4375	----------	.3125	1.	----------	.6875
.510	.825	.5625	0.75	.46875	1.25	1.875	1.
.825	1.135	.6875	.9375	.53125	1.5	2.125	1.125
1.135	1.510	.75	1.125	.625	1.625	2.375	1.3125
1.510	2.010	.8125	1.25	.625	1.875	2.875	1.3125
2.010	2.510	.875	1.3125	.6875	2.	3.	2.4375
2.510	3.010	.875	1.375	----------	1.875	3.	----------
3.010	3.510	.9375	1.4375	----------	2.	3.125	----------
3.510	4.010	.9375	1.5	----------	2.	3.25	----------
4.010	6.260	1.	1.5	----------	2.125	3.25	----------

NOTE 3: For diameters 0.059 to 0.510 in, use thin blank for all pitches, recessing sides where applicable.
Above 0.510 to 1.135 in, use thick blank for pitches coarser than 12 TPI, thin blank for pitches 12 to 28 TPI, and fine pitch instrument blank for pitches 30 and finer.
Above 1.135 to 6.260 in incl., use thick blank for pitches coarser than 10 TPI, thin blank for pitches 10 to 28 TPI, and fine pitch instrument blank for pitches 30 and finer.

and gaging elements are packaged separately, the containers should be suitably marked and/or the gaging elements suitably tagged.

4.5.4. Indicating Thread Gages for Differential Gaging.

4.5.4.1. Purpose. The purpose of indicating thread gages used in differential gaging within this standard is two-fold. The gages are used: (a) by consumers, but only where it is required by supplemental specifications to determine final conformance, (b) by manufacturers, to determine cumulative effect of deviations of product thread elements as an aid in control of manufacturing. For gaging practice, see par. 3.1.4, p. 6.04.

4.5.4.2. Basic Design. The design is specified only to the extent that it affects the results obtained in gaging. Other design details pertaining to frame construction, method of operation, readout, etc., are not included herein.

4.5.4.3. Gaging Elements. The gaging elements for functional differential reading to verify conformance of product thread elements shall be so designed that:

(a) The first set shall engage over a length which approximates the thickness of the GO thread ring blank. The thread form of the gaging elements shall be the same as that of the applicable GO thread ring gage.

(b) The second set shall engage over a length of approximately two pitches and contact the thread flanks $0.375H$ (i.e. the same as that of the comparable LO thread snap gage).

NOTE: Some representative gaging elements in current use are shown in subsection 6, p. 6.27. See the fourth paragraph under subsection 1, p. 6.01, par. 5.4, p. 6.21, par. 5.5, regarding use of gaging elements.

4.5.4.4. Identification. Where practicable, the gaging elements should be marked with the minimum marking essential for identification. When space available for marking is inadequate and the comparators and gaging elements are packaged separately, the containers should be suitably marked and/or the gaging elements suitably tagged.

4.5.5. Plain Gages for Major Diameter.

4.5.5.1. Purpose. The GO and LO thread ring gages clear the major diameter of the product external thread. To check the major diameter limits, plain ring, snap, or indicating gages are required. For gaging practice, see par. 3.1.5, p. 6.04.

4.5.5.2. Basic Design. To assure that the maximum-material limit is not exceeded, a plain cylindrical ring gage is used for the GO gage while a snap or indicating gage is preferred to assure conformance within the minimum-material limit. Plain progressive snap or indicating gages may be used.

Gage Blanks. Plain cylindrical ring blanks and plain progressive adjustable snap gages have been standardized for various size ranges. See CS8 or B47.1.

4.5.5.3. Identification. Fixed limit gages for major diameter of product external threads are to be identified by GO and the major diameter as follows: GO .2500.

4.6. Thread Setting Plug Gages.

4.6.1. Purpose. Thread setting plug gages are used to set adjustable thread ring gages, thread snap limit gages, and indicating thread gages to specified size. Thread setting plug gages are also applied to detect wear on gages and gaging elements in use. GO thread setting plug gages are made to the maximum-material limit of the thread specification while LO thread setting plug gages are made to the minimum-material limit of the thread specification. For gaging practice, see par. 3.1.2, p. 6.03.

4.6.2. Basic Design. Thread setting plug gages are of two standard designs which are designated as basic-crest (full form) and truncated setting plugs. The basic-crest GO setting plug is one having a width of flat at the crest equal to $0.125p$. The truncated GO setting plug is the same as the basic-crest setting plug except that it is longer and the crest of the thread is truncated a greater amount for half the length of the gage giving a full form portion and a truncated portion.

Gage Blanks. For practical and economic reasons the lengths of setting plug gages have been standardized for various size ranges and pitches. See CS8 or B47.1 and table 6.12. The length of the full form and the length of the truncated sections are each at least equal in length to the thickness of the corresponding thread ring gage.

4.6.3. Thread Form. The specifications for thread form of setting plug gages are stated in detail below and are summarized in table 6.7 and figure 6.2.

4.6.3.1. Thread Crests of Truncated and Basic-Crest Maximum-Material-Limit (GO) Thread Setting Plugs.

The major diameter of the basic-crest setting plug and of the full form portion of the truncated maximum-material-limit (GO) thread setting plug is equal to the maximum major diameter of the product external thread.

The major diameter of the truncated portion of the truncated maximum-material-limit (GO) thread setting plug is equal to the maximum major diameter of the product external thread minus ($0.060 \sqrt[3]{p^2} + 0.017p$). See col. 10 of table 6.5.

4.6.3.2. Thread Crests of Truncated and Basic-Crest Minimum-Material-Limit (LO) Thread Setting Plugs.

The major diameter of the basic-crest setting plug and of the full form portion of the truncated minimum-material-limit (LO) thread setting plug is equal to the maximum major diameter of the product external thread. (Same as GO thread setting plug.) The maximum major diameter of the gage must correspond to a truncation that is not less than $0.067H$ ($0.067p$ flat) or 0.0009 in. (0.001 in flat) whichever is the greatest truncation.

NOTE: Method of Computation. Select the smallest of following three values. (a) Maximum major diameter of the product external thread (Max pitch diameter of product external thread plus $0.75H$ (b) Minimum pitch dimaeter of the product external thread plus ($H - 0.00173$) minus gage tolerance. (c) Minimum pitch diameter of the product external thread plus $0.75p$.

The major diameter of the truncated portion of the truncated minimum-material-limit (LO) thread setting plug is equal to the minimum pitch diameter of the product external thread plus $0.5H$.

4.6.3.3. Thread Roots. The minor diameter of thread setting plug gages shall be cleared beyond a $0.125p$ width of flat either by an extension of the sides of the thread toward a sharp V or by an undercut no wider than $0.125p$. See figures 6.2 and 6.3.

4.6.3.4. Pitch Diameter, Limitation of Taper. To effect proper setting of a thread gage, the maximum permissible taper over the entire length of the setting plug shall be within the following limits: For sizes to and including 1.50 in. nominal diameter, maximum taper equals 0.0001 in., except that for threads coarser than 16 threads per inch the maximum taper equals 0.00015 in. For sizes larger than 1.50 in. to and including 6.25 in. nominal-diameter, maximum taper equals 0.0002 in. The permissible taper shall be back taper (largest diameter at entering end) and shall be confined within the gage pitch diameter limits.

4.6.3.5. End Threads. The feather edge at both ends of the threaded section of the setting plug shall be removed. On pitches coarser than 28 threads per inch, not more than one complete turn of the end threads shall be removed to obtain a full thread blunt start. On pitches 28 threads per inch and finer, a 60° chamfer from the axis of the gage is acceptable in lieu of the blunt start.

4.6.3.6. Lead Deviation. Deviation in lead shall be within the limits specified. See table 2.22, par. 4.3.3.3, p. 6.05.

4.6.3.7. Half-Angle Deviations. Deviations in half-angle shall be within the limits specified. See table 2.22.

4.6.4. Identification. The GO thread setting plug for Class 3A gage is basic and is applicable to Class 2A after coating. Accordingly, it is recommended that the gage be identified by set plug, nominal size, threads per inch, series, and GO pitch diameter.

Example:

SET PLUG .250–20 UNC GO PD .2175

The GO thread setting plug gages for Classes 1A and 2A are under basic, having a common allowance. Accordingly, it is recommended that the gage be identified by set plug, nominal size, threads per inch, series, class, and GO pitch diameter.

Example:

SET PLUG .250–20 UNC 1A-2A GO PD .2164

The LO thread setting plug gage is different for each class and accordingly should be identified by set plug, nominal size, threads per inch, series, class, and LO pitch diameter.

Example:

SET PLUG .250–20 UNC-2A LO PD .2127

4.7. Plain Plug Acceptance Check Gages.

4.7.1. Purpose. GO and NOT GO plain plug acceptance check gages verify the minor diameter limits of size of thread ring gages after the thread rings have been properly set with the applicable thread setting plug gages. For gaging practice, see par. 3.1.2, p. 6.03.

4.7.2. Basic Design. The direction of the gage tolerances on plain plug acceptance check gages is reversed as follows: The GO plain plug gage is made to the minimum minor diameter of the thread ring gage with the tolerance *taken minus*. See table 6.10. The NOT GO plain plug gage is made to the maximum minor diameter of the thread ring gage with the tolerance *taken plus*.

Gage Blanks. For standardization and economic reasons the gaging members and handles have been standardized for various size ranges. See CS8 or B47.1.

4.7.3. Identification.

The GO and NOT GO plain plug acceptance check gages for the GO thread ring gage should be identified as GO and NOT GO Acceptance Checks for GO Thread Ring Minor Dia XXXX–XXXX.

The GO and NOT GO plain plug acceptance check gages for the LO thread ring gage should be identified as GO and NOT GO Acceptance Checks for LO Thread Ring Minor Dia XXXX–XXXX.

5. RECOMMENDED GAGING PRACTICES

5.1. Dimensional Acceptability Of Threads.—General practice as to the dimensional acceptability of threads shall be based on the interpretations of pitch diameter limits of size in subsection on Limits of size in section 3 and the following specifications of gages and gaging practices:

(*a*) *At maximum-material limits*[2]—For referee purposes, the dimensional acceptability of threads at the maximum-material limits shall be based on gaging with GO thread plug and ring gages conforming as closely as practicable to the limits of size of the thread and to the thread form and length specified for such gages. (See par. 2.3, p. 6.01.)

(*b*) *At minimum-material limits.*—Unless otherwise specified on the drawing or procurement document, dimensional acceptability at the minimum-material pitch-diameter limits shall be based on the following accepted practices:

(1) *Functional* (*virtual*) *diameter gaging practice*—Functional (virtual) diameter gaging practice, involving the use of thread plug gages and thread ring gages, conforming as closely as practicable to the limits of size of the thread and to the thread form and lengths specified in this section for such gages, is specified for the minimum-material limits of classes 1A and 2A external threads, and classes 1B, 2B, and 3B internal threads.

[2] External and internal threads larger than 6 in nominal diameter present additional problems for technical and economical reasons. It is recommended that acceptance of these be alternatively based on measurement of the thread elements. A clear understanding of requirements and method of gaging should be reached between supplier and consumer.

(2) *Single element gaging practice.*—Single element gaging practice, involving the use of thread snap gages or indicating type gages having thread form in accordance with this section, or its equivalent, engaging the thread over a length of two pitches, is specified for the minimum-material limits of class 3A external threads.

5.2. Procedure In Setting Adjustable Limit And Indicating Thread Gages.—The size of adjustable limit or indicating thread gages is controlled by utilizing the applicable W tolerance thread setting plugs. The observance of uniform setting procedures will aid in the proper setting and surveillance of the thread gages and facilitate correlation of gaging results.

5.2.1. Adjustable Thread Ring Gages.—In setting an AGD adjustable thread ring gage, the sealing compound should be removed and the locking screw loosened. Turning the adjusting screw to the right enlarges the ring so that it turns freely onto the thread setting plug. Alternately adjusting the adjusting screw and tightening the locking screw, a firm fit on the smallest portion of the thread in the ring should result. While making the adjustment, the knurled outside diameter and both sides of the ring should be lightly tapped with a soft-tip or plastic hammer to permit the threads of the ring to wrap themselves around the threads of the setting plug.

Care should be taken to assure that there is no lateral displacement of the sectors comprising the ring gage that would produce a lead deviation beyond the prescribed tolerance zone. After satisfactory adjustment has been obtained, the ring is to be removed from the plug and the same procedure of tapping is repeated with slightly greater emphasis to the sides. If the thread ring gage possesses proper rigidity, the same feel should be still there when the setting gage again is turned into the ring. A tighter fit or inability to reenter the setting gage denotes a fault of the locking device, that should then be taken apart and checked for dimensional conformity to CS8 or B47.1. It is often advisable to do this before even attempting to adjust the thread ring gage. When proper adjustment has been obtained, the gage should be sealed.

In setting to a truncated setting plug, the ring gage may be set to either the full or the truncated portion. It is common practice to set slightly freer than a snug fit to the truncated portion and then to check the root clearance and wear of flank angle by screwing the ring onto the full portion. Extreme caution is required when this practice is followed to prevent damage to the thread crest of the setting plug. The opposite practice is to adjust and set the ring to the full portion and then determine the fit of the gage on the truncated portion. If the thread form of the ring gage is satisfactory, there will be slight or no change of fit. In the case of a worn thread ring gage, the presence of shake or play when on the truncated portion indicates that the sides of the thread are no longer straight near the root and the gage should be relapped or discarded.

In order to provide maximum wear life of a setting plug, the plug should be threaded into a ring as few times as possible. This will prevent uneven wear and a taper on the truncated end of the plug. When setting plugs are thus used properly they do not wear unevenly. However, when setting plugs are applied repeatedly to check thread ring gages, the criteria for acceptability will vary with the type and application of the ring. A LO ring, for example, should be a snug fit at full engagement and provide some resistance to turning at one or two turns engagement. GO thread ring gages should also be a snug fit at full engagement. When the length of the product thread permits engagement with the full length of the GO ring, the requirement as to partial engagement may be relaxed to permit a slightly freer fit. However, there should be no relaxation in the requirements when short product threads, that only partly engage the GO ring, are being engaged.

If a basic-crest setting plug is used to set a thread ring gage, root clearance of the thread in the ring should be determined by the procedure outlined below.

The ring gage should be given further inspection to determine whether or not the minor diameter is within the specified limits. The minor diameter may be inspected by means of GO and NOT GO plain cylindrical plug acceptance check gages or by direct measurement.

5.2.1.1. Procedure for Determining the Clearance in Thread Ring Gages.—The roots of threads of ring gages, particularly LO ring gages, frequently do not clear the maximum major diameter of the external thread. To assist the gage maker and gage inspector, the recommended procedure for determining the clearance at root of thread of ring gages is given to supplement, or substitute for, the use of truncated setting plugs described in par. 5.2.1. For this purpose an optical examination of a sulfur-graphite, plaster of Paris, copper-amalgam, or other suitable cast of the thread is made by means of a projection comparator, toolmaker's microscope, or universal measuring microscope. The actual magnification of the instrument as used must be known.

(*a*) *Methods of making sulfur-graphite casts.*—Sulfur-graphite casts are made from a thorough mixture of finely powdered graphite and crushed lump sulfur which is heated in a ladle until the sulfur is completely melted and becomes viscous. This mixture may be used repeatedly by crushing and remelting. The graphite should constitute about 7 percent of the mixture by weight, although in the practice of various users, the proportion varies from 4 to 20 percent. The graphite is added to eliminate reflections that would be produced by a plain sulfur cast, and to reduce the tendency to shrink upon cooling.

The casting mold may be formed by holding the ring gage between thin plates in the jaws of a vise, the top edge of the plate on one side being well below the thread axis. For small sizes of threads, a convenient arrangement is to use a taper mandrel that is provided with a lengthwise groove having smooth surfaces and an included angle of about 90°, into which the mixture is poured, and in which the cast is later mounted for examination. The bottom of the slot has a slight taper toward the axis at the small end. A square metal stop clamped in the groove serves as a wall in casting. The mandrel is also useful in making copper-amalgam casts, in which case the casting mixture is pressed in.

The sulfur-graphite casting mixture is poured into the mold when the temperature is from 260° to 266° F, and allowed to solidify with slow cooling. The cast may be marked with an identification number with a steel stylus. Sulfur-graphite casts warp considerably after a few hours.

(*b*) *Method of making plaster of Paris casts.*—A plaster of Paris cast is usually made to determine errors in thread angle, and this cast can usually be used to determine clearance. Such a cast is made by mixing 5 parts (28 g or 1 oz) of a good grade of dental plaster of Paris with from 4 to 5 (26 ml) parts by weight of potassium-bichromate solution made by dissolving 40 g in 1 liter of water. The potassium bichromate inhibits rusting of the gage. This mixture is applied to the threads inside a mold which may be fashioned from cardboard or a strip of copper, with modeling clay pressed into the threads along the outside bottom edges of the mold. It should be allowed to harden completely before removal. Plaster of Paris casts have less shrinkage than sulfur-graphite, but do not retain dimensions over extended periods of time. They are difficult to remove from rough finish threads without damage.

(*c*) *Determining clearance of GO thread ring gages.*—The flat at the crest of the *maximum* external thread is $0.125p$, therefore, if the root of thread of the GO ring is relieved to a width of $0.125p$, the ring threads clear the maximum major diameter of the thread. If the roots of the GO ring gage threads are not relieved, they must be to a sharp enough V to clear a flat of $0.125p$. The flanks of the thread should be straight to the point where the $0.125p$ flat will make contact with the flanks of the thread. The width of flat on the chart or template used should be $0.125p$ times the magnification of the comparator.

(*d*) *Determining clearance of LO thread ring gages.*—The flat at the crest of a screw with maximum major diameter and minimum pitch diameter is determined by the formula:

$$\text{Flat} = \frac{p}{2} - h' \tan 30° = \frac{p}{2} - 0.57735h'$$

for the Unified form of thread, where h' = maximum major diameter minus minimum pitch diameter.

If the LO ring gage has a relief of $0.25p$ as recommended, it is necessary to determine whether or not the relief is deep enough. To do this, make a chart or template representing a 60° thread with a flat at the crest equal to the flat, as determined by the above formula, times the magnification of the comparator. This chart or template should fit the image of the thread and contact the flanks of the thread image without contacting in the relief. If the ring threads are not relieved, they must be sharp enough to permit the chart or template to contact on the flanks of the image rather than in the root.

5.2.2. Thread Snap Gages.—The gaging elements of most types of thread snap gages are mounted on eccentric pins or studs which can be securely locked in position by means of locking screws or nuts. Since thread snap gages may be of different designs, the above description is used only to illustrate a general classification.

It is essential that proper setting procedures be utilized to assure uniform contact pressure between the gaging elements and their applicable thread setting plugs. The gaging elements should be adjusted so that the thread setting plug will have a minimum perceptible drag when passing it through the gaging elements. One method is to adjust the gage so that the pressure between the gaging elements and the thread setting plug will just support the weight of the thread snap gage and, as the setting plug is slowly rotated, the thread snap gage will drop off by its own weight.

In setting large diameter thread snap gages, it may be desirable to support the thread snap gage in a vise or other holding means. Care should be taken to avoid deformation of the gage frame. Uniform gaging pressure can be attained by holding the gage frame in a vertical position and adjusting the gaging elements so that the thread setting plug will have perceptible drag and will just drop through the gaging elements by its own weight.

Care should be taken not to use too much force when checking or setting thread snap gages so that deformation, brinelling, or permanent damage to the gaging elements, gage frame, or thread setting plug does not occur.

Standard AGD truncated or basic-crest thread setting plugs may be used for setting thread snap gages. Large diameter thread snap gages are sometimes adjusted and set to the proper pitch diameter by direct measurement, size blocks, or various types of setting bars. Details of design and specific instructions covering the use of various types of setting means for large diameter thread snap gages are available directly from the gage manufacturer.

5.2.3. Indicating Thread Gages.—Indicating thread gages are of various designs but most of them are of the comparator type which compare and indicate the variation in size between a thread setting plug of known size and the size of the product thread being checked. Indicating thread gages provide an adjustable gaging force as an inherent part of the gage body construction. This gaging force may be varied according to the particular characteristics (i.e., weight, size, shape, etc.) of the product being checked. The accuracy of the setting and gaging is not normally influenced by variations in the gaging force as the gage is set and used with the same force applied in both instances. Care should be used in selecting the gaging force to be applied in relation to the deformability of product threads.

Usually the applicable GO and LO AGD trun-

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cated or basic crest thread setting plugs are used to set the indicating thread gages. However, a thread setting plug of other than the applicable size is sometimes used and the tolerance zone for the product thread is established with reference to the size of the thread setting plug employed. This practice is advantageous as it eliminates the necessity for having applicable setting plugs for each of the various classes of thread as well as special limits. Modification of limits of size to provide allowance for coating and limits of size after coating may be readily established with reference to the size of a thread setting plug gage.

Gage manufacturers usually offer specific information regarding the operation, checking, setting, and surveillance to cover their particular designs of indicating type thread gages.

5.3. Limit Gages For Use In Manufacturing.

5.3.1. In the manufacture of product threads it is necessary to control the limits of size and the various individual thread elements so that the threads produced will be acceptable with final conformance gages. Adoption and use of specific manufacturing gages is the prerogative of individual organizations. If the producer uses gages other than those described in this section, he should evaluate the results obtained to assure correlation with the final conformance gages specified in this section and final conformance within the specifications in section 2.

5.3.2. Limit gages used in manufacturing checking may be of the same general design of thread plug and ring gages used in final conformance gaging. It is important, however, that thread plug and ring gages used in manufacturing checking have pitch diameter tolerances so applied as to be within the product limits of size: i.e., GO thread plugs with tolerance plus, HI thread plugs with tolerance minus, GO thread rings and GO setting plugs with tolerance minus, LO thread rings and LO setting plugs with tolerance plus. Whereas final conformance gages should be as close as practical to the extreme limits of size of the product threads, gages for manufacturing checking should be as far removed from those extremes as is practicable while still within X gage tolerances. When X pitch diameter tolerance is specified for setting plugs, it is recommended that W tolerances for lead and half-angle be specified. (See par. 4.3.3.1, p. 6.05.)

5.3.3. A practice sometimes utilized is to check the pitch diameter of new gages as received, to assign for final conformance gaging those closest to the extreme sizes of the product thread and to assign for manufacturing checking those farthest from the extreme limits of size of the product thread.

5.3.4. Periodic surveillance of both final conformance and manufacturing gages will disclose when the manufacturing gages, due to wear, approach approximately the same size as those used as final conformance gages. At such time either of two courses of action is suggested.

(a) Manufacturing gages (GO) may be transferred to the final conformance application, and be replaced with new gages from the manufacturing gage stock, or

(b) Final conformance gages (HI/LO) may be transferred to the manufacturing gage application, and vice versa.

Perhaps the most difficult point to reconcile in such a program is that of deviations resulting from normal use. Starting threads of both plugs and rings bear the brunt of use when making an inspection. Wear is seldom uniformly distributed over the gaging length and the thread flanks, resulting in inaccuracies of flank angle and pitch diameter. It is important for the success of such a program that inspection and manufacturing personnel agree on the position for the pitch diameter check and the degree of taper which may be tolerated before that gage should be taken out of service. The HI/LO gaging practice which permits the minimum-material-limit gages to assemble for their entire length, provided a definite drag is achieved on or before the third thread of entry, has alleviated appreciably the problem of worn end threads.

5.3.5. There are a number of other styles of limit thread gages utilized as manufacturing gages for technical or economic reasons. Among these are caliper or snap gages using gaging elements of various configurations. Included are those utilizing rolls, segments, serrated anvils, wires, probes, and ball points. Whereas all of these would accept perfect threads with little or no appreciable difference, they may react quite differently on threads having acceptable deviations.

5.3.6. There is an additional problem, primarily stemming from economics, where a relatively few parts with threads are involved, when neither limit nor indicating gages are available and it is economically impracticable to procure them. Such situations are daily problems in model shops, experimental and research departments, tool rooms, and job shops. A discussion of some commonly used practices follows:

5.3.7. Adequate means for determining accuracy of thread angle, thread form, and lead (both linear and helical) are essential. Optical projection or mechanical gages of a general nature are used frequently for such checking.

5.3.8. Numerical values for groove diameter may be determined by use of the three-wire method or for LO minimum-material limit by the use of thread micrometers. The accuracy of these values is affected by the following factors.

5.3.9. Values obtained from three-wire measurement are influenced by:

Deviation in geometry and pitch of product thread.

Product thread characteristics (cleanliness, surface texture, hardness, etc.).

Measuring force exerted over the wires.

Operating skill in handling part, wires, and micrometer.

5.3.10. Values obtained with thread micrometers are influenced by factors enumerated in par. 5.3.9, as applicable, and accuracy of the cone and vee contact elements.

5.3.11. To make use of the values covered in par. 5.3.8 (as applicable to the maximum-material limit, i.e., functional diameter), the diameter equivalents of deviations in lead and half-angle must be taken into account.

5.3.12. For use as a manufacturing check at minimum-material limit the values covered in par. 5.3.8 may be used without change. However, one must realize that these values may be more restrictive of pitch diameter limits than would be experienced with limit gages.

5.4. DIFFERENTIAL GAGING.

5.4.1. Differential Gaging provides an economical method of checking for thread element deviations of product complete threads. The principle involved is the determination of values for two essential features or characteristics and by subtraction to determine the difference, i.e., the differential reading. This principle as utilized in checking Unified Screw Threads is a convenient and effective manner of evaluating the effect of deviations of the several elements and some other characteristics. It is helpful to the manufacturer in control of tools and processes. It is not intended that values determined for Differential Gaging be utilized for verification of size conformance.

5.4.2. The following differential readings determined thru the use of appropriate gaging elements are utilized for final conformance gaging of thread elements when specified. See par. 4.5.4.3, p. 6.16, and par. 5.5.

5.4.3. Functional Differential Reading Par. 4.5.4.3, p. 6.16, utilizes Gaging Elements 6.5(a), p. 6.27, for determination of GO functional size, and 6.5(b) for determination of LO minimum-material limit. When the difference between values so determined (Functional Differential Reading) exceeds the specified percentage of the applicable pitch diameter tolerance, it is necessary to make a further analysis to determine if either lead or flank angle exceeds the allowable tolerance. Functional Differential Reading may not be used in thread analysis. (See par. 5.5.)

NOTE 1: The numerical value determined for the Functional Differential Reading will not correlate with that determined by measurement, nor that determined in Thread Analysis except in the case of a perfect thread. Reason is that the contour of the gaging elements 6.5(b), p. 6.27, engage a significant portion of the flank angle and approximately two pitches length of engagement. To be completely assured that no single element exceeds the specified tolerance, the Functional Differential Reading should not exceed one-half of the specified tolerance.

5.4.4. Cumulative Differential Reading.—The size (using gaging elements 6.5(d), (f), (g), or (i) with (j), (k), (l), or (m), p. 6.28, profile) devoid of any effect from lead or angle deviations is subtracted from the value for functional size (using gaging elements 6.5(a)) to establish the CUMULATIVE DIFFERENTIAL READING. When this differential reading does not exceed the specified percentage of the applicable pitch diameter tolerance, the thread elements (lead and flank angle) are well within tolerance. If differential reading exceeds the specified percentage of the applicable pitch diameter tolerance, it is necessary to make a further analysis of lead and flank angle separately. See pars. 5.4.5, 5.4.6, and 5.5. The values determined and utilized in Differential Gaging should not be used for verification of size conformance.

5.4.5. Lead Differential Reading.—Lead Deviation is evaluated using gaging elements as provided in subsection 6, p. 6.27. Gaging elements 6.5(a) engage the thread over approximately the normal length of engagement. Gaging elements 6.7(n) engage the thread over a length not exceeding one pitch. Both contact the thread with a flank engagement of $0.625H$. Care must be taken to avoid any error in product thread cylindricity affecting the readings. The difference between the values is used to determine the LEAD DIFFERENTIAL READING. It is intended that this reading should not exceed the specified percentage of the applicable pitch diameter tolerance.

5.4.6. Flank Angle Differential Reading.—Flank Angle Deviation is evaluated using gaging elements as provided in subsection 6, p. 6.27. Gaging elements 6.5(c) engage the thread flank $0.375H$ (i.e., that which is available at minimum-material condition of the major diameter). Gaging elements 6.6(l) contact the gage flank with curved contacts, or contacts having a slight flat. Both gaging elements engage the thread not over one pitch in length. Care must be taken to avoid any effect of product thread cylindricity affecting the reading. The difference between the values so determined, multiplied by two, is the FLANK ANGLE DIFFERENTIAL READING. It is intended that this reading should not exceed the specified percentage of the applicable pitch diameter tolerance.

5.5. THREAD ANALYSIS UTILIZING INDICATING THREAD GAGES.

5.5.1. Differential Gaging provides an economical method of checking to verify conformance of thread elements of product complete threads. However, when a numerical value for deviations in each of the several elements is desired, more comprehensive Differential Gaging and Thread Analysis are utilized as covered in the following paragraphs.

The most effective manner by which to convey and understand Thread Analysis utilizing Indicating Thread Gages is to outline the procedures and interpretations. The following applies to gages for product external threads. Comparable techniques and procedures are utilized for checking product internal threads but are not covered in detail herein. Details of gaging elements are presented in subsection 6, p. 6.27.

5.5.2. Differential Gaging Procedures.—The value yielded for the product complete thread, when checked with an indicating thread gage utilizing gaging elements 6.5(a), p. 6.27, to determine Functional Diameter, should at no point along the thread exceed the specified maximum-material limit.

On a perfect thread, the reading obtained when utilizing applicable indicating thread gages would be identical for Functional, Pitch, Groove, and Ridge Diameters.

The deviation in any single thread element, such as lead and flank angle, may not exceed the diameter equivalent of the allowable specified percentage of the pitch diameter tolerance. This is interpreted to mean that no deviation in any single thread element may exceed the allowable specified percentage of the pitch diameter tolerance even though the size of the thread falls within the specified maximum and minimum-material limits.

Any deviations in lead and flank angle of product threads are reflected in the direction of maximum material. Thus, the numerical value for Functional Diameter will differ from the numerical values for LO Minimum-Material Size or Pitch Diameter, as applicable. This difference in numerical values is referred to as the Differential Reading of which there are four as covered in par. 5.4. These numerical values are affected by some features of the gaging elements and some conditions of the product threads which are overlooked all too frequently. The following examples in this category and explanations may be of assistance in evaluating and selecting the applicable gaging elements.

NOTE 1: Pitch Diameter.—It is recognized that numerical values determined by various gaging elements reflect deviations in pitch and flank angle. (See subsection 6, p. 6.27.)
When pitch and flank angle of product threads are *within* acceptable deviations (see par. 5.5.2.1) the difference in numerical values *between gaging elements engaging in the groove or engaging both the thread ridge and groove is of negligible magnitude.* A few examples are given below to illustrate the magnitude of this difference on product threads having maximum permissible progressive lead deviation for Unified Threads over a length of engagement comparable to the thickness of the applicable GO thread ring gage. See par. 4.5.4.3., p. 6.16. These values are yielded by the following formula:

$$V = 0.866LT/NTR$$

where: V = Variation between pitch diameter and groove diameter values
LT = max acceptable lead deviation in product thread
NTR = number of threads in thread ring gage.

	1A	2A	3A
.250–20 UNC	0.00021	0.00014	0.00010
.250–28 UNF	.00013	.00009	.00007
.250–32 UNEF	----------	.00007	.00005
.750–10 UNC	.00029	.00020	.00015
.750–16 UNF	.00021	.00014	.00010
.750–20 UNEF	----------	.00011	.00007

NOTE 2: Flank Angle

(a) Effect of engagement of gaging contacts on thread flanks. Functional Differential Reading utilizes 0.625H and 0.375H flank engagements for verifying conformance, whereas Cumulative Differential Reading utilizes 0.625H and curved (or slight flat) contacts to determine a numerical value representative of the extent of the deviation. Values achieved are significantly different as illustrated by the formulas and tabulation which follow.

Formulas:

$$\text{Plus Angle} \begin{cases} A = 0.10825\, p \tan 30^\circ \\ B = A \cot(\alpha +) \\ \text{Variation} = 2(0.10825\, p - B) \end{cases}$$

$$\text{Minus Angle} \begin{cases} A = 0.10825\, p \tan 30^\circ \\ B = A \cot(\alpha -) \\ \text{Variation} = 4(B - 0.10825\, p) \end{cases}$$

	1A		2A		3A	
	+ angle	− angle	+ angle	− angle	+ angle	− angle
.250–20 UNC	0.00106	0.00240	0.00072	0.00164	0.00056	0.00112
.250–28 UNF	.00092	.00216	.00064	.00136	.00050	.00100
.250–32 UNEF	---------	---------	.00060	.00136	.00046	.00100
.750–10 UNC	.00166	.00372	.00104	.00244	.00086	.00180
.750–16 UNF	.00142	.00370	.00098	.00204	.00076	.00156
.750–20 UNEF	---------	---------	.00082	.00184	.00064	.00156

(b) Effect of deviations in plus direction and minus direction. The dual formulas and sets of values in the table result from the unequal heights above and below the pitch line (addendum and dedendum). This complexity may be resolved by locating the curved (or slight flat) contacts above the pitch line as shown in 6.6(l) and (m), p. 6.29.

(c) Effect of deviations in major diameter. A specific deviation in flank angle yields significantly different values when the major diameter is at maximum and when it is at minimum when using 0.625H and curved (or slight flat) contacts. This complexity may be resolved by using 6.5(c), p.6.28, (0.375H) which bears on flank length and 6.5(d), 6.6(l), or (m) (curved or slight flat) contacts. Multiplying the resultant figure by two converts the reading to that which is applicable to the full 0.625H length of flank.

5.5.2.1. When the Cumulative Differential Reading is not greater than the allowable specified percentage of the pitch diameter tolerance, the product thread is verified as well within the specification. (See par. 5.4.4, p. 6.21.) When the Cumulative Differential Reading is greater than the allowable specified percentage of the pitch diameter tolerance, the product thread must be analyzed further to assure that the diameter equivalent of the deviation of either lead or flank angle does not exceed the allowable percentage of the pitch diameter tolerance. Lead equivalent deviation, for practical purposes, applies over the length of the applicable GO thread ring blank in CS8 or B47.1.

5.5.3. Analysis of Deviations in Product Threads.

5.5.3.1. Deviation in Lead. Deviation in lead is especially important since it affects pitch diameter in the ratio of 1.732 to 1 in a 60° thread. To check deviation in lead:

(a) Determine the straightness of the product thread by checking at different positions along the product thread using the 6.5(d), (e), (g), or (i), p. 6.28, gaging elements and note the position of the first full thread.

(b) Determine and note the functional diameter of the product thread.

(c) Engage the product thread at the position of the first full product thread as determined in (a) with the first thread of the functional diameter gaging elements 6.5(a) or with 6.7(n) single rib gaging elements, and note the difference in readings. This is the Lead Differential Reading. If the difference is greater than the allowable percentage of pitch diameter tolerance, exclusive of taper, it signifies that the lead deviation is excessive.

NOTE 3: In steps (b) and (c) the results are not affected by deviation in flank angle since the length of flank angle contact in both steps is the same. The only difference in contact is in the length of engagement. Lead deviation may be wholly compensated for by taper deviation since the diameter equivalent of lead deviation will not influence the reading until it exceeds the taper deviation. The extent of taper deviation is known as measured in step (a). If the lead differential reading exceeds this taper deviation by more than the pitch diameter equivalent for lead deviation, the lead deviation is excessive. If the lead differential reading does not exceed the permissible taper deviation, it indicates that the pitch diameter equivalent for lead deviation is less than the maximum taper deviation. If the taper deviation is within the required percentage of pitch diameter tolerance, then it would follow that the lead deviation is also within the required percentage of pitch diameter tolerance and in conformance with specified tolerance.

5.5.3.2. Deviation in Flank Angle. Deviation in flank angle may be revealed by engaging the first full product thread with the 6.5(d), (f), (g), or (i) gaging elements (see 6.5, p. 6.28) and then engaging the same thread with 6.7(n) single rib gaging elements or 6.5(a) gaging elements. If this Flank Angle Differential Reading exceeds the specified percentage of pitch diameter tolerance, it may be that the product thread has excessive flank angle deviation. (See Note 6.)

Analysis of Thread Flank Deviation. With the above types of elements, there are two product deviations which can affect the differential reading. These are: direction of angle deviation (Note 4) and actual major diameter of product thread (Note 5). To reduce these effects, the gaging elements may consist of 6.6(l) or (m) limited contact elements used in conjunction with $0.375H$ LO single element profile elements 6.5c. The difference between readings obtained using this combination of gaging elements, multiplied by two, is the diameter equivalent of flank angle variation present in that product thread.

NOTE 4: The reading for a plus angle deviation on the product thread checked, will be greater than that for a minus angle deviation of the same angular mangitude. This results from unequal height of profile, above and below the pitch line (addendum and dedendum) for Unified threads.

NOTE 5: The differential so obtained is greater for a product thread having maximum major diameter than for one having minimum major diameter.

5.5.3.3. Taper. Taper is determined by checking at several positions along and over the length of engagement of the product thread using the 6.5(d), (e), (f), (g), or (i) gaging elements, p. 6.28.

5.5.3.4. Deviation in Minor Diameter or Root Fillet. Oversized minor diameter or root fillet may be revealed by engaging the first full product thread in the 6.5(d), (f), (g), or (i) gaging elements and then engaging the same thread in the 6.7(n) single rib gaging elements or 6.5(a) gaging elements. If this Flank Angle Differential Reading exceeds the specified percentage of pitch diameter tolerance, it may be that the product thread has an oversized minor diameter or root fillet. (See Note 6.)

NOTE 6: For further analysis of product thread profile and control of threading tools, optical projection methods are suggested. They are particularly useful in checking thread form, flank angle, and pitch deviations of product threads and manufacturing tools.

5.5.3.5. Out-of-Round. Out-of-Round in a product thread may be elliptical, oval, egg-shaped, or lobed (frequently called clover leaf). Ovality is detected most effectively with two-point gaging contacts in an indicating thread gage. Lobing can be detected most effectively with three-point gaging contacts in an indicating thread gage. See figures 6.13, 6.14, and 6.15, p. 6.24, and notes 7 and 8.

NOTE 7: A gage having two gaging elements is preferred for detecting an elliptical condition, while a gage having three gaging elements is preferred for detecting the multi-lobed condition.

NOTE 8: Any helix variation (deviation in helical path or "drunkenness") may be reflected in the check for roundness. When an excessive deviation from roundness is detected, further analysis should be made utilizing equipment of a universal nature capable of differentiating and evaluating helix variation, or equipment especially made for evaluating helical path deviation. This check is applicable when the product thread call-out specifies control and inspection of thread elements.

5.5.4. Determining Allowances on Pitch Diameter to Compensate for Lead Deviation in Product Threads with Long Length of Engagement.

5.5.4.1. Determine the straightness of the product thread and note the location of the first full product thread with reference to the starting thread using the pitch diameter gaging elements with an indicating thread gage.

5.5.4.2. Determine and note the functional diameter of the product thread using the functional diameter indicating thread gage.

5.5.4.3. Engage the first full product thread (as determined in par. 5.5.4.1) in the first thread of the functional diameter gaging elements and note the size indication.

5.5.4.4. Subtract the first full product thread diameter numerical value (par. 5.5.4.3) from the functional diameter numerical value (par. 5.5.4.2). This difference in readings is the differential numerical value and represents the pitch diameter equivalent of the lead deviation in the product thread over a length equal to the length of the functional diameter gaging elements.

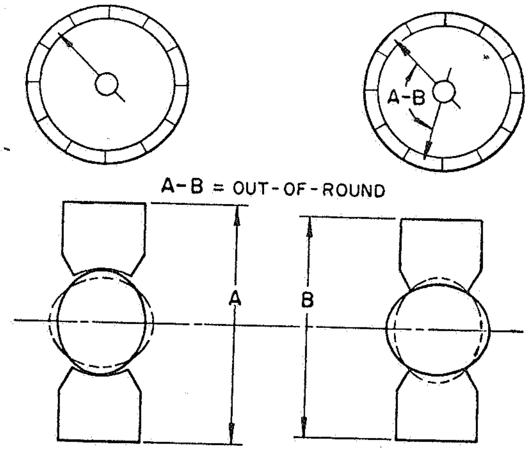

FIGURE 6.13. *Out-of-round: elliptical, oval, or egg-shaped. (Utilizing segments for gaging elements).*

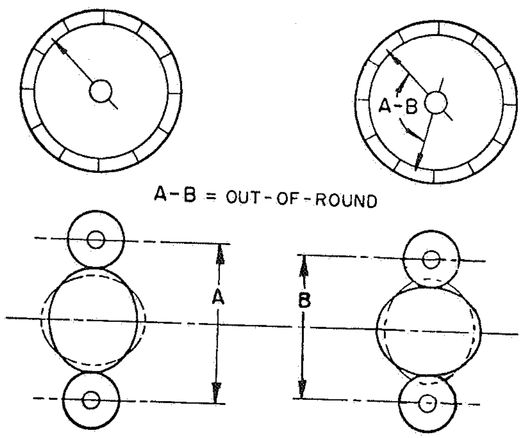

FIGURE 6.14. *Out-of-round: elliptical, oval, or egg-shaped. (Utilizing rolls for gaging elements).*

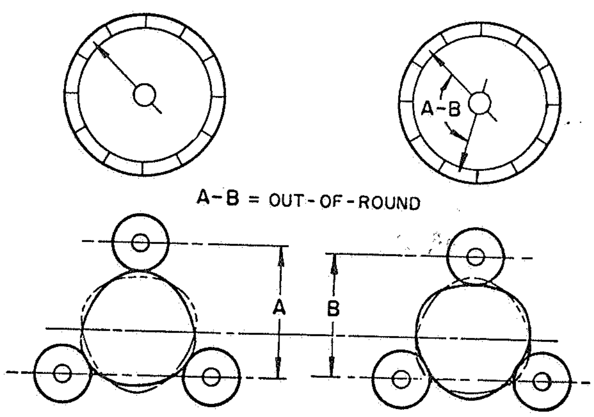

FIGURE 6.15. *Out-of-round: Lobed. (Utilizing rolls for gaging elements).*

5.5.4.5. Divide the length of engagement of the product thread by the length of the functional diameter gaging elements. This result is the Length Factor.

5.5.4.6. Multiply the differential reading (par. 5.5.4.4) by the length factor (par. 5.5.4.5). This result is the amount by which the specified maximum-material functional diameter of that external product thread must be below the specified maximum-material limit. This will compensate for the lead deviation in that product thread and will assure acceptance over full length engagement with a mating product thread made to its specified maximum-material size.

5.6. GAGING FUNCTIONAL DEPTH LIMITS OF PRODUCT INTERNAL THREADS.

5.6.1. The data herein represents current practice and should be helpful in specifying depth limit steps on thread plug gages. Specifications for the location of depth limit steps on GO thread plug gages, which are otherwise made in accordance with details in this section, are as follows.

5.6.2. Object of Depth Limit Steps. The object of depth limit steps on GO plug thread gages is to determine the extent a product functionally conforms to the specified thread depth.

There are two types of specifications referring to depth of internal threads. One type specifies minimum depth only and therefore requires only one depth limit step on the gage. The other type specifies minimum and maximum values for depth of thread and requires two depth limit steps on the gage.

5.6.3. Use of Gages with Depth Limit Steps. The step limit GO thread plug gage is applied to the product as far as it will go without the application of significant force which would tend to deform the product material. The position of the limit steps in relation to the face of the product is noted to determine conformance.

5.6.4. Location of Limit Steps. Limit steps shall be located with reference to the front end face of the gage as shown in figures 6.16 and 6.17 and at a point on the circumference that will approximately bisect the crest flat of the gage.

The first full crest of the GO thread plug gage with a depth limit step shall start at a location $0.5p$ from the front end face of the gage as shown in figures 6.16 and 6.18.

The limit step face shall be straight for the depth of thread and shall be ground at 90 degrees to the axis of the gage.

Reversible style thread gages are generally made with only one set of limit steps from one end of the gage in order to eliminate confusion and error from runout of one set of steps running into steps from the other end.