Product (Dimensions and Tolerances) Standards for Threaded Fasteners

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The information contained in this booklet represents a significant collection of technical information about product standards for threaded fasteners. This information will help to achieve increased reliability at a decreased cost. Assemblage of this information will provide a single point of reference that might otherwise be time consuming to obtain. Most of information given in this booklet is mainly derived from literature on the subject from the sources as per the references given at the end of this booklet. For more information, please refer them. All information contained in this booklet has been assembled with great care. However, the information is given for guidance purposes only. The ultimate responsibility for its use and any subsequent liability rests with the end user. Please view the disclaimer uploaded at http://www.practicalmaintenance.net.

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Introduction

Most industrial threaded fasteners are covered by two basic standards: one for materials and properties called materials standards; the other, for dimensions and tolerances called product standards. Information about product standards is given in this booklet. For information about materials and properties, please see booklet titled Mechanical Properties and Identification Markings for Threaded Fasteners (at www.practicalmaintenance.net).

There are two main systems for measuring weights and distances: the metric system and the imperial system. The primary standardization organizations for the metric system product standards for fasteners are the International Organization for Standardization (ISO) and the German Institute for Standardization (DIN) whereas for the imperial fasteners they are American Society of Mechanical Engineers (ASME). It may be noted that ASME is inclined towards setting codes and standards for mechanical devices, the American National Standards Institute, abbreviated as ANSI accredits standards for the products, processes, systems, services, and resources of the United States. Though there are many ASME and ISO product standards for threaded fasteners, important information about only some product standards for education purpose is given in this booklet. For users of Indian Standards, important information on some Indian Standards (IS) is also given.

It may be noted that each metric standard is product specific. For example, ISO 4014 (DIN 931) is the specification for hexagon head bolts (Product grades A and B) and ISO 8765 (DIN 960) is the specification for hexagon head bolts with metric fine pitch thread (Product grades A and B). The specification used to produce the corresponding inch series fasteners is ASME B18.2.1. However, the ASME B18.2.1 specification covers the dimensional requirements for nine product types of inch series bolts and screws. Therefore, one must state the pattern of the desired product; in this case, hex bolts. Under the metric system, each of the product types would have its own individual standard.

As there is a move towards the adoption of ISO fastener standard in place of metric fastener standard by ASME, ASTM and SAE, information on metric fastener standard by ASME, ASTM and SAE is not given in this booklet.

Note:

It may be noted that in ISO standards, comma (,) is used as a decimal marker.

Dimensions of Bolts, Screws and Nuts as per ASME

Important information about dimensions and tolerances for bolts, screws and nuts as per ASME standards B18.2.1 and B18.2.2 is given in this chapter.

ASME B18.2.1

ASME B18.2.1 covers the dimensional requirements for inch series square head, hex, heavy hex, and askew head bolts; hex (hex cap), heavy hex, hex flange, and lobe head screws; and lag screws recognized as American National Standard.

Terminology

In this standard, “short bolt” or “short screw” means a bolt or screw of a diameter-length combination that is required to be threaded for full length, whereas “long bolt” or “long screw” means a bolt or screw of a diameter-length combination that is not threaded for full length.

Body Length, L_B

Body length is the distance measured parallel to the axis of the bolt or screw from the underhead bearing surface to the last scratch of thread or, for rolled threads, to the top of the extrusion angle.

Grip Gaging Length, L_G

Grip gaging length is the distance measured parallel to the axis of the bolt or screw from the underhead bearing surface to the face of a noncounterbored/noncountersunk standard GO thread ring gage assembled by hand as far as the thread will permit. Thus, it is the distance from the bearing face to the first full form (full profile) thread.

For fasteners not threaded to full length, grip gaging length represents the minimum design grip length of the joint (minimum thickness of materials which can be clamped) excluding the washer thickness.

Thread Length

Thread length is the length from the extreme point of the bolt or screw to the last complete (full form) thread. For bolts and screws in this standard, other than lag screws, the Nominal Thread Length (L_T) is a reference dimension intended for calculation purposes only.

General Data for Both Bolts and Screws

Width Across Flats

Width across flats of head is the overall distance measured perpendicular to the axis of product between two opposite sides of the head.

Head Height

The head height is the overall distance measured parallel to the axis of product from the top of the head to the bearing surface and shall include the thickness of the washer face where provided.

Bolt or Screw Length

The bolt or screw length is the distance measured parallel to the axis of product from the bearing surface of the head to the extreme end of the bolt or screw, including the point if the product is pointed.

Unless otherwise specified, bolts need not be pointed. Products designated as screws, with the exception of lag screws, are required to have a chamfered point.

Threads

Threads on all products in this standard, except lag screws, shall meet the requirements of ASME B1.1. For lag screw thread dimensions, please see the standard.

Thread series on all bolts and screws may be coarse (UNC), fine (UNF), or 8 thread series (8 UN), except askew head bolts, which shall be unified coarse (UNC) only, and lag screws, which are specified in the standard.

Unless otherwise specified, size limits for standard external thread, Class 2A apply prior to coating. The external thread allowance may be used to accommodate the coating thickness on plated or coated parts, provided that the maximum coating thickness is no more than one-fourth of the allowance.

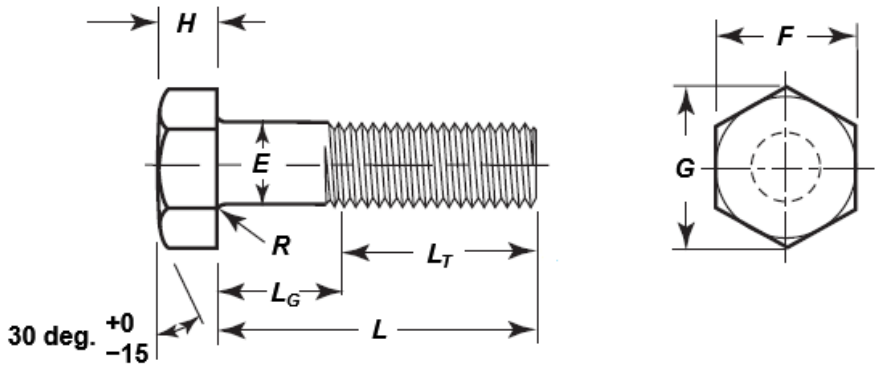
Designation

Bolts and screws shall be designated in the sequence by: product name; nominal size (fractional or decimal equivalent); threads per inch (omit for lag screws); product length (fractional or two-place decimal equivalent); material, including specification where necessary; and protective finish, if required.

For Example: Hex Cap Screw per ASME B18.2.1. $^{1}/_{2}$ - 13 × 4. ASTM A 354 Grade BD, plain finish.

It may be noted that in above example, the screw will be provided Class 2A thread as nothing is specified in the designation. As nominal size is 1/2 in. and threads per inch is 13, the screw has unified coarse (UNC) thread. Thread series (UNC) is not required to be specified since threads per inch is specified.

Bolts



Dimensions of Hex and Heavy Hex Bolts

Following tables show dimensions of hex bolts and heavy hex bolts.

Dimensions of Hex Bolts (All dimensions are in inches)														
Nominal Size or Basic Product Diameter		Full Size Body Diameter, *E*		Width Across Flats, *F*			Width Across Corners, *G*		Head Height, *H*			Radius of Fillet, *R*		Thread Length,* L_T
		Max.	Min.	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.	Max.	Min.	Nom.
1/4	0.2500	0.260	0.237	7/16	0.438	0.425	0.505	0.484	11/64	0.188	0.150	0.03	0.01	0.750
5/16	0.3125	0.324	0.298	1/2	0.500	0.484	0.577	0.552	7/32	0.235	0.195	0.03	0.01	0.875
3/8	0.3750	0.388	0.360	9/16	0.562	0.544	0.650	0.620	1/4	0.268	0.226	0.03	0.01	1.000
7/16	0.4375	0.452	0.421	5/8	0.625	0.603	0.722	0.687	19/64	0.316	0.272	0.03	0.01	1.125
1/2	0.5000	0.515	0.482	3/4	0.750	0.725	0.866	0.826	11/32	0.364	0.302	0.03	0.01	1.250
5/8	0.6250	0.642	0.605	15/16	0.938	0.906	1.083	1.033	27/64	0.444	0.378	0.06	0.02	1.500
3/4	0.7500	0.768	0.729	1 1/8	1.125	1.088	1.299	1.240	1/2	0.524	0.455	0.06	0.02	1.750
7/8	0.8750	0.895	0.852	1 5/16	1.312	1.269	1.516	1.447	37/64	0.604	0.531	0.06	0.02	2.000
1	1.0000	1.022	0.976	1 1/2	1.500	1.450	1.732	1.653	43/64	0.700	0.591	0.09	0.03	2.250
1 1/8	1.1250	1.149	1.098	1 11/16	1.688	1.631	1.949	1.859	3/4	0.780	0.658	0.09	0.03	2.500
1 1/4	1.2500	1.277	1.223	1 7/8	1.875	1.812	2.165	2.066	27/32	0.876	0.749	0.09	0.03	2.750
1 3/8	1.3750	1.404	1.345	2 1/16	2.062	1.994	2.382	2.273	29/32	0.940	0.810	0.09	0.03	3.000
1 1/2	1.5000	1.531	1.470	2 1/4	2.250	2.175	2.598	2.480	1	1.036	0.902	0.09	0.03	3.250
1 5/8	1.6250	1.658	1.591	2 7/16	2.438	2.356	2.815	2.616	1 3/32	1.116	0.978	0.09	0.03	3.500
1 3/4	1.7500	1.785	1.716	2 5/8	2.625	2.538	3.031	2.893	1 5/32	1.196	1.054	0.12	0.04	3.750
1 7/8	1.8750	1.912	1.839	2 13/16	2.812	2.719	3.248	3.099	1 1/4	1.276	1.130	0.12	0.04	4.000
2	2.000	2.039	1.964	3	3.000	2.900	3.464	3.306	1 11/32	1.388	1.175	0.12	0.04	4.250
2 1/4	2.2500	2.305	2.214	3 3/8	3.375	3.262	3.897	3.719	1 1/2	1.548	1.327	0.19	0.06	4.750
2 1/2	2.5000	2.559	2.461	3 3/4	3.750	3.625	4.330	4.133	1 21/32	1.708	1.479	0.19	0.06	5.250
2 3/4	2.7500	2.827	2.711	4 1/8	4.125	3.988	4.763	4.546	1 13/16	1.869	1.632	0.19	0.06	5.750
3	3.0000	3.081	2.961	4 1/2	4.500	4.350	5.196	4.959	2	2.060	1.815	0.19	0.06	6.250
3 1/4	3.2500	3.335	3.210	4 7/8	4.875	4.712	5.629	5.372	2 3/16	2.251	1.936	0.19	0.06	6.750
3 1/2	3.5000	3.589	3.461	5 1/4	5.250	5.075	6.062	5.786	2 5/16	2.380	2.057	0.19	0.06	7.250
3 3/4	3.7500	3.858	3.726	5 5/8	5.625	5.437	6.495	6.198	2 1/2	2.572	2.241	0.19	0.06	7.750
4	4.0000	4.111	3.975	6	6.000	5.800	6.928	6.612	2 11/16	2.764	2.424	0.19	0.06	8.250

* Thread lengths, L_T, shown are for bolt lengths 6 inches and shorter. For longer bolt lengths add 0.250 inch to thread lengths shown.

Dimensions of Heavy Hex Bolts (All dimensions are in inches)														
Nominal Size or Basic Product Diameter		Full Size Body Diameter, *E*		Width Across Flats, *F*			Width Across Corners, *G*		Head Height, *H*			Radius of Fillet, *R*		Thread Length,* L_T
		Max.	Min.	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.	Max.	Min.	Nom.
3/8	0.3750	0.388	0.360	11/16	0.688	0.669	0.794	0.763	1/4	0.268	0.226	0.03	0.01	1.000
1/2	0.5000	0.515	0.482	7/8	0.875	0.850	1.010	0.969	11/32	0.364	0.302	0.03	0.01	1.250
5/8	0.6250	0.642	0.605	1 1/16	1.062	1.031	1.227	1.175	27/64	0.444	0.378	0.06	0.02	1.500
3/4	0.7500	0.768	0.729	1 1/4	1.250	1.212	1.443	1.383	1/2	0.524	0.455	0.06	0.02	1.750
7/8	0.8750	0.895	0.852	1 7/16	1.438	1.394	1.660	1.589	37/64	0.604	0.531	0.06	0.02	2.000
1	1.0000	1.022	0.976	1 5/8	1.625	1.575	1.876	1.796	43/64	0.700	0.591	0.09	0.03	2.250
1 1/8	1.1250	1.149	1.098	1 13/16	1.812	1.756	2.093	2.002	3/4	0.780	0.658	0.09	0.03	2.500
1 1/4	1.2500	1.277	1.223	2	2.000	1.938	2.309	2.209	27/32	0.876	0.749	0.09	0.03	2.750
1 3/8	1.3750	1.404	1.345	2 3/16	2.188	2.119	2.526	2.416	29/32	0.940	0.810	0.09	0.03	3.000
1 1/2	1.5000	1.531	1.470	2 3/8	23.75	2.300	2.742	2.622	1	1.036	0.902	0.09	0.03	3.250
15/8	1.6250	1.658	1.591	2 9/16	2.562	2.481	2.959	2.829	1 3/32	1.116	0.978	0.09	0.03	3.500
1 3/4	1.7500	1.785	1.716	2 3/4	2.750	2.662	3.175	3.035	1 5/32	1.196	1.054	0.12	0.04	3.750
1 7/8	1.8750	1.912	1.839	2 15/16	2.938	2.844	3.392	3.242	1 1/4	1.276	1.130	0.12	0.04	4.000
2	2.0000	2.039	1.964	3 1/8	3.125	3.025	3.608	3.449	1 11/32	1.388	1.175	0.12	0.04	4.250
2 1/4	2.2500	2.305	2.214	3 1/2	3.500	3.388	4.041	3.862	1 1/2	1.548	1.327	0.19	0.06	4.750
2 1/2	2.5000	2.559	2.461	3 7/8	3.875	3.750	4.474	4.275	1 21/32	1.708	1.479	0.19	0.06	5.250
2 3/4	2.7500	2.827	2.711	4 1/4	4.250	4.112	4.907	4.688	1 13/16	1.869	1.632	0.19	0.06	5.750
3	3.0000	3.081	2.961	4 5/8	4.625	4.475	5.340	5.102	2	2.060	1.815	0.19	0.06	6.250

* Thread lengths, LT, shown are for bolt lengths 6 inches and shorter. For longer bolt lengths add 0.250 inch to thread lengths shown.

Thread Length

Nominal thread length equals twice the basic thread diameter +0.25 in. for nominal bolt lengths up to and including 6 in. and twice the basic thread diameter +0.50 in. for nominal

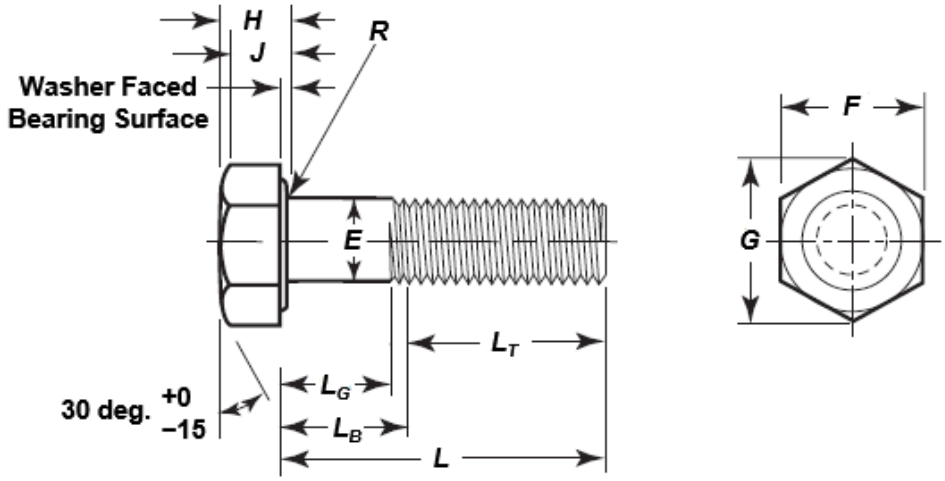
lengths over 6 in. The nominal thread length, L_T, a reference dimension is used to calculate thread length.

The length of thread on bolts is controlled by the grip gaging length. The maximum grip gaging length, L_G, as calculated and rounded to two decimal places for any bolt not threaded full length, shall be equal to the nominal bolt length minus the nominal thread length (L_G, max. = L, nom. − L_T) with a tolerance of minus a length equal to five coarse thread pitches.

For bolts that are threaded full length, L_G, max. defines the unthreaded length under the head and shall not exceed the length of 2.5 times the thread pitch for sizes up to and including 1 in. and 3.5 times the thread pitch for sizes larger than 1 in.

All bolts of nominal lengths equal to or shorter than the nominal thread length, L_T, plus a length equivalent to 2.5 times the thread pitch for sizes up to and including 1 in. and 3.5 times the thread pitch for sizes larger than 1 in. shall be threaded for full length.

Screws



Dimensions of Hex Cap Screws and Heavy Hex Screws

Washer Face

Thickness of the washer face shall be not less than 0.015 in. or greater than 0.025 in. for screw sizes ¾ in. and smaller and not less than 0.015 in. nor greater than 0.035 in. for sizes larger than ¾ in. The washer face diameter shall be equal to the maximum width across flats with a tolerance of −10%. The washer face is not applicable to hex flange or lobe head screws.

Fillet

For styles of head-to-shank fillets and maximum-minimum limits for R, please see the standard.

Thread Length

The length of thread on screws is controlled by the grip gaging length, L_G, max., and body length, L_B, min. For more information on length of thread, please see the standard.

Following tables show dimensions of hex cap screws and heavy hex screws.

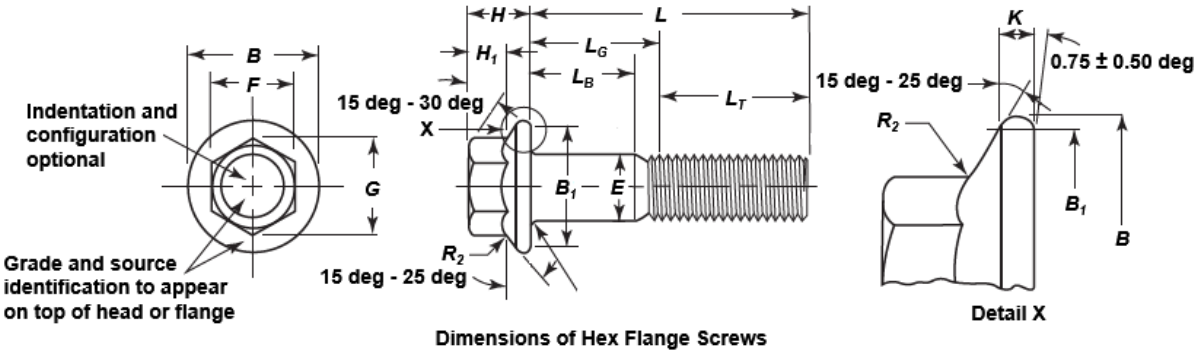
Dimensions of Hex Cap Screws (All dimensions are in inches)													
Nominal Size or Basic Product Diameter		Body Diameter, *E*		Width Across Flats, *F*			Width Across Corners, *G*		Head Height, *H*			Minimum Wrenching Height, *J*	Thread Length,* L_T
		Max.	Min.	Basic	Max.	Min.	Nom.	Min.	Basic	Max.	Min.		Nom.
1/4	0.2500	0.2500	0.2450	7/16	0.438	0.428	0.505	0.488	5/32	0.163	0.150	0.106	0.750
5/16	0.3125	0.3125	0.3065	1/2	0.500	0.489	0.577	0.557	13/64	0.211	0.195	0.140	0.875
3/8	0.3750	0.3750	0.3690	9/16	0.562	0.551	0.650	0.628	15/64	0.243	0.226	0.160	1.000
7/16	0.4375	0.4375	0.4305	5/8	0.625	0.612	0.722	0.698	9/32	0.291	0.272	0.195	1.125
1/2	0.5000	0.5000	0.4930	3/4	0.750	0.736	0.866	0.840	5/16	0.323	0.302	0.215	1.250
9/16	0.5625	0.5625	0.5545	13/16	0.812	0.798	0.938	0.910	23/64	0.371	0.348	0.250	1.375
5/8	0.6250	0.6250	0.6170	15/16	0.938	0.922	1.083	1.051	25/64	0.403	0.378	0.269	1.500
3/4	0.7500	0.7500	0.7410	1 1/8	1.125	1.100	1.299	1.254	15/32	0.483	0.455	0.324	1.750
7/8	0.8750	0.8750	0.8660	1 5/16	1.312	1.285	1.516	1.465	35/64	0.563	0.531	0.378	2.000
1	1.0000	1.0000	0.9900	1 1/2	1.500	1.469	1.732	1.675	39/64	0.627	0.591	0.416	2.250
1 1/8	1.1250	1.1250	1.1140	1 11/16	1.688	1.631	1.949	1.859	11/16	0.718	0.658	0.461	2.500
1 1/4	1.2500	1.2500	1.2390	1 7/8	1.875	1.812	2.165	2.066	25/32	0.813	0.749	0.530	2.750
1 3/8	1.3750	1.3750	1.3630	2 1/16	2.062	1.994	2.382	2.273	27/32	0.878	0.810	0.569	3.000
1 1/2	1.5000	1.5000	1.4880	2 1/4	2.250	2.175	2.598	2.480	1 5/16	0.974	0.902	0.640	3.250
1 5/8	1.6250	1.6250	1.6130	2 7/16	2.438	2.356	2.815	2.686	1	1.038	0.962	0.694	3.500
1 3/4	1.7500	1.7500	1.7380	2 5/8	2.625	2.538	3.031	2.893	1 3/32	1.134	1.054	0.748	3.750
1 7/8	1.8750	1.8750	1.8630	2 13/16	2.812	2.719	3.248	3.099	1 5/32	1.198	1.114	0.802	4.000
2	2.0000	2.0000	1.9880	3	3.000	2.900	3.464	3.306	1 7/32	1.263	1.175	0.825	4.250
2 1/4	2.2500	2.2500	2.2380	3 3/8	3.375	3.262	3.897	3.719	1 3/8	1.423	1.327	0.933	5.000#
2 1/2	2.5000	2.5000	2.4880	3 3/4	3.750	3.625	4.330	4.133	1 17/32	1.583	1.479	1.042	5.500#
2 3/4	2.7500	2.7500	2.7380	4 1/8	4.125	3.988	4.763	4.546	1 11/16	1.744	1.632	1.151	6.000#
3	3.0000	3.0000	2.9880	4 1/2	4.500	4.350	5.196	4.959	1 7/8	1.935	1.815	1.290	6.500#

Dimensions of Heavy Hex Screws (All dimensions are in inches)													
Nominal Size or Basic Product Diameter		Body Diameter, *E*		Width Across Flats, *F*			Width Across Corners, *G*		Head Height, *H*			Minimum Wrenching Height, *J*	Thread Length,* L_T
		Max.	Min.	Basic	Max.	Min.	Nom.	Min.	Basic	Max.	Min.		Nom.
3/8	0.3750	0.3750	0.360	11/16	0.688	0.669	0.794	0.763	15/64	0.243	0.226	0.160	1.000
1/2	0.5000	0.5000	0.482	7/8	0.875	.0850	1.010	0.969	5/16	0.323	0.302	0.215	1.250
5/8	0.6250	0.6250	0.605	1 1/16	1.062	1.031	1.227	1.175	25/64	0.403	0.378	0.269	1.500
3/4	0.7500	0.7500	0.729	1 1/4	1.250	1.212	1.443	1.383	15/32	0.483	0.455	0.324	1.750
7/8	0.8750	0.8750	0.852	1 7/16	1.438	1.394	1.660	1.589	35/64	0.563	0.531	0.378	2.000
1	1.0000	1.0000	0.976	1 5/8	1.625	1.575	1.876	1.796	39/64	0.627	0.591	0.416	2.250
1 1/8	1.1250	1.1250	1.098	1 13/16	1.812	1.756	2.093	2.002	11/16	0.718	0.658	0.461	2.500
1 1/4	1.2500	1.2500	1.223	2	2.000	1.938	2.309	2.209	25/32	0.813	0.749	0.530	2.750
1 3/8	1.3750	1.3750	1.345	2 3/16	2.188	2.119	2.526	2.416	27/32	0.878	0.810	0.569	3.000
1 1/2	1.5000	1.5000	1.470	2 3/8	2.375	2.300	2.742	2.622	15/16	0.974	0.902	0.640	3.250
1 5/8	1.6250	1.6250	1.591	2 9/16	2.562	2.481	2.959	2.829	1	1.038	0.962	0.694	3.500
1 3/4	1.7500	1.7500	1.716	2 3/4	2.750	2.662	3.175	3.035	1 3/32	1.134	1.054	0.748	3.750
1 7/8	1.8750	1.8750	1.839	2 15/16	2.938	2.844	.392	3.242	1 5/32	1.198	1.114	0.802	4.000
2	2.0000	2.0000	1.964	3 1/8	3.125	3.025	3.608	3.449	1 7/32	1.263	1.175	0.825	4.250
2 1/4	2.2500	2.2500	2.214	3 1/2	3.500	3.388	4.041	3.862	1 3/8	1.423	1.327	0.933	5.000#
2 1/2	2.5000	2.5000	2.461	3 7/8	3.8750	3.750	4.474	4.275	1 17/32	1.583	1.479	1.042	5.500#
2 3/4	2.7500	2.7500	2.711	4 1/4	4.2500	41.112	4.907	4.688	1 11/16	1.744	1.632	1.151	6.000#
3	3.0000	3.0000	2.961	4 5/8	4.6250	4.475	5.340	5.102	1 7/8	1.935	1.815	1.290	6.500#
3 1/4	3.2500	3.2500	3.2100	5	5.0000	4.838	5.774	5.515	2	2.126	1.998	1.399	7.000#
3 1/2	3.5000	3.5000	3.4610	5 3/8	5.3750	5.200	6.207	5.928	2 1/4	2.256	2.120	1.484	7.500#
3 3/4	3.7500	3.7500	3.7109	5 3/4	5.7500	5.562	6.640	6.341	2 3/8	2.447	2.303	1.612	8.000#
4	4.0000	4.0000	3.9609	6 1/8	6.1250	5.925	7.073	6.755	2 1/2	2.576	2.424	1.697	8.500#
4 1/4	4.2500	4.2500	4.2228	6 1/2	6.5000	6.288	7.506	7.168	2 3/4	2.768	2.608	1.826	9.000#
4 1/2	4.5000	4.5000	4.4727	6 7/8	6.8750	6.650	7.939	7.581	2 7/8	2.896	2.728	1.910	9.500#
4 3/4	4.7500	4.7500	4.7227	7 1/4	7.2500	7.012	8.372	7.994	3	3.088	2.912	2.038	10.00#
5	5.0000	5.0000	4.9726	7 5/8	7.6250	7.375	8.805	8.408	3 1/8	3.217	3.033	2.123	10.500#
5 1/4	5.2500	5.2500	5.2226	8	8.0000	7.738	9.238	8.821	3 3/8	3.408	3.216	2.251	11.000#
5 1/2	5.5000	5.5000	5.4726	8 3/8	8.3750	8.100	9.671	9.234	3 1/2	3.538	3.338	2.337	11.500#
5 3/4	5.7500	5.7500	5.7225	8 3/4	8.7500	8.462	10.104	9.647	3 5/8	3.729	3.521	2.465	12.000#
6	6.0000	6.0000	5.9725	9 1/8	9.1250	8.825	10.537	10.060	3 3/4	3.858	3.642	2.549	12.500#

* Thread lengths, LT, shown are for bolt lengths 6 inches and shorter. For longer bolt lengths add 0.250 inch to thread lengths shown.
# Thread lengths, LT, shown are for bolt lengths over 6 inches.

Wrenching Height, *J* is a distance measured from the bearing surface up the side of the head at the corners.

Hex Flange Screws



Dimensions of Hex Flange Screws

Hex flange screws (bolts) are regular hex head bolts with built-in washer. The stress under the face of a standard hexagon headed nut can result in indentation into standard strength steel surfaces. Washers have traditionally been used to protect the joint surface from damage during the tightening process and to distribute the load under the bolt head and nut. Standard washers are typically softer than the nuts and bolts that they are used with and can often plastically deform under the high compressive stress that they must sustain. Flange headed nuts and bolts do not suffer from this effect since the washer face is as strong as the bolt/nut itself. Washers are also used with irregular and oversized holes.

In recent years, washers have started to be replaced by flange headed bolts. Flange headed bolts have been developed to eliminate the deficiencies that have been found with the use of washers. Hexagon flange bolts are commonly used in automotive industry.

Following table shows dimensions of hex flange screws.

Dimensions of Hex Flange Screws (All dimensions are in inches)													
Nominal Size	Body Diam., *E*		Width Across Flats, *F*			Width Across Corners, *G*		Maximum Flange Diam., *B*	Minimum Flange Thickness, *K*	Maximum Head Height, *H*	Minimum Hex Height, H_1	Minimum Bearing Diam., B_1	Thread Length*, L_T, Nom.
	Max.	Min.	Basic	Max.	Min.	Max.	Min.						
1/4	0.2500	0.2450	3/8	0.3750	0.367	0.433	0.409	0.56	0.04	0.28	0.17	0.480	0.750
5/16	0.3125	0.3065	1/2	0.5000	0.489	0.577	0.548	0.68	0.05	0.32	0.21	0.600	0.875
3/8	0.3750	0.3690	9/16	0.5625	0.551	0.650	0.618	0.81	0.06	0.39	0.25	0.730	1.000
7/16	0.4375	0.4305	5/8	0.6250	0.612	0.722	0.685	0.93	0.07	0.46	0.30	0.850	1.125
1/2	0.5000	0.4930	3/4	0.7500	0.736	0.866	0.825	1.07	0.08	0.51	0.34	0.980	1.250
9/16	0.5625	0.5545	13/16	0.8125	0.798	0.938	0.895	1.19	0.09	0.57	0.38	1.100	1.375
5/8	0.6250	0.6170	15/16	0.9375	0.922	1.083	1.034	1.33	0.10	0.62	0.42	1.230	1.500
3/4	0.7500	0.7410	1 1/8	1.1250	1.100	1.299	1.234	1.59	0.11	0.73	0.51	1.470	1.750

* Thread lengths, L_T, shown are for bolt lengths 6 inches and shorter. For longer bolt lengths add 0.250 inch to thread lengths shown.

For hex cap and heavy hex cap screws, top of head shall be full form and chamfered, with the diameter of chamfer circle being equal to the maximum width across flats within a tolerance of −15%. For hex flange and lobe head screws, top of head may be full form or indented at the option of the manufacturer. If full form, the top of head shall be chamfered or rounded with the diameter of chamfer circle or start of rounding being equal to the maximum width across flats, within a tolerance of −15%. If the top of head is indented, the periphery may be rounded.

For information on other products (square head bolts, askew head bolts, lobe head screws; and lag screws) please see the standard.

ASME B18.2.2

ASME B18.2.2 cover the complete general and dimensional data for the various types of inch series square and hex nuts, including machine screw nuts and coupling nuts, recognized as American National Standard.

General Data

Width Across Flats

The width across flats of a nut is the distance measured, perpendicular to the axis of nut, overall between two opposite sides of the nut.

Nut Thickness

The nut thickness is the overall distance, measured parallel to the axis of a nut, from the top of the nut to the bearing surface and shall include the thickness of the washer face where provided.

Washer Face Diameter

Unless otherwise specified, the diameter of washer face shall be within the limits of the maximum width across flats and 95% of the minimum width across flats.

Threads

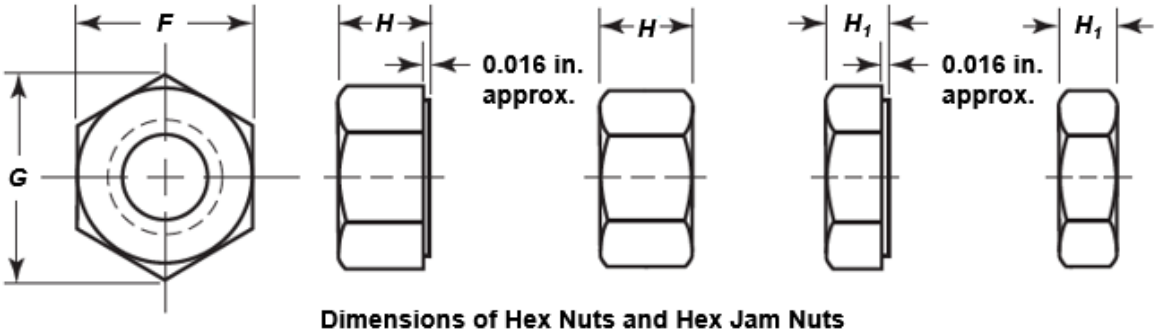
Threads shall be Unified Standard, Class 2B, of the series specified in the notes on respective dimensional tables, in accordance with ASME B1.1. Class 3B may be specified by the purchaser if designated at the time of inquiry and order.

Designation

Nuts shall be designated in the sequence by: product name; dimensional standard, nominal size (fraction or decimal); threads per inch; mechanical and performance standard, and grade protective finish (including specification and thickness), if required.

For Example: Hex Nut, ASME B18.2.2, ¾-16, SAE J995 Grade 5, Steel.

Dimensions of Hex Nuts and Hex Jam Nuts

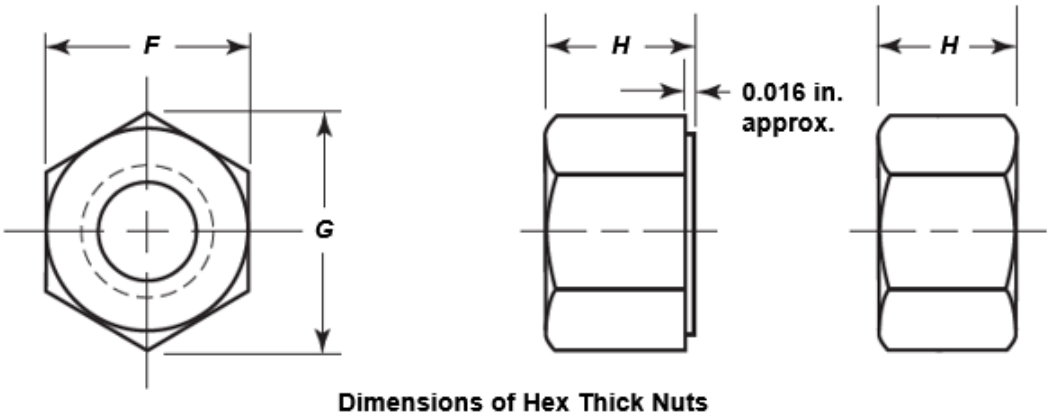


Dimensions of Hex Nuts and Hex Jam Nuts

Following table shows dimensions of hex nuts and hex jam nuts.

Dimensions of Hex Nuts and Hex Jam Nuts (All dimensions are in inches)									
Nominal Size	Basic Major Diameter of Thread	Width Across Flats, *F*		Width Across Corners, *G*		Thickness Hex Nuts, *H*		Thickness Jam Nuts, H_1	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
¼	0.2500	0.428	0.438	0.488	0.505	0.212	0.226	0.150	0.163
5⁄16	0.3125	0.489	0.500	0.557	0.577	0.258	0.273	0.180	0.195
⅜	0.3750	0.551	0.563	0.628	0.650	0.320	0.337	0.210	0.227
7⁄16	0.4375	0.675	0.688	0.768	0.794	0.365	0.385	0.240	0.260
½	0.5000	0.736	0.750	0.840	0.866	0.427	0.448	0.302	0.323
9⁄16	0.5625	0.861	0.875	0.982	1.010	0.473	0.496	0.301	0.324
⅝	0.6250	0.922	0.938	1.051	1.083	0.535	0.559	0.363	0.387
¾	0.7500	1.088	1.125	1.240	1.299	0.617	0.665	0.398	0.446
⅞	0.8750	1.269	1.312	1.447	1.516	0.724	0.776	0.458	0.510
1	1.0000	1.450	1.500	1.653	1.732	0.831	0.887	0.519	0.575
1⅛	1.1250	1.631	1.688	1.859	1.949	0.939	0.999	0.579	0.639
1¼	1.2500	1.812	1.875	2.066	2.165	1.030	1.094	0.687	0.751
1⅜	1.3750	1.994	2.062	2.273	2.382	1.138	1.206	0.747	0.815
1½	1.5000	2.175	2.250	2.480	2.598	1.245	1.317	0.808	0.880
1⅝	1.6250	2.35	2.43	2.679	2.805	1.364	1.416	0.868	0.944
1¾	1.7500	2.538	2.625	2.893	3.031	1.460	1.540	0.929	1.009
1⅞	1.8750	2.722	2.813	3.103	3.247	1.567	1.651	0.989	1.073
2	2.0000	2.900	3.000	3.306	3.464	1.675	1.763	1.050	1.138
2¼	2.2500	3.263	3.375	3.719	3.897	1.890	1.986	1.155	1.267
2½	2.5000	3.625	3.750	4.133	4.330	2.105	2.209	1.401	1.427
2¾	2.7500	3.988	4.125	4.546	4.763	2.319	2.431	1.522	1.556
3	3.0000	4.350	4.500	4.959	5.196	2.534	2.654	1.643	1.685
3¼	3.2500	4.713	4.875	5.373	5.629	2.749	2.877	1.748	1.814
3½	3.5000	5.075	5.250	5.786	6.062	2.964	3.100	1.870	1.943
3¾	3.7500	5.438	5.625	6.199	6.495	3.178	3.322	1.990	2.072
4	4.0000	5.800	6.000	6.612	6.928	3.393	3.545	2.112	2.201

Dimensions of Hex Thick Nuts

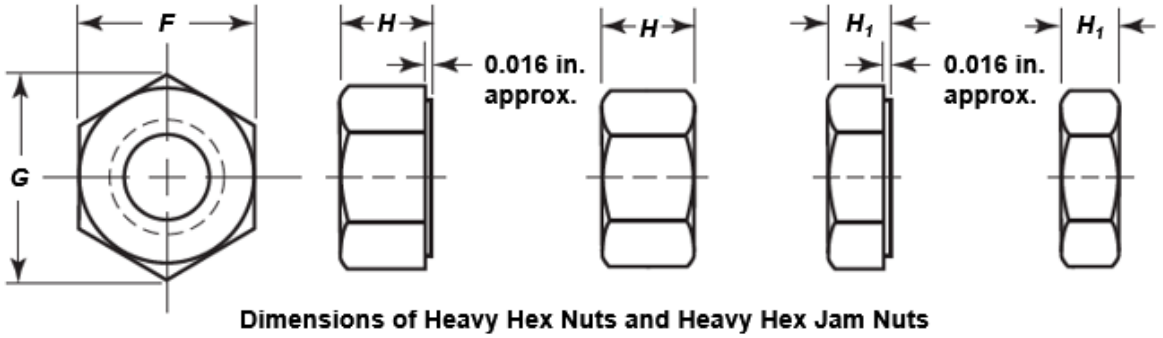


Dimensions of Hex Thick Nuts

Following table shows dimensions of hex thick nuts

Dimensions of Hex Thick Nuts (All dimensions are in inches)									
Nominal Size	Basic Major Diameter of Thread	Width Across Flats, *F*			Width Across Corners, *G*		Thickness Hex Nuts, *H*		
		Basic	Min.	Max.	Min.	Max.	Basic	Min.	Max.
¼	0.2500	7/16	0.428	0.438	0.488	0.505	9/32	0.274	0.288
5/16	0.3125	½	0.489	0.500	0.557	0.577	21/64	0.320	0.336
⅜	0.3750	9/16	0.551	0.562	0.628	0.650	13/32	0.398	0.415
7/16	0.4375	11/16	0.675	0.688	0.768	0.794	29/64	0.444	0.463
½	0.5000	¾	0.736	0.750	0.840	0.866	9/16	0.552	0.573
9/16	0.5625	⅞	0.861	0.875	0.892	1.010	39/64	0.598	0.621
⅝	0.6250	15/16	0.922	0.938	1.051	1.083	23/32	0.706	0.731
¾	0.7500	1⅛	1.088	1.125	1.240	1.299	13/16	0.798	0.827
⅞	0.8750	1 5/16	1.269	1.312	1.447	1.516	29/32	0.890	0.922
1	1.0000	1½	1.450	1.500	1.653	1.732	1	0.982	1.018
1⅛	1.1250	1 11/16	1.631	1.688	1.859	1.949	1 5/32	1.136	1.176
1¼	1.2500	1⅞	1.812	1.875	2.066	2.165	1¼	1.228	1.272
1⅜	1.3750	2 1/16	1.994	2.062	2.273	2.382	1⅜	1.351	1.399
1½	1.5000	2¼	2.175	2.250	2.480	2.598	1½	1.474	1.526

Dimensions of Heavy Hex Nuts and Heavy Hex Jam Nuts



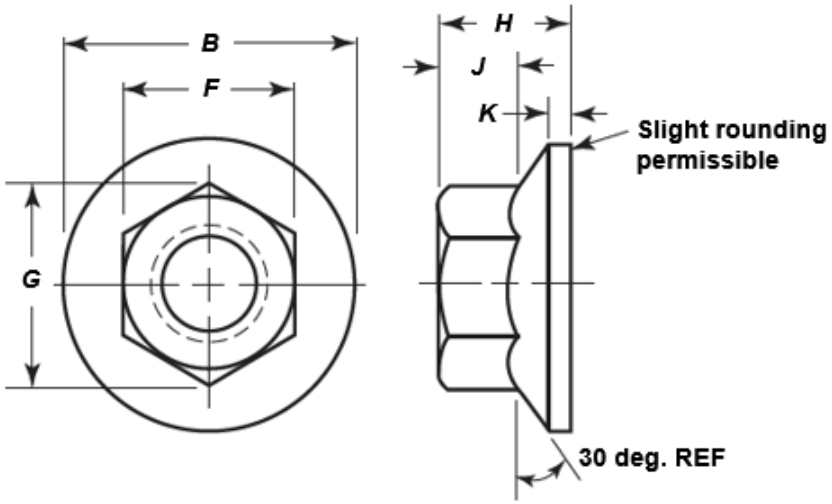
Dimensions of Heavy Hex Nuts and Heavy Hex Jam Nuts

Following table shows dimensions of heavy hex nuts and heavy hex jam nuts

Dimensions of Heavy Hex Nuts and Heavy Hex Jam Nuts (All dimensions are in inches)												
Nominal Size	Basic Major Diameter of Thread	Width Across Flats, F			Width Across Corners, G		Thickness Heavy Hex Nuts, H			Thickness Heavy Hex Jam Nuts, H1		
		Basic	Min.	Max.	Min.	Max.	Basic	Min.	Max.	Basic	Min.	Max.
¼	0.2500	½	0.488	0.500	0.556	0.577	15/64	0.218	0.250	11/64	0.156	0.188
5/16	0.3125	9/16	0.546	0.562	0.622	0.650	19/64	0.280	0.314	13/64	0.186	0.220
⅜	0.3750	11/16	0.669	0.688	0.763	0.794	23/64	0.341	0.377	15/64	0.216	0.252
7/16	0.4375	¾	0.728	0.750	0.830	0.866	27/64	0.403	0.441	17/64	0.247	0.285
½	0.5000	⅞	0.850	0.875	0.969	1.010	31/64	0.464	0.504	19/64	0.277	0.317
9/16	0.5625	15/16	0.909	0.938	1.037	1.083	35/64	0.526	0.568	21/64	0.307	0.349
⅝	0.6250	1 1/16	1.031	1.062	1.175	1.227	39/64	0.587	0.631	23/64	0.337	0.381
¾	0.7500	1¼	1.212	1.250	1.382	1.443	47/64	0.710	0.758	27/64	0.398	0.446
⅞	0.8750	1 7/16	1.394	1.438	1.589	1.660	55/64	0.833	0.885	31/64	0.458	0.510
1	1.0000	1⅝	1.575	1.625	1.796	1.876	63/64	0.956	1.012	35/64	0.519	0.575
1⅛	1.1250	1 13/16	1.756	1.812	2.002	2.093	1 7/64	1.079	1.139	39/64	0.579	0.639
1¼	1.2500	2	1.938	2.000	2.209	2.309	1 7/32	1.187	1.251	23/32	0.687	0.751
1⅜	1.3750	2 3/16	2.119	2.188	2.416	2.526	1 11/32	1.310	1.378	25/32	0.747	0.815
1½	1.5000	2⅜	2.300	2.375	2.622	2.742	1 15/32	1.433	1.505	27/32	0.808	0.880
1⅝	1.6250	2 9/16	2.481	2.562	2.828	2.959	1 19/32	1.556	1.632	29/32	0.868	0.944
1¾	1.7500	2¾	2.662	2.750	3.035	3.175	1 23/32	1.679	1.759	31/32	0.929	1.009
1⅞	1.8750	2 15/16	2.844	2.938	3.242	3.392	1 27/32	1.802	1.886	1 1/32	0.989	1.073
2	2.0000	3⅛	3.025	3.125	3.449	3.608	1 31/32	1.925	2.013	1 3/32	1.050	1.138
2¼	2.2500	3½	3.388	3.500	3.862	4.041	2 13/64	2.155	2.251	1 13/64	1.155	1.251
2½	2.5000	3⅞	3.750	3.875	4.275	4.474	2 29/64	2.401	2.505	1 29/64	1.401	1.505
2¾	2.7500	4¼	4.112	4.250	4.688	4.907	2 45/64	2.647	2.759	1 37/64	1.522	1.634

3	3.0000	4 5/8	4.475	4.625	5.102	5.340	2 61/64	2.893	3.013	1 45/64	1.643	1.763
3 1/4	3.2500	5	4.838	5.000	5.515	5.774	3 3/16	3.124	3.252	1 13/16	1.748	1.876
3 1/2	3.5000	5 3/8	5.200	5.375	5.928	6.207	3 7/16	3.370	3.506	1 15/16	1.870	2.006
3 3/4	3.7500	5 3/4	5.562	5.750	6.341	6.640	3 11/16	3.616	3.760	2 1/16	1.990	2.134
4	4.0000	6 1/8	5.925	6.125	6.755	7.073	3 15/16	3.862	4.014	2 3/16	2.112	2.264

Dimensions of Hex Flange Nuts and Large Hex Flange Nuts



Dimensions of Hex Flange Nuts and Large Hex Flange Nuts

Following table shows dimensions of hex flange nuts and large hex flange nuts

Dimensions of Hex Flange Nuts and Large Hex Flange Nuts (All dimensions are in inches)											
Nominal Size	Basic Major Diameter of Thread	Width Across Flats, *F*		Width Across Corners, *G*		Diameter Flange, *B*		Nut Thickness, *H*		Minimum Wrenching Length, *J*	Minimum Flange Thickness, *K*
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		
Hex Flange Nuts											
No. 6	0.1380	0.302	0.312	0.342	0.361	0.406	0.422	0.156	0.171	0.10	0.02
8	0.1640	0.334	0.344	0.381	0.397	0.452	0.469	0.187	0.203	0.13	0.02
10	0.1900	0.365	0.375	0.416	0.433	0.480	0.500	0.203	0.219	0.13	0.03
12	0.2160	0.428	0.438	0.488	0.505	0.574	0.594	0.222	0.236	0.14	0.04
1/4	0.2500	0.428	0.438	0.488	0.505	0.574	0.594	0.222	0.236	0.14	0.04
5/16	0.3125	0.489	0.500	0.557	0.577	0.660	0.680	0.268	0.283	0.17	0.04
3/8	0.3750	0.551	0.562	0.628	0.650	0.728	0.750	0.330	0.347	0.23	0.04
7/16	0.4375	0.675	0.688	0.768	0.794	0.910	0.937	0.375	0.395	0.26	0.04
1/2	0.5000	0.736	0.750	0.840	0.866	1.000	1.031	0.437	0.458	0.31	0.05
9/16	0.5625	0.861	0.875	0.982	1.010	1.155	1.188	0.483	0.506	0.35	0.05
5/8	0.6250	0.922	0.938	1.051	1.083	1.248	1.281	0.545	0.569	0.40	0.05
3/4	0.7500	1.088	1.125	1.240	1.299	1.460	1.500	0.627	0.675	0.46	0.06
Large Hex Flange Nuts											
1/4	0.2500	0.428	0.438	0.488	0.505	0.700	0.728	0.281	0.312	0.15	0.04
5/16	0.3125	0.489	0.500	0.557	0.577	0.790	0.820	0.343	0.375	0.20	0.04
3/8	0.3750	0.551	0.562	0.628	0.650	0.885	0.915	0.390	0.406	0.24	0.04
7/16	0.4375	0.675	0.688	0.768	0.794	1.100	1.131	0.437	0.468	0.26	0.04
1/2	0.5000	0.736	0.750	0.840	0.866	1.175	1.205	0.485	0.515	0.29	0.06
9/16	0.5625	0.861	0.875	0.982	1.010	1.260	1.300	0.546	0.578	0.37	0.06
5/8	0.6250	0.922	0.938	1.051	1.083	1.280	1.360	0.600	0.640	0.42	0.06

For dimensions of square and hex machine screw nuts; small pattern hex machine screw nuts; square nuts; hex flat nuts and hex flat jam nuts; hex slotted nuts; hex thick slotted nuts; heavy square nuts; heavy hex flat nuts and heavy hex flat jam nuts; heavy hex slotted nuts and hex coupling nuts, please see the standard.

ASME B18.24: Part Identifying Number (PIN) Code System Standard for B18 Fastener Products

ASME B18.24 is intended to provide all users with the capability to identify externally threaded, internally threaded, and non-threaded fastener products by a pre-selected order of coding as specified in it. The B18 PIN is a self-contained code, with distinct identification linkage to individual ASME B18 fastener product standards. The PIN code concept provides for direct traceability back to the applicable B18 product standard. This standard is not intended for use as a substitute for the correct usage of the B18 standards for fastener selection and specification. The PIN code is intended as an alternative to the plain text product callout as prescribed in the "Designation" or "Ordering" section of the source B18 product standard.

Adoption of ISO Fastener Standards

Metric fasteners are used throughout the world to assemble most products that are traded internationally. Unfortunately, there are currently three similar, yet slightly different metric fastener standard systems in use; ISO, US (ASME, ASTM, and SAE), and DIN. Maintaining three sets of standards that cover the same engineered components is poor engineering practice and results in poor economics.

Recent reviews of the US created metric fastener standards have found that the ASME, ASTM, and SAE metric fastener standards have no technical superiority to the current ISO fastener standards. Based on that conclusion the ASME B18 and ASTM F16 committees have started withdrawing the US metric fastener standards they have issued since the 1970's and are encouraging users to move to the equivalent ISO standards.

Following table shows some of the ASME metric fastener standards that have been withdrawn.

Metric Product	Withdrawn ASME Standard	Replacement Standard
Style 1 Hex Nut	B18.2.4.1M	ISO 4032
Style 2 Hex Nut	B18.2.4.2M	ISO 4033
Jam Nut	B18.2.4.5M	ISO4035
Hex Cap Screw	B18.2.3.1M	ISO 4014 and ISO 4017

ASTM F568M is also withdrawn to encourage the adoption of ISO 898-1.

DIN formally withdrew most of its fastener standards in April of 2001 when issuing DIN 918. This standard announces the withdrawal and indicates the ISO standards that should be used to replace the withdrawn DIN standards.

As per technical bulletin (March 2012) of Industrial Fasteners Institute, USA, the ISO metric fastener standards started development about 40 years ago. They are now used around the world to assemble internationally traded goods. It is time to move all metric fastener designs and requirements to the adoption of ISO fastener standard and abandon most, if not all, of the ASME, ASTM, SAE, and DIN metric fastener standards.

Dimensions of Machine Screws and Machine Screw Nuts

Information about machine screws and important information about dimensions of machine screws and machine screw nuts as per ASME standards B18.6.3 is given in this chapter.

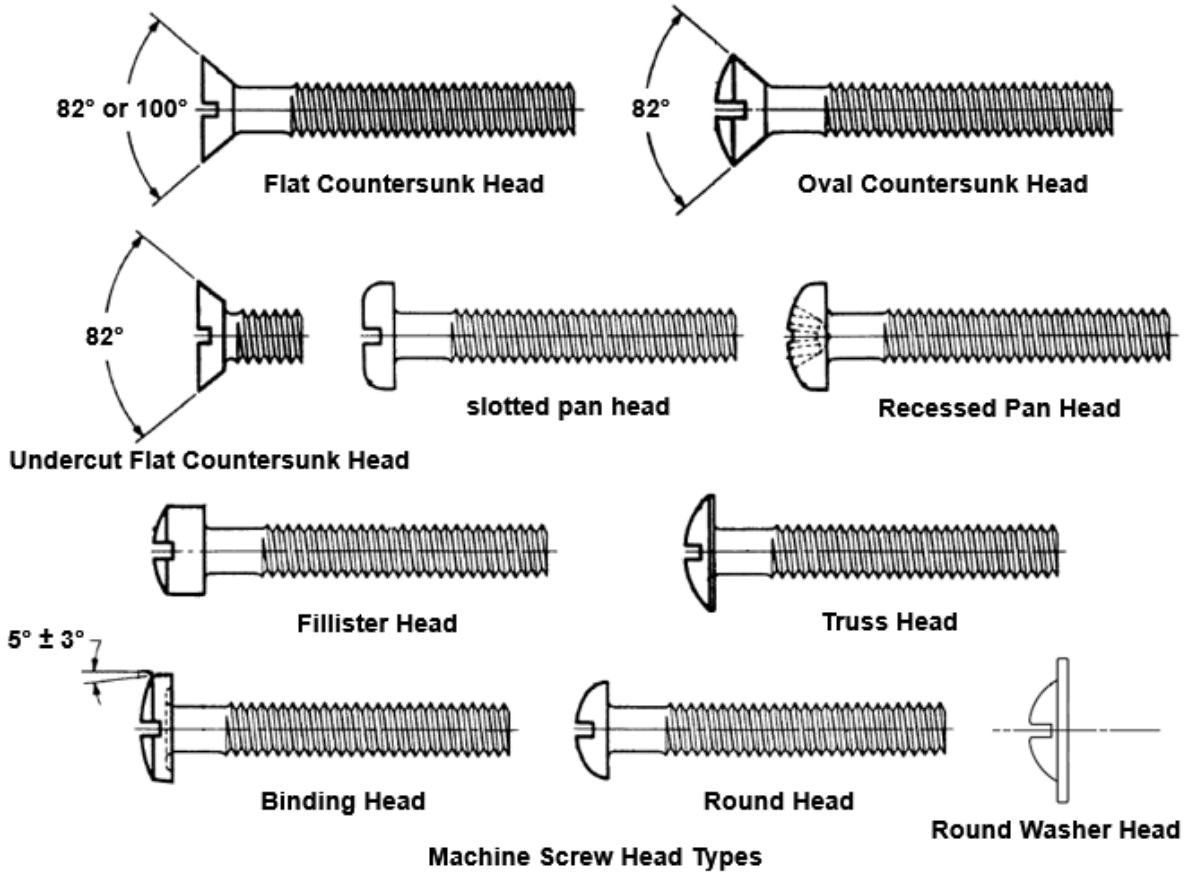
Machine Screws

Despite their widespread use, there is no strict definition for machine screws. Machine screws are usually distinguished from other common fastener by size. Machine screws tend to be somewhat smaller (both in length and diameter) than common fasteners. Most machine screws are fully threaded, meaning that the threading runs the full length of the fastener shank just below the head right to the end. They are available in a variety of configurations (head types and drive types).

Machine screws are used with a tapped hole or a nut. They are used to fasten various components together in machines, tools, appliances, electronic devices and vehicles.

ASME B18.6.3 is intended to cover the complete general and dimensional data for the various types of slotted and recessed head machine screws and machine screw nuts recognized as American National Standard.

Machine Screw Head Types



Machine Screw Head Types

The head types given below describe the overall shape of the machine screw heads.

Flat Countersunk Head

The flat countersunk head has a flat top surface and a conical bearing surface with a head angle for one style of approximately 82° and for another style of approximately 100°.

Oval Countersunk Head

The oval countersunk head has a rounded top surface and a conical bearing surface with a head angle of approximately 82°.

Undercut Flat and Oval Countersunk Heads

For short lengths, 82° flat and oval countersunk head machine screws have heads undercut to 70% of normal side height to afford greater length of thread on the screws.

Flat and Oval Countersunk Trim Heads

Flat and oval countersunk trim heads are similar to the 82° flat and oval countersunk heads except that the size of head for a given size screw is one or two sizes smaller than the regular flat and oval countersunk head size. Trim heads are furnished only in cross recessed (cross recess is a drive type) head types.

Pan Head

The **slotted pan head** has a flat top surface rounded into cylindrical sides and a flat bearing surface. The **recessed pan head** has a rounded top surface blending into cylindrical sides and a flat bearing surface.

Fillister Head

The fillister head has a rounded top surface, cylindrical sides, and a flat bearing surface.

Truss Head

The truss head has a low rounded top surface with a flat bearing surface, the diameter of which for a given screw size is larger than the diameter of the corresponding pan head.

Binding Head

The binding head has a rounded top surface and slightly tapered sides. The bearing surface is flat. If specified by purchaser, slotted heads shall have an annular undercut adjacent to the shank.

Hex Head

The hex head has a flat or indented top surface, six flat sides, and a flat bearing surface. Dimensions for regular and large heads are given in the following section.

Hex Washer Head

The hex washer head has an indented top surface and six flat sides formed integrally with a flat washer that projects beyond the sides and provides a flat bearing surface. Dimensions for hex washer head are also given in the following section.

Round Head

The round head has a semielliptical top surface and a flat bearing surface. In recognition of superior slot driving characteristics of pan head screws over round head screws, and the overlap in the dimensions of cross recessed pan heads and round heads, it is recommended that pan head screws be used in new designs and wherever possible substituted in existing designs.

Round Washer Head

The round washer head has a semielliptical top surface formed integrally with a flat washer that projects beyond the crown of the head and provides a flat bearing surface.

Application of Head Types

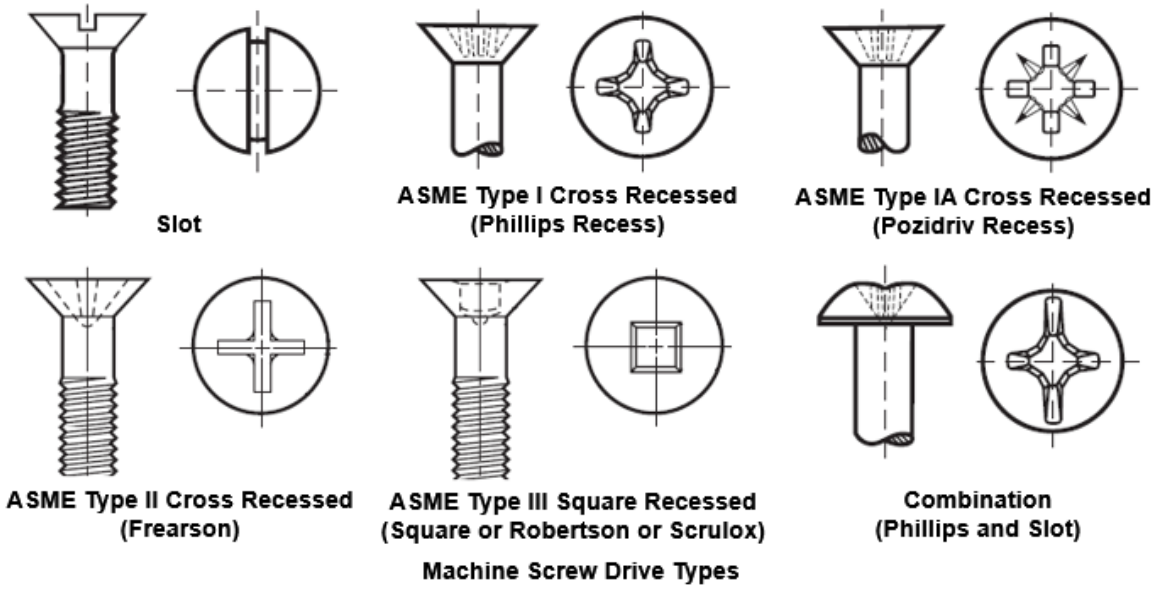
Flat countersunk head machine screws are chosen for applications where the installed fastener needs to sit flush with the surface it is being driven into. A flattened top and countersunk underside profile mean that they offer a neat and flush surface finish on joined panels and components.

Oval head machine screws offer something of a middle ground between the traditional, industrial pan head (round head) machine screw, and a flat countersunk head version. While pan head machine screws remain noticeably raised from the surface once driven home, oval heads are less noticeable due to underside creating a slightly countersunk profile. However, they do not countersink as neatly as flat head machine screws.

Fillister head screws are similar to a pan head machine screw but with greater side height. It may be noted that fillister head screws, are similar to cheese head screws because both have cylindrical sides and a flat mating surface. However, while the cheese head screw has a flat top, the fillister screw head has a domed top resulting in an overall deeper head. Fillister head screws are the preferred head type for counterbored holes.

Hex head machine screws may be installed using a standard ring or open ended spanner for extra torque. However, they may also have a recessed drive socket in the head, indicating that they are meant for use with a more typical screw driving tool.

Machine Screw Drive Types



Machine Screw Drive Types

A screw drive (socket) is a feature on the screw that allows it to be turned. The 'Driver' is a mating tool, which is used to turn the screw.

Slot Drive

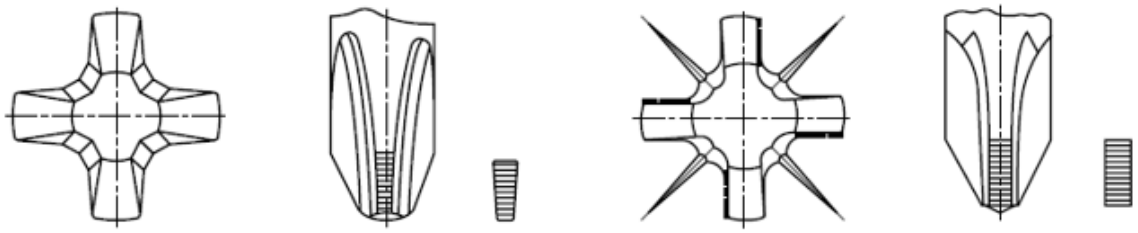
Slot drives have a single horizontal indentation (the slot) in the fastener head and is driven by a flat-bladed screwdriver. Slot drives are used in applications where minimal torque is needed. However, this design is not well–suited for installation by power tools, because a power driver often 'cam out' (slips out) of the slot. This often causes damage to the screw and surrounding material. For this reason, cross-recess (x-recess) drives have replaced the slot drive in numerous applications.

ASME Type I Cross Recessed Drive (Phillips Recess)

ASME Type I cross recessed drive, the Phillips drive, was developed as a direct solution to problem with slotted drives, the cam out potential. However, the design has tendency to cam out at lower torque levels than other cross recessed designs.

ASME Type IA Cross Recessed Drive (Pozidriv Recess)

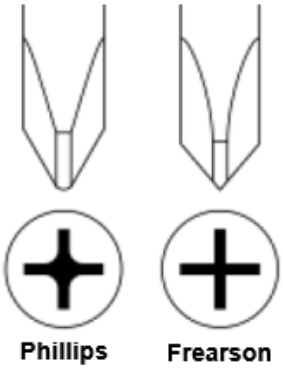
ASME Type IA cross recessed drive, the Pozidriv drive is an improved version of the Phillips drive. It was designed to allow more torque to be applied and greater engagement than Phillips drives. As a result, the Pozidriv is less likely to cam out. A Phillips screw head is significantly different from a Pozidriv. Pozidriv screws have a set of radial indentations set at 45° from the main cross recess on the head of the screw to make them visually distinct from Phillips screws.



Phillips and Pozidriv Screwdrivers

Though Phillips and Pozidriv screwdrivers are broadly interchangeable, they may cause damage to screw head or screwdriver if incorrectly used.

ASME Type II Cross Recessed Drive (Frearson)



Phillips and Frearson Comparison

ASME Type II cross recessed drive, the Frearson drive is similar to a Phillips but the Frearson has a sharp tip. As shown in above figure, the Frearson recess has a perfect, sharp cross, allowing for higher applied torque, unlike the rounded, tapered Phillips head, which can cam out at high torque.

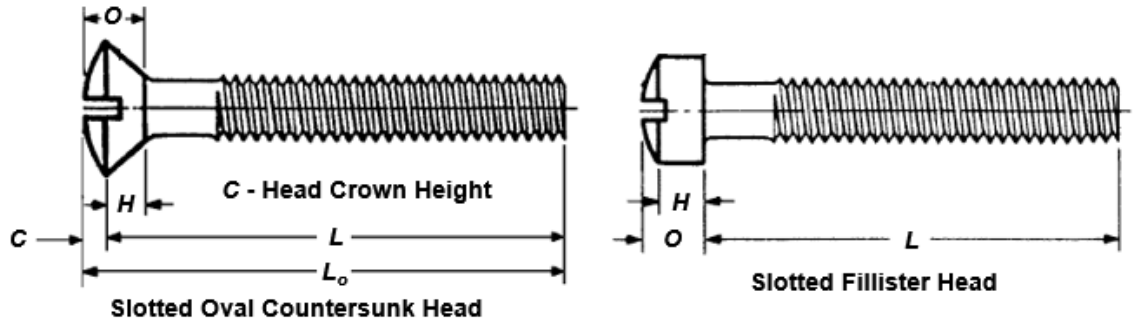
ASME Type III Square Recessed Drive (Square or Robertson or Scrulox)

ASME Type III square recessed drive has a square-shaped socket in the screw head and a square protrusion on the tool. Both the tool and the socket have a slight taper. The taper makes inserting the tool easier, and tends to keep the screw on the tool tip without the user needing to hold it there.

Combination Drive (Phillips and Slot)

Heads of combination drive screws are designed to accommodate more than one kind of driver. The most common of them is a combination of a slot and Phillips head.

General Data



Head Height and Length of Machine Screws

Head Height

Total or overall head heights (*O*) shall be measured from the top of the head to the plane of the bearing surface for flat bearing surface type heads, to the plane of the undercut for undercut countersunk heads, and to the junction of the conical bearing surface with the basic screw diameter for countersunk heads.

Head side heights (*H*) shall be measured from the theoretical intersection of the top surface of head with the head diameter to the plane of the bearing surface for flat bearing surface type heads, to the plane of the undercut for undercut countersunk heads, and to the junction of the conical bearing surface with the basic screw diameter for countersunk heads.

Length

The nominal length of screw *L* shall be measured, parallel to the axis of screw, from the extreme point to the plane of the bearing surface for screws having perpendicular bearing surface type heads, and to the theoretical intersection of the top surface of head with the head diameter for screws having countersunk type heads. For all oval heads, the overall length L_o shall be measured, parallel to the axis of the screw, from the extreme point to the top of the head, where: $L_o = L + C$ (*C* is crown height of head).

Threads

The threads on machine screws, except for the No. 0000, No. 000, and No. 00 sizes, which are covered in Appendix V of the standard, shall be Unified Standard, Class 2A, UNC and

UNF series, or UNRC and UNRF series, at option of manufacturer, in accordance with ASME B1.1.

Threads shall be Unified Standard, Class 2B, UNC or UNF series for hexagon machine screw nuts, and UNC series for square machine screw nuts, in accordance with ASME B1.1.

Length of Thread

For Sizes No. 5 and Smaller: Screws of nominal lengths equal to three diameters and shorter shall have full form threads extending to within one pitch (thread) of the bearing surface of the head, or closer, if practicable. Nominal lengths greater than three diameters, up to and including 1⅛ in., shall have full form threads extending to within two pitches (threads) of the bearing surface of the head, or closer, if practicable. Screws of longer nominal lengths shall, unless otherwise specified, have a minimum length of full form thread of 1 in.

For Sizes No. 6 and Larger: Screws of nominal lengths equal to three diameters and shorter shall have full form threads extending to within one pitch (thread) of the bearing surface of the head, or closer, if practicable. Nominal lengths greater than three diameters, up to and including 2 in., shall have full form threads extending to within two pitches (threads) of the bearing surface of the head, or closer, if practicable. Screws of longer nominal lengths shall, unless otherwise specified, have a minimum length of full form thread of 1.50 in.

Points

Unless otherwise specified, machine screws shall have plain sheared ends. Where so specified, header points shall be as specified in the standard (Table 19).

Material

Unless otherwise specified, machine screws shall be fabricated from carbon steel and shall have a minimum tensile strength of 60,000 psi.

Machine screw nuts are normally supplied in steel. Unless otherwise specified, no physical requirements shall apply.

Designation

Machine screws shall be designated in the sequence by: product name including head type and driving provision and designation of the standard, nominal size (number, fraction, or decimal equivalent); threads per inch; nominal length (fraction or decimal equivalent); header point, if desired, material, protective coating, if required.

Example: Hexagon Washer Head Machine Screw, ASME B18.6.3, 0.375 - 16 × 1.50, Header Point, Carbon Steel.

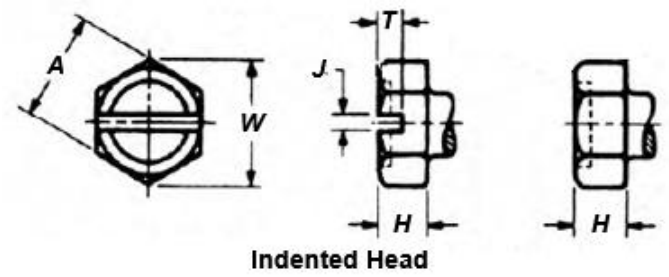
Machine screws nuts shall be designated in the sequence by: product name and designation of the standard, nominal size (number, fraction, or decimal equivalent); threads per inch, material, protective coating, if required.

Example: Hexagon Machine Screw Nut, ASME B18.6.3, 10 - 24, Steel, Zinc Plated per ASTM F 1941 Fe/Zn 5C.

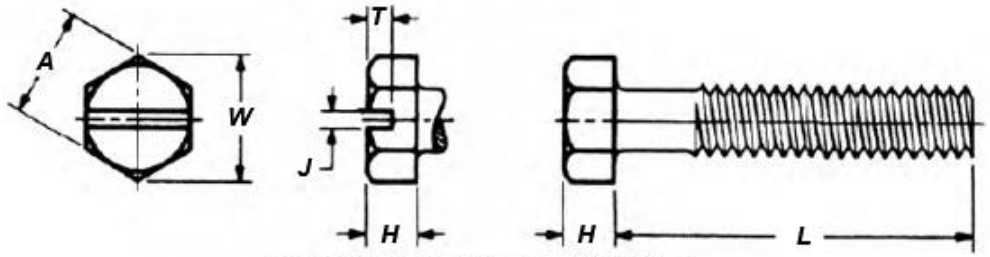
Dimensional information on only hex head machine screws and nuts is given in this booklet (in the following sections). For dimensional information on other types of machine screws (head types and drive types), please see the standard (ASME B18.6.3).

Plain and Slotted Regular and Large Hex Head Machine Screws

Following figure and table show dimensions of plain and slotted regular and large hex head machine screws.



Indented Head



Trimmed Head or Fully Upset Head

Dimensions of Plain and Slotted Hex Head Machine Screws

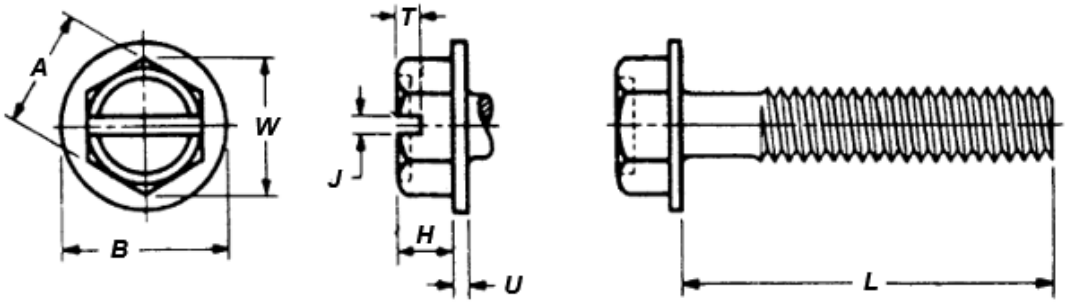
Dimensions of Plain and Slotted Regular and Large Hex Head Machine Screws (All dimensions are in inches)												
Nominal Size or Basic Screw Dia.	Regular Head			Large Head			Head Height, *H*		Slot Width, *J*		Slot Depth, *T*	
	Width Across Flats, *A*		Across Corners, *W*, Min.	Width Across Flats, *A*		Across Corners, *W*, Min.						
	Max.	Min.		Max.	Min.		Max.	Min.	Max.	Min.	Max.	Min.
1 0.0730	0.125	0.120	0.134	-	-	-	0.044	0.036	-	-	-	-
2 0.0860	0.125	0.120	0.134	-	-	-	0.050	0.040	-	-	-	-
3 0.0990	0.188	0.181	0.202	-	-	-	0.055	0.044	-	-	-	-
4 0.1120	0.188	0.181	0.202	0.219	0.213	0.238	0.060	0.049	0.039	0.031	0.036	0.025
5 0.1250	0.188	0.181	0.202	0.250	0.244	0.272	0.070	0.058	0.043	0.035	0.042	0.030
6 0.1380	0.250	0.244	0.272	-	-	-	0.093	0.080	0.048	0.039	0.046	0.033
8 0.1640	0.250	0.244	0.272	0.312	0.305	0.340	0.110	0.096	0.054	0.045	0.066	0.052
10 0.1900	0.312	0.305	0.340	-	-	-	0.120	0.105	0.060	0.050	0.072	0.057
12 0.2160	0.312	0.305	0.340	0.375	0.367	0.409	0.155	0.139	0.067	0.056	0.093	0.077
¼ 0.2500	0.375	0.367	0.409	0.438	0.428	0.477	0.190	0.172	0.075	0.064	0.101	0.083
5/16 0.3125	0.500	0.489	0.545	-	-	-	0.230	0.208	0.084	0.072	0.122	0.100
3/8 0.3750	0.562	0.551	0.614	-	-	-	0.295	0.270	0.094	0.081	0.156	0.131

Notes:

1. Unless otherwise specified by purchaser, hex head machine screws are not slotted.
2. Where specifying nominal size in decimals, zeros preceding the decimal and in the fourth decimal place shall be omitted.
3. Unless otherwise specified by purchaser, regular hex heads shall be furnished, and both regular and large head styles may be of indented head, trimmed head, or fully upset head construction, at the option of manufacturer.
4. Large hex head is intended for screw and washer assemblies (sems) as specified in ASME B18.13, and other applications requiring large bearing.
5. Slot depth beyond bottom of indentation on indented heads shall not be less than one-third of the minimum slot depth specified.

Plain and Slotted Hex Washer Head Machine Screws

Following figure and table show dimensions of plain and slotted hex washer head machine screws.



Dimensions of Plain and Slotted Hex Washer Head Machine Screws

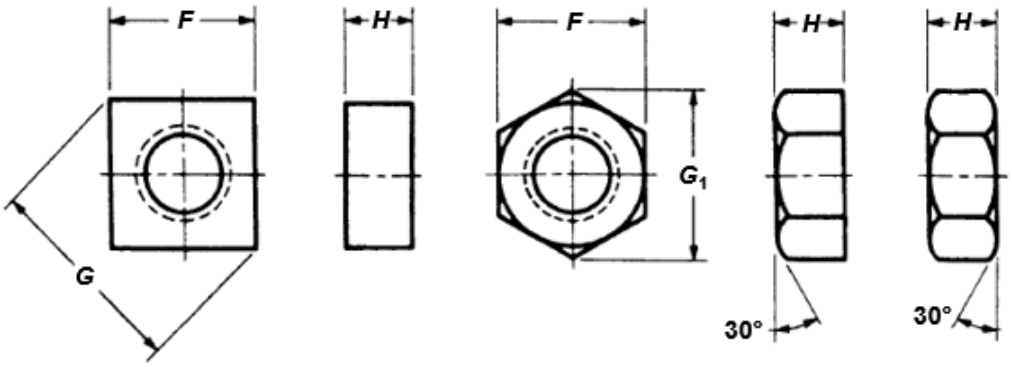
Dimensions of Plain and Slotted Hex Washer Head Machine Screws (All dimensions are in inches)													
Nominal Size or Basic Screw Dia.	Width Across Flats, *A*		Width Across Corners *W*, Min.	Head Height, *H*		Washer Diameter, B		Washer Thickness, *U*		Slot Width, *J*		Slot Depth, *T*	
	Max.	Min.		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
2 0.0860	0.125	0.120	0.134	0.050	0.040	0.166	0.154	0.016	0.010	-	-	-	-
3 0.0990	0.125	0.120	0.134	0.055	0.044	0.177	0.163	0.016	0.010	-	-	-	-
4 0.1120	0.188	0.181	0.202	0.060	0.049	0.243	0.225	0.019	0.011	0.039	0.031	0.042	0.025
5 0.1250	0.188	0.181	0.202	0.070	0.058	0.260	0.240	0.025	0.015	0.043	0.035	0.049	0.030
6 0.1380	0.250	0.244	0.272	0.093	0.080	0.328	0.302	0.025	0.015	0.048	0.039	0.053	0.033
8 0.1640	0.250	0.244	0.272	0.110	0.096	0.348	0.322	0.031	0.019	0.054	0.045	0.074	0.052
10 0.1900	0.312	0.305	0.340	0.120	0.105	0.414	0.384	0.031	0.019	0.060	0.050	0.080	0.057
12 0.2160	0.312	0.305	0.340	0.155	0.139	0.432	0.398	0.039	0.022	0.067	0.056	0.103	0.077
¼ 0.2500	0.375	0.367	0.409	0.190	0.172	0.520	0.480	0.050	0.030	0.075	0.064	0.111	0.083
5/16 0.3125	0.500	0.489	0.545	0.230	0.208	0.676	0.624	0.055	0.035	0.084	0.072	0.134	0.100
⅜ 0.3750	0.562	0.551	0.614	0.295	0.270	0.780	0.720	0.063	0.037	0.094	0.081	0.168	0.131

Notes:

1. Unless otherwise specified by purchaser, hex washer head machine screws are not slotted.
2. Slot depth beyond bottom of indentation shall not be less than one-third of the minimum slot depth specified.

Dimensions of Square and Hex Machine Screw Nuts

Following figure and table show dimensions of square and hex machine screw nuts.



Dimensions of Square and Hex Machine Screw Nuts

Dimensions of Square and Hex Machine Screw Nuts (All dimensions are in inches)									
Nominal Size or Basic Thread Dia.	Width Across Flats, *F*			Width Across Corners				Thickness, *H*	
				Square, *G*		Hex, G_1			
	Basic	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
0 0.0600	5/32	0.156	0.150	0.221	0.206	0.180	0.171	0.050	0.043
1 0.0730	5/32	0.156	0.150	0.221	0.206	0.180	0.171	0.050	0.043
2 0.0860	3/16	0.188	0.180	0.265	0.247	0.217	0.205	0.066	0.057
3 0.0990	3/16	0.188	0.180	0.265	0.247	0.217	0.205	0.066	0.057
4 0.1120	1/4	0.250	0.241	0.354	0.331	0.289	0.275	0.098	0.087
5 0.1250	5/16	0.312	0.302	0.442	0.415	0.361	0.344	0.114	0.102
6 0.1380	5/16	0.312	0.302	0.442	0.415	0.361	0.344	0.114	0.102
8 0.1640	11/32	0.344	0.332	0.486	0.456	0.397	0.378	0.130	0.117
10 0.1900	3/8	0.375	0.362	0.530	0.497	0.433	0.413	0.130	0.117
12 0.2160	7/16	0.438	0.423	0.619	0.581	0.505	0.482	0.161	0.148
1/4 0.2500	7/16	0.438	0.423	0.619	0.581	0.505	0.482	0.193	0.178
5/16 0.3125	9/16	0.562	0.545	0.795	0.748	0.650	0.621	0.225	0.208
3/8 0.3750	5/8	0.625	0.607	0.884	0.833	0.722	0.692	0.257	0.239

Notes:

1. Square machine screw nuts shall have tops and bottoms flat, and un-chamfered. The flat surfaces shall be perpendicular to the axis of the threaded hole pitch cylinder within a tolerance of 4 deg.
2. Hexagon machine screw nuts shall have top and bottom surfaces flat, with chamfered corners. The flat surface diameters shall be equal to the maximum width across flats, with a tolerance of minus 15%. The bearing surface shall be perpendicular to the axis of the threaded hole pitch cylinder within a tolerance of 4 deg.
3. Bottoms of hexagon machine screw nuts may be supplied with flat, but un-chamfered surfaces at the option of the manufacturer.

Small Pattern Hex Machine Screw Nuts

Small pattern hex machine screw nuts are designed to be used with machine screws in areas where there is limited space for wrenching.

For dimensions of small pattern hex machine screw nuts, please see ASME B18.2.2.

Difference Between Hex Cap Screws and Hex Machine Screws

Hex cap screws tend toward larger diameters. The threaded end of a cap screw is chamfered.

Machine screws are only available in smaller diameters. The threaded end of the fastener is not chamfered but rather simply sheared.

Dimensions of Bolts, Screws and Nuts as per ISO

Important information about dimensions and tolerances (product standards) for bolts, screws and nuts as per ISO standards 4014 4017, 4032, 4033 and 4035 is given in this chapter. In ISO standards, the product grade refers to the quality of the product and to the size of the tolerances. In view of this, information on tolerances for fasteners (ISO 4759) is also given in this chapter. It may be noted that as per ISO practice, a comma (,) is used as a decimal marker instead of a point (.) in this chapter.

ISO 4759: Tolerances for Fasteners

ISO 4759 consists of the following parts, under the general title Tolerances for fasteners:

- Part 1: Bolts, screws, studs and nuts - Product grades A, B and C
- Part 3: Plain washers for bolts, screws and nuts - Product grades A and C

ISO 4759-1 specifies a selection of tolerances for bolts, screws, studs and nuts with ISO metric threads and with product grades A, B and C and for tapping screws with product grade A.

It may be noted that, the product grades refer to the size of the tolerances where grade A is the most precise and grade C is the least precise

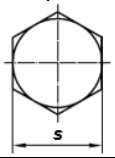
The tolerances, except tolerances for threads, are selected from the system of limits and fits specified in ISO 286-1 and ISO 286-2. The tolerances for metric threads are taken from the series of tolerance classes specified in ISO 965-3. The tolerances for tapping screw threads are covered in ISO 1478.

The tolerances of form and position are specified and indicated in accordance with ISO 1101, ISO 8015 and ISO 2692.

The tolerances specified in this standard apply to fasteners prior to coating unless otherwise specified. The dimensions and tolerances are given in millimetres.

Following tables show dimensional tolerances for threads and an external feature (width across flats for bolts/screws).

Feature	**Tolerance for Product Grades**		
	A	**B**	**C**
External threads (bolts, screws and nut end of studs)	6g	6g	8g (but 6g for property class 8.8 and higher)
Internal thread (nuts)	6H	6H	7H

Feature	**Tolerance for Product Grades**			
	A		**B and C**	
External (e.g. bolts) width across flats 	*s*	Tolerance	*s*	Tolerance
	≤ 30	h13	≤ 18	h14
	< 30	h14	> 18 ≤ 60	h15
			> 60 ≤ 180	h16
			> 180	h17

For information on dimensional tolerance for other feature of external (bolts) and internal (nuts) products; and geometrical tolerances, please see the standard.

ISO 225: Fasteners - Bolts, screws, studs and nuts - Symbols and descriptions of dimensions

ISO 225 defines the symbols and gives descriptions of the dimensions of bolts, screws, studs and nuts for use in the appropriate product standards and drawings. Indian standard, IS 8536 is identical to ISO 225.

Following tables shows symbols which are used in this booklet and gives descriptions for them as per ISO 225.

Designation of Dimensions of Bolts, Screws and Studs	
Symbol	**Description**
a	distance from the bearing face to the first full form (full profile) thread (screw)
b	thread length
c	height of the washer-faced portion or thickness of the flange or collar
d	basic major diameter (nominal diameter) of thread
d_a	inner diameter of the bearing face
d_k	diameter of the head
d_s	diameter of the unthreaded shank
d_w	outer diameter of the washer face (bearing face)
e	width across corners
f	height of the raised (oval) portion of a raised countersunk head
k	height of the head
k_w	wrenching height
l	nominal length
l_f	transition length
l_g	distance from the bearing face to the first full form (full profile) thread (bolt)
l_s	length of unthreaded shank
l_t	overall length
m	wing diameter of cross recesses
n	width of the slot
r	radius of curvature under head
s	width across flats
t	depth of the internal driving feature or slot
u	incomplete thread end
v_u	depth of indentation under the head
w	thickness between driving feature and bearing face
x	length of the thread run-out
α	angle of countersunk head
β	angle of the chamfer (hexagon head)

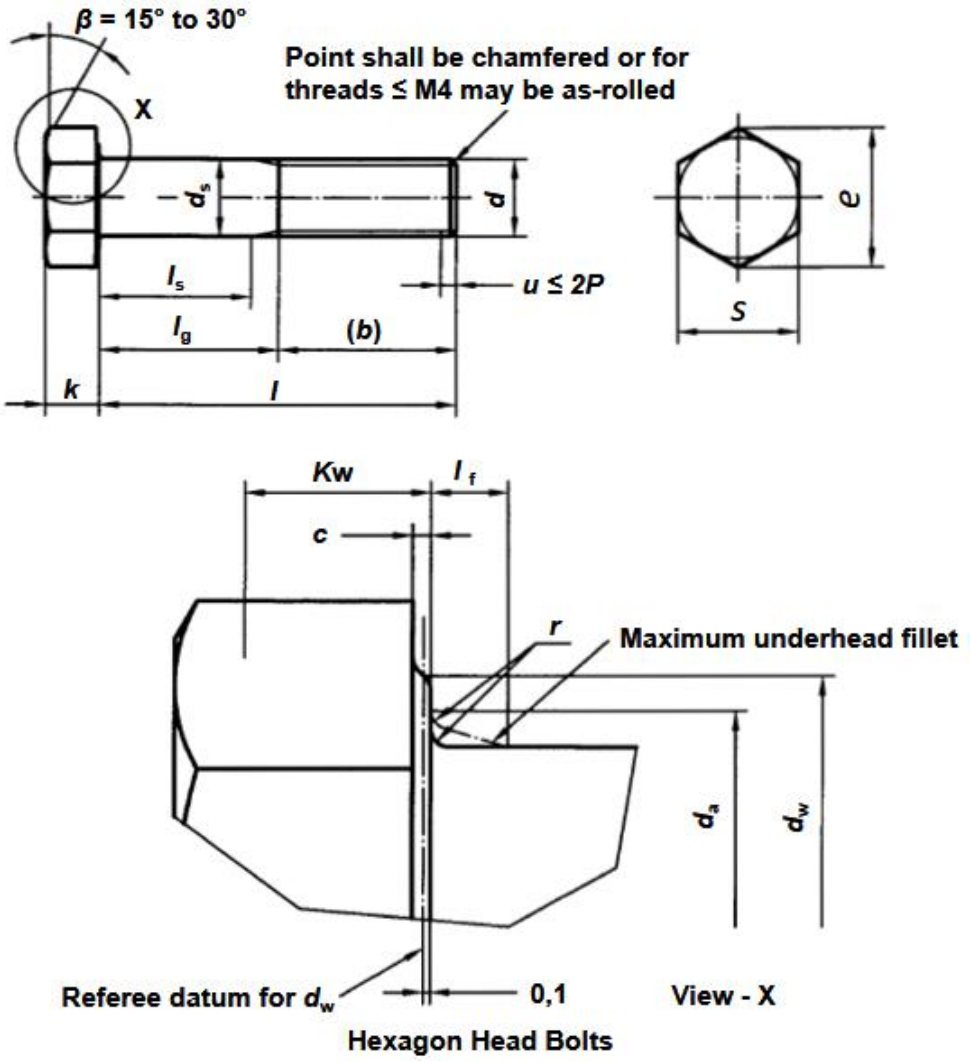
Designation of Dimensions of Nuts	
Symbol	**Description**
c	height of the washer-faced portion or thickness of the flange or collar
D	basic major diameter (nominal diameter) of thread
d_a	diameter of the countersink
d_c	diameter of flange or collar
d_w	outer diameter of the bearing face
e	width across corners
h	overall height of prevailing torque type nuts or slotted nuts
m	height of the nut, or height of the nut without prevailing torque feature as applicable
m_w	wrenching height
n	width of the slot
s	width across flats
β	angle of the chamfer
θ	countersink angle

ISO 4014: Hexagon Head Bolts - Product Grades A and B

ISO 4014 specifies the characteristics of hexagon head bolts with threads from M1,6 up to and including M64, of product grade A for threads M1,6 to M24 and nominal lengths up to and including 10 d or 150 mm, whichever is shorter and product grade B for threads over M24 or nominal lengths over10 d or 150 mm, whichever is shorter.

Dimensions

All dimensions are in mm.



Information on selected dimensions (*b* ref., *e* min., *k* nom. and *s* nom.) for preferred threads and non-preferred threads is given in the following tables.

Dimensions of Hexagon Head Bolts, Preferred Threads - Product Grades A and B								
Thread (*d*)	Pitch *P*	*b* ref.			*e* min.		*k* nom.	*s* nom.
		l_{nom}≤125	125<l_{nom}≤200	l_{nom}>200	Grade A	Grade B		
M1,6	0,35	9	15	28	3,41	3,28	1,1	3,20
M2	0,4	10	16	29	4,32	4,18	1,4	4,00
M2,5	0,45	11	17	30	5,45	5,31	1,7	5,00
M3	0,5	12	18	31	6,01	5,88	2	5,50
M4	0,7	14	20	33	7,66	7,50	2,8	7,00

M5	0,8	16	22	35	8,79	8,63	3,5	8,00
M6	1	18	24	37	11,05	10,89	4	10,00
M8	1,25	22	28	41	14,38	14,20	5,3	13,00
M10	1,5	26	32	45	17,77	17,59	6,4	16,00
M12	1,75	30	36	49	20,03	19,85	7,5	18,00
M16	2	38	44	57	26,75	26,17	10	24,00
M20	2,5	46	52	65	33,53	32,95	12,5	30,00
M24	3	54	60	73	39,98	39,55	15	36,00
M30	3,5	66	72	85	-	50,85	18,7	46,00
M36	4	-	84	97	-	60,79	22,5	55,00
M42	4,5	-	96	109	-	71,30	26	65,00
M48	5	-	108	121	-	82,60	30	75,00
M56	5,5	-	-	137	-	93,56	35	85,00
M64	6	-	-	153	-	104,86	40	95,00

Dimensions of Hexagon Head Bolts, Non-Preferred Threads - Product Grades A and B								
Thread	Pitch	*b* ref.			*e* min.		*k* nom.	*s* nom.
(*d*)	*P*	$l_{nom} \leq 125$	$125 < l_{nom} \leq 200$	$l_{nom} > 200$	Grade A	Grade B		
M3,5	0,6	13	19	32	6,58	6,44	2,4	6,00
M14	2	34	40	53	23,36	22,78	8,8	21,00
M18	2,5	42	48	61	30,14	29,56	11,5	27,00
M22	2,5	50	56	69	37,72	37,29	14	34,00
M27	3	60	66	79	-	45,20	17	41,00
M33	3,5	-	78	91	-	55,37	21	50,00
M39	4	-	90	103	-	66,44	25	60,00
M45	4,5	-	102	115	-	76,95	28	70,00
M52	5	-	116	129	-	88,25	33	80,00
M60	5,5	-	-	145	-	99,21	38	90,00

Popular lengths for M6 to M36 bolts (preferred threads), are as under. It may be noted that popular lengths are defined in terms of l_s and l_g.

d	**M6**		**M8**		**M10**		**M12**		**M16**		**M20**		**M24**		**M30**		**M36**	
l	l_s	l_g	l_s	l_g	l_s	l_g	l_s	l_g	l_s	l_g	l_s	l_g	l_s	l_g	l_s	l_g	l_s	l_g
nom.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
30	7	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	12	17	-	-	**For sizes above the solid, boldface stepped line ISO 4017 is recommended**													-
40	17	22	11,75	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	22	27	16,75	23	11,5	19	-	-	-	-	-	-	-	-	-	-	-	-
50	27	32	21,75	28	16,5	24	11,25	20	-	-	-	-	-	-	-	-	-	-
55	32	37	26,75	33	21,5	29	16,25	25	-	-	-	-	-	-	-	-	-	-
60	37	42	31,75	38	26,5	34	21,25	30	-	-	-	-	-	-	-	-	-	-
65	-	-	36,75	43	31,5	39	26,25	35	17	27	-	-	-	-	-	-	-	-
70	-	-	41,75	48	36,5	44	31,25	40	22	32	-	-	-	-	-	-	-	-
80	-	-	51,75	58	46,5	54	41,25	50	32	42	21,5	34	-	-	-	-	-	-
90	-	-	-	-	56,5	64	51,25	60	42	52	31,5	44	21	36	-	-	-	-
100	-	-	-	-	66,5	74	61,25	70	52	62	41,5	54	31	46	-	-	-	-
110	-	-	-	-	-	-	71,25	80	62	72	51,5	64	41	56	26,5	44	-	-
120	-	-	-	-	-	-	81,25	90	72	82	61,5	74	51	66	36,5	54	-	-
130	-	-	-	-	-	-	-	-	76	86	65,5	78	55	70	40,5	58	-	-
140	-	-	-	-	-	-	-	-	86	96	75,5	88	65	80	50,5	68	36	56
150	-	-	-	-	-	-	-	-	96	106	85,5	98	75	90	60,5	78	46	66
160	-	-	-	-	-	-	-	-	106	116	95,5	108	85	100	70,5	88	56	76
180	-	-	-	-	-	-	-	-	-	-	115,5	128	105	120	90,5	108	76	96
200	-	-	-	-	-	-	-	-	-	-	135,5	148	125	140	110,5	128	96	116
220	-	-	-	-	-	-	-	-	-	-	-	-	132	147	117,5	135	103	123
240	-	-	-	-	-	-	-	-	-	-	-	-	152	167	137,5	155	123	143
260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	157,5	175	143	163
280	-	-	-	-	-	-	-	-	-	-	-	-	-	-	177,5	195	163	183
300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	197,5	215	183	203
320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	203	223
340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	223	243
360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	243	263

$k_{w,\,min} = 0{,}7\ k_{min}$
$l_{g,\,max.} = l_{nom} - b$
$l_{s,\,min.} = l_{g,\,max.} - 5P$
l_g is the minimum grip length.

For information on popular lengths for d < M6, d > M36 having preferred threads and popular lengths having non-preferred threads, please see the standard.

It may be noted that in the tables for dimensions of hexagon head bolts given above, information on only *b* ref., *e* min., *k* nom. and *s* nom. is given. For information on *c*, d_a, d_s, d_w, l_f, k_w and *r*, please see the standard.

Specifications and Reference Standards

Information on important specifications and reference standards is as under.

Specifications and Reference Standards			
Material		Steel	Stainless Steel
General requirements	International Standard	ISO 8992	
Thread	Tolerance	6g	
	International Standards	ISO 724, ISO 965-1	
Mechanical Properties	Property Class*	*d* < 3 mm: as agreed 3mm ≤ *d* ≤ 39mm: 5.6, 8.8, 9.8, 10.9 *d* > 39 mm: as agreed	d ≤ 24 mm: A2-70, A4-70 24 mm < *d* ≤ 39 mm: A2-50, A4-50 *d* > 39 mm: as agreed
	International Standards	3mm ≤ *d* ≤ 39mm: ISO 898-1 *d* <3 mm and *d* > 39mm: as agreed	*d* ≤ 39 mm: ISO 3506-1 *d* > 39 mm: as agreed
Tolerances	Product grade	For *d* ≤ 24mm and *l* ≤ 10 d or 150mm#: A For *d* > 24 mm or *l* > 10 d or 150 mm#: B	
	International Standard	ISO 4759-1	
Finish and/or coating		Requirements for coatings are covered in ISO 4042 and ISO 10683. Limits for surface discontinuities are covered in ISO 6157-1.	Plain
Acceptability		For acceptance procedure, See ISO 3269.	

* For other property classes see ISO 898-1 for steel and ISO 3506-1 for stainless steel respectively.
# Whichever is shorter.

Designation

Example - A hexagon head bolt with thread M12, nominal length *l* = 80 mm and property class 8.8 is designated as: Hexagon head bolt ISO 4014 - M12 × 80 - 8.8

ISO 4017: Hexagon head screws - Product grades A and B

ISO 4017 specifies the characteristics of hexagon head screws with threads from M1,6 up to and including M64, of product grade A for threads M1,6 to M24 and nominal lengths up to and including 10 *d* or 150 mm, whichever is the shorter, and product grade B for threads over M24 or nominal lengths over 10 *d* or 150 mm, whichever is the shorter.

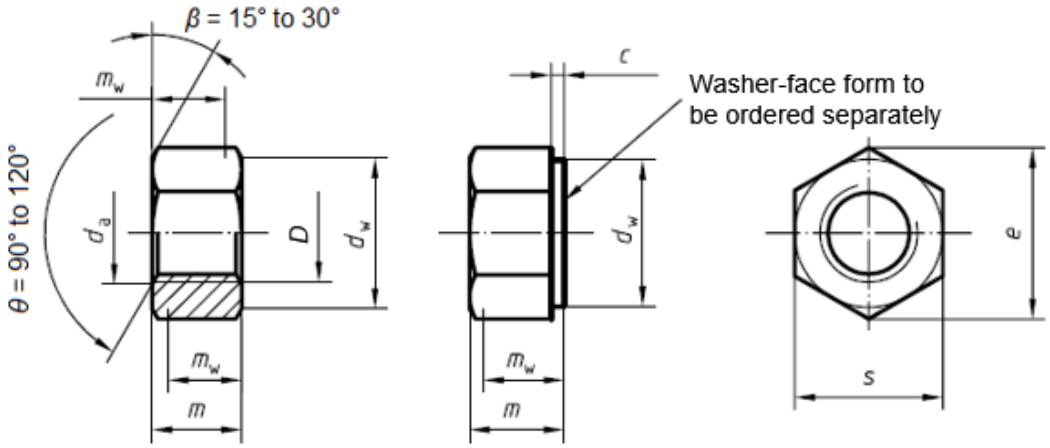
It may be noted that this type of product is the same as that covered by ISO 4014 with the exception of threading up to head and nominal lengths up to and including 200 mm as preferred lengths. In view of this, more information on the standard is not given here.

ISO 4032: Hexagon Regular Nuts (Style 1) - Product Grades A and B

ISO 4032 specifies the characteristics of hexagon regular nuts (style 1), with threads from M1,6 up to including M64, with product grade A for threads $D \leq$ M16 and product grade B for threads $D >$ M16.

Dimensions

All dimensions are in mm.



Hexagon Regular Nuts (Style 1)

It may be noted that unless otherwise specified in the order, nuts are delivered without washer-face.

Information on selected dimensions (*e* min., *m* and *s* nom.) for preferred threads and non-preferred threads is given in the following tables.

Dimensions of Hexagon Regular Nuts (Style 1), Preferred Threads - Product Grades A and B					
Thread (*D*)	Pitch *P*	*e* min.	*m*		*s* nom. = max.
			max.	min.	
M1,6	0,35	3,41	1,30	1,05	3,20
M2	0,4	4,32	1,60	1,35	4,00
M2,5	0,45	5,45	2,00	1,75	5,00
M3	0,5	6,01	2,40	2,15	5,50
M4	0,7	7,66	3,20	2,90	7,00
M5	0,8	8,79	4,70	4,40	8,00
M6	1	11,05	5,20	4,90	10,00
M8	1,25	14,38	6,80	6,44	13,00
M10	1,5	17,77	8,40	8,04	16,00
M12	1,75	20,03	10,80	10,37	18,00
M16	2	26,75	14,80	14,10	24,00
M20	2,5	32,95	18,00	16,90	30,00
M24	3	39,55	21,50	20,20	36,00
M30	3,5	50,85	25,60	24,30	46,00
M36	4	60,79	31,00	29,40	55,00
M42	4,5	71,30	34,00	32,40	65,00
M48	5	82,60	38,00	36,40	75,00
M56	5,5	93,56	45,00	43,40	85,00
M64	6	104,86	51,00	49,10	95,00

Dimensions of Hexagon Regular Nuts, Non-Preferred Threads - Product Grades A and B					
Thread (*D*)	Pitch *P*	*e* min.	*m*		*s* nom. = max.
			max.	min.	
M3,5	0,6	6,58	2,80	2,55	6,00
M14	2	23,36	12,80	12,10	21,00
M18	2,5	29,56	15,80	15,10	27,00
M22	2,5	37,29	19,40	18,10	34,00
M27	3	45,20	23,80	22,50	41,00
M33	3,5	55,37	28,70	27,40	50,00
M39	4	66,44	33,40	31,80	60,00
M45	4,5	76,95	36,00	34,40	70,00
M52	5	88,25	42,00	40,40	80,00
M60	5,5	99,21	48,00	46,40	90,00

Specifications and Reference Standards

Information on important specifications and reference standards is as under.

Specifications and Reference Standards			
Material		Steel	Stainless Steel
General requirements	International Standard	ISO 8992	
Thread	Tolerance	6H	
	International Standards	ISO 724, ISO 965-1	
Mechanical Properties	Property Class*	*D* < M3: as agreed M3 ≤ *D* ≤ M39: 6,8,10 *D* > M39: as agreed	*D* ≤ M24: A2-70, A4-70 M24 < *D* ≤ M39: A2-50, A4-50 *D* > M39: as agreed
	International Standards	M3 ≤ *D* ≤ M39:ISO 898-1 *D* < M3 and *D* > M39: as agreed	*D* ≤ M39: ISO 3506-2 *D* > M39: as agreed
Tolerances	Product Grade	*D* ≤ M16: A *D* > M16: B	
	International Standards	ISO 4759-1	

* For other property classes see ISO 898-2 for steel and ISO 3506-2 for stainless steel respectively.

Designation

Example - A hexagon nut, style 1, with thread M12 and property class 8 is designated as follows:

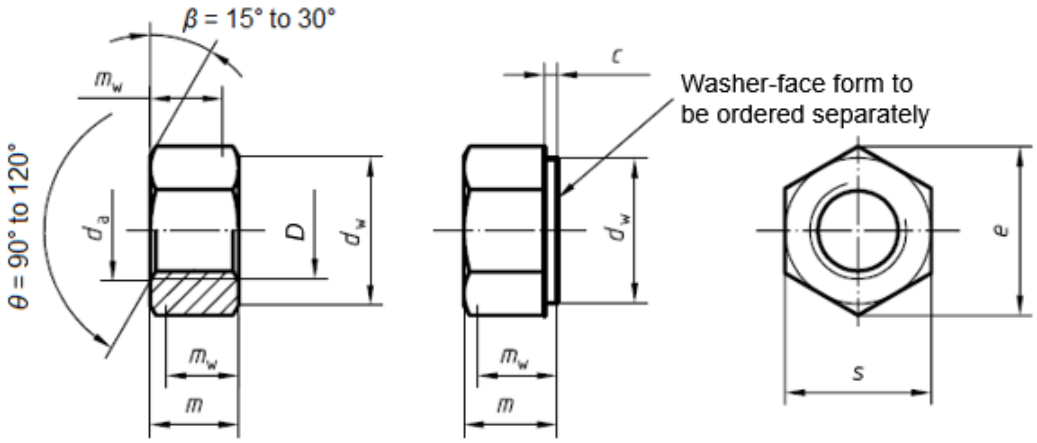
Hexagon nut ISO 4032 - M12 - 8

ISO 4033: Hexagon High Nuts (Style 2) - Product Grades A and B

ISO 4033 specifies the characteristics of hexagon high nuts (style 2), with threads from M5 up to and including M36, with product grade A for threads *D* ≤ M16 and product grade B for threads *D* > M16.

Dimensions

All dimensions are in mm.



Hexagon High Nuts (Style 2)

Information on selected dimensions (*e* min., *m* and *s* nom.) is given in the following table.

Dimensions of Hexagon High Nuts (Style 2) - Product Grades A and B					
Thread (*D*)	Pitch *P*	*e* min.	*m*		*s* nom. = max.
			max.	min.	
M5	0,8	8,79	5,10	4,80	8,00
M6	1	11,05	5,70	5,40	10,00
M8	1,25	14,38	7,50	7,14	13,00
M10	1,5	17,77	9,30	8,94	16,00
M12	1,75	20,03	12,00	11,57	18,00
(M14)	2	23,36	14,10	13,40	21,00
M16	2	26,75	16,40	15,70	24,00
M20	2,5	32,95	20,30	19,00	30,00
M24	3	39,55	23,90	22,60	36,00
M30	3,5	50,85	28,60	27,30	46,00
M36	4	60,79	34,70	33,10	55,00

If possible, the size in parentheses should be avoided.

Note: Hexagon high nuts (style 2) are intended for use with property classes 8, 9 and 12 (for reason / explanation please see ISO 898-2).

Specifications and Reference Standards

Information on important specifications and reference standards is as under.

Specifications and reference Standards		
Material		Steel
General requirements	International Standard	ISO 8992
Thread	Tolerance	6H
	International Standards	ISO 724, ISO 965-1
Mechanical Properties	Property Class*	9 and 12
	International Standard	ISO 898-2
Tolerances	Product Grade	*D* ≤ M16: A *D* > M16: B
	International Standard	ISO 4759-1

* For other property classes see ISO 898-2.

Designation

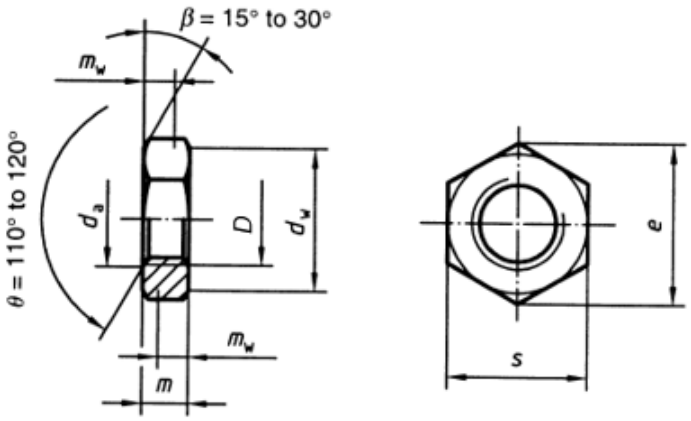
Example - A hexagon nut, style 2, with thread M12 and property class 9 is designated as: Hexagon nut ISO 4033 - M12 - 9

ISO 4035: Hexagon Thin Nuts Chamfered (Style 0) - Product Grades A and B

ISO 4035 specifies the characteristics of chamfered hexagon thin nuts (style 0), with threads from M1,6 up to and including M64, with product grade A for threads $D \leq$ M16 and product grade B for threads $D >$ M16.

Dimensions

All dimensions are in mm.



Hexagon Thin Nuts Chamfered

Information on selected dimensions (*e* min., *m* and *s* nom.) for preferred threads and non-preferred threads is given in the following tables.

Hexagon Thin Nuts Chamfered, Preferred Threads - Product Grades A and B					
Thread (*D*)	Pitch *P*	*e* min.	*m*		*s* nom. = max.
			max.	min.	
M1,6	0,35	3,41	1	0,75	3,20
M2	0,4	4,32	1,2	0,95	4,00
M2,5	0,45	5,45	1,6	1,35	5,00
M3	0,5	6,01	1,8	1,55	5,50
M4	0,7	7,66	2,2	1,95	7,00
M5	0,8	8,79	2,7	2,45	8,00
M6	1	11,05	3,2	2,9	10,00
M8	1,25	14,38	4	3,7	13,00
M10	1,5	17,77	5	4,7	16,00
M12	1,75	20,03	6	5,7	18,00
M16	2	26,75	8	7,42	24,00
M20	2,5	32,95	10	9,10	30,00
M24	3	39,55	12	10,9	36,00
M30	3,5	50,85	15	13,9	46,00
M36	4	60,79	18	16,9	55,00
M42	4,5	71,30	21	19,7	65,00
M48	5	82,60	24	22,7	75,00
M56	5,5	93,56	28	26,7	85,00
M64	6	104,86	32	30,4	95,00

Hexagon Thin Nuts Chamfered , Non-Preferred Threads - Product Grades A and B					
Thread (D)	Pitch P	e min.	m		s nom. = max.
			max.	min.	
M3,5	0,6	6,58	2	1,75	6,00
M14	2	23,36	7	6,42	21,00
M18	2,5	29,56	9	8,42	27,00
M22	2,5	37,29	11	9,9	34,00
M27	3	45,20	13,5	12,4	41,00
M33	3,5	55,37	16,5	15,4	50,00
M39	4	66,44	19,5	18,2	60,00
M45	4,5	76,95	22,5	21,2	70,00
M52	5	88,25	26	24,7	80,00
M60	5,5	99,21	30	28,7	90,00

Specifications and Reference Standards

Information on important specifications and reference standards is as under.

Specifications and Reference Standards			
Material		Steel	Stainless Steel
General requirements	International Standard	ISO 8992	
Thread	Tolerance	6H	
	International Standards	ISO 261, ISO 965	
Mechanical Properties	Property Class	D < M3: as agreed M3 ≤ D ≤ M39: 04,05 D > M39: as agreed	D ≤ M24: A2-035, A4-035 M24 < D ≤ M39: A2-025 D > M39: as agreed
	International Standards	D < M3: as agreed M3 ≤ D ≤ M39:ISO 898/2 D > M39: as agreed	D ≤ M39: ISO 3506-2 D > M39: as agreed
Tolerances	Product Grade	D ≤ M16: A D > M16: B	
	International Standards	ISO 4759/1	

Designation

Example - A chamfered hexagon thin nut with thread M12 and property class 05 is designated as follows:

Hexagon thin nut ISO 4035 - M12 - 05

ISO Product Standards on Bolts, Screws and Nuts

As this booklet is made for education purpose of maintenance engineers, information on all ISO product (dimensions and tolerances) standards for bolts, screws and nuts is not given. Following are remaining ISO product standards for bolts, screws and nuts. The list will be helpful in searching desired information.

- ISO 4015: Hexagon head bolts - Product grade B - Reduced shank (shank diameter approximately equal to pitch diameter)
- ISO 4016: Hexagon head bolts - Product grade C
- ISO 4018: Hexagon head screws - Product grade C
- ISO 8765: Hexagon head bolts with metric fine pitch thread - Product grades A and B
- ISO 8676: Hexagon head screws with metric fine pitch thread - Product grades A and B

- ISO 4034: Hexagon regular nuts (style 1) - Product grade C
- ISO 8673: Hexagon regular nuts (style 1) with metric fine pitch thread - Product grades A and B
- ISO 8674: Hexagon high nuts (style 2) with metric fine pitch thread - Product grades A and B
- ISO 8675: Hexagon thin nuts chamfered (style 0) with metric fine pitch thread - Product grades A and B

- ISO 4162: Hexagon bolts with flange - Small series - Product grade A with driving feature of product grade B (from M5 up to and including M16, and property classes 8.8 to 10.9 and A2-70).
- ISO 15071: Hexagon bolts with flange - Small series - Product grade A (from M5 up to and including M16, and property classes 8.8, 9.8, 10.9 and A2-70).
- ISO 4161: Hexagon nuts with flange, style 2 - Coarse thread (from M5 to M20 inclusive)
- ISO 15072: Hexagon bolts with flange with metric fine pitch thread - Small series - Product grade A (from 8 mm up to and including 16 mm and property classes 8.8, 9.8, 10.9, 12.9/12.9 and A2-70).
- ISO 10663: Hexagon nuts with flange, style 2 - Fine pitch thread (from 8 mm to 20 mm).

- ISO 8992: Fasteners - General requirements for bolts, screws, studs and nuts
- ISO 4753: Fasteners - Ends of parts with external ISO metric thread

Indian Product Standards (IS) for Bolts, Screws and Nuts

Indian has adopted ISO product standards. ISO standard numbers and corresponding Indian standard numbers for bolts, screws and nuts are given in the following table.

ISO Standard Number	Corresponding Indian Standard Number
4014	IS 1364 (Part 1)
4015	IS 14894
4016	IS 1363 (Part 1)
8765	IS 13726
4017	IS 1364 (Part 2)
4018	IS 1363 (Part 2)
8676	IS 13725
4032	IS 1364 (Part 3)
4033	IS 1364 (Part 6)
4034	IS 1363 (Part 3)
4035	IS 1364 (Part 4)
8673	IS 13722
8674	IS 13723
8675	IS 13724
4753	IS 1368

Dimensions of Slotted and Cross Recessed Screws as per ISO

Important information about dimensions and tolerances (product standards) for slotted and cross recessed screws as per ISO standards 1207, 1580, 2009, 2010, 7045, 7046 and 7047; and information about cross recesses for screws as per ISO 4757 is given in this chapter.

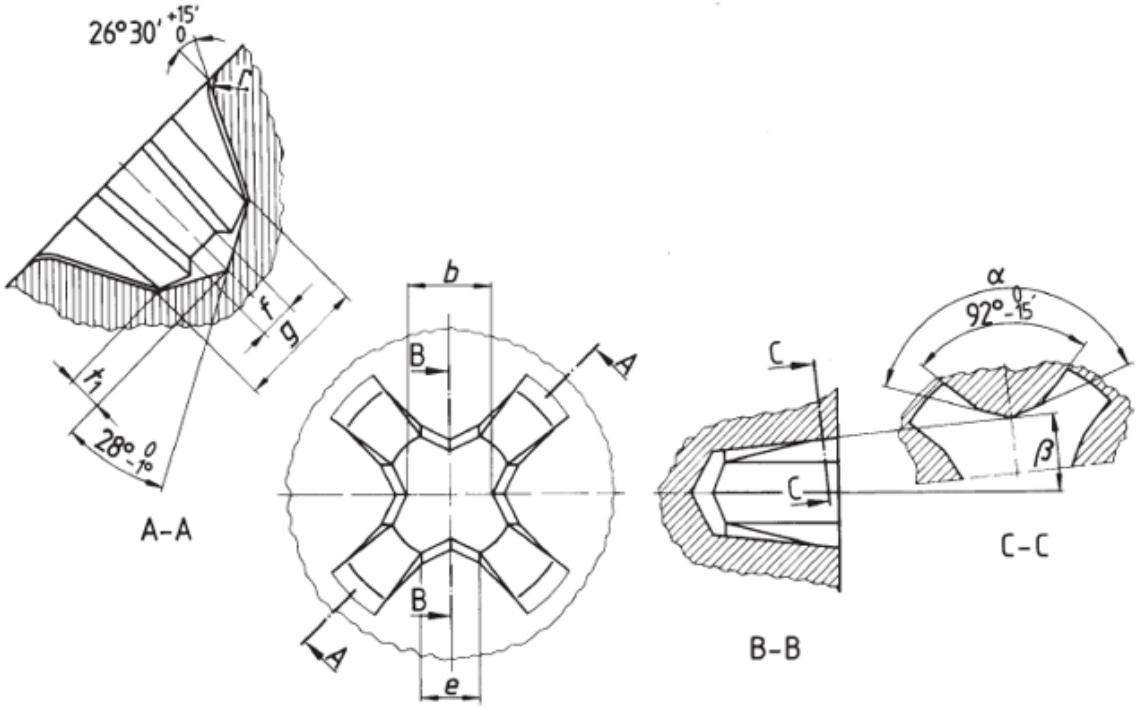
Notes:
1. Description of symbols is as per ISO 225 (please see page number 25 of this booklet).
2. All dimensions in this chapter are in mm.
3. As per ISO practice, a comma (,) is used as a decimal marker instead of a point (.) in this chapter.

ISO 4757: Cross Recesses for Screws

ISO 4757 defines two types of cross recesses for screws: recess type H and recess type Z.

Recess Type H (Phillips)

The Phillips cross recessed head is the world's most widely used system.



Recess Type H

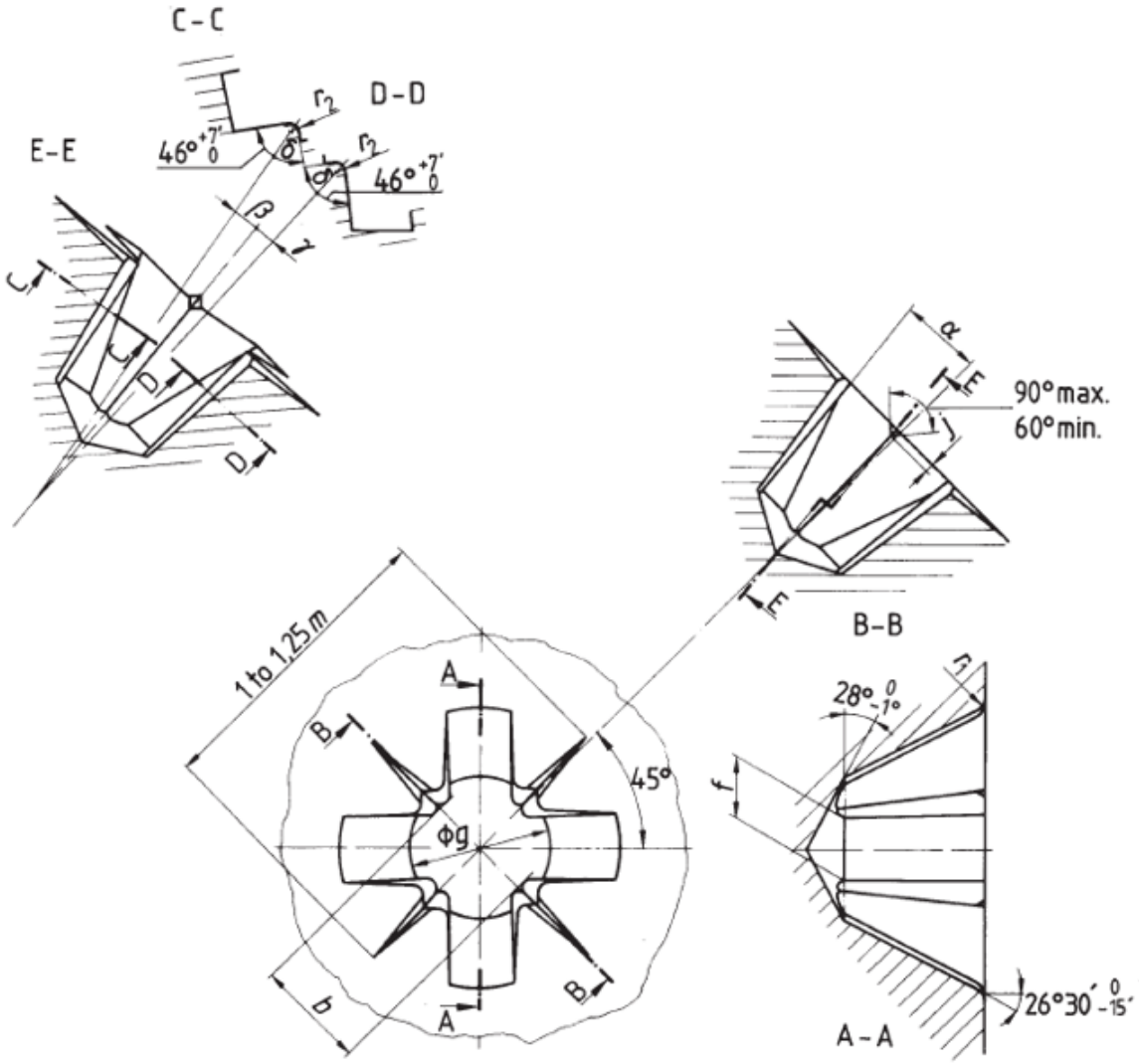
Above figure shows construction of H type recess. Each standard size of a recess is given a recess number. Following table shows value of *b* for various recess number.

Recess Type H					
Recess No.	0	1	2	3	4
b + 0 −0,03	0,61	0,97	1,47	2,41	3,48

For other dimensions of a recess, please see the standard.

Recess Type Z (Pozidriv)

The Pozidriv cross recessed head is used principally in Europe.



Above figure shows construction of Z type recess. Each standard size of a recess is given a recess number. Following table shows value of *b* for various recess number.

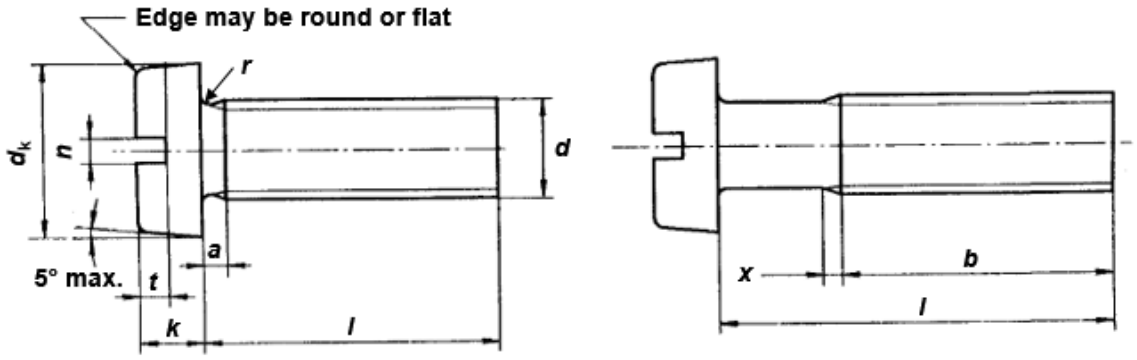
Recess Type Z					
Recess No.	0	1	2	3	4
b + 0 −0,05	0,76	1,27	1,83	2,72	3,96

For other dimensions of a recess, please see the standard.

ISO 1207: Slotted Cheese Head Screws - Product Grade A

ISO 1207 specifies the characteristics of slotted cheese head screws of product grade A and with threads from M1,6 to M10 inclusive.

Dimensions



Slotted Cheese Head Screws

Information on selected dimensions (*b*, d_k, *k*, *n* and *t*) and popular lengths, also called commercial lengths (shown by ✓) is given in the following tables.

Thread (*d*)	M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
P[#]	0,35	0,4	0,45	0.5	0,6	0,7	0,8	1	1,25	1,5
b	25	25	25	25	38	38	38	38	38	38
d_k nom. = max.	3,00	3,80	4,50	5,50	6,00	7,00	8,50	10,00	13,00	16,00
k nom. = max.	1,10	1,40	1,80	2,00	2,40	2,60	3,30	3.9	5,0	6,0
n nom.	0,4	0,5	0,6	0,8	1	1,2	1,2	1.6	2	2,5
t min.	0,45	0,60	0,70	0,85	1,00	1,10	1,30	1,60	2,00	2,40

Popular / commercial Lengths (popular lengths are shown by ✓)										
Nominal Length	**Thread (*d*)**									
	M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
2	✓									
3	✓	✓	✓							
4	✓	✓	✓	✓						
5	✓	✓	✓	✓	✓	✓				
6	✓	✓	✓	✓	✓	✓	✓			
8	✓	✓	✓	✓	✓	✓	✓	✓		
10	✓	✓	✓	✓	✓	✓	✓	✓	✓	
12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
(14)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
20		✓	✓	✓	✓	✓	✓	✓	✓	✓
25			✓	✓	✓	✓	✓	✓	✓	✓
30				✓	✓	✓	✓	✓	✓	✓
35					✓	✓	✓	✓	✓	✓
40						✓	✓	✓	✓	✓
45							✓	✓	✓	✓
50							✓	✓	✓	✓
(55)								✓	✓	✓
60								✓	✓	✓
(65)									✓	✓
70									✓	✓
(75)									✓	✓
80									✓	✓

* Sizes in parentheses should be avoided if possible.

[#] *P* = pitch of the thread

Screws with nominal lengths above the dotted line are threaded up to the head (*b* = *l* − *a*).

The shank diameter is approximately equal to the pitch diameter or equal to the major thread diameter permissible.

Specifications and Reference International Standards

Information on important specifications and reference standards is as under.

Material		Steel	Stainless steel
General requirements	International Standard	ISO 8992	
Thread	Tolerance	6g	
	International Standards	ISO 261, ISO 965-2	
Mechanical properties	Property class	4.8, 5.8	A2-50, A2-70
	International Standards	ISO 898-1	ISO 3506
Tolerances	Product grade	A	
	International Standard	ISO 4759-1	

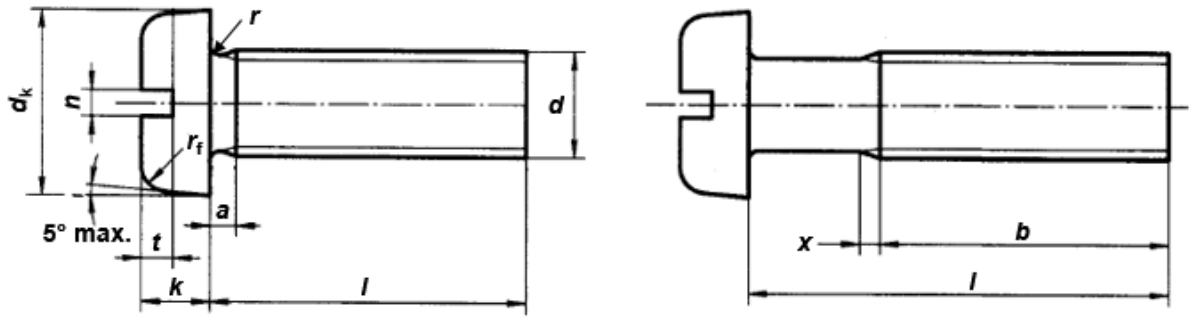
Designation

Example - A slotted cheese head screw with thread M5, nominal length *l* =20 mm and property class 4.8 is designated as: Cheese head screw ISO 1207 - M5 × 20 - 4.8.

ISO 1580: Slotted Pan Head Screws - Product Grade A

ISO 1580 specifies the characteristics of slotted pan head screws of product grade A and with threads from M1,6 to M10 inclusive.

Dimensions



Slotted Pan Head Screws

Information on selected dimensions (*b*, d_k, *k*, *n* and *t*) is given in the following table.

Thread (*d*)	M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
P[#]	0,35	0,4	0,45	0.5	0,6	0,7	0,8	1	1,25	1,5
b	25	25	25	25	38	38	38	38	38	38
d_k nom. = max.	3,2	4,0	5,0	5,6	7,00	8,00	9,50	12,00	16,00	20,00
k nom. = max.	1,00	1,30	1,50	1,80	2,10	2,40	3,00	3,6	4,8	6,0
n nom.	0,4	0,5	0,6	0,8	1	1,2	1,2	1.6	2	2,5
t min.	0,35	0,5	0.6	0,7	0,8	1	1.2	1,4	1.9	2,4

* Sizes in parentheses should be avoided if possible.
[#] *P* = pitch of the thread

Popular (commercial) lengths are almost similar (with small variation) to slotted cheese head screws as per ISO 1207.

Important Specifications and Reference International Standards

Material		Steel	Stainless steel
Mechanical properties	Property class	4.8, 5.8	A2-50, A2-70
	International Standards	ISO 898-1	ISO 3506

Designation

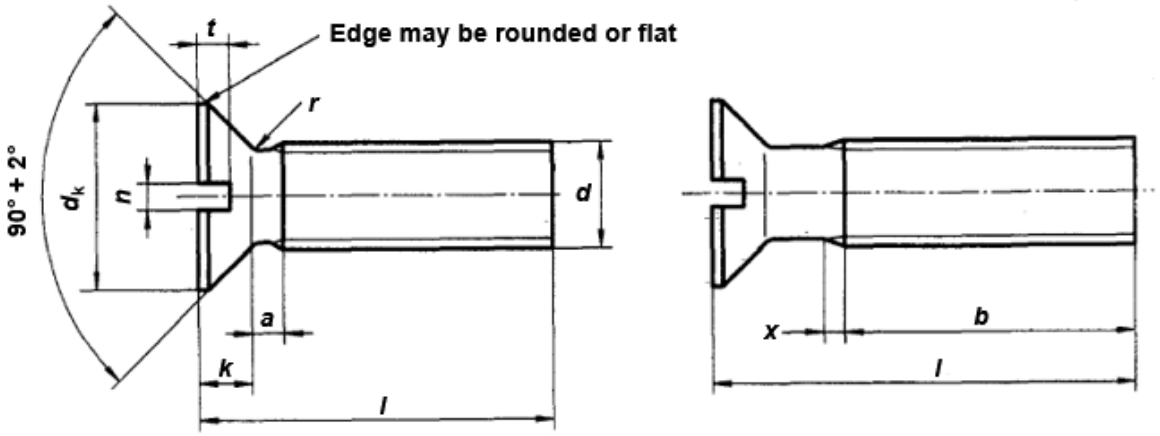
Example - A slotted pan head screw with thread M5, nominal length *l* =20 mm and property class 4.8 is designated as: Pan head screw ISO 1580 - M5 × 20 - 4.8.

It may be noted that the main difference between slotted pan head screws and slotted cheese head screws is in the diameter of their heads (d_k). The head diameter of slotted pan head screws is larger than the head diameter of slotted cheese head screws.

ISO 2009: Slotted Countersunk Flat Head Screws - Product Grade A

ISO 2009 specifies the characteristics of slotted countersunk flat head screws of product grade A and with threads from M1,6 to M10 inclusive.

Dimensions



Slotted Countersunk Flat Head Screws

Information on selected dimensions (*b*, d_k, *k*, *n* and *t*) is given in the following table.

Thread (*d*)	M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
P[#]	0,35	0,4	0,45	0.5	0,6	0,7	0,8	1	1,25	1,5
b	25	25	25	25	38	38	38	38	38	38
d_k nom. = max.	3,00	3,80	4,70	5,50	7,30	8,40	9,30	11,3	15,80	18,30
k nom. = max.	1	1,2	1,5	1,65	2,35	2,7	2,7	3,3	4,65	5
n nom.	0,4	0,5	0,6	0,8	1	1,2	1,2	1.6	2	2,5
t min.	0,32	0,40	0,50	0,60	0,90	1,0	1,1	1,2	1,8	2,0

* Sizes in parentheses should be avoided if possible.
[#] *P* = pitch of the thread

Important Specifications and Reference International Standards

Material		Steel	Stainless steel
Mechanical properties	Property class	4.8, 5.8	A2-50, A2-70
	International Standards	ISO 898-1	ISO 3506

Designation

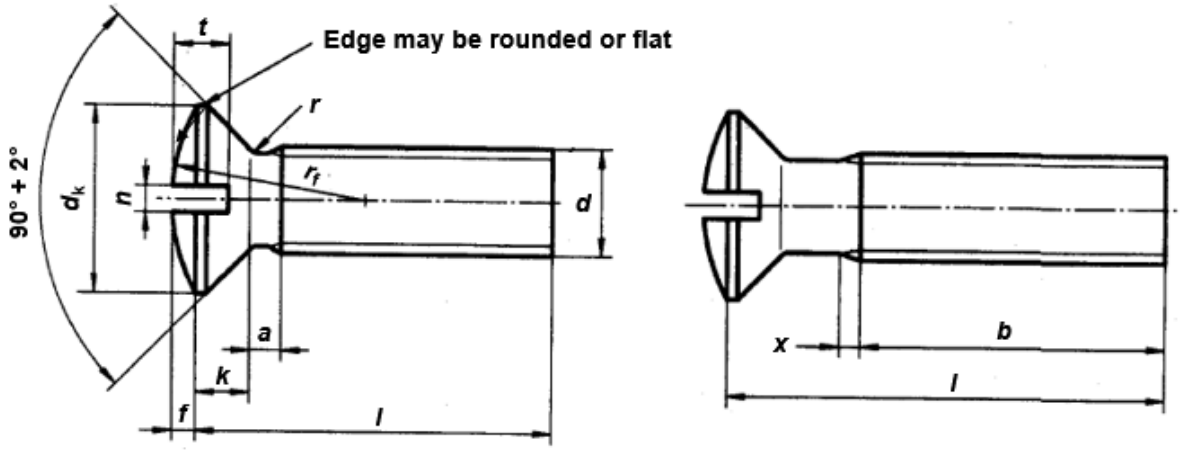
Example - A slotted countersunk flat head screw with thread M5, nominal length *l* =20 mm and property class 4.8 is designated as follows:

Countersunk flat head screw ISO 2009 - M5 × 20 - 4.8.

ISO 2010: Slotted Raised Countersunk Head Screws - Product Grade A

ISO 2010 specifies the characteristics of countersunk slotted raised head screws of product grade A and with threads from M1,6 to M10 inclusive.

Dimensions



Slotted Raised Countersunk Head Screws

Information on selected dimensions (*b*, d_k, *k*, *f*, *n* and *t*) is given in the following table.

Thread (*d*)	M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
P[#]	0,35	0,4	0,45	0.5	0,6	0,7	0,8	1	1,25	1,5
b	25	25	25	25	38	38	38	38	38	38
d_k nom. = max.	3,00	3,80	4,70	5,50	7,30	8,40	9,30	11,3	15,80	18,30
f ≈	0,4	0,5	0,6	0,7	0,8	1	1,2	1,4	2	2,3
k nom. = max.	1	1,2	1,5	1,65	2,35	2,7	2,7	3,3	4,65	5
n nom.	0,4	0,5	0,6	0,8	1	1,2	1,2	1.6	2	2,5
t min.	0,64	0,80	1,0	1,2	1,4	1,6	2,0	2,4	3,2	3,8

* Sizes in parentheses should be avoided if possible.
[#] *P* = pitch of the thread

Important Specifications and Reference International Standards

Material		Steel	Stainless steel
Mechanical properties	Property class	4.8, 5.8	A2-50, A2-70
	International Standards	ISO 898-1	ISO 3506

Designation

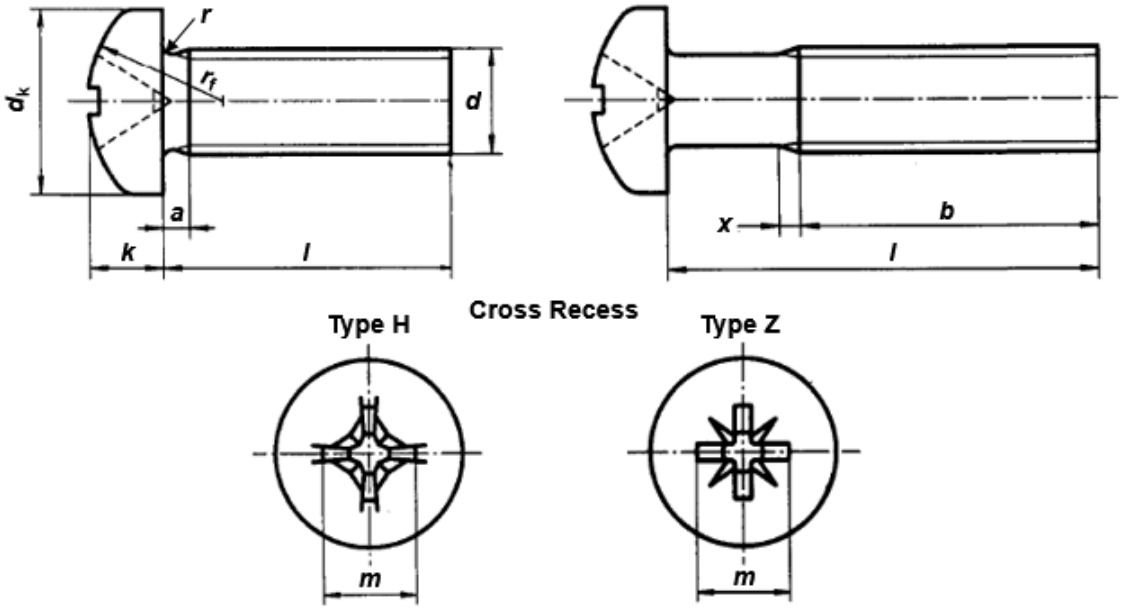
Example - A countersunk slotted raised head screw with thread M5, nominal length *l* = 20 mm and property class 4.8 is designated as follows:

Countersunk raised head screw ISO 2010 - M5 × 20 - 4.8

ISO 7045: Pan Head Screws with Type H or Type Z Cross Recess - Product Grade A

ISO 7045 specifies the characteristics of pan head screws of product grade A, with threads from M1,6 to M10 inclusive, and with type H or type Z cross recess.

Dimensions



Pan Head Screws with Type H or Type Z Cross Recess

Information on selected dimensions (b, d_k, k, m, and cross recess penetration) is given in the following table.

Thread (d)			M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
P (Pitch of the thread)			0,35	0,4	0,45	0.5	0,6	0,7	0,8	1	1,25	1,5
b			25	25	25	25	38	38	38	38	38	38
d_k	nom. = max.		3,2	4,0	5,0	5,6	7,00	8,00	9,50	12,00	16,00	20,00
k	nom. = max.		1,30	1,60	2,10	2,40	2,60	3,10	3,70	4,6	6,0	7,50
Recess Number			0		1		2			3	4	
Cross Recess Type H	m	ref.	1,7	1,9	2,7	3	3,9	4,4	4,9	6,9	9	10,1
	Penetration	max.	0,95	1,2	1,55	1,8	1,9	2,4	2,9	3,6	4,6	5,8
		min.	0,7	0,9	1,15	1,4	1,4	1,9	2,4	3,1	4	5,2
Cross Recess Type Z	m	ref.	1,6	2,1	2,6	2,8	3,9	4,3	4,7	6,7	8,8	9,9
	Penetration	max.	0,9	1,42	1,5	1,75	1,93	2,34	2,74	3,46	4,5	5,69
		min.	0,65	1,17	1,25	1,5	1,48	1,89	2,29	3,03	4,05	5,24

* Sizes in parentheses should be avoided if possible.

Important Specifications and Reference International Standards

Material		Steel	Stainless steel
Mechanical properties	Property class	4.8	A2-50, A2-70
	International Standards	ISO 898-1	ISO 3506

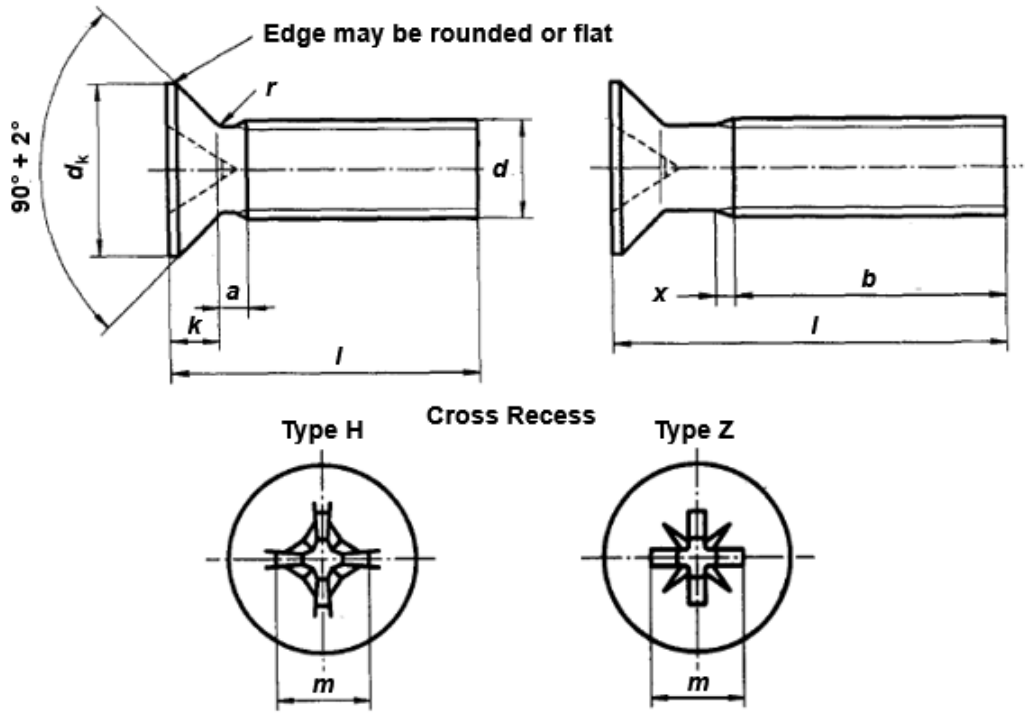
Designation

Example - A cross-recessed pan head screw with thread M5, nominal length *l* =20 mm, property class 4.8 and cross recess type Z is designated as: Pan head screw ISO 7045 - M5 × 20 - 4.8 - Z

ISO 7046-1: Countersunk Flat Head Screws (Common Head Style) with Type H or Type Z Cross Recess - Product Grade A - Part 1: Steel Screws of Property Class 4.8

ISO 7046-1 specifies the characteristics of countersunk flat head screws with threads from M1,6 to M10 inclusive, of product grade A and property class 4.8, and with type H or type Z cross recess.

Dimensions



Countersunk Flat Head Screws with Type H or Type Z Cross Recess

Information on selected dimensions (*b*, d_k, *k*, *m*, and cross recess penetration) is given in the following table.

Thread (*d*)			M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
P (Pitch of the thread)			0,35	0,4	0,45	0.5	0,6	0,7	0,8	1	1,25	1,5
b			25	25	25	25	38	38	38	38	38	38
d_k	nom. = max.		3,0	3,8	4,7	5,5	7,30	8,40	9,30	11,30	15,80	18,30
k	nom. = max.		1	1,2	1,5	1,65	2,35	2,7	2,7	3,3	4,65	5
Recess Number			0		1		2			3	4	
Cross Recess Type H	*m*	ref.	1,6	1,9	2,9	3,2	4,4	4,6	5,2	6,8	8,9	10
	Penetration	max.	0,9	1,2	1,8	2,1	2,4	2,6	3,2	3,5	4,6	5,7
		min.	0,6	0,9	1,4	1,7	1,9	2,1	2,7	3	4	5,1
Cross Recess Type Z	*m*	ref.	1,6	1,9	2,8	3	4,1	4,4	4,9	6,6	8,8	9,8
	Penetration	max.	0,95	1,2	1,73	2,01	2,2	2,51	3,05	3,45	4,6	5,64
		min.	0,7	0,95	1,48	1,76	1,75	2,06	2,6	3	4,15	5,19

* Sizes in parentheses should be avoided if possible.

Important Specification and Reference International Standard

Material		Steel
Mechanical properties	Property class	4.8
	International Standards	ISO 898-1

Designation

Example - A cross-recessed countersunk flat head screw with thread M5, nominal length *l* = 20 mm, property class 4.8 and cross recess type Z is designated as follows:

Countersunk flat head screw ISO 7046 - 1 - M5 × 20 - 4.8 - Z

ISO 7046-2: Countersunk Flat Head Screws (Common Head Style) with Type H or Type Z Cross Recess - Product Grade A - Part 2: Steel Screws of Property Class 8.8, Stainless Steel Screws and Non-Ferrous Metal Screws.

Introduction

The penetration depth of cross recesses for countersunk flat head screws is intended to satisfy two requirements, which act in opposite directions for a given head dimension.

Firstly, there is the requirement for sufficient head strength to attain the proof and breaking loads of the respective property class. A shallow cross recess increases the head strength. On the other hand, it is necessary for the wrench ability of the screw to be satisfactory; this can only be achieved by a sufficiently deep cross recess.

ISO 7721-2 was developed in order to find a compromise which, as far as possible, would meet both requirements.

ISO 7721-2 specifies deep cross recesses for countersunk head screws of low strength: a good wrench ability is achieved and the head strength is still sufficient. This execution is used in ISO 7046-1.

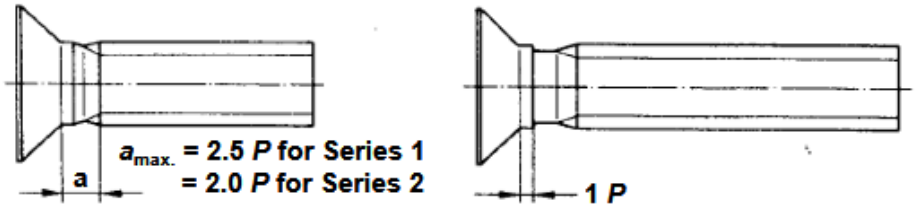
For screws of higher strength, sufficient head strength can only be attained by a shallower penetration depth of the cross recesses. If such screws also require good wrench ability, then, under the conditions of the common head style, it is necessary for a shoulder to be provided under the head, in addition to the larger penetration depth, in order to guarantee sufficient head strength. ISO 7046-2 covers both possibilities.

This compromise results in different, but interchangeable, types of cross-recessed flat countersunk head screws.

ISO 7046-2 specifies the characteristics of recessed countersunk flat head screws with threads M2 up to and including M10, of grade A and of property class 8.8 for steel, A2-70 for stainless steel and CU2 and CU3 for non-ferrous metals.

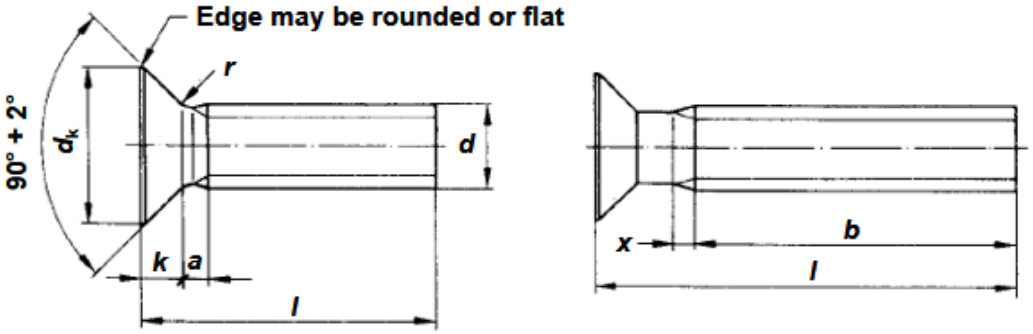
Dimensions

The shank diameter is approximately equal to the pitch diameter or equal to the major diameter permissible.

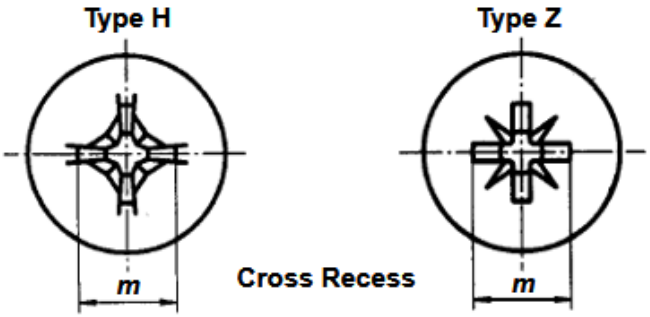


Note: For other dimensions see the following figures.

Screw with Underhead Shoulder for Penetration Depth Series 1 (Deep)



Screw without Underhead Shoulder for Penetration Depth Series 2 (Shallow)



Countersunk Flat Head Screws with Type H or Type Z Cross Recess - Property Class 8.8

Information on selected dimensions (*b*, d_k, *k*, *m*, and cross recess penetration) is given in the following table.

Thread (*d*)			M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
P (Pitch of the thread)			0,4	0,45	0.5	0,6	0,7	0,8	1	1,25	1,5
b		min.	25	25	25	38	38	38	38	38	38
d_k, actual		max.	3,8	4,7	5,5	7,30	8,40	9,30	11,30	15,80	18,30
		min.	3,5	4,4	5,2	6,9	8	8,9	10,9	15,4	17,8
k		max.	1,2	1,5	1,65	2,35	2,7	2,7	3,3	4,65	5
Recess Number			0	1		2			3	4	
Cross Recess Series 1(Deep) Type H	*m*	ref.	1,9	2,9	3,2	4,4	4,6	5,2	6,8	8,9	10
	Penetration	min.	0,9	1,4	1,7	1,9	2,1	2,7	3	4	5,1
		max.	1,2	1,8	2,1	2,4	2,6	3,2	3,5	4,6	5,7
Cross Recess Series 1(Deep) Type Z	*m*	ref.	1,9	2,8	3	4,1	4,4	4,9	6,6	8,8	9,8
	Penetration	max.	0,95	1,48	1,76	1,75	2,06	2,6	3	4,15	5,19
		min.	1,2	1,73	2,01	2,2	2,51	3,05	3,45	4,6	5,64
Cross Recess Series 2(Shallow) Type H	*m*	ref.	1,9	2,7	2,9	4,1	4,6	4,8	6,6	8,7	9,6
	Penetration	max.	0,9	1,25	1,4	1,6	2,1	2,3	2,8	3,9	4,8
		min.	1,2	1,55	1,8	2,1	2,6	2,8	3,3	4,4	5,3
Cross Recess Series 2(Shallow) Type Z	*m*	ref.	1,9	2,5	2,8	4	4,4	4,6	6,3	8,5	9,4
	Penetration	max.	0,95	1,22	1,48	1,61	2,06	2,27	2,73	3,87	4,78
		min.	1,2	1,47	1,73	2,05	2,51	2,72	3,18	4,32	5,23

* Sizes in parentheses should be avoided if possible.

Important Specifications and Reference International Standards

Material		Steel	Stainless steel
Mechanical properties	Property class	8.8	A2-70
	International Standards	ISO 898-1	ISO 3506

Designation

Example - For the designation of a cross recessed countersunk flat head screw, with thread M5, nominal length *l* = 20 mm, property class 8.8 and cross recess type Z, penetration depth series 1 or 2 at manufacturer's option:

Countersunk head screw ISO 7046-2 - M5 × 20 - 8.8 - Z

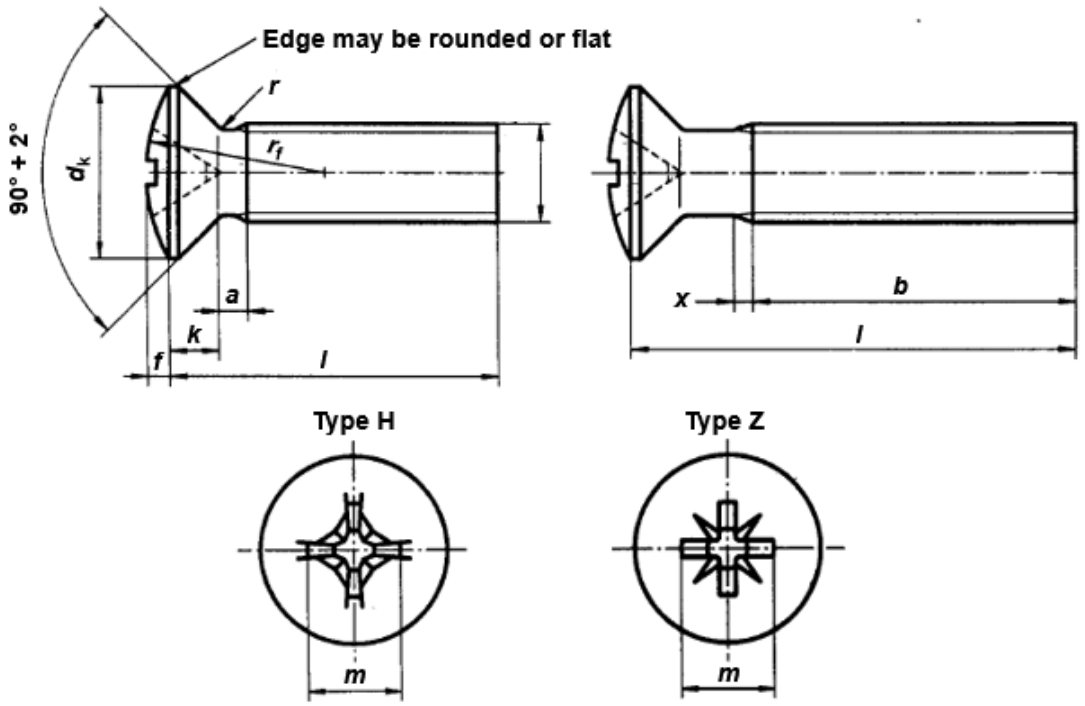
If, in special cases, one of the two series is wanted, the number of the series should be included in the designation, for example:

Countersunk head screw ISO 7046-2 - M5 × 20 - 8.8 - Z1

ISO 7047: Raised Countersunk Head Screws (Common Head Style) with Type H or Type Z Cross Recess - Product Grade A

ISO 7047 specifies the characteristics of countersunk raised head screws of product grade A, with threads from M1,6 to M10 inclusive and with type H or type Z cross recess.

Dimensions



Raised Countersunk Head Screws with Type H or Type Z Cross Recess

Information on selected dimensions (*b*, d_k, *f*, *k*, *m*, and cross recess penetration) is given in the following table.

Thread (*d*)			M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10
P (Pitch of the thread)			0,35	0,4	0,45	0.5	0,6	0,7	0,8	1	1,25	1,5
b			25	25	25	25	38	38	38	38	38	38
d_k	nom. = max.		3,0	3,8	4,7	5,5	7,30	8,40	9,30	11,30	15,80	18,30
k	nom. = max.		1	1,2	1,5	1,65	2,35	2,7	2,7	3,3	4,65	5
Recess Number			0		1		2			3	4	
Cross Recess Type H	*m*	ref.	1,9	2	3	3,4	4,8	5,2	5,4	7,3	9,6	10,4
	Penetration	max.	1,2	1,5	1,85	2,2	2,75	3,2	3,4	4	5,25	6
		min.	0,9	1,2	1,5	1,8	2,25	2,7	2,9	3,5	4,75	5,5
Cross Recess Type Z	*m*	ref.	1,9	2,2	2,8	3,1	4,6	5	5,3	7,1	9,5	10,3
	Penetration	max.	1,2	1,4	1,75	2,08	2,7	3,1	3,35	3,85	5,2	6,05
		min.	0,95	1,15	1,5	1,83	2,25	2,65	2,9	3,4	4,75	5,6

* Sizes in parentheses should be avoided if possible.

Important Specifications and Reference International Standards

Material		Steel	Stainless steel
Mechanical properties	Property class	4.8	A2-50, A2-70
	International Standards	ISO 898-1	ISO 3506

Designation

Example - A cross-recessed countersunk raised heed screw with thread M5, nominal length l = 20 mm, property class 4.8 and cross recess type Z is designated as follows:

Countersunk raised head screw ISO 7047 - M5 × 20 - 4.8 - Z

Indian Product Standards (IS) for Slotted and Cross Recessed Screws

Indian has adopted ISO product standards. ISO standard numbers and corresponding Indian standard numbers for slotted and cross recessed screws are given in the following table.

ISO Standard Number	Corresponding Indian Standard Number
4757	7478
1207	1366
1580	6101
2009	1365
2010	8911
7045	7483
7046-1	7485 (Part 1)
7046-2	7485 (Part 2)
7047	7486

Product Standards for Structural Fasteners

Information about product (dimensional) standards for structural fasteners as per ASME, ISO and IS standards is given in this chapter.

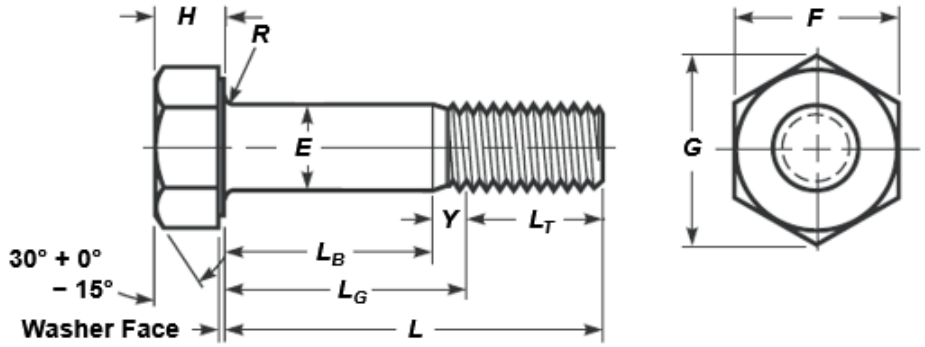
ASME B18.2.6

ASME B18.2.6 covers the complete general and dimensional data for five products in the inch series recognized as American National Standard. These five structural products include:

1. Heavy Hex Structural Bolts: ASTM A325 or ASTM A490
2. Heavy Hex Nuts: ASTM A563
3. Hardened Steel Washers; Circular, Circular Clipped or Beveled: ASTM F436
4. Compressible Washer - Type Direct Tension Indicators: ASTM F959
5. Twist-Off-Type Tension Control Structural Bolts: Heavy Hex and Round: ASTM F1852

Note: All dimensions in this Standard are in inches

Dimensions of Heavy Hex Structural Bolts: ASTM A325 or ASTM A490



Heavy Hex Structural Bolts

Dimensions

Following table shows important dimensions of heavy hex structural bolts.

Dimensions of Heavy Hex Structural Bolts														
Nominal Size or Basic Product Diameter		Body Diameter, *E*		Width Across Flats, *F*			Width Across Corners, *G*		Head Height, *H*			Radius of Fillet, *R*		Thread Length, L_T
		Max.	Min.	Nominal	Max.	Min.	Max.	Min.	Nominal	Max.	Min.	Max.	Min.	Ref.
½	0.500	0.515	0.482	⅞	0.875	0.850	1.010	0.969	5⁄16	0.323	0.302	0.031	0.009	1.00
⅝	0.625	0.642	0.605	1 1⁄16	1.062	1.031	1.227	1.175	25⁄64	0.403	0.378	0.062	0.021	1.25
¾	0.750	0.768	0.729	1¼	1.250	1.212	1.443	1.383	15⁄32	0.483	0.455	0.062	0.021	1.38
⅞	0.875	0.895	0.852	1 7⁄16	1.438	1.394	1.660	1.589	35⁄64	0.563	0.531	0.062	0.031	1.5
1	1.000	1.022	0.976	1⅝	1.625	1.575	1.876	1.796	39⁄64	0.627	0.591	0.093	0.062	1.75
1⅛	1.125	1.149	1.098	1 13⁄16	1.812	1.756	2.093	2.002	11⁄16	0.718	0.658	0.093	0.062	2.00
1¼	1.250	1.277	1.223	2	2.000	1.938	2.309	2.209	25⁄32	0.813	0.749	0.093	0.062	2.00
1⅜	1.375	1.404	1.345	2 3⁄16	2.188	2.119	2.526	2416	27⁄32	0.878	0.810	0.093	0.062	2.25
1½	1.500	1.531	1.470	2⅜	2.375	2.300	2.742	2.622	15⁄16	0.974	0.902	0.093	0.062	2.25

Bolt Length

Bolts are normally furnished in ¼ in. length increments.

Threads

Threads shall be cut or rolled in accordance with ASME B1.1 Unified Coarse, Class 2A. When specified, 8 thread series may be used on bolts over 1 in. in diameter. Structural bolts shall not be undersized to accommodate heavy coatings. Threads which have been hot-dipped or mechanically zinc coated shall meet the requirements specified in ASTM A325.

Thread Length

The length of thread on bolts shall be controlled by the grip gaging length, L_G max., and the body length, L_B min.

The maximum grip gaging length, as calculated and rounded to two decimal places for any bolt not threaded full length, shall be equal to the nominal bolt length minus the thread length (L_G max. = L nom. − L_T).

Thread length, L_T, is a reference dimension, intended for calculation purposes only, which represents the distance from the extreme end of the bolt to the last complete (full form) thread.

Materials and Processing

Chemical and mechanical properties of steel bolts shall conform to ASTM A325 or ASTM A490.

Finish

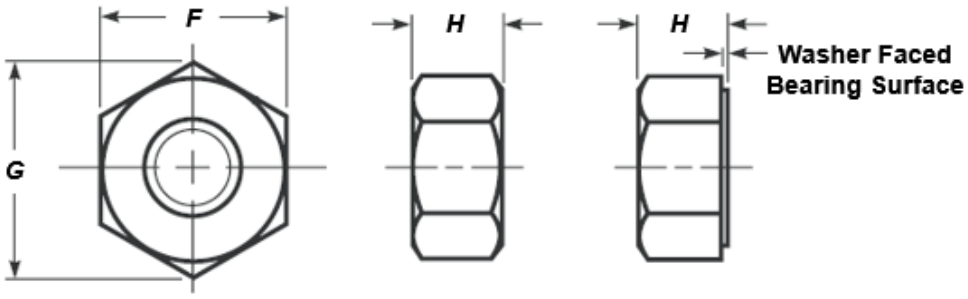
Structural fasteners shall be plain finish unless a zinc coating for all but A490 bolts is specified. ASTM A490 forbids any bolt from having a metallic coating. ASTM A325 structural bolts may be coated with zinc in accordance with ASTM F2329 or ASTM B695 Class 50, Type I.

Designation

Heavy hex structural bolts shall be designated in the sequence by: product name, specification, nominal size (fractional or decimal equivalent), threads per inch, product length (fractional or two decimal place equivalent), material (including specification and type where necessary), and protective finish (if required).

Example - Heavy Hex Structural Bolt, ASME B18.2.6, ¾ - 10 × 2¼, Type 1, Hot-Dip Zinc Coated, ASTM F2329.

Heavy Hex Nuts: ASTM A563



Heavy Hex Nuts for Use with Structural Bolts

Dimensions

Following table shows important dimensions of heavy hex nuts for use with structural bolts.

Dimensions of Heavy Hex Nuts for Use with Structural Bolts									
Nominal Size or Basic Major Diameter of Thread		Width Across Flats, *F*			Width Across Corners, *G*		Thickness *H*		
		Nominal	Max.	Min.	Max.	Min.	Nominal	Max.	Min.
½	0.500	⅞	0.875	0.850	1.010	0.969	31/64	0.504	0.464
⅝	0.625	11/16	1.062	1.031	1.227	1.175	39/64	0.631	0.587
¾	0.750	1¼	1.250	1.212	1.443	1.382	47/64	0.758	0.710
⅞	0.875	17/16	1.438	1.394	1.660	1.589	55/64	0.885	0.833
1	1.000	1⅝	1.625	1.575	1.876	1.796	63/64	1.012	0.956
1⅛	1.125	113/16	1.812	1.756	2.093	2.002	17/64	1.139	1.079
1¼	1.250	2	2.000	1.938	2.309	2.209	17/32	1.215	1.187
1⅜	1.375	23/16	2.188	2.119	2.526	2.416	111/32	1.378	1.310
1½	1.500	2⅜	2.375	2.300	2.742	2.622	115/32	1.505	1.433

Threads

Threads shall be UNC or 8 UN Class 2B in accordance with ASME B1.1. When specified, 8 thread series may be used on nuts over 1 in. in diameter.

Materials

Chemical and mechanical properties of heavy hex nuts shall conform to ASTM A 563.

Finish

Unless otherwise specified, nuts shall be supplied with a plain (as-processed) finish, unplated or uncoated. If zinc coatings are required, they shall be in accordance with ASTM A563.

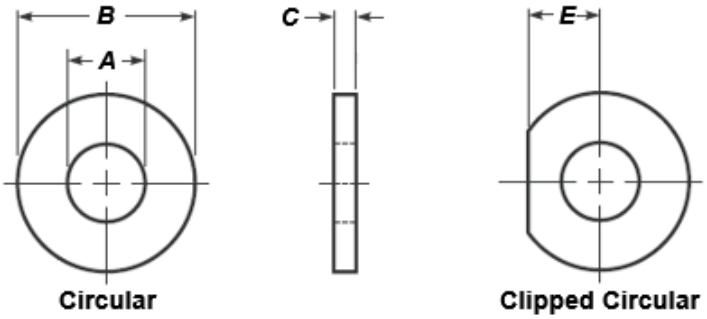
Designation

Nuts shall be designated in the sequence by: product name, specification, nominal size (fraction or decimal), threads per inch, material (including specification where necessary), and protective finish (if required).

Example - Heavy Hex Nut ASME B18.2.6, ½ - 13, ASTM A563 Grade C, Plain Finish

Hardened Steel Circular and Square Washers

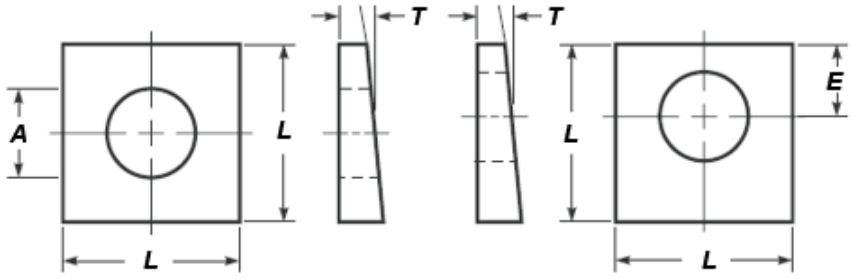
Dimensions



Hardened Steel Circular and Circular Clipped Washers

Dimensions for Hardened Steel Circular and Circular Clipped Washers									
Basic Size or Nominal Washer Size	Inside Diameter, *A*			Outside Diameter, *B*			Thickness, *C*		Nominal Edge Distance, *E*
	Nominal	Tolerance		Nominal	Tolerance				
		Plus	Minus		Plus	Minus	Min.	Max.	
½	0.531	0.0313	0	1.063	0.0313	0.0313	0.097	0.177	0.438
⅝	0.688	0.0313	0	1.313	0.0313	0.0313	0.122	0.177	0.547
¾	0.813	0.0313	0	1.469	0.0313	0.0313	0.122	0.177	0.656
⅞	0.938	0.0313	0	1.750	0.0313	0.0313	0.136	0.177	0.766
1	1.125	0.0313	0	2.000	0.0313	0.0313	0.136	0.177	0.875
1⅛	1.250	0.0313	0	2.250	0.0313	0.0313	0.136	0.177	0.984
1¼	1.375	0.0313	0	2.500	0.0313	0.0313	0.136	0.177	1.094
1⅜	1.500	0.0313	0	2.750	0.0313	0.0313	0.136	0.177	1.203
1½	1.625	0.0313	0	3.000	0.0313	0.0313	0.136	0.177	1.313

Note: Clipped edge E shall not be closer than 0.875 times the nominal bolt diameter from the center of the washer.



Hardened Steel Square and Clipped Square Beveled Washers

Dimensions for Hardened Steel Square and Clipped Square Beveled* Washers							
Nominal Washer Size		Inside Diameter, *A*			Minimum Side Length, *L*	Thickness, *T*	Nominal Edge Distance, *E*
		Nominal	Tolerance				
			Plus	Plus			
½	0.500	0.531	0.0313	0	1.750	0.313	0.438
⅝	0.625	0.688	0.0313	0	1.750	0.313	0.547
¾	0.750	0.813	0.0313	0	1.750	0.313	0.656
⅞	0.875	0.938	0.0313	0	1.750	0.313	0.766
1	1.000	1.125	0.0313	0	1.750	0.313	0.875
1⅛	1.125	1.250	0.0313	0	2.250	0.313	0.984
1¼	1.250	1.375	0.0313	0	2.250	0.313	1.094
1⅜	1.375	1.500	0.0313	0	2.250	0.313	1.203
1½	1.500	1.625	0.0313	0	2.250	0.313	1.313

* The slope or taper in thickness shall be 0.98:6 to 1.02:6.

Note: Nonclipped washers may be rectangular providing neither side dimension is less than *L*, and one side may be longer than that of the *L* min. included in the table.

Materials and Mechanical Properties

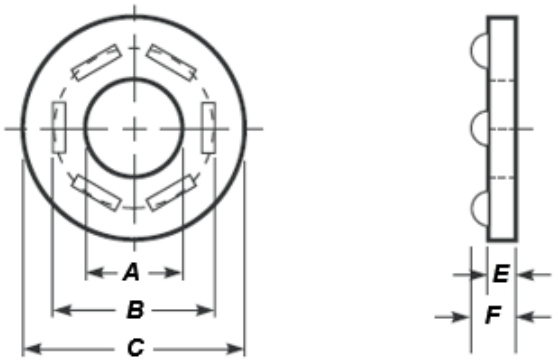
Materials and properties shall conform to the requirements established by ASTM F436.

Designation

Washers shall be designated in the sequence by: product name, specification, nominal size (fraction or decimal), material specification, and protective finish (if required).

Example - Hardened Steel Circular Washer, ASME B18.2.6, 1⅛, ASTM F436, Hot-Dip Galvanized in Accordance with ASTM A153 Class C.

Compressible Washer-Type Direct Tensions Indicators



Washer-Type Direct Tension Indicators

Dimensions

All washer-type direct tension indicators, Type A325 and A490, shall conform to the dimensions given in the following table.

Dimensions for Compressible Washer-Type Direct Tensions Indicators

Direct Tension Indicator Size, in.	All Types			Type A325					Type A490				
	Inside Diameter, *A*		Protrusion Tangential Diameter, *B*	Outside Diameter, *C*		Number of Protru-sions	Thickness		Outside Diameter, *C*		Number of Protru-sions	Thickness	
							Without Protrusion *E*	With Protrusion *F*				Without Protrusion *E*	With Protrusion *F*
	Min.	Max.	Max.	Min.	Max.		Min.	Max.	Min.	Max.		Min.	Max.
½	0.523	0.527	0.788	1.167	1.187	4	0.104	0.180	1.355	1.375	5	0.104	0.180
⅝	0.654	0.658	0.956	1.355	1.375	4	0.126	0.220	1.605	1.625	5	0.126	0.220
¾	0.786	0.790	1.125	1.605	1.625	5	0.126	0.230	1.730	1.750	6	0.142	0.240
⅞	0.917	0.921	1.294	1.855	1.875	5	0.142	0.240	1.980	2.000	6	0.158	0.260
1	1.048	1.052	1.463	1.980	2.000	6	0.158	0.270	2.230	2.250	7	0.158	0.270
1⅛	1.179	1.183	1.631	2.230	2.250	6	0.158	0.270	2.480	2.500	7	0.158	0.280
1¼	1.311	1.315	1.800	2.480	2.500	7	0.158	0.270	2.730	2.750	8	0.158	0.280
1⅜	1.442	1.446	1.969	2.730	2.750	7	0.158	0.270	2.980	3.000	8	0.158	0.280
1½	1.573	1.577	2.138	2.980	3.000	8	0.158	0.270	3.230	3.250	9	0.158	0.280

Finish

Unless otherwise specified, direct tension indicators shall be supplied with a plain finish, unplated, or uncoated. If a protective coating is required, it shall be in accordance with ASTM F959.

Materials and Properties

Direct tension indicators shall conform to the requirements of ASTM F959.

Designation

Compressible washer-type direct tension indicators shall be designated in the sequence by: product name, specification, nominal size (fractional or decimal equivalent), Type (325 or 490), and finish (plain, zinc, or epoxy).

Example - DTI, ASME B18.2.6, ½, Type 325 per ASTM F959, Plain Finish

Note: For information on twist-off-type tension control structural bolts: heavy hex and round: ASTM F1852, please see the standard (ASME B18.2.6).

ISO Standards for Structural Fasteners

Following were (as now withdrawn) ISO standards for structural bolts and nuts.

ISO 4775:1984
Hexagon nuts for high-strength structural bolting with large width across flats - Product grade B - Property classes 8 and 10

ISO 7411:1984
Hexagon bolts for high-strength structural bolting with large width across flats (thread lengths according to ISO 888) - Product grade C - Property classes 8.8 and 10.9

ISO 7412:1984
Hexagon bolts for high-strength structural bolting with large width across flats (short thread length) - Product grade C - Property classes 8.8 and 10.9

ISO 7413:1984
Hexagon nuts for structural bolting, style 1, hot-dip galvanized (oversize tapped) - Product grades A and B - Property classes 5, 6 and 8

ISO 7414:1984
Hexagon nuts for structural bolting with large width across flats, style 1 - Product grade B - Property class 10

ISO 7417:1984
Hexagon nuts for structural bolting - Style 2, hot-dip galvanized (oversize tapped) - Product grade A - Property class 9

ISO 7415:1984
Plain washers for high-strength structural bolting, hardened and tempered

ISO 7416:1984
Plain washers, chamfered, hardened and tempered for high-strength structural bolting

As above listed ISO standards are withdrawn, information about ISO 7412:1984 (withdrawn) only is given here.

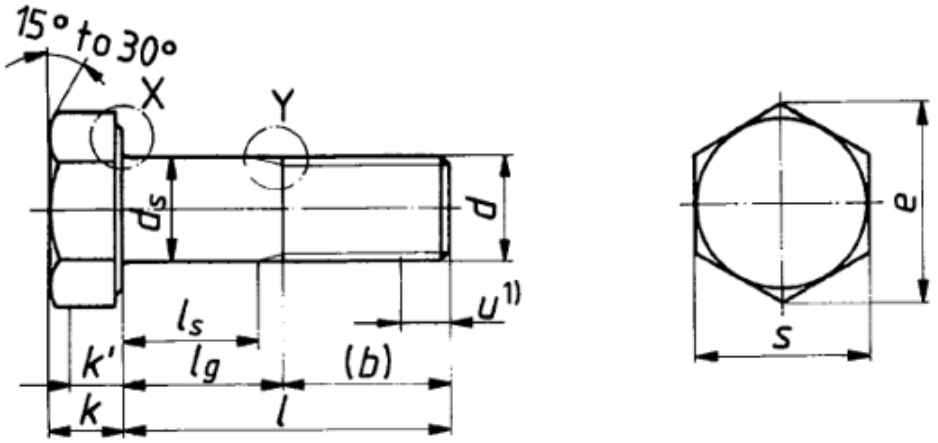
ISO 7412:1984 - Hexagon Bolts for High-Strength Structural Bolting with Large Width Across Flats (Short Thread Length) - Product Grade C - Property Classes 8.8 And 10.9

ISO 7412:1984 gives specifications for large series hexagon, high-strength structural bolts with metric dimensions in property classes 8.8 and 10.9, and thread sizes from M12 up to and including M36, with short thread lengths.

Bolts to this standard when matched with the appropriate nut (see IS0 4775) have been designed to provide an assembly with a high level of assurance against failure by thread stripping on overtightening. This applies to all property classes and finishes except 8.8S U[#] and 10.9S U[#] bolts which may be adopted by agreement between the purchaser and the supplier. 8.8S U and 10.9S U bolts must be matched with 6H galvanized nuts to IS0 4775 and the resulting assembly may show failure by thread stripping on overtightening.

[#] the letter S to denote a high-strength structural bolt with a large series hexagon head; and the letter U to indicate when, by agreement between the manufacturer and the user, bolts have been made with threads undersized before galvanizing.

Dimensions



Hexagon Bolts for High-Strength Structural Bolting with Large Width Across Flats

Information on selected dimensions (*b*, *k*, *k*', *e* and *s*) is given in the following table (all dimensions are in mm).

Hexagon Bolts for High-Strength Structural Bolting with Large Width Across Flats									
Thread Size *d*		M12*	M16	M20	(M22)[#]	M24	(M27)[#]	M30	M36
***P* (pitch of thread)**		1,75	2	2,5	2,5	3	3	3,5	4
b_{ref}	For lengths $l_{nom} \leq 100$ mm	25	31	36	38	41	44	49	56
	For lengths $l_{nom} > 100$ mm	32	38	43	45	48	51	56	63
k	nom.	7,5	10	12,5	14	15	17	18,5	22,5
k'	min.	4,9	6,5	8,1	9,2	9,9	11,3	12,4	15,0
e	min.	22,78	29,56	37,29	39,55	45,20	50,85	55,37	66,44
s	max.	21	27	34	36	41	46	50	60
	min.	20,16	26,16	33	35	40	45	49	58,8

* Non-preferred for technical reasons.
[#] Indicates second choice diameter.

Note: For hot-dip galvanized bolts, the above dimensions apply before galvanizing.

Specifications and Reference Standards

Information on important specifications and reference standards is as under.

Material		**Steel**
Thread	Tolerance	6g[#]
	International Standards	ISO 261, ISO 965
Mechanical properties	Property class	8.8, 10.9
	International Standards	ISO 898-1
Associated nuts		IS0 4775 or IS0 7414
Associated plain hole washers		IS0 7415
Associated chamfered hole washers		IS0 7416

[#] The tolerance class specified applies before electroplating or hot-dip galvanizing.

Note: For fasteners with zinc electroplated or hot-dip galvanized coatings the manufacturer shall apply a suitable lubricant coating on the bolts, or the mating nuts, to ensure that seizure shall not take place in assembly.

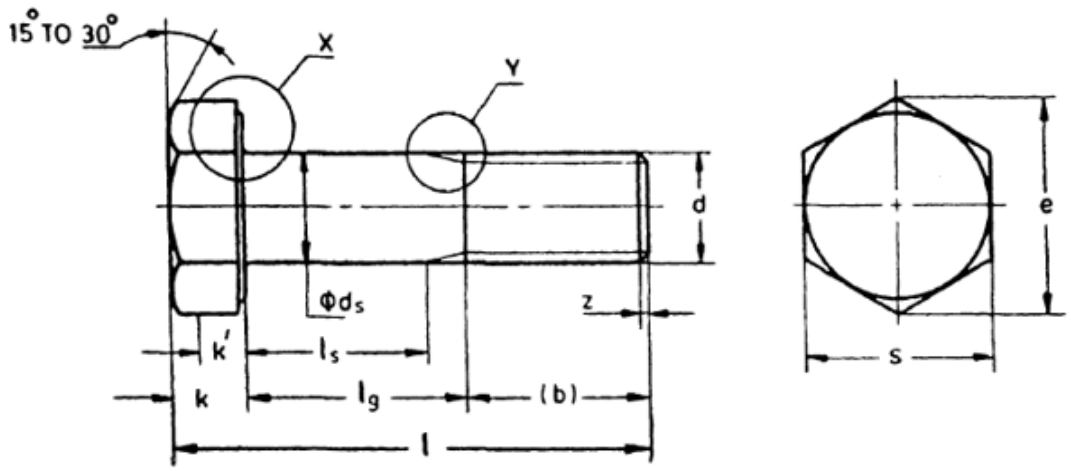
IS Standards for Structural Fasteners

Information on three IS standards for structural fasteners, IS 3757, IS 6623 and IS 6649 is as under.

IS: 3757 - Specification for High Strength Structural Bolts

IS: 3757 covers the requirements for large series hexagon, high strength structural steel bolts in property classes 8.8 and 10.9 and in the size range M16 to M36 with short thread lengths suitable for use in both friction-type and bearing-type structural steel joints. Bolts to this standard when matched with the appropriate nuts have been designed to provide an assembly with a high level of assurance against failure by thread stripping on overtightening.

Dimensions



Dimensions for High Strength Structural Bolts

Information on selected dimensions (*b*, *k*, *k*', *e* and *s*) is given in the following table (all dimensions are in mm).

Dimensions for High Strength Structural Bolts*								
Thread Size *d*		M16	M20	(M22)#	M24	(M27)#	M30	M36
***P* (pitch of thread)**		2	2.5	2.5	3	3	3.5	4
b_{ref}	For lengths $l_{nom} \leq 100$ mm	31	36	38	41	44	49	56
	For lengths $l_{nom} > 100$ mm	38	43	45	48	51	56	63
k	nom.	10	12.5	14	15	17	18.5	22.5
k'	min.	6.5	8.1	9.2	9.9	11.3	12.4	15.0
e	min.	29.56	37.29	39.55	45.20	50.85	55.37	66.44
s	max.	27	34	36	41	46	50	60
	min.	26.16	33	35	40	45	49	58.8

* For hot-dip galvanized bolts, the above dimensions apply before galvanizing.
# Sizes shown in brackets are of second preference.

Following are the important technical requirements for this standard.

Grade

Unless otherwise specified, the bolts shall be of product grade C as specified in IS: 1367 (Part 2)-1979.

Mechanical Properties

The bolts shall be of property class 8.8 or 10.9 as specified in IS: 1367 (Part 3)-1979.

Finish

Unless specified otherwise, the bolts shall be supplied in the dull black heat-treated condition with a residual coating of light oil.

Where property class 8.8 bolts are required to be hot-dip galvanized, they shall be galvanized in accordance with the requirements of IS: 1367 (Part 13). For fasteners with hot-dip galvanized coatings, the bolts or the mating nuts shall be provided with a suitable lubricant which shall be clean and dry to the touch to ensure that seizure shall not take place in assembly.

Nuts

The high strength structural nuts to be used with these bolts shall conform to the requirements of IS: 6623 High strength structural nuts. These nuts shall be of the property class and finish for each type of bolt as follows:

Bolt Property Class and Finish	Nut Property Class and Finish
8.8S, dull black	8S or 10S, dull black
8.8S, hot-dip galvanized	10S, hot-dip galvanized
10.9S, dull black	10S, dull black

Washers

Hardened and tempered washers to be used with these bolts shall conform to the requirements of IS: 6649 Hardened and tempered washers for high strength structural bolts and nuts.

Designation

High strength structural bolts shall be designated by name, size, nominal length, the number of this standard and the property class identification symbol 8.8S or 10.9S - the suffix letter S denotes a high strength structural bolt with a large series hexagon head. In case of hot dip galvanized bolts, the word ‘galvanized’ shall be added to the designation.

Example:

A high strength structural bolt of size M24, length 140 mm, property class 8.8 and galvanized shall be designated as: High Strength Structural Bolt M24 × 140 IS: 3757 - 8.8S galvanized.

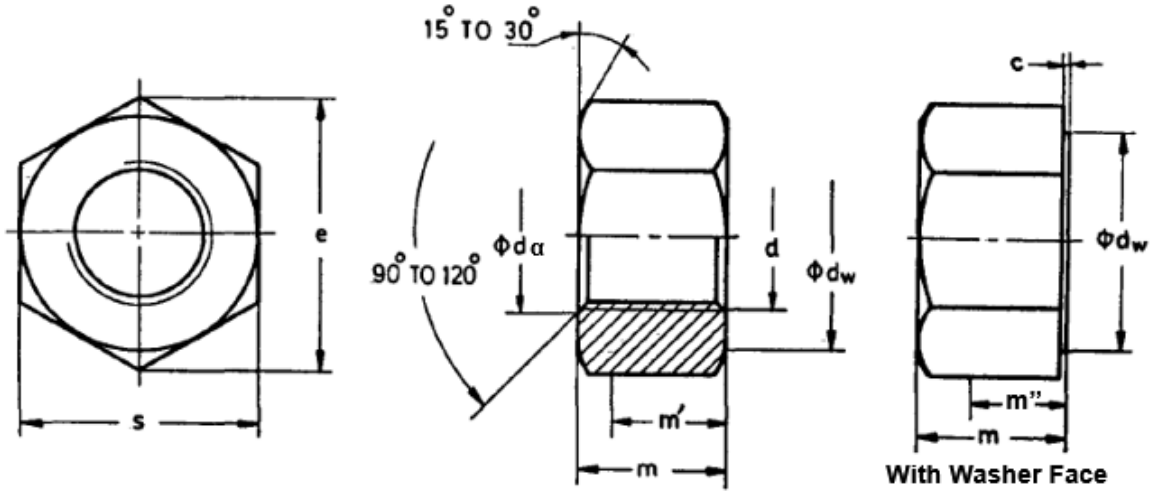
If the bolt in the above example is required with a hot-dip galvanized high strength structural nut (see IS: 6623), the letter N shall be added to the designation as follows:

High Strength Structural Bolt M24 × 140 N IS: 3757 - 8.8S galvanized.

IS: 6623 - High Strength Structural Nuts

IS: 6623 covers the requirements of large series hexagon, high strength structural steel nuts of property classes 8 and 10 in the size range of M12 to M36 suitable for use in both friction-type and bearing-type of structural steel connections.

Dimensions



High Strength Structural Nuts

Information on selected dimensions (*m*, *c*, *e* and *s*) is given in the following table (all dimensions are in mm).

	Dimensions for High Strength Structural Nuts								
Thread Size *d*		M12	M16	M20	(M22)#	M24	(M27)#	M30	M36
***P* (pitch of thread)**		1.75	2	2.5	2.5	3	3	3.5	4
m	max.	12.3	17.1	20.7	23.6	24.2	27.6	30.7	36.6
	min.	11.9	16.4	19.4	22.3	22.9	26.3	29.1	35.0
c	max.	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
	min.	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
e	min.	22.78	29.56	37.29	39.55	45.20	50.85	55.37	66.44
s	max.	21.00	27	34	35	41	46	50	60
	min.	20.16	26.16	33	34	40	45	49	58.8

Sizes shown in brackets are of second preference.

Following are the important technical requirements for this standard.

Mechanical Properties

The nuts shall be of property class 8 or 10 as specified in IS 1367(Part 6) except that all nuts shall be hardened and then tempered at a temperature of at least 425° C.

Finish

Unless otherwise specified, the nuts shall be supplied in the dull black heat-treated condition with a residual coating of light oil.

Where the nuts of property class 10, are required to be hot-dip galvanized, they shall be galvanized in accordance with the requirements of IS 1367 (Part 13). For fasteners with hot-dip galvanized coatings, the nuts of the mating bolts shall be provided with a suitable lubricant coating.

Designation

The high strength structural nuts shall be designated by name, size, and property class identification symbol 8S or 10S (the suffix letter S denotes a high strength structural nut with

a large series hexagon) and number of this Indian Standard. In case of hot-dip galvanized nuts the word ‘galvanized’ shall also be added to the designation.

Example:

A high strength structural nut of size M24, property class 8 and galvanized shall be designated as: High Strength Structural Nut - M24 IS 6623 - 8S Galvanized

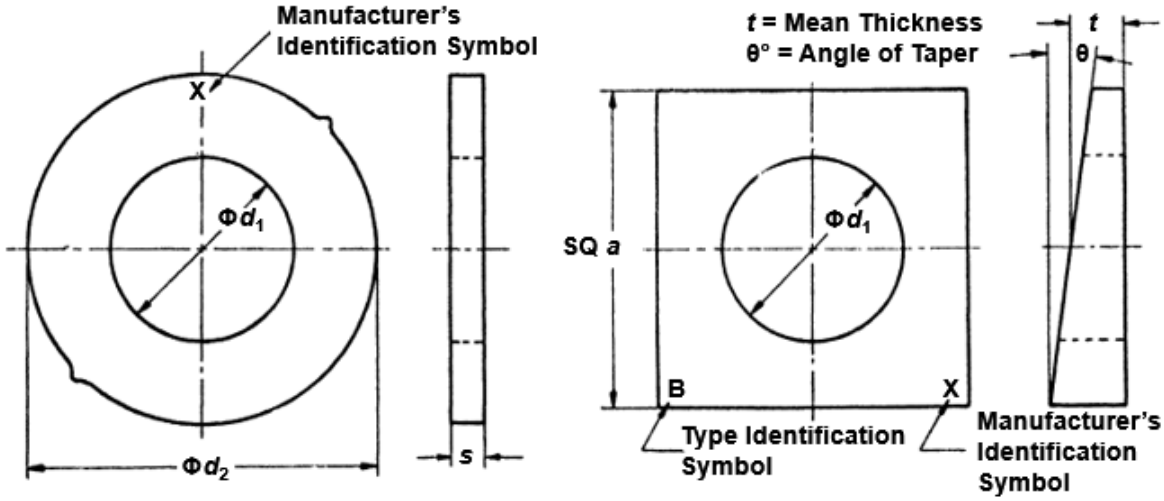
IS 6649 - Hardened and Tempered Washers for High Strength Structural Bolts and Nuts

IS 6649 covers the requirements for through hardened and tempered steel washers intended for assembly with large series hexagon, high strength structural bolts and nuts in the size range M16 to M36.

These washers shall be of the following types:

Type A - Plain hole circular washers.
Type B - Square taper washers for use with channels (6° taper)
Type C - Square taper washers for use with I-beams (8° taper)

Dimensions



Washers for High Strength Structural Bolts and Nuts

Type A plain hole circular washers shall be identified by the provision of two nibs as shown in above figure. Information on selected dimensions for plain hole circular washers and square taper washers is given in the following tables (all dimensions are in mm).

Dimensions for Plain Hole Circular Washers (Type A)								
Nominal Size (Thread size *d* of associated bolt)		M16	M20	(M22)#	M24	(M27)#	M30	M36
d_1	Min.	18	22	24	26	30	33	39
	Max.	18.43	22.52	24.52	26.52	30.52	33.62	39.62
d_2	Min.	32.4	40.4	42.4	48.4	54.1	58.1	70.1
	Max.	34	42	44	50	56	60	72
s	Min.	3.1	3.1	3.4	3.4	3.4	3.4	3.4
	Max.	4.6	4.6	4.6	4.6	4.6	4.6	4.6

Sizes shown within brackets are non-preferred.

Dimensions for Square Taper Washers (Type B and Type C)								
Nominal Size (Thread size *d* of associated bolt)		M16	M20	(M22)#	M24	(M27)#	M30	M36
d_1	Min.	18	22	24	26	30	33	39
	Max.	18.43	22.52	24.52	26.52	30.52	33.62	39.62
a	Min.	42	42	42	42	55	55	55
	Max.	45	45	45	45	58	58	58
t	Min.	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Max.	8.5	8.5	8.5	8.5	8.5	8.5	8.5
θ°	Type B	6	6	6	6	6	6	6
	Type C	8	8	8	8	8	8	8

Sizes shown within brackets are non-preferred.

Following are the important technical requirements for this standard.

Heat Treatment

The washers shall be through hardened and tempered. Carburized washers are not suitable.

Hardness

The washers shall be subjected to a hardness test in accordance with IS: 1586 and the hardness shall be between 35 to 45 HRC. The minimum hardness for hot-dip galvanized washers shall be 26 HRC.

Finish

Unless specified otherwise, the washers shall be supplied in the dull black heat-treated condition with a residual coating of light oil.

Where washers are required to be hot-dip galvanized, they shall conform to IS: 4759 except that the minimum value of average mass of coating shall be 300 g/m^3.

For hot-dip galvanized washers. precautions to avoid hydrogen embrittlement will be necessary and shall be taken as per IS: 6158.

Designation

Hardened and tempered washers shall be designated by the word 'washer', nominal size, type and the number of this standard. In case of hot-dip galvanized washers the word 'galvanized' shall be added to the designation.

Examples:

A plain hole circular washer of nominal size M24 conforming to this standard and galvanized shall be designated as:

Washer M24 A IS: 6649 galvanized.

A square taper washer of 6° taper for use with channels, of nominal size M24 conforming to this standard and galvanized shall be designated as:

Washer M24 B IS: 6649 galvanized.

Product Standards for Socket Cap Screws and Socket Screw Keys

Socket cap screws were developed for applications with limited space. They have internal wrenching features that allow them to be used in locations where externally wrenched fasteners aren't desirable. The tools for driving socket screws are hexagon or spline keys and bits. Technically, a bolt is installed by turning a nut to tighten the fastener, while a cap screw in installed by turning the head of the screw to assemble and tighten. Therefore, cap screws are often threaded into a tapped hole on a piece of equipment or machinery. Information about socket cap screws based on ASME B18.3 and ISO product (dimensional) standards is given in this chapter.

ASME B18.3: Socket Cap, Shoulder, Set Screws, and Hex Keys (Inch Series)

ASME B18.3 covers complete general and dimensional data for various types of hexagon and spline (fluted) socket cap screws, shoulder screws, set screws, and hexagon and spline keys recognized as an American National Standard.

Socket Cap Screws Head Types

Socket Head Cap Screws

The head of socket head cap screws is having a flat chamfered top surface with smooth or knurled cylindrical sides and a flat bearing surface. Drilled hexagon socket head cap screws are having two, four, and six holes drilled in the head of hexagon socket head cap screws for lock wire application. The size of component parts can be reduced by using socket head cap screws since the cylindrical heads of socket head cap screws need less space than hex heads and require no additional wrench space. They are used for critical vehicle applications, machine tools, tools and dies, and a wide range of engineering applications.

Socket Flat Countersunk Head Cap Screws

Socket flat countersunk head cap screws are shaving a flat top surface and a conical bearing surface with included angle of approximately 82 degrees.

Socket Button Head Cap Screws

The head of socket button head cap screws is having a low rounded top surface with a large flat bearing surface.

Socket Cap Screws Head Types

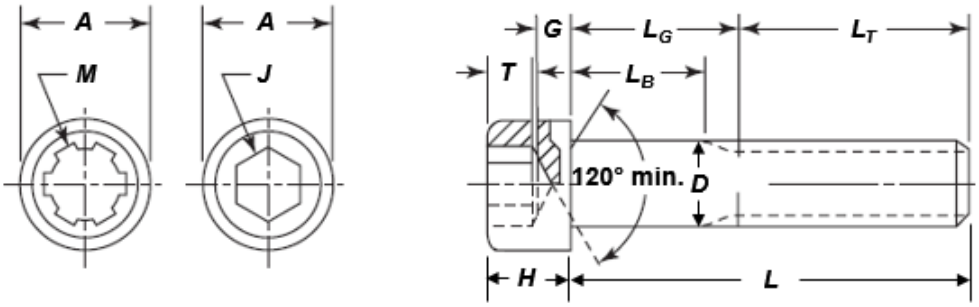
Socket Low Head Cap Screws

Socket low head cap screws are similar to socket head cap screws, except they have reduced head height and a smaller socket size. They are designed to be used in applications where height clearance is a problem. They are used in parts too thin for standard socket head cap screws and where clearance is limited.

Socket Head Shoulder Screws

The socket head shoulder screw is a hexagon socket head screw having a cylindrical shoulder under the head. They are used in tool and die industry. They also replace costly special parts such as pivots, guides, linkages, etc.

Hexagon and Spline Socket Head Cap Screws



Hexagon and Spline Socket Head Cap Screws

Dimensions (only important dimensions are shown) of hexagon and spline socket head cap screws shall be as per the following table.

Dimensions of Hexagon and Spline Socket Head Cap Screws (in inch)

Nominal Size (Basic Screw Diameter)		Head Diameter, *A*		Head Height, *H*		Nom. Spline Socket Size, *M*	Nom. Hexagon Socket Size, *J*		Minimum Key Engagement, *T*	Min. Wall Thickness, *G*
		Max.	Min.	Max.	Min.					
0	(0.0600)	0.096	0.091	0.060	0.057	0.060	-	0.050	0.025	0.020
1	(0.0730)	0.118	0.112	0.073	0.070	0.072	1/16	0.062	0.031	0.025
2	(0.0860)	0.140	0.134	0.086	0.083	0.096	5/64	0.078	0.038	0.029
3	(0.0990)	0.161	0.154	0.099	0.095	0.096	5/64	0.078	0.044	0.034
4	(0.1120)	0.183	0.176	0.112	0.108	0.111	3/32	0.094	0.051	0.038
5	(0.1250)	0.205	0.198	0.125	0.121	0.111	3/32	0.094	0.057	0.043
6	(0.1380)	0.226	0.218	0.138	0.134	0.133	7/64	0.109	0.064	0.047
8	(0.1640)	0.270	0.262	0.164	0.159	0.168	9/64	0.141	0.077	0.056
10	(0.1900)	0.312	0.303	0.190	0.185	0.183	5/32	0.156	0.090	0.065
1/4	(0.2500)	0.375	0.365	0.250	0.244	0.216	3/16	0.188	0.120	0.095
5/16	(0.3125)	0.469	0.457	0.312	0.306	0.291	1/4	0.250	0.151	0.119
3/8	(0.3750)	0.562	0.550	0.375	0.368	0.372	5/16	0.312	0.182	0.143
7/16	(0.4375)	0.656	0.642	0.438	0.430	0.454	3/8	0.375	0.213	0.166
1/2	(0.5000)	0.750	0.735	0.500	0.492	0.454	3/8	0.375	0.245	0.190
5/8	(0.6250)	0.938	0.921	0.625	0.616	0.595	1/2	0.500	0.307	0.238
3/4	(0.7500)	1.125	1.107	0.750	0.740	0.620	5/8	0.625	0.370	0.285
7/8	(0.8750)	1.312	1.293	0.875	0.864	0.698	3/4	0.750	0.432	0.333
1	(1.0000)	1.500	1.479	1.000	0.988	0.790	3/4	0.750	0.495	0.380
1 1/8	(1.1250)	1.688	1.665	1.125	1.111	-	7/8	0.875	0.557	0.428
1 1/4	(1.2500)	1.875	1.852	1.250	1.236	-	7/8	0.875	0.620	0.475
1 3/8	(1.3750)	2.062	2.038	1.375	1.360	-	1	1.000	0.682	0.523
1 1/2	(1.5000)	2.250	2.224	1.500	1.485	-	1	1.000	0.745	0.570
1 3/4	(1.7500)	2.625	2.597	1.750	1.734	-	1 1/4	1.250	0.870	0.665
2	(2.0000)	3.000	2.970	2.000	1.983	-	1 1/2	1.500	0.995	0.760
2 1/4	(2.2500)	3.375	3.344	2.250	2.232	-	1 3/4	1.750	1.120	0.855
2 1/2	(2.5000)	3.750	3.717	2.500	2.481	-	1 3/4	1.750	1.245	0.950
2 3/4	(2.7500)	4.125	4.090	2.750	2.730	-	2	2.000	1.370	1.045
3	(3.0000)	4.500	4.464	3.000	3.979	-	2 1/4	2.250	1.495	1.140
3 1/4	(3.2500)	4.875	4.837	3.250	3.228	-	2 1/4	2.250	1.620	1.235
3 1/2	(3.5000)	5.250	5.211	3.500	3.478	-	2 3/4	2.750	1.745	1.330
3 3/4	(3.7500)	5.625	5.584	3.750	3.727	-	2 3/4	2.750	1.870	1.425
4	(4.0000)	6.000	5.958	4.000	3.976	-	3	3.000	1.995	1.520

General Notes

Heads may be plain or knurled at the option of the manufacturer, unless specified otherwise by the customer. For knurled screws, the maximum head diameter shall be measured across the tops of the knurl, and the minimum head diameter shall be the diameter of the unknurled portion or the diameter across the tops of the knurl for those screws not having an unknurled portion, just above the radius or chamfer at the bottom edge of the head.

Threads shall be Unified external threads with radius root: Class 3A UNRC and UNRF Series for screw sizes 0 (0.060 in.) through 1 in.; Class 2A UNRC and UNRF Series for sizes over 1 in. to 1½ in., inclusive; and Class 2A UNR Series for sizes larger than 1½ in. For plated or unplated screws, acceptability shall be based upon System 22, ASME B1.3M. Class 3A does not provide a plating allowance. When plated products are required, it is recommended that they be procured from the manufacturer

Alloy steel cap screws shall be fabricated from an alloy steel and shall conform in all respects to ASTM A 574. Corrosion-resistant steel cap screws shall be fabricated from a corrosion-resistant steel and shall conform in all respects to ASTM F 837.

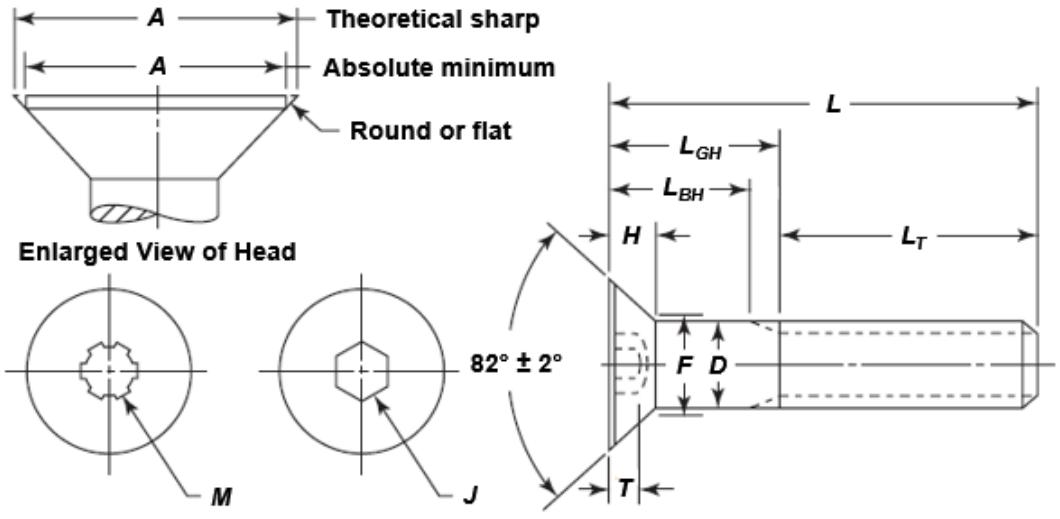
It is recommended that hexagon and spline socket head cap screws be designated in accordance with the data, preferably in the sequence by: product name, designation of the standard, nominal size (number, fractional or decimal equivalent), thread pitch, nominal length (fractional or decimal equivalent), material, protective finish, if required.

Examples:

Hexagon Socket Head Cap Screws, ASME B18.3, 6-32 × ¾, Alloy Steel
Spline Socket Head Cap Screws, ASME B18.3, 0.138-32 × 0.750, Alloy Steel, Zinc Plated.

For information (dimensions) about hexagon socket size, *J* and spline socket size *M*, please see the standard.

Hexagon and Spline Socket Flat Countersunk Head Cap Screws



Hexagon and Spline Socket Flat Countersunk Head Cap Screws

Dimensions (only important dimensions are shown) of hexagon and spline socket flat countersunk head cap screws shall be as per the following table.

Dimensions of Hexagon and Spline Socket Flat Countersunk Head Cap Screws (in inch)								
Nominal Size (Basic Screw Diameter)		Head Diameter, *A*		Reference Head Height, *H*	Spline Socket Size, *M*	Nominal Hexagon Socket Size, *J*		Min. Key Engage-ment, *T*
		Theo. Sharp, Max.	Absolute, Min.					
0	(0.0600)	0.138	0.117	0.044	0.048	-	0.035	0.025
1	(0.0730)	0.168	0.143	0.054	0.060	-	0.050	0.031
2	(0.0860)	0.197	0.168	0.064	0.060	-	0.050	0.038
3	(0.0990)	0.226	0.193	0.073	0.072	1/16	0.062	0.044
4	(0.1120)	0.255	0.218	0.083	0.072	1/16	0.062	0.055
5	(0.1250)	0.281	0.240	0.090	0.096	5/64	0.078	0.061
6	(0.1380)	0.307	0.263	0.097	0.096	5/64	0.078	0.066
8	(0.1640)	0.359	0.311	0.112	0.111	3/32	0.094	0.076
10	(0.1900)	0.411	0.359	0.127	0.145	1/8	0.125	0.087
1/4	(0.2500)	0.531	0.480	0.161	0.183	5/32	0.156	0.111
5/16	(0.3125)	0.656	0.600	0.198	0.216	3/16	0.188	0.135
3/8	(0.3750)	0.781	0.720	0.234	0.251	7/32	0.219	0.159
7/16	(0.4375)	0.844	0.781	0.234	0.291	1/4	0.250	0.159
1/2	(0.5000)	0.938	0.872	0.251	0.372	5/16	0.312	0.172
5/8	(0.6250)	1.188	1.112	0.324	0.454	3/8	0.375	0.220
3/4	(0.7500)	1.438	1.355	0.396	0.454	1/2	0.500	0.220
7/8	(0.8750)	1.688	1.604	0.468	-	9/16	0.562	0.248
1	(1.0000)	1.938	1.841	0.540	-	5/8	0.625	0.297
1 1/8	(1.1250)	2.188	2.079	0.611	-	3/4	0.750	0.325
1 1/4	(1.2500)	2.438	2.316	0.683	-	7/8	0.875	0.358
1 3/8	(1.3750)	2.688	2.553	0.755	-	7/8	0.875	0.402
1 1/2	(1.5000)	2.938	2.791	0.827	-	1	1.000	0.435

General Notes

For head diameter, maximum sharp values under column *A* are theoretical values only, as it is not practical to make the edges of the head sharp. The maximum sharp value represents the exact diameter of the hole countersunk to exactly 82°, in which a screw having maximum head size will fit flush.

Threads shall be Unified external threads with radius root: Class 3A UNRC and UNRF Series for sizes 0 (0.060 in.) through 1 in.; Class 2A UNRC and UNRF Series for sizes over 1 in. to 1½ in., inclusive. Acceptability shall be based on System 22, ASME B1.3M. Class 3A does not provide a plating allowance. When plated products are required, it is recommended that they be procured from the manufacturer.

Alloy steel flat countersunk head cap screws shall be fabricated from an alloy steel and shall conform in all respects to ASTM F 835. Corrosion-resistant steel flat countersunk head cap screws shall be fabricated from austenitic corrosion-resistant steel and shall conform in all respects to ASTM F 879.

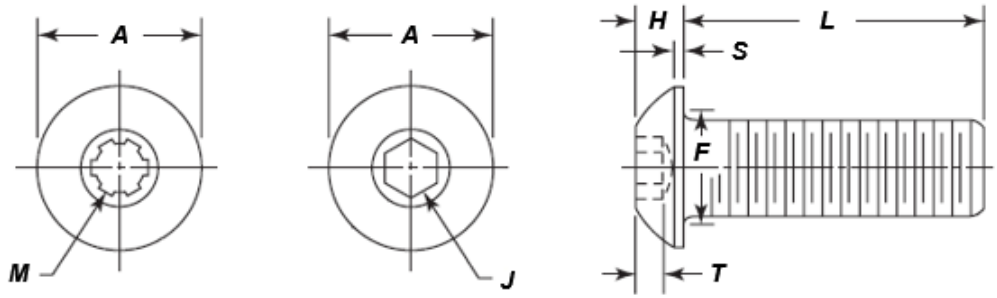
It is recommended that hexagon and spline flat countersunk socket head cap screws be designated in accordance with the data, preferably in the sequence by: product name, designation of the standard, nominal size (number, fractional or decimal equivalent), thread pitch, nominal length (fractional or decimal equivalent), material, protective finish, if required.

Examples:

Hexagon Socket Flat Countersunk Head Cap Screws, ASME B18.3, ¼-28 × 1¾, Alloy Steel
Hexagon Socket Flat Countersunk Head Cap Screws, ASME B18.3, 0.250-28 × 1.750, Corrosion-Resistant Steel

Hexagon Socket Flat Countersunk Head Cap Screws, ASME B18.3, 6-32 × 0.500, Alloy Steel, Zinc Plated.

Hexagon and Spline Socket Button Head Cap Screws



Hexagon and Spline Socket Button Head Cap Screws

Dimensions (only important dimensions are shown) of hexagon and spline socket button head cap screws shall be as per the following table.

Dimensions of Hexagon and Spline Socket Button Head Cap Screws (in inch)										
Nominal Size (Basic Screw Diameter)		Head Diameter, A		Head Height, H		Head Side Height, S	Spline Socket Size, *M*	Nominal Hexagon Socket Size, *J*		Min. Key Engage-ment, *T*
		Max.	Min.	Max.	Min.					
0	(0.0600)	0.114	0.104	0.032	0.026	0.010	0.048	-	0.035	0.020
1	(0.0730)	0.139	0.129	0.039	0.033	0.010	0.060	-	0.050	0.028
2	(0.0860)	0.164	0.154	0.046	0.038	0.010	0.060	-	0.050	0.028
3	(0.0990)	0.188	0.176	0.052	0.044	0.010	0.072	1⁄16	0.062	0.035
4	(0.1120)	0.213	0.201	0.059	0.051	0.015	0.072	1⁄16	0.062	0.035
5	(0.1250)	0.238	0.226	0.066	0.058	0.015	0.096	5⁄64	0.078	0.044
6	(0.1380)	0.262	0.250	0.073	0.063	0.015	0.096	5⁄64	0.078	0.044
8	(0.1640)	0.312	0.298	0.087	0.077	0.015	0.111	3⁄32	0.094	0.052
10	(0.1900)	0.361	0.347	0.101	0.091	0.020	0.145	1⁄8	0.125	0.070
1⁄4	(0.2500)	0.437	0.419	0.132	0.122	0.031	0.183	5⁄32	0.156	0.087
5⁄16	(0.3125)	0.547	0.527	0.166	0.152	0.031	0.216	3⁄16	0.188	0.105
3⁄8	(0.3750)	0.656	0.636	0.199	0.185	0.031	0.251	7⁄32	0.219	0.122
1⁄2	(0.5000)	0.875	0.851	0.265	0.245	0.046	0.372	5⁄16	0.312	0.175
5⁄8	(0.6250)	1.000	0.970	0.331	0.311	0.062	0.454	3⁄8	0.375	0.210

General Notes

Hexagon and spline socket button head cap screws are designed and recommended for light fastening applications such as guards, hinges, etc. It is not suggested for use in critical high strength applications where socket head cap screws should normally be used.

Threads shall be Unified external threads with radius root: Class 3A UNRC and UNRF Series. Acceptability shall be based on System 22, ASME B1.3M. Class 3A does not provide a plating allowance. When plated products are required, it is recommended that they be procured from the manufacturer.

Alloy steel button head cap screws shall be fabricated from an alloy steel and shall conform in all respects to ASTM F 835. Corrosion-resistant steel button head cap screws shall be fabricated from austenitic corrosion-resistant steel and shall conform in all respects to ASTM F 879.

It is recommended that hexagon and spline socket button head cap screws be designated in accordance with the data, preferably in the sequence by: product name, designation of the standard, nominal size (number, fractional or decimal equivalent), thread pitch, nominal length (fractional or decimal equivalent), material, protective finish, if required.

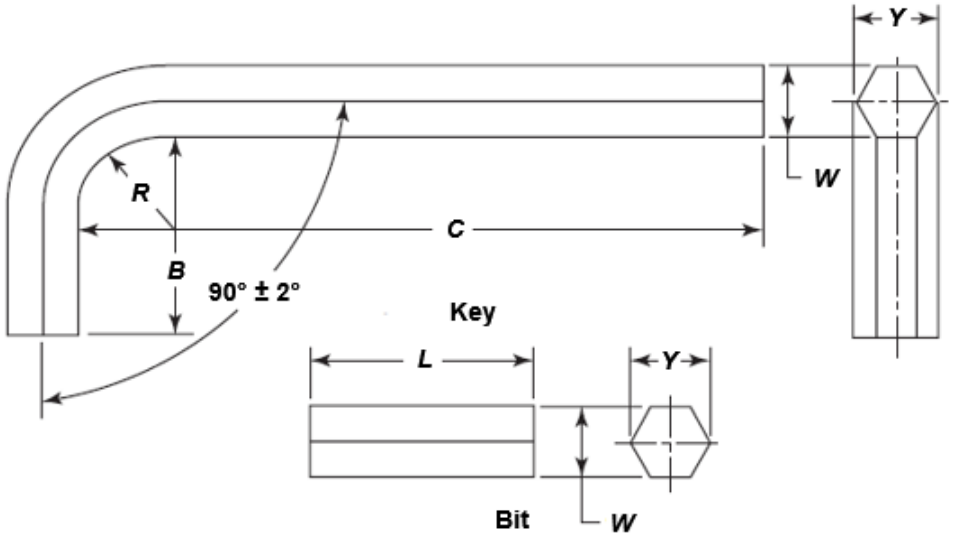
Examples:

Hexagon Socket Button Head Cap Screws, ASME B18.3, 10-32 × ¾, Alloy Steel
Hexagon Socket Button Head Cap Screws, ASME B18.3, 0.190-32 × 0.750, Alloy Steel, Zinc Plated.

For information on low head hexagon socket cap screws and hexagon socket head shoulder screws, please see the standard.

Hexagon Keys and Bits

A hexagon key is an internal wrenching tool used to tighten hexagon socket head fasteners and set screws. Hexagon key is also known as Allen key.



Hexagon Keys and Bits

Dimensions of hexagon keys and bits shall be as per the following table.

Dimensions of Hexagon Keys and Bits (in inch)

Nominal Key or Bit and Socket Size		Hexagon Width Across Flats, *W*		Hexagon Width Across Corners, *Y*		Length, *B*		Length, *C*				Length of Bit, *L*
								Short Series		Long Series		
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
-	0.028	0.0280	0.0275	0.0314	0.0300	0.312	0.125	1.312	1.125	2.688	2.500	-
-	0.035	0.0350	0.0345	0.0393	0.0378	0.438	0.250	1.312	1.125	2.766	2.578	-
-	0.050	0.0500	0.0490	0.0560	0.0540	0.625	0.438	1.750	1.562	2.938	2.750	-
1/16	0.062	0.0625	0.0615	0.0701	0.0680	0.656	0.469	1.844	1.656	3.094	2.906	-
5/64	0.078	0.0781	0.0771	0.0880	0.0859	0.703	0.516	1.969	1.781	3.281	3.094	-
3/32	0.094	0.0937	0.0927	0.1058	0.1035	0.750	0.562	2.094	1.906	3.469	3.281	-
7/64	0.109	0.1094	0.1079	0.1238	0.1210	0.797	0.609	2.219	2.031	3.656	3.469	-
1/8	0.125	0.1250	0.1235	0.1418	0.1390	0.844	0.656	2.344	2.156	3.844	3.656	-
9/64	0.141	0.1406	0.1391	0.1593	0.1566	0.891	0.703	2.469	2.281	4.031	3.844	-
5/32	0.156	0.1562	0.1547	0.1774	0.1745	0.938	0.750	2.594	2.406	4.219	4.031	-
3/16	0.188	0.1875	0.1860	0.2135	0.2105	1.031	0.844	2.844	2.656	4.594	4.406	-
7/32	0.219	0.2187	0.2172	0.2490	0.2460	1.125	0.938	3.094	2.906	4.969	4.781	-
1/4	0.250	0.2500	0.2485	0.2845	0.2815	1.219	1.031	3.344	3.156	5.344	5.156	-

5/16	0.312	0.3125	0.3110	0.3570	0.3531	1.344	1.156	3.844	3.656	6.094	5.906	-
3/8	0.375	0.3750	0.3735	0.4285	0.4238	1.469	1.281	4.344	4.156	6.844	6.656	-
7/16	0.438	0.4375	0.4355	0.5005	0.4944	1.594	1.406	4.844	4.656	7.594	7.406	-
1/2	0.500	0.5000	0.4975	0.5715	0.5650	1.719	1.531	5.344	5.156	8.344	8.156	-
9/16	0.562	0.5625	0.5600	0.6420	0.6356	1.844	1.656	5.844	5.656	9.094	8.906	-
5/8	0.625	0.6250	0.6225	0.7146	0.7080	1.969	1.781	6.344	6.156	9.844	9.656	-
3/4	0.750	0.7500	0.7470	0.8580	0.8512	2.219	2.031	7.344	7.156	11.344	11.156	-
7/8	0.875	0.8750	0.8720	1.0020	0.9931	2.469	2.281	8.344	8.156	12.844	12.656	-
1	1.000	1.0000	0.9970	1.1470	1.1350	2.719	2.531	9.344	9.156	14.344	14.156	-
1 1/4	1.250	1.2500	1.2430	1.4337	1.4138	3.250	2.750	11.500	11.000	-	-	3.750
1 1/2	1.500	1.5000	1.4930	1.7204	1.6981	3.750	3.250	13.500	13.000	-	-	4.500
1 3/4	1.750	1.7500	1.7430	2.0072	1.9825	4.250	3.750	15.500	15.000	-	-	5.250
2	2.000	2.0000	1.9930	2.2939	2.2668	4.750	4.250	17.500	17.000	-	-	6.000
2 1/4	2.250	2.2500	2.2430	2.5807	2.5511	5.250	4.750	19.500	19.000	-	-	6.750
2 3/4	2.750	2.7500	2.7420	3.1541	3.1187	6.250	5.750	23.500	23.000	-	-	8.250
3	3.000	3.0000	2.9920	3.4409	3.4030	6.750	6.250	25.500	25.000	-	-	9.000

General Notes

Hexagon keys are furnished as short arm series or long arm series.

Alloy steel hexagon keys and bits shall be fabricated from an alloy steel having two or more of the following alloying elements: chromium, nickel, molybdenum, or vanadium, in sufficient quantity to ensure that the specified minimum hardness of 48 HRC at the surface for nominal sizes up to and including 3/8 in., and 45 HRC for nominal sizes over 3/8 in., is met when hexagon keys and bits are hardened by quenching from the austenitizing temperature and tempered.

It is recommended that hexagon keys or bits be designated in accordance with the data, preferably in the sequence by: product name, designation of the standard, nominal key or bit size, series, protective finish, if required.

Examples:

Hexagon Key, ASME B18.3, 1/8 Short Arm Series
Hexagon Key, ASME B18.3, 1/8 Long Arm Series, Nickel Plated.
Hexagon Key Bit, ASME B18.3, 1 1/2 Hex

For information about dimensions of spline keys and bits, please see the standard.

Note

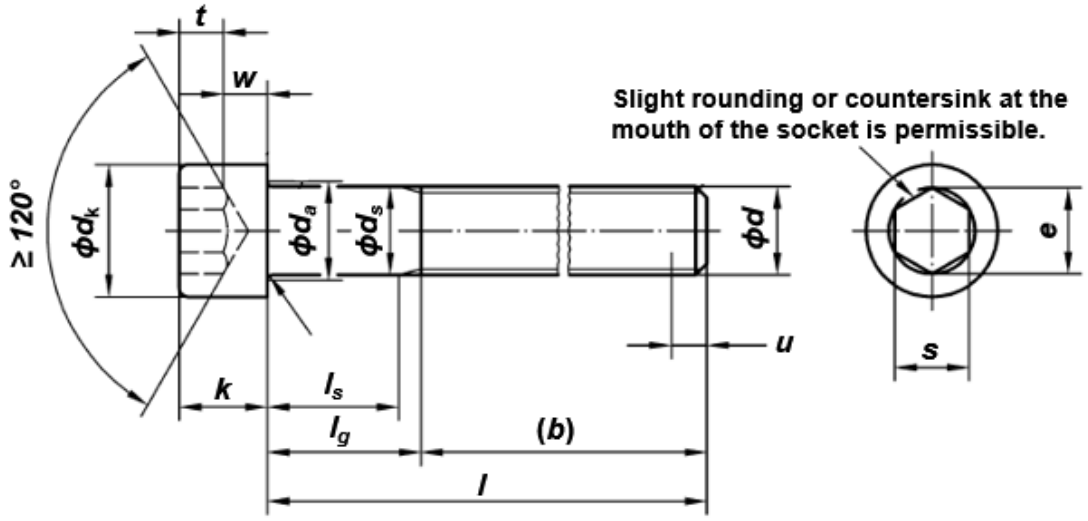
Because of the high hardness of socket cap screws, shoulder screws, set screws (set screws are covered in the following chapter), hexagon keys and spline keys, it is recommended that they not be electroplated.

Hexagon and Spline Socket Head Cap Screws (1936 Series)

Prior to 1961, the 1936 Series of socket head cap screws were recognized as standard. The 1936 Series screws are no longer stocked by screw manufacturers and are now available only on special order. The major differences between the 1936 Series screws and the present standard screws (1960 Series) are that, for some sizes, the 1936 Series had smaller head diameters and/ or socket sizes and/or different thread lengths.

ISO 4762: Hexagon Socket Head Cap Screws

ISO 4762 specifies the characteristics of hexagon socket head cap screws with coarse pitch thread from M1,6 up to and including M64 and product grade A.



Hexagon Socket Head Cap Screws

Dimensions (only important dimensions are shown) of hexagon socket head cap screws shall be as per the following table.

Dimensions of Hexagon Socket Head Cap Screws (All dimensions are in millimetres)										
Thread (*d*)	Pitch, *P*	*b* ref.	d_k			*k*		*s* nom.	*e* min.	*t* min.
			max. Plain	max. Knurled	min.	max.	min.			
M1,6	0,35	15	3,00	3,14	2,86	1,60	1,46	1,5	1,733	0,7
M2	0,4	16	3,80	3,98	3,62	2,00	1,86	1,5	1,733	1
M2,5	0,45	17	4,50	4,68	4,32	2,50	2,36	2	2,303	1,1
M3	0,5	18	5,50	5,68	5,32	3,00	2,86	2,5	2,873	1,3
M4	0,7	20	7,00	7,22	6,78	4,00	3,82	3	3,443	2
M5	0,8	22	8,50	8,72	8,28	5,00	4,82	4	4,583	2,5
M6	1	24	10,00	10,22	9,78	6,00	5,7	5	5,723	3
M8	1,25	28	13,00	13,27	12,73	8,00	7,64	6	6,863	4
M10	1,5	32	16,00	16,27	15,73	10,00	9,64	8	9,149	5
M12	1,75	36	18,00	18,27	17,73	12,00	11,57	10	11,429	6
(M14)*	2	40	21,00	21,33	20,67	14,00	13,57	12	13,716	7
M16	2	44	24,00	24,33	23,67	16,00	15,57	14	15,996	8
M20	2,5	52	30,00	30,33	29,67	20,00	19,48	17	19,437	10
M24	3	60	36,00	36,39	35,61	24,00	23,48	19	21,734	12
M30	3,5	72	45,00	45,39	44,61	30,00	29,48	22	25,154	15,5
M36	4	84	54,00	54,46	53,54	36,00	35,38	27	30,854	19
M42	4,5	96	63,00	63,46	62,54	42,00	41,38	32	36,571	24
M48	5	108	72,00	72,46	71,54	48,00	47,38	36	41,131	28
M56	5,5	124	84,00	84,54	83,46	56,00	55,26	41	46,831	34
M64	6	140	96,00	96,54	95,46	64,00	63,26	46	52,531	38

* If possible, the size in brackets should be avoided.

Requirements and Reference International Standards

Information about some requirements and reference standards is as under.

Material		Steel	Stainless Steel
Thread	Tolerance	5g6g for property class 12.9; for other property classes: 6g	
	International Standards	ISO 261, ISO 965-2, ISO 965-3	
Mechanical Properties	Property Class	M3: as agreed ≥ M3 and ≤ M39: 8.8, 10.9, 12.9 > M39: as agreed	≤ M24: A2-70, A3-70, A4-70, A5-70 > M24 and ≤ M39: A2-50, A3-50, A4-50, A5-50 > M39: as agreed
	International Standards	ISO 898-1	ISO 3506-1
Tolerances	Product Grade	A	
	International Standards	ISO 4759-1	

Designation

Example: A hexagon socket head cap screw with thread M5, nominal length *l* = 20 mm and property class 12.9 is designed as - Hexagon socket head cap screw ISO 4762-M5×20-12.9

ISO 12474: Hexagon Socket Head Cap Screws with Metric Fine Pitch Thread

ISO 12474 specifies the characteristics of hexagon socket head cap screws with metric fine pitch thread with nominal thread diameters, d, from 8 mm up to 36 mm and product grade A. For more information, please see the standard.

Caution

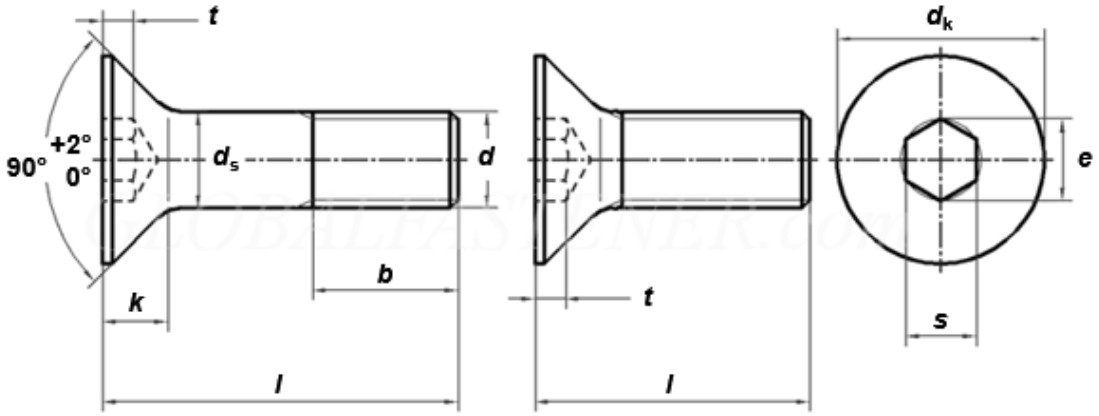
Although the ASTM (USA) standard specifies only one strength level, metric socket head cap screws are manufactured around the world to various standards. These standards allow strength levels and materials different from the ASTM standard. For example, property class 6.8 has a nominal tensile strength (600 MPa) only one half of property class 12.9 (1200 MPa). Therefore, there are metric socket head cap screws in distribution that look similar but have different strengths. Hence, the user of metric socket head cap screws must be aware of the strength level of the fasteners he or she is buying. Purchasing by the simple description, metric socket head cap screw can result in one of many strength levels being sold. This can result in undesirable product performance.

ISO 10642: 2019: Fasteners - Hexagon Socket Countersunk Head Screws with Reduced Loadability

This document specifies the characteristics of hexagon socket countersunk head screws with reduced loadability due to head design (head dimensions and penetration of the hexagon socket), in steel and stainless steel, with metric coarse pitch threads M2 to M20, and with product grade A. The reduced loadability implies a limitation of ultimate tensile load.

ISO 10642:2019, the third edition cancels and replaces the second edition (ISO 10642:2004), which has been technically revised. The main changes compared to the previous edition are as follows:

- Screw of thread size M2 and M2,5 have been added
- Screws made of stainless steel have been added.
- Head height k_{min} has been added as reference dimension.
- Wall thickness between driving feature and bearing face w_{min} has been replaced by the depth of the internal driving feature t_{max}.



Hexagon Socket Countersunk Head Screws

Dimensions (only important dimensions are shown) of hexagon socket countersunk head screws shall be as per the following table.

Dimensions of Hexagon Socket Countersunk Head Screws (All dimensions are in millimetres)														
Thread Size *d*			**M2**	**M2,5**	**M3**	**M4**	**M5**	**M6**	**M8**	**M10**	**M12**	**(M14)[&]**	**M16**	**M20**
P	Pitch		0,4	0,45	0,5	0,7	0,8	1	1,25	1,5	1,75	2	2	2,5
b	Ref.		-	-	18	20	22	24	28	32	36	42	48	60
d_k	Theoretical	max	4,7	5,88	6,72	8,96	11,2	13,44	17,92	22,4	26,88	30,8	33,6	40,32
	Actual	max	4,09	5,08	5,81	7,96	10,07	12,16	16,43	20,69	24,81	28,31	30,61	36,75
		min	3,7	4,8	5,54	7,53	9,43	11,34	15,24	19,22	23,12	26,52	29,01	35,4
d_s		max	2	2,5	3	4	5	6	8	10	12	14	16	20
		min	1,86	2,36	2,86	3,82	4,82	5,82	7,78	9,78	11,73	13,73	15,73	19,67
e[@]		min	1,454	1,733	2,303	2,873	3,443	4,583	5,723	6,863	9,149	11,429	11,429	13,716
k	Ref.	max	1,35	1,69	1,86	2,48	3,1	3,72	4,96	6,2	7,44	8,4	8,8	10,16
		min	1,13	1,408	1,522	2,121	2,669	3,218	4,366	5,563	6,711	7,588	7,874	9,037
s	Nominal Size		1,3	1,5	2	2,5	3	4	5	6	8	10	10	12
		max	1,36	1,56	2,08	2,58	3,08	4,095	5,14	6,14	8,175	10,175	10,175	12,212
		min	1,32	1,52	2,02	2,52	3,02	4,02	5,02	6,02	8,025	10,025	10,025	12,032
t		max	0,85	1,15	1,25	1,65	2	2,5	3,2	3,9	4,9	5,1	5,4	6,4
		min	0,75	1	1,1	1,4	1,75	2,2	2,9	3,5	4,3	4,5	4,8	5,6
Minimum tensile load(N)-8.8*			1330	2180	3220	5620	9080	12900	23400	37100	53900	73600	100000	162000
Minimum tensile load(N)-10.9*			1730	2820	4180	7300	11800	16700	30500	48200	70200	96000	130000	204000
Minimum tensile load(N)-12.9*			2020	3310	4910	8560	13800	19600	35700	56600	82400	112000	154000	239000
Minimum tensile load(N)-50[#]			830	1360	2010	3510	5680	8060	14600	23200	33710	46180	62670	97920
Minimum tensile load(N)-70[#]			1160	1900	2810	4910	7950	11270	20400	32400	47190	64650	87760	137120
Minimum tensile load(N)-80[#]			1330	2180	3220	5620	9080	12880	23430	37120	53940	73890	100320	156720

[&] If possible, the size in brackets should be avoided.

[@] e_{min} =1,14 s_{min}

* 80% of the values for $F_{m,\,min}$ as specified in ISO 898-1.

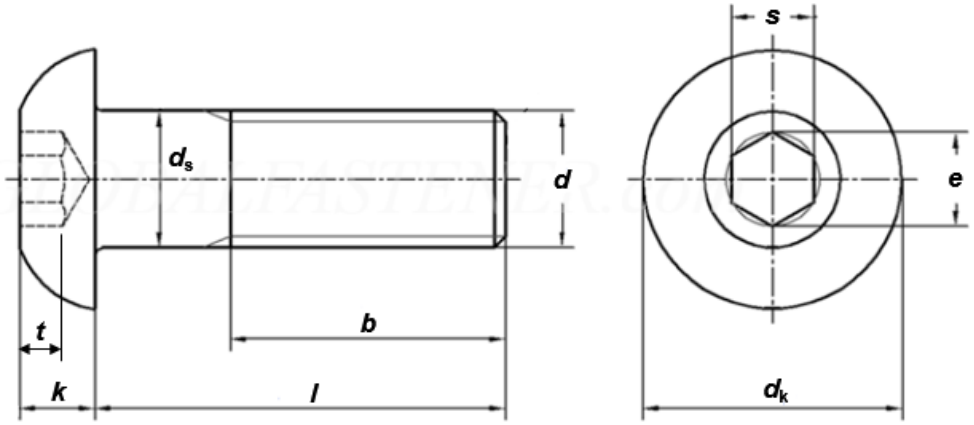
[#] 80% of the values for $F_{m,\,min}$ as specified in ISO 3506-1.

Designation

Example: A hexagon socket countersunk head screw with thread M12, nominal length *l* = 40 mm and property class 12.9 is designed as - Hexagon socket countersunk head screw ISO 10642-M12 × 40-12.9

ISO 7380-1: Button Head Screws - Part 1: Hexagon Socket Button Head Screws

ISO 7380-1 specifies the characteristics of hexagon socket button head screws with threads from M3 up to and including M16, with product grade A and with reduced loadability.



Hexagon Socket Button Head Screws

Dimensions (only important dimensions are shown) of hexagon socket button head screws shall be as per the following table.

Dimensions of Hexagon Socket Button Head Screws (All dimensions are in millimetres)									
Thread *d*		M3	M4	M5	M6	M8	M10	M12	M16
P		0,5	0,7	0,8	1	1,25	1,5	1,75	2
b	Ref.	18	20	22	24	28	32	36	44
d_k	max.	5,7	7,6	9,5	10,5	14	17,5	21	28
	min.	5,4	7,24	9,14	10,07	13,57	17,07	20,48	27,48
e	min.	2,303	2,873	3,443	4,583	5,723	6,863	9,149	11,42
k	max.	1,65	2,2	2,75	3,3	4,4	5,5	6,6	8,8
	min.	1,4	1,95	2,5	3	4,1	5,2	6,24	8,44
s	nominal	2	2,5	3	4	5	6	8	10
	max.	2,08	2,58	3,08	4,095	5,14	6,14	8,175	10,17
	min.	2,02	2,52	3,02	4,02	5,02	6,02	8,025	10,02
t	min.	1,04	1,3	1,56	2,08	2,6	3,12	4,16	5,2

Because of their head configurations, these screws may not meet the minimum ultimate tensile loads specified in ISO 898-1 and ISO 3506-1 when tested in accordance with the standards. As per the standard, these screws shall withstand 80% of the minimum ultimate tensile strength values specified in the standards ISO 898-1 and ISO 3506-1.

Designation

Example - A hexagon socket button head screw with thread M12 and nominal length *l* = 40 mm and property class 12.9, is designated as follows:

Hexagon socket button head screw ISO 7380-1 - M12 x 40 - 12.9

ISO 7380-2: Button Head Screws - Part 2: Hexagon Socket Button Head Screws with Collar

ISO 7380-2 specifies the characteristics of hexagon socket button head screws with collar with threads from M3 up to and including M16, with product grade A and with reduced loadability. For more information, please see the standard.

ISO 7379: Hexagon Socket Head Shoulder Screws

ISO 7379 lays down the specification for hexagon socket head shoulder screws with metric dimensions and nominal shoulder diameters from 6,5 to 25 mm inclusive. For more information on ISO 7379, please see the standard.

Indian Product Standards (IS) for Socket Cap Screws

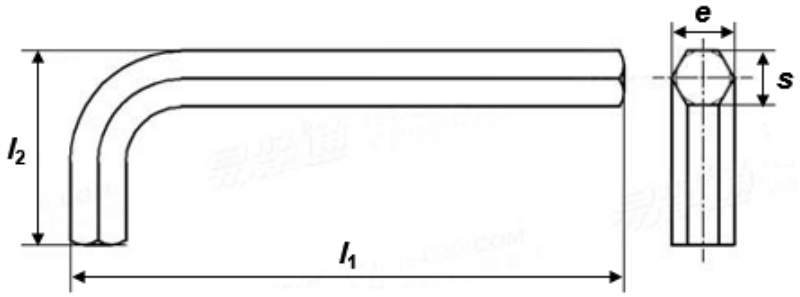
Indian has adopted ISO product standards. Indian standard, IS 2269 is identical to ISO 4762: Hexagon Socket Head Cap Screws.

The Indian standard for countersunk head screws with hexagon socket is IS 6761.

ISO 2936: Assembly Tools for Screws and Nuts - Hexagon Socket Screw Keys

ISO 2936 specifies the dimensions, the method of test, the designation, and the marking of hexagon socket screw keys. It also specifies the minimum values of Rockwell hardness that are to be met.

The specifications of this standard apply for tightening of hexagon socket screws for property class less than or equal to 12,9 as defined in ISO 898-1 and for tightening of socket set screws as defined in ISO 898-5



Hexagon Socket Screw Keys

Dimensions (only important dimensions are shown) of Hexagon Socket Screw Keys shall be as per the following table.

Dimensions of Hexagon Socket Screw Keys (All dimensions are in millimetres)								
Width across flats, *s*			**Width across corners, *e***		**Length l_1**			**Length l_2**
nom.	**max.**	**min.**	**max.**	**min.**	**Standard**	**Long**	**Extra-long**	
0,7	0,71	0,70	0,79	0,76	33	-	-	7
0,9	0,89	0,88	0,99	0,96	33	-	-	11
1,3	1,27	1,24	1,42	1,37	41	63,5	81	13
1,5	1,50	1,48	1,68	1,63	46,5	63,5	91,5	15,5
2	2,00	1,96	2,25	2,18	52	77	102	18
2,5	2,50	2,46	2,82	2,75	58,5	87,5	114,5	20,5
3	3,00	2,96	3,39	3,31	66	93	129	23
3,5	3,50	3,45	3,96	3,91	69,5	98,5	140	25,5
4	4,00	3,95	4,53	4,44	74	104	144	29
4,5	4,50	4,45	5,1	5,04	80	114,5	156	30,5
5	5,00	4,95	5,67	5,58	85	120	165	33
6	6,00	5,95	6,81	6,71	96	141	186	38
7	7,00	6,94	7,94	7,85	102	147	197	41
8	8,00	7,94	9,09	8,97	108	158	208	44
9	9,00	8,94	10,23	10,1	114	169	219	47
10	10,00	9,94	11,37	11,23	122	180	234	50
11	11,00	10,89	12,51	12,31	129	191	247	53
12	12,00	11,89	13,65	13,44	137	202	262	57
13	13,00	12,89	14,79	14,56	145	213	277	63
14	14,00	13,89	15,93	15,7	154	229	294	70
15	15,00	14,89	17,07	16,83	161	240	307	73

16	16,00	15,89	18,21	17,97	168	240	307	76
17	17,00	16,89	19,35	19,09	177	262	337	80
18	18,00	17,89	20,49	20,21	188	262	358	84
19	19,00	18,87	21,63	21,32	199	-	-	89
21	21,00	20,87	23,91	23,58	211	-	-	96
22	22,00	21,87	25,05	24,71	222	-	-	102
23	23,00	22,87	26,16	25,86	233	-	-	108
24	24,00	23,87	27,33	26,97	248	-	-	114
27	27,00	26,87	30,75	30,36	277	-	-	127
29	29,00	28,87	33,03	32,59	311	-	-	141
30	30,00	29,87	34,17	33,75	315	-	-	142
32	32,00	31,84	36,45	35,98	347	-	-	157
36	36,00	35,84	41,01	40,5	391	-	-	176

Designation

A socket screw key conforming to this international standard shall be designated by:

- Socket screw key
- reference to this international standard, i.e. ISO 2936
- its width across the flats, *s*, in millimetres
- capital letter M in the case of the design with a long length
- capital letter L in the case of the design with an extra-long length

Example: A hexagon socket screw key, with a width across flats *s* = 10 mm and long length (M) is designated as follows.

Socket screw key ISO 2936 - 10 M

IS 3082: Assembly Tools for Screws and Nuts - Hexagon Socket Screw Keys

Indian Standard IS 3082, is identical with ISO 2936: Assembly Tools for Screws and Nuts - Hexagon Socket Screw Keys, issued by the International Organization for Standardization (ISO).

Use of Hexagon Keys

Always ensure to use snug fit keys having full wall contact to get desired tightening torque. A worn out key will slip in the socket and may damage it making it useless to tighten later to required torque even with a good key. A good quality key has high strength and ductility. A good quality key shall twist and shear off clean without damaging socket when excessively tightened (destruction test).

As a thumb rule, a fastener will get adequately tightened when the short arm is inserted in the socket and the long arm is deflected or bent through an angle of 25-30 degrees by the application of force near the end of the long arm.

Please remember that cost of a key is negligible as compared to problems one may face later due to bad workmanship (use of a bad key).

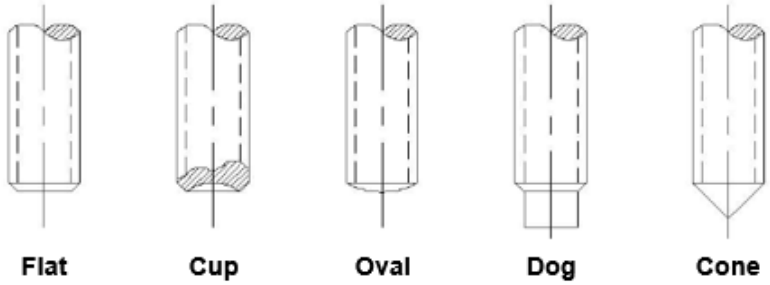
Product Standards for Set Screws

With the exception of the antiquated square head, set screws are headless fasteners and therefore threaded for their entire length. They are also known as grub screws. A set screw is driven with an internal-wrenching drive, such as a hex socket (Allen), spline socket or a slot. Lacking heads, set screws are categorized by drive type and point style. Unlike most other threaded fasteners, they are basically a compression device normally used to generate axial thrust. The fastening action is by friction between the screw and the shaft, often (but not always) with some amount of elastic or plastic deformation of one or both. They are used to hold parts like collar, sleeve, coupling, gear, pulley etc. on a shaft to prevent relative motion. General information about set screws and information about ASTM and ISO product (dimensional) standards for set screws is given in this article.

Drive Types

Most headless set screws use socket (either hex or fluted) drive or a slot drive. Socket type set screws need a hexagon or spline key (Allen key) whereas slotted set screws need standard flat-head screwdriver to drive them. The type of drive affects the seating torque that can be attained because it determines how much torque can be transmitted to the screw. Less torque can be transmitted through a slot drive than a socket drive. Therefore, holding power of the slotted screw is about 45% less. Although slotted varieties are available, they are less common than socket type, because slotted varieties are inherently less robust and more easily deformed during insertion under high torque forces.

Point Types



Set Screw Point Types

Set screws have a specified point type (style). The point is designed to bear on a mating part to provide holding power. As shown in above figure, available types of point for set screws are flat, cup, oval, dog (full or half) and cone. Cup points as supplied by some manufacturers may be externally or internally knurled.

Holding Power

Socket set screws offer three types of holding power: torsional (resistance to rotation); axial (resistance to lateral movement); and vibrational.

Holding power is almost directly proportional to seating torque in a cup, flat, and oval point screws. Holding power can be increased by increasing seating torque.

By its penetration, the set screw point can add as a much as 15% to total holding power. Cone points, with deepest penetration, give the greatest increase; oval points, with minimum penetration, the least. Making 1 the holding power index for cup point, value of holding power index for other types is as under.

Point Type	Holding Power Index (Relative Power)
Cup	1.00
Cone	1.07
Flat and Dog	0.92
Oval	0.90

In cases where point penetration is desired, relative hardness between set screw and shaft is also a factor. A 10-point differential between the screw's normal Rockwell C 50 and shaft should be maintained for full holding power. As much as 15% loss in holding power can result from a lower differential.

Selection of Point Type

Selection of point type is normally determined by the nature of the application - materials, their relative hardness, frequency of assembly and re-assembly, etc. The most frequent areas of application of each type are as under.

Plain Cup

Cup point is the most common type. This type works well because the surface is rounded so that a small surface area is in contact, but it does not have extremely high stress at one point like that of a cone point. It is used against hardened shafts and in soft materials (e.g. zinc) where high tightening torques are impractical.

Knurled Cup

Used for quick and permanent location of gears, collars, pulleys, etc. Counterclockwise locking knurls resist screw loosening even in poorly tapped holes. It also resists most severe vibration.

It is recommended that knurl cup point set screws should not be reused because the cutting edges of the knurls are deflected when tightened. During removal, the cutting edges are torn and no longer have full strength to resist unscrewing.

Flat

Used where parts must be frequently re-set as it causes little or no damage to part it bears against. It can be used against hardened shafts (usually with ground flat for better contact) and as adjusting screw. It is also preferred for thin wall thickness and on soft plugs.

Oval

Used for frequent adjustment without deformation of part it bears against. It is also used for seating against an angular surface.

Cone

Used for permanent location of parts. Deep penetration gives highest holding power. In material over Rockwell C15, point is spotted to half its length to develop shear strength across point. It is also used for pivots and fine adjustment.

Dog (Half Dog)

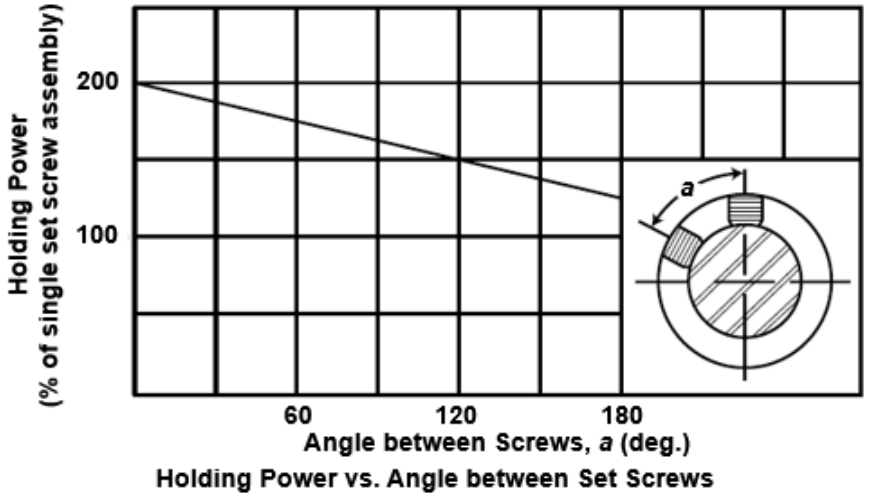
Used for permanent location of one part to another. Point is spotted in the hole drilled in shaft or against flat (milled). It often replaces dowel pins.

Dog point set screws, which have a slightly narrower diameter shaft protruding from the set screw opposite the head end is sometimes used as a sort of spindle or pivot because it can be inserted into or support other components/pieces of equipment that are required to rotate around it.

Size Selection of Socket Set Screws

Set screw selection often begins with the common assumption stating that set screw diameter should be equal to approximately one-half shaft diameter. This rule of thumb often gives satisfactory results. However, manufacturers' data or data supplied by standard machine design texts will give more reliable results.

Two set screws give more holding power than one but as shown in the following figure, not necessarily twice as much.



Holding Power vs. Angle between Set Screws

Holding power is approximately doubled when the second set screw is installed in an axial line with the first but is only about 30% greater when the screws are diametrically opposed. Where design dictates that the two screws be installed on the same circumferential line, displacement of 60° is recommended as the best compromise between maximum holding power and minimum metal between tapped holes. This displacement gives 1.75 times the holding power of one screw.

The data in the following tables offers a simplified means for selecting diameter and seating torque of a set screw on a given diameter shaft.

Torsional holding power in inch-pounds and axial holding power in pounds are tabulated for cup point socket screws, seated at recommended installation torques. Shafting used was hardened to Rockwell C15. Test (by UNBRAKO) involved Class 3A screw threads in Class 2B tapped holes. Data was determined experimentally in a long series of tests in which holding power was defined as the minimum load to produce 0.010 inch relative movement of shaft and collar.

It may be noted that tabulated axial and torsional holding powers are typical strengths and should be used accordingly, with specific safety factors appropriate to the given application and load conditions. Good results have been obtained with a factor of 1.5-2.0 under static load conditions (i.e., where a collar is supporting a vertical load on a post) and of 4.0-8.0 for various dynamic situations.

Nom. Size	Seating Torque in-lbs	Axial Holding Power, pounds	Shaft Diameter (shaft hardness RC 15 to RC 35)											
			1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16
			Torsional Holding Power inch-lbs.											
#0	1.0	50	1.5	2.3	3.1	3.9	4.7	5.4	6.2	-	-	-	-	-
#1	1.8	65	2.0	3.0	4.0	5.0	6.1	7.1	8.1	10.0	-	-	-	-
#2	1.8	85	2.6	4.0	5.3	6.6	8.0	9.3	10.6	13.2	16.0	-	-	-
#3	5	120	3.2	5.6	7.5	9.3	11.3	13.0	15.0	18.7	22.5	26.3	-	-
#4	5	160	-	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	35.0	40.0	-
#5	10	200	-	-	12.5	15.6	18.7	21.8	25.0	31.2	37.5	43.7	50.0	56.2
#6	10	250	-	-	-	19	23	27	31	39	47	55	62	70
#8	20	385	-	-	-	30	36	42	48	60	72	84	96	108
#10	36	540	-	-	-	-	51	59	68	84	101	118	135	152
1/4	87	1000	-	-	-	-	-	-	125	156	187	218	250	281
5/16	165	1500	-	-	-	-	-	-	-	234	280	327	375	421
3/8	290	2000	-	-	-	-	-	-	-	-	375	437	500	562
7/16	430	2500	-	-	-	-	-	-	-	-	-	545	625	702
1/2	620	3000	-	-	-	-	-	-	-	-	-	-	750	843
9/16	620	3500	-	-	-	-	-	-	-	-	-	-	-	985

Nom. Size	Seating Torque in-lbs	Axial Holding Power, pounds	Shaft Diameter (shaft hardness RC 15 to RC 35)											
			5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4
			Torsional Holding Power inch-lbs.											
#5	10	200	62	-	-	-	-	-	-	-	-	-	-	-
#6	10	250	78	94	109	-	-	-	-	-	-	-	-	-
#8	20	385	120	144	168	192	-	-	-	-	-	-	-	-
#10	36	540	169	202	236	270	338	-	-	-	-	-	-	-
1/4	87	1000	312	357	437	500	625	750	-	-	-	-	-	-
5/16	165	1500	468	562	656	750	937	1125	1310	1500	-	-	-	-
3/8	290	2000	625	750	875	1000	1250	1500	1750	2000	-	-	-	-
7/16	430	2500	780	937	1095	1250	1560	1875	2210	2500	3125	-	-	-
1/2	620	3000	937	1125	1310	1500	1875	2250	2620	3000	3750	4500	-	-
9/16	620	3500	1090	1310	1530	1750	2190	2620	3030	3500	4370	5250	6120	-
5/8	1325	4000	1250	1500	1750	2000	2500	3000	3750	4000	5000	6000	7000	8000
3/4	2400	5000	-	1875	2190	2500	3125	3750	4500	5000	6250	7500	8750	10000
7/8	3600	5600	-	-	2620	3000	3750	4500	5250	6000	7500	9000	10500	12000
1	5000	6500	-	-	-	3500	4375	5250	6120	7000	8750	10500	12250	14000

A negligible difference exists in the performance of coarse and fine threads of the same class of fit. Most inch set screws are class 3A fit. This is to provide resistance to the set screw “backing out” of its threaded hole during service.

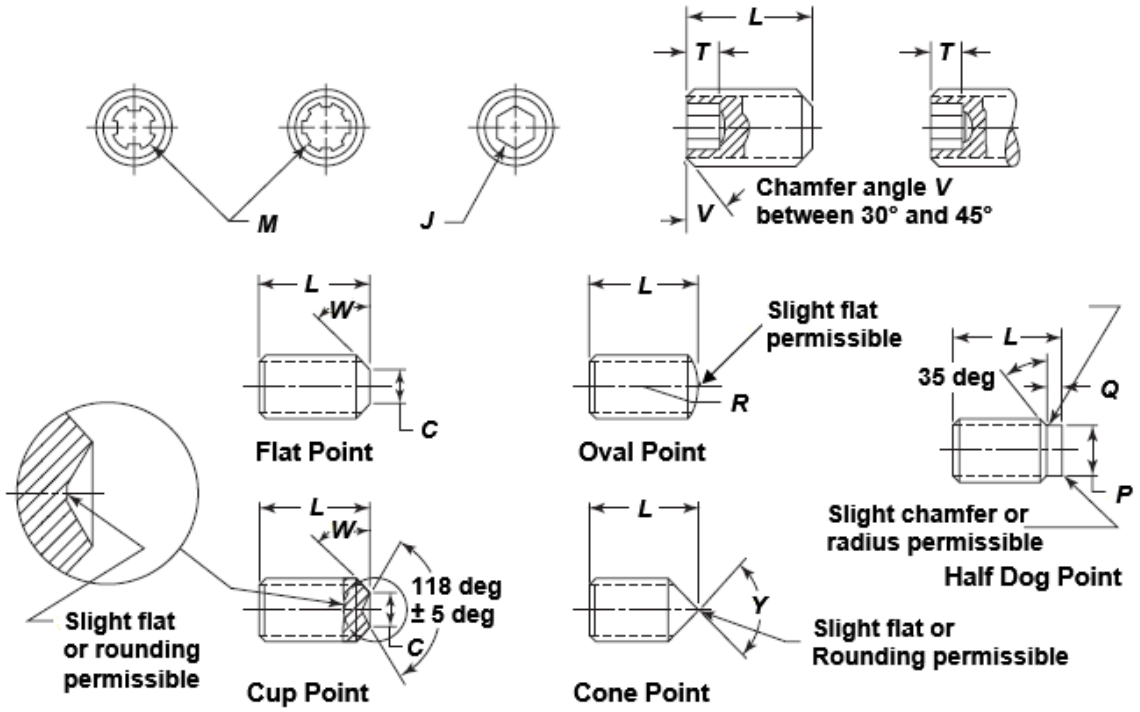
Length of Thread Engagement

The length of thread engagement does not have a noticeable effect on axial and torsional holding power, provided there is sufficient engagement to prevent thread stripping during tightening. In general, the minimum recommended length of engagement is 1 to 1.5 times the major diameter of the set screw for threading in brass, cast iron, and aluminum; and 0.75 to 1 times the diameter for use in steel and other materials of comparable hardness. The lengths of engagement specified are for full threads engaged (not overall screw length).

Set Screws and Keyways

When a set screw is used in combination with a key, the screw diameter should be equal to the width of the key. In this combination, the set screw holds the parts in an axial direction only. The key and keyway assembly carries the torsional load on the parts.

ASME B18.3: Socket Cap, Shoulder, and Set Screws, Hex and Spline Keys



Dimensions of Socket Set Screws

As per ASME B18.3, dimensions (only important dimensions are shown) of hexagon socket set screws (*J*) shall be as shown in the following table. For information on spline socket set screws (*M*), please see the standard.

Dimensions of Hexagon Socket Set Screws (All dimensions are in inch)

Nominal Size (Basic Screw Dia.)		Nominal Hexagon Socket Size, *J*		Minimum Key Engagement *T*, for Hex Socket, T_H	Cup and Flat Point Diameters, *C*		Shortest Optimum Nominal Length, *L* to which T_H Applies		
					Max.	Min.	Cup and Flat Points	90° Cone and Oval Points	Half Dog Point
0	0.060	-	0.028	0.050	0.033	0.027	0.13	0.13	0.13
1	0.073	-	0.035	0.060	0.040	0.033	0.13	0.19	0.13
2	0.086	-	0.035	0.060	0.047	0.039	0.13	0.19	0.19
3	0.099	-	0.050	0.070	0.054	0.045	0.19	0.19	0.19
4	0.112	-	0.050	0.070	0.061	0.051	0.19	0.19	0.19
5	0.125	1/16	0.062	0.080	0.067	0.057	0.19	0.19	0.19
6	0.138	1/16	0.062	0.080	0.074	0.064	0.19	0.25	0.19
8	0.164	5/64	0.078	0.090	0.087	0.076	0.19	0.25	0.25
10	0.190	3/32	0.094	0.100	0.102	0.088	0.19	0.25	0.25
1/4	0.250	1/8	0.125	0.125	0.132	0.118	0.25	0.31	0.31
5/16	0.312	5/32	0.156	0.156	0.172	0.156	0.31	0.44	0.38
3/8	0.375	3/16	0.188	0.188	0.212	0.194	0.38	0.44	0.44
7/16	0.437	7/32	0.219	0.219	0.252	0.232	0.44	0.63	0.50
1/2	0.500	1/4	0.250	0.250	0.291	0.270	0.50	0.63	0.63
5/8	0.625	5/16	0.312	0.312	0.371	0.347	0.63	0.88	0.88
3/4	0.750	3/8	0.375	0.375	0.450	0.425	0.75	1.00	1.00
7/8	0.875	1/2	0.500	0.500	0.530	0.502	0.88	1.00	1.00
1	1.000	9/16	0.562	0.562	0.609	0.579	1.00	1.25	1.25
1 1/8	1.125	9/16	0.562	0.562	0.689	0.655	1.25	1.50	1.25
1 1/4	1.250	5/8	0.625	0.625	0.767	0.733	1.25	1.50	1.50
1 3/8	1.375	5/8	0.625	0.625	0.848	0.808	1.50	1.75	1.50
1 1/2	1.500	3/4	0.750	0.750	0.926	0.886	1.50	2.00	1.75
1 3/4	1.750	1	1.000	1.000	1.086	1.039	1.75	2.25	2.00
2	2.000	1	1.000	1.000	1.244	1.193	2.00	2.50	2.50

General Notes

The socket set screw is a screw threaded the entire length except for its length of point. The point is designed to bear on a mating part. As shown in above figure, common point styles (types) are cup, flat, oval, cone, and half dog.

For information on dimensions of hex keys and bits for hexagon sockets, please see the standard or previous chapter of this booklet.

The key engagement dimensions given in columns T_H of above table shall apply only to nominal screw lengths equal to or longer than the lengths (Shortest Optimum Nominal Length) listed in above table. For hexagon socket key engagement dimensions in screws of shorter nominal lengths than those listed in above table, please see the standard.

Threads shall be Unified external thread: Class 3A, UNC and UNF Series. When using set screws longer than 1.5 basic diameters in length, the pitch diameter of the set screw may need to be reduced, or the tapped hole's pitch diameter may need to be increased to avoid interference during assembly.

Class 3A threads do not provide a plating allowance. When set screws must be plated, they should be manufactured with an undersized pitch diameter to accommodate the plating. When standard socket set screws are plated, thread interference is likely to occur during assembly.

Alloy steel socket set screws shall be fabricated from alloy steel and shall conform in all respects to ASTM F 912. Corrosion-Resistant Steel socket set screws shall be fabricated from austenitic corrosion-resistant steel and shall conform in all respects to ASTM F880.

Designation

It is recommended that Hexagon and Spline Socket Set Screws be designated in accordance with the data, preferably in the sequence by:

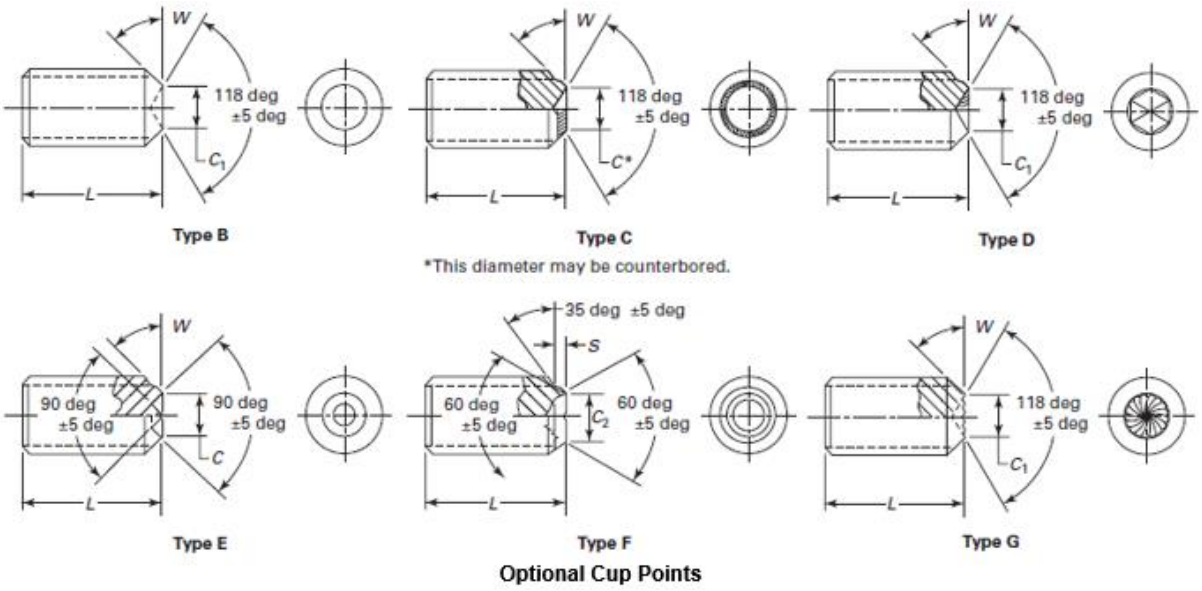
- product name and point style
- designation of the standard
- nominal size (number, fractional or decimal equivalent)
- thread pitch
- nominal length (fractional or decimal equivalent)
- material
- protective finish, if required

Examples:

Hexagon Socket Set Screw, Cup Point, ASME B18.3, ¼-20 × ¼, Alloy Steel
Spline Socket Set Screw, Flat Point, ASME B18.3, 0.112-40 × 0.125, Alloy Steel, Zinc Plated.
Hexagon Socket Set Screw, Cup Point, ASME B18.3, 6-32 × 0.250, Corrosion-Resistant Steel

Optional Cup Points

Type A point is the cup point dimensioned in above figure and table. Types B, C, D, E, F, and G shown in the following figure are typical variations of the cup point, which are supplied by some manufacturers. For their dimensions (C_1, C_2 and S), please see the standard.



Recommended Seating Torques

Recommended seating torques (in-lbs.) by UNBRAKO are shown in the following table. It may be noted that the values are applicable only to nominal minimum lengths shown in the table or longer.

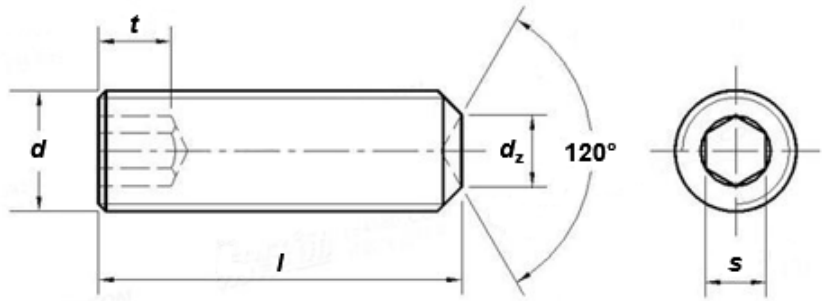
Recommended Seating Torques by UNBRAKO for Set Screws (in-lbs.)				
Nominal Size (Basic Screw Dia.)		Nom. Min. Screw Length	Alloy Steel	Stainless Steel
0	0.060	3/32	1.0	0.4
1	0.073	1/8	1.8	1.2
2	0.086	1/8	1.8	1.2
3	0.099	5/32	5	4
4	0.112	5/32	5	4
5	0.125	5/32	10	7
6	0.138	3/16	10	7
8	0.164	3/16	20	16
10	0.190	3/16	36	26
1/4	0.250	5/16	87	70
5/16	0.312	3/8	165	130
3/8	0.375	7/16	290	230
7/16	0.437	1/2	430	340
1/2	0.500	9/16	620	500
5/8	0.625	11/16	1325	980
3/4	0.750	3/4	2400	1700
7/8	0.875	3/4	3600	3000
1	1.000	7/8	5000	4000
1 1/8	1.125	1	7200	5600
1 1/4	1.250	1 1/8	9600	7700
1 3/8	1.375	1 1/4	9600	7700
1 1/2	1.500	1 1/4	11320	9100

ASME B18.6.2: Slotted Head Cap Screws, Square Head Set Screws and Slotted Headless Set Screws

For information about slotted head cap screws (flat countersunk head, round head and fillister head), square head set screws and slotted headless set screws, see ASME B18.6.2.

ISO 4029: Hexagon Socket Set Screws with Cup Point

ISO 4029 specifies the characteristics of hexagon socket set screws with cup point and threads from M1,6 up to and including M24 and of product grade A.



Hexagon Socket Set Screws with Cup Point

As per ISO 4029, dimensions (only important dimensions are shown) of hexagon socket set screws with cup point shall be as shown in the following table.

Dimensions of Hexagon Socket Set Screws with Cup Point (All dimensions are in mm)														
Thread (*d*)		M1,6	M2	M2,5	M3	M4	M5	M6	M8	M10	M12	M16	M20	M24
P	Pitch	0,35	0,4	0,45	0,5	0,7	0,8	1	1,25	1,5	1,75	2	2,5	3
d_z	max.	0,80	1,00	1,20	1,40	2,00	2,50	3,00	5,0	6,0	8,00	10	14	16
	min.	0,55	0,75	0,95	1,15	1,75	2,25	2,75	4,7	5,7	7,64	9,64	13,57	15,57
s	Nominal	0,7	0,9	1,3	1,5	2	2,5	3	4	5	6	8	10	12
	max.	0,724	0,913	1,3	1,58	2,08	2,58	3,08	4,095	5,14	6,14	8,175	10,175	12,212
	min.	0,71	0,887	1,275	1,52	2,02	2,52	3,02	4,02	5,02	6,02	8,025	10,025	12,032
*t**	Short Screw, min.	0,7	0,8	1,2	1,2	1,5	2	2	3	4	4,8	6,4	8	10
	Long Screw, min.	1,5	1,7	2	2	2,5	3	3,5	5	6	8	10	12	15

* For more information, please see the standard.

Requirements and Reference International Standards

Information about some requirements and reference standards is as under.

Material		Steel	Stainless Steel
Thread	Tolerance	6g	
	International Standards	ISO 261, ISO 965-2, ISO 965-3	
Mechanical Properties	Property Class	45H	A1-12H, A2-21H, A3-21H, A4-21H, A5-21H
	International Standards	ISO 898-5	ISO 3506-3
Tolerances	Product Grade	A	
	International Standards	ISO 4759-1	

For proof torque values of steel screws and stainless steel screws, please see ISO 898-5 and ISO 3506-3 respectively. The screws shall withstand the proof torque values given in the standards without splitting or cracking. Information about ISO 898-5 and ISO 3506-3 is uploaded in the booklet titled 'Mechanical Properties and Identification Markings for Threaded Fasteners' at www.practicalmaintenance.net.

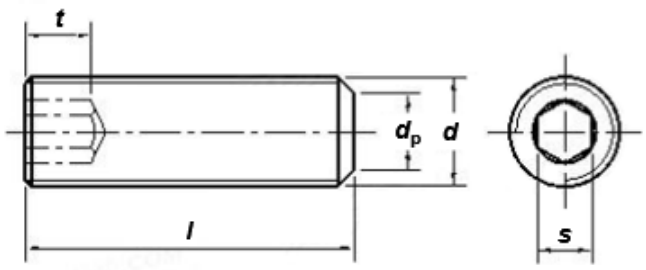
Designation

Example - A hexagon socket set screw with cup point, thread M6, nominal length *l* = 12 mm and of property class 45H, is designated as follows.

Hexagon socket set screw ISO 4029 - M6×12 - 45H

ISO 4026: Hexagon Socket Set Screws with Flat Point

ISO 4026 specifies the characteristics of hexagon socket set screws with flat point and threads from M1,6 up to and including M24 and of product grade A.



Hexagon Socket Set Screws with Flat Point

As per ISO 4026, dimensions (only important dimensions are shown) of hexagon socket set screws with flat point shall be as shown in the following table.

Dimensions of Hexagon Socket Set Screws with Flat Point (All dimensions are in mm)														
Thread (*d*)		M1,6	M2	M2,5	M3	M4	M5	M6	M8	M10	M12	M16	M20	M24
P	Pitch	0,35	0,4	0,45	0,5	0,7	0,8	1	1,25	1,5	1,75	2	2,5	3
d_p	max.	0,8	1	1,5	2	2,5	3,5	4	5,5	7	8,5	12	15	18
	min.	0,55	0,75	1,25	1,75	2,25	3,2	3,7	5,2	6,64	8,14	11,57	14,57	17,57
s	Nominal	0,7	0,9	1,3	1,5	2	2,5	3	4	5	6	8	10	12
	max.	0,724	0,913	1,3	1,58	2,08	2,58	3,08	4,095	5,14	6,14	8,175	10,175	12,212
	min.	0,71	0,887	1,275	1,52	2,02	2,52	3,02	4,02	5,02	6,02	8,025	10,025	12,032
*t**	Short Screw, min.	0,7	0,8	1,2	1,2	1,5	2	2	3	4	4,8	6,4	8	10
	Long Screw, min.	1,5	1,7	2	2	2,5	3	3,5	5	6	8	10	12	15

* For more information, please see the standard.

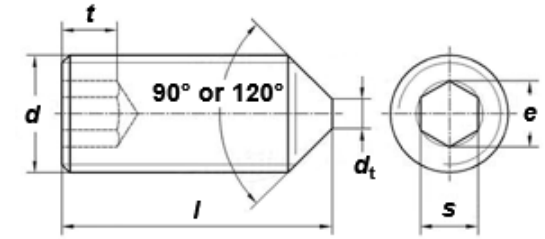
Designation

Example - A hexagon socket set screw with flat point, thread M6, nominal length *l* = 12 mm and of property class 45H, is designated as follows.

Hexagon socket set screw ISO 4026 - M6×12 - 45H

ISO 4027: Hexagon Socket Set Screws with Cone Point

ISO 4027 specifies the characteristics of hexagon socket set screws with cone point and threads from M1,6 up to and including M24 and of product grade A.



Hexagon Socket Set Screws with Cone Point

As per ISO 4027, dimensions (only important dimensions are shown) of hexagon socket set screws with cone point shall be as shown in the following table.

Dimensions of Hexagon Socket Set Screws with Cone Point (All dimensions are in mm)														
Thread (*d*)		M1,6	M2	M2,5	M3	M4	M5	M6	M8	M10	M12	M16	M20	M24
P	Pitch	0,35	0,4	0,45	0,5	0,7	0,8	1	1,25	1,5	1,75	2	2,5	3
d_t	max.	0,4	0,5	0,65	0,75	1	1,25	1,5	2	2,5	3	4	5	6
s	Nominal	0,7	0,9	1,3	1,5	2	2,5	3	4	5	6	8	10	12
	max.	0,724	0,913	1,3	1,58	2,08	2,58	3,08	4,095	5,14	6,14	8,175	10,175	12,212
	min.	0,71	0,887	1,275	1,52	2,02	2,52	3,02	4,02	5,02	6,02	8,025	10,025	12,032
*t**	Short Screw, min.	0,7	0,8	1,2	1,2	1,5	2	2	3	4	4,8	6,4	8	10
	Long Screw, min.	1,5	1,7	2	2	2,5	3	3,5	5	6	8	10	12	15

* For more information, please see the standard.

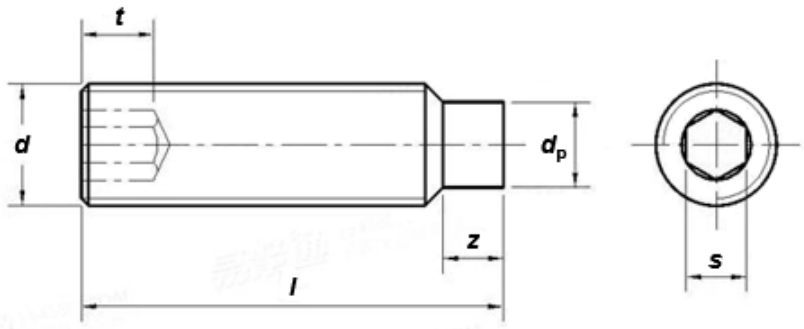
Designation

Example - A hexagon socket set screw with cone point, thread M6, nominal length *l* = 12 mm and of property class 45H, is designated as follows:

Hexagon socket set screw ISO 4027 - M6×12- 45H

ISO 4028: Hexagon Socket Set Screws with Dog Point

ISO 4028 specifies the characteristics of hexagon socket set screws with dog point and threads from M1,6 up to and including M24 and of product grade A.



Hexagon Socket Set Screws with Dog Point

As per ISO 4028, dimensions (only important dimensions are shown) of hexagon socket set screws with dog point shall be as shown in the following table.

Dimensions of Hexagon Socket Set Screws with Dog Point (All dimensions are in mm)														
Thread (*d*)		M1,6	M2	M2,5	M3	M4	M5	M6	M8	M10	M12	M16	M20	M24
P	Pitch	0,35	0,4	0,45	0,5	0,7	0,8	1	1,25	1,5	1,75	2	2,5	3
d_p	max.	0.80	1.00	1.50	2.00	2.50	3.5	4.0	5.5	7.0	8.50	12.00	15.00	18.00
	min.	0.55	0.75	1.25	1.75	2.25	3.2	3.7	5.2	6.64	8.14	11.57	14.57	17.57
s	Nominal	0,7	0,9	1,3	1,5	2	2,5	3	4	5	6	8	10	12
	max.	0,724	0,913	1,3	1,58	2,08	2,58	3,08	4,095	5,14	6,14	8,175	10,175	12,212
	min.	0,71	0,887	1,275	1,52	2,02	2,52	3,02	4,02	5,02	6,02	8,025	10,025	12,032
*t**	Short Screw, min.	0,7	0,8	1,2	1,2	1,5	2	2	3	4	4,8	6,4	8	10
	Long Screw, min.	1,5	1,7	2	2	2,5	3	3,5	5	6	8	10	12	15
z	Short Dog Pt. max.	0.65	0.75	0.88	1.00	1.25	1.50	1.75	2.25	2.75	3.25	4.3	5.3	6.3
	Short Dog Pt. min.	0.40	0.50	0.63	0.75	1.00	1.25	1.50	2.00	2.50	3.00	4.0	5.0	6.0
	Long Dog Pt. max.	1.05	1.25	1.50	1.75	2.25	2.75	3.25	4.3	5.3	6.3	8.36	10.36	12.43
	Long Dog Pt. min.	0.80	1.00	1.25	1.50	2.00	2.50	3.00	4.00	5.00	6.00	8.00	10.00	12.00

* For more information, please see the standard.

Designation

Example - A hexagon socket set screw with dog point, thread M6, nominal length *l* = 12 mm and of property class 45H, is designated as follows.

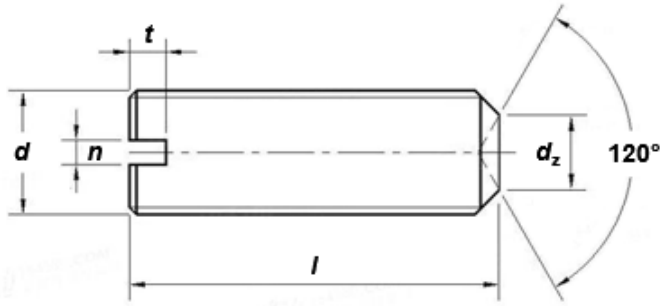
Hexagon socket set screw ISO 4028 - M6×12 - 45H

Note

Requirements and reference standards for hexagon socket set screws with flat point, cone point and dog point are identical to the requirements for hexagon socket set screws with cup point.

ISO 7436: Slotted Set Screws with Cup Point

ISO 7436 specifies the characteristics of slotted set screws with cup point and thread sizes from M 1,6 to M 12 inclusive and product grade A.



Slotted Set Screws with Cup Point

As per ISO 7436, dimensions (only important dimensions are shown) of slotted set screws with cup point shall be as shown in the following table.

Dimensions of Slotted Set Screws with Cup Point (All dimensions are in mm)												
Thread (*d*)		M1,6	M2	M2,5	M3	(M3,5)*	M4	M5	M6	M8	M10	M12
P	Pitch	0,35	0,4	0,45	0,5	0,6	0,7	0,8	1	1,25	1,5	1,75
d_z	min.	0,55	0,75	0,95	1,15	1,45	1,75	2,25	2,75	4,7	5,7	7,7
	max.	0,8	1	1,2	1,4	1,7	2	2,5	3	5	6	8
n	Nominal	0,25	0,25	0,4	0,4	0,5	0,6	0,8	1	1,2	1,6	2
	min.	0,31	0,31	0,46	0,46	0,56	0,66	0,86	1,06	1,26	1,66	2,06
	max.	0,45	0,45	0,6	0,6	0,7	0,8	1	1,2	1,51	1,91	2,31
t	min.	0,56	0,64	0,72	0,8	0,96	1,12	1,28	1,6	2	2,4	2,8
	max.	0,74	0,84	0,95	1,05	1,21	1,42	1,63	2	2,5	3	3,6

* Sizes in brackets should be avoided if possible.

Requirements and Reference International Standards

Information about some requirements and reference standards is as under.

Material		Steel	Stainless Steel
Thread	Tolerance	6g	
	International Standards	ISO 261, ISO 965	
Mechanical Properties	Property Class	14H, 22H	A1-50
	International Standards	ISO 898-5	ISO 3506
Tolerances	Product Grade	A	
	International Standards	ISO 4759-1	

Designation

Example - A slotted sat screw with cup point, thread size M5, nominal length *l* = 12 mm and of property class 14H, is designated as follows.

Set screw ISO 7436 – M5×12 - 14H

ISO Standards for Slotted Set Screws with other Points

ISO standards for slotted set screws with other type of points are as under.

ISO 4766: Slotted set screws with flat point
ISO 7434: Slotted set screws with cone point
ISO 7435: Slotted set screws with long dog point
ISO 2342: Slotted headless screws with shank

ISO standards 4766, 7434 and 7435 specify the characteristics of slotted set screws with respective point type and threads from M1,6 up to and including M12 and of product grade A. ISO 2342 specifies the characteristics of slotted headless screws with shank with threads from M1 up to and including M10. For more information on them please see the standards.

IS Standards

Bureau of Indian Standards (IS) has adopted ISO Standards for hexagon socket and slotted set screws as under.

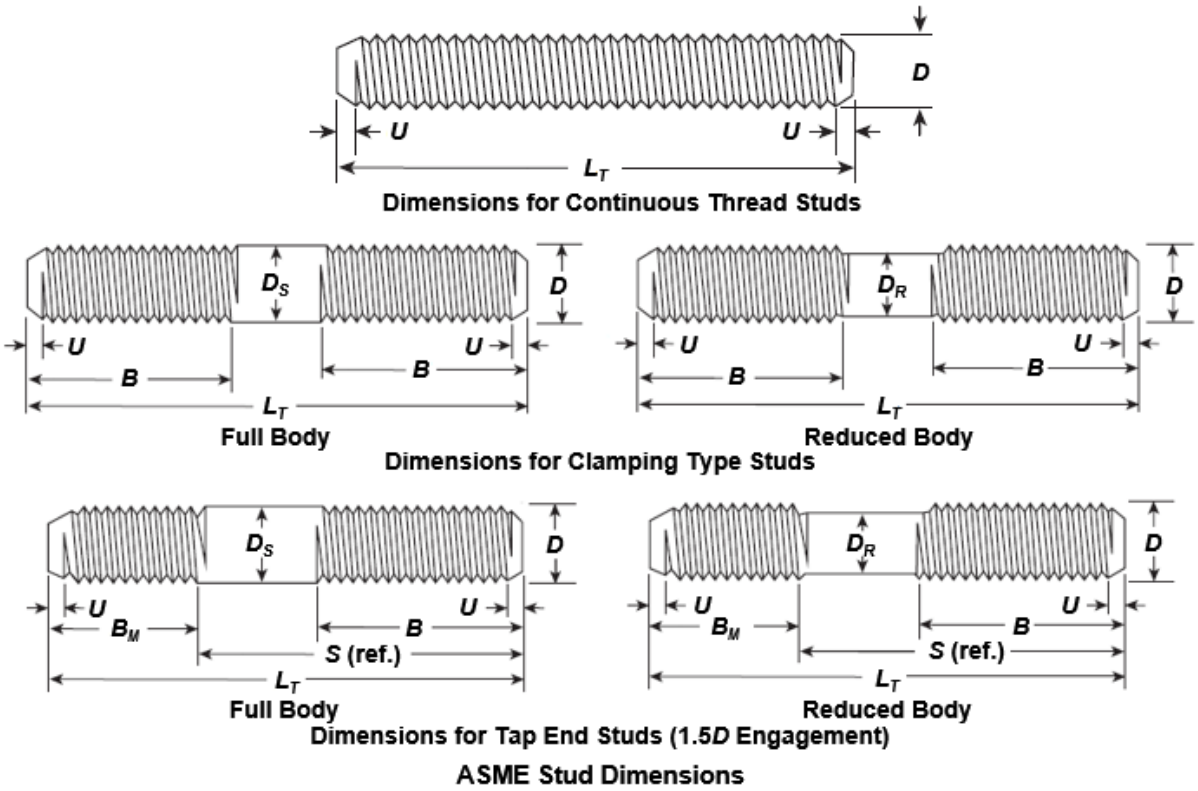
ISO Standard	IS Standard
ISO 4026: Hexagon socket set screws with flat point	IS 6094 (Part 1)
ISO 4027: Hexagon socket set screws with cone point	IS 6094 (Part 2)
ISO 4028: Hexagon socket set screws with dog point	IS 6094 (Part 3)
ISO 4029: Hexagon socket set screws with cup point	IS 6094 (Part 4)
ISO 4766: Slotted set screws with flat point	IS 15628
ISO 7434: Slotted set screws with cone point	IS 15629
ISO 7435: Slotted set screws with long dog point	IS 15630
ISO 7436: Slotted set screws with cup point	IS 15631

Product Standards for Studs

Stud is a fastener which is threaded at both ends with generally an unthreaded shank in between. One end (which often has a thread tolerance which results in thread interference) is secured into a tapped hole, the other is used with a nut. When a nut is used on each end of a stud that is threaded over its complete length or threaded at both ends with screw threads of the same length and configuration on each end is called a stud bolt. Due to uniform cross section, there is no stress concentration in studs. A stud bolt can be tightened from either side of the joint. Stud bolts are widely used in the petrochemical and nuclear industry. Information about ASME, DIN and IS product (dimensional) standards for studs is given in this chapter.

ASME B18.31.2: Continuous and Double-End Studs (Inch Series)

ASME B18.31.2 covers the complete dimensional and general data for continuous thread and double- end inch-dimensioned studs recognized as American National Standard.



In above figure:
B = full nut end thread length
B_M = tap end thread length (full threads)
L_T = overall length (nominal length)
S = standoff (when installed) = $L_T - B_M$
U = length to first full form thread

$U_{max} = 2P$

Continuous Thread Stud

Continuous thread studs are threaded over their complete length.

Double-End Stud (clamping type - identical ends)

Double-end stud (clamping type) are studs with screw threads of the same length and configuration on each end. This type of stud serves the function of clamping two bodies (for example, two flanges) together with a nut on each end.

Double-End Stud (Tap End Type)

Double-end stud (tap end type) is a stud designed to be installed in a tapped hole and usually with different threaded lengths on each end. For the tap end of the studs, both regular unified threads and interference-fit threads can be provided.

Dimensions

Dimensions (only some common dimensions are shown) of tap end studs (1.5*D* engagement) shall be as shown in the following table. All dimensions are in inches, and apply before coating, unless otherwise specified. Dimension *B*, value of nut end thread length is same for tap end studs and clamping type studs. For more information on clamping type studs and continuous thread studs, please see the standard.

Dimensions for Tap End Studs (1.5*D* Engagement)						
Nominal Size Diameter, *D*	**Tap End Full Thread Length, B_M**			**Minimum Nut End Full Thread Length, B_{min}**		
	Nominal	Min.	Max.	$L \le 10$	$10 < L \le 16$	$L > 16$
¼	0.375	0.350	0.400	0.750	1.000	1.500
5⁄16	0.469	0.440	0.498	0.875	1.125	1.625
⅜	0.563	0.532	0.594	1.000	1.250	1.750
7⁄16	0.656	0.620	0.692	1.125	1.375	1.875
½	0.750	0.708	0.792	1.250	1.500	2.000
9⁄16*	0.844	0.802	0.896	1.375	1.625	2.125
⅝	0.938	0.892	0.983	1.500	1.750	2.250
¾	1.125	1.075	1.175	1.750	2.000	2.500
⅞	1.313	1.258	1.368	2.000	2.250	2.750
1	1.500	1.438	1.562	2.250	2.500	3.000
1⅛	1.688	1.625	1.750	2.500	2.750	3.250
1¼	1.875	1.813	1.938	2.750	3.000	3.500
1⅜	2.063	2.000	2.125	3.000	3.250	3.750
1½	2.250	2.188	2.313	3.250	3.500	4.000
1⅝	2.438	2.375	2.500	3.500	3.750	4.250
1¾	2.625	2.563	2.688	3.750	4.000	4.500
1⅞	2.813	2.750	2.875	4.000	4.250	4.750
2	3.000	2.925	3.075	4.250	4.500	5.000
2¼	3.375	3.300	3.450	4.750	5.000	5.500
2½	3.750	3.675	3.825	5.250	5.500	6.000
2¾	4.125	4.050	4.200	5.750	6.000	6.500
3	4.500	4.425	4.575	-	6.500	7.000
3¼	4.875	4.775	4.975	-	7.000	7.500
3½	5.250	5.150	5.350	-	7.500	8.000
3¾	5.625	5.525	5.725	-	8.000	8.500
4	6.000	5.900	6.100	-	8.500	9.000

* Nonpreferred size; not recommended for new design due to limited availability.

Length

The **overall length**, L_T, of the stud is the distance, parallel to the axis of the stud from one end to the other end, measured to the extreme condition on each end. Tolerances for overall stud lengths are given in the standard.

For both continuous and double-end type studs, the **nominal length** is the same as the overall length without tolerances.

Points

Unless otherwise specified, studs with either pointed or unpointed ends may be provided.

Pointed ends shall be chamfered from a diameter equal to or slightly less than the thread root diameter. The length of the point to the first full formed thread at major diameter shall not exceed U_{max}. U_{max} is equal to two thread pitches.

Screw Threads

UNC, UNF, and 8UN Thread Series and Tolerance Class

Threads shall be unified inch coarse, fine, or 8-thread series Class 2A in accordance with ASME B1.1.

Class 5 Interference-Fit Threads (For Tap End Studs)

In addition to the threads identified above, interference-fit threads may be ordered for the tap end of tap end type studs. These threads shall be interference fit (Class 5) of the modified National thread form in the coarse thread series (NC) in sizes 0.250 in. through 1.500 in. in accordance with ASME B1.12 as specified by the purchaser.

Materials and Mechanical Properties

Unless otherwise specified,

Steel studs shall conform to the requirements of ASTM A 354, SAE J429, or ASTM A 449, as identified by the purchaser.

Studs of corrosion resistant steels shall conform to the requirements of ASTM F 593, including passivation in accordance with ASTM A 380.

Nonferrous studs shall conform to the requirements of ASTM F 468.

Designation

Studs shall be designated in accordance with the data, preferably in the sequence by:

- product name
- product standard (ASME B18.31.2)
- nominal diameter and thread pitch
- nominal length
- material (applicable standard and grade or alloy)
- protective coating, if required

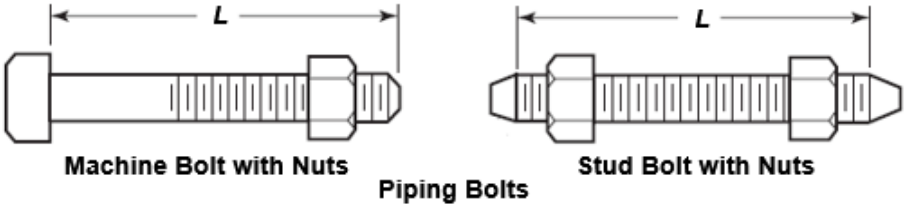
In addition, pointed ends must be specified, or unpointed ends may be provided. For tap end studs, show tap end thread type from ASME B1.12, length, and nut end thread, as shown in Example 3 below.

Examples:

1. Continuous thread stud, ASME B18.31.2, ½-13 × 4, SAE J429 Grade 5, zinc plated per ASTM F1941 Classification Code Fe/ Zn 5A, pointed ends
2. Clamping type stud, reduced diameter body, ASME B18.31.2, ⅜-16 × 2, ASTM F468 nickel-copper alloy 400, pointed ends
3. Tap end stud, full body, ASME B18.31.2, 1⅛ NC-5 HF × 6½ × 1⅛-8UN, ASTM F593 Alloy Group 2, Cold Worked Condition, pointed ends

ASME B16.5: Pipe Flanges and Flanged Fittings

ASME B16.5 covers pressure-temperature ratings, materials, dimensions, tolerances, marking, testing, and methods of designating openings for pipe flanges and flanged fittings. Also included in this standard are requirements and recommendations regarding flange bolting, gaskets, and joints.



Piping Bolts

As shown in above figure, the standard covers two types of bolts for piping - machine bolt with nuts and stud bolt with nuts.

It may be noted that the length of the stud bolt does not include the height of the points. The length is measured from first thread to first thread, excluding points. First thread is defined as the intersection of the major diameter of the thread with the base of the point. Points are flat and chamfered. The difference in definition of stud bolt length is the main difference between stud bolts as per ASME B18.31.2 and ASME B16.5. For more information, please see the standard.

DIN Standards for Studs

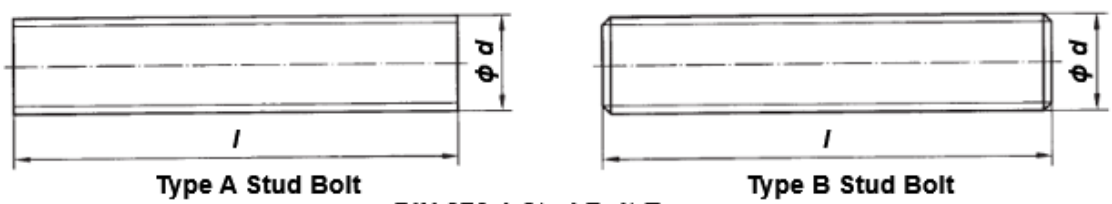
Information about various Metric DIN standards for studs is as under.

DIN 976: Metric Thread Stud Bolts

DIN 976 stud bolts are headless bolts threaded all the way from one end to the other (fully threaded). This standard has two parts as under.

DIN 976-1

DIN 976-1 specifies dimensions and technical delivery conditions for stud bolts with metric thread made of steel, stainless steel or nonferrous metal.



DIN 976-1 Stud Bolt Types

As shown in above figure, there are two types of stud bolts. Type A stud bolt has RL (As-rolled end) type thread end as in DIN EN ISO 4753. Type B stud bolt has CH (Chamfered end) type thread end as in DIN EN ISO 4753.

The standard covers stud bolts with threads produced to tolerance 6g which is customary for bolt/nut assemblies.

Stud bolts as per this standard are designated as per the following example.

Designation of an M10 stud bolt (M10) of type B (B), with a nominal length, *l*, of 80 mm (80), of property class 8.8: Stud bolt DIN 976-1 - M10 × 80 - B - 8.8

DIN 976-2

DIN 976-2 contains dimensional and technical requirements of stud bolts with metric interference thread MFS (as per DIN 8141-1) and specifies their designation. The stud bolts are intended for use in light metals, including aluminium.

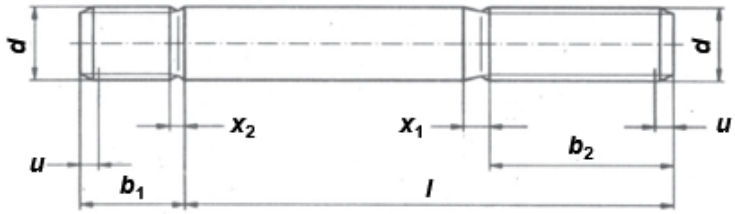
As per the standard, the thread ends shall be CH (Chamfered end) type as in DIN EN ISO 4753.

Stud bolts as per this standard are designated as per the following example.

Designation of a stud bolt with series MFS 12 interference-fit thread, with a nominal length, *l*, of 80 mm and assigned to property class 8.8: Stud bolt DIN 976-2 - MFS 12 × 80 - 8.8

For more information, please see the standard.

DIN 835, DIN 938, DIN 939, DIN 940 and DIN 949 (949 Part 1 and 949 Part 2)



b_1 = length of thread stud end u = incomplete thread,
b_2 = length of thread nut end $u_{max} = 1{,}5P$

Dimensions of Studs as per DIN Standards

Dimensions

l = length of stud, *d* = nominal diameter, *x* = thread run-out, *P* = pitch of thread

Double ended studs are NOT called out by their overall length.

Called out length of a stud (*l*) = nut end thread length (b_2) + the length of unthreaded portion.

To calculate the overall length of a double end stud, add the stud end thread length (b_1) to the called out length (*l*).

Some general guidelines for calculating the nut end thread length (b_2) are as under:

Studs whose (l) dimension is less than or equal to 2 times their nominal diameter (d) + 6 mm, will normally be fully threaded.

For studs whose (l) dimension is greater than or equal to 2 times their nominal diameter + 6 mm, but not longer than 125 mm, the b_2 dimension = 2 times the nominal diameter + 6 mm.

For studs whose (l) dimension is greater than or equal to 125 mm but less than 200 mm, the b_2 dimension = 2 times the nominal diameter + 12 mm.

For studs whose (l) dimension is greater than or equal to 200 mm, the b_2 dimension = 2 times the nominal diameter + 25 mm.

Stud end length (b_1) as per various DIN Standards can be calculated as under:

Stud end length (b_1) = d (nominal diameter in mm) x multiplier.

The stud end length is based on the work piece in which the stud has to be screwed in.

The value of multiplier for various DIN Standards is given in the following table.

DIN Standard	Multiplier
835	2.0
938	1.0
939	1.25
940	2.5
949 Part 1	2.0
949 Part 2	2.5

The main difference between DIN 835, 938, 939, 940 and DIN 949 is the type of stud end thread for interference-fit. In case of DIN 835, 938, 939 and 940, the stud end thread fit is Sk6 as specified in DIN 13-51 whereas in case of DIN 949, the stud end thread is with metric interference-fit, MFS as specified in DIN 8141-1. To achieve an interference fit, the studs shall be installed in holes produced to DIN 8141-1.

Studs as per DIN 949 Part 1, with property class 5.6 and 8.8, length of engagement (b_1) equal to about 2d is called type A studs whereas studs as per DIN 949 Part 2, with property class 10.9, length of engagement (b_1) equal to about 2.5d is called type B studs.

Research on interference-fit threads has shown that tolerance Sk6 specified for the pitch diameter of external threads does not ensure sufficient tightness of fit. Thus, an interference-fit thread (MFS) stud has been developed in which a tight fit is achieved by an increased external thread major diameter.

If interference-fit thread is not wanted for stud end, the stud is designated Fo (without interference-fit thread) or Sn4. In that case studs will have thread tolerance class 6g on both ends (DIN 13-12 and DIN 13-15).

Use

Studs as per DIN 835 (b_1 = 2d) are intended for use mainly in aluminium alloys.
Studs as per DIN 938 (b_1 = 1d) are intended for use mainly in steel.
Studs as per DIN 939 (b_1 = 1.25d) are intended for use mainly in cast iron.
Studs as per DIN 940 (b_1 = 2.5d) are intended for use mainly in light metals of low strength.
Studs as per DIN 949 are intended for use in light metal including aluminium.

Designation Examples

Designation of an M12 stud with interference-fit thread as in DIN 13-51, with b_1 = 1d, a nominal length, l, of 80 mm, and assigned to property class 8.8: Stud DIN 938-M12 × 80-8.8

Designation of an M12 stud without interference-fit (Fo), with b_1 = 1d, a nominal length, l, of 80 mm, and assigned to property class 8.8: Stud DIN 938-M12 Fo × 80-8.8

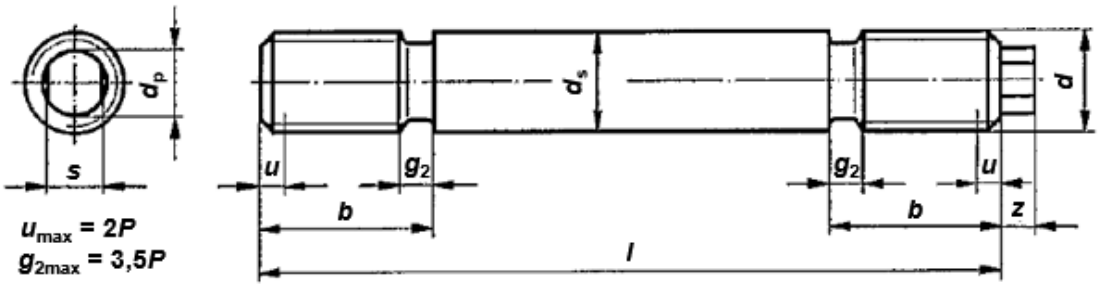
Designation of a type B stud with series MFS 12 type metric interference-fit thread, a nominal length, l, of 80 mm, and assigned to property class 10.9: Stud DIN 949 - B MFS 12 × 80 - 10.9

Note

Sometimes, stud end is called metal end.

DIN 2509: Double End Studs

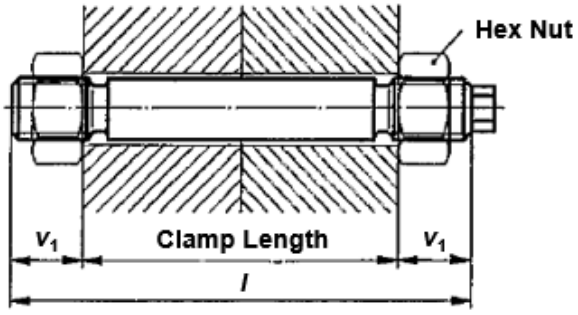
DIN 2509 contains dimensional and technical requirements of double end studs and specifies their designation.



Dimensions of Double End Studs as per DIN 2509

Double end studs (M12 to M100) as per this standard are designed to be used for clamping two components together by tightening nuts that are screwed onto both ends. A flattened dog point on one thread end is intended to prevent the double end stud from turning during assembly.

For sizes up to M39, the standard specifies two thread lengths for each size. The short thread is designed for nuts specified in DIN 934. The long thread is designed for style 1 ISO nuts, as specified in DIN 970 which have an increased nut height and which shall be given preference because of their higher resistance to stripping.



Application of DIN 2509 Double End Studs

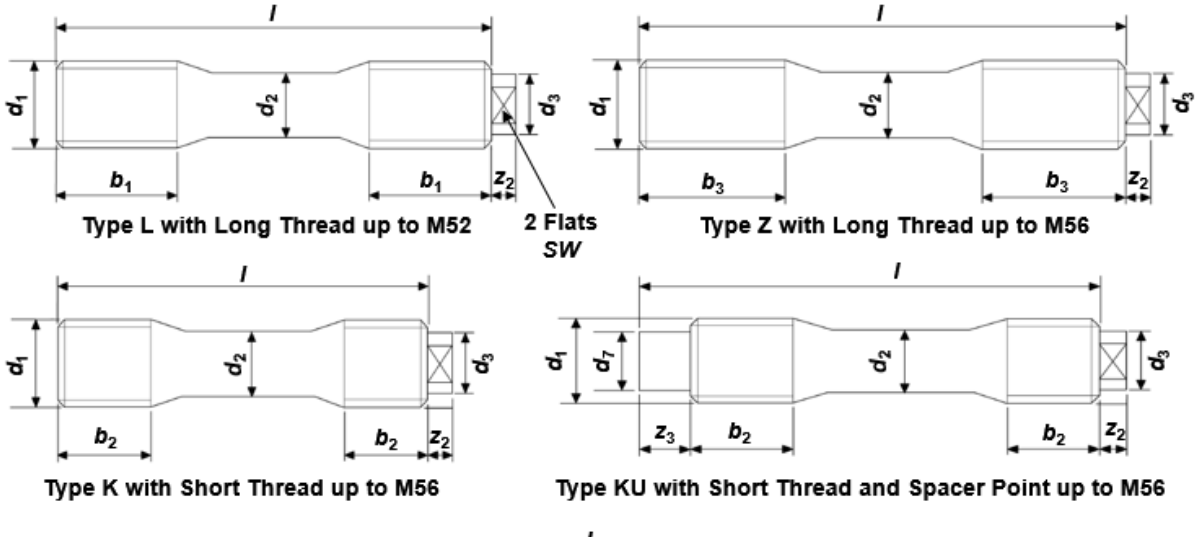
Above figure shows requirement of distance v_1 for application of the studs.

Following table shows dimensions of stud sizes from M12 to M39. For larger studs, please see the standard.

Dimensions of Double End Studs as per DIN 2509 (all dimensions are in mm)																
d	**Pitch *P***	**Thread Length, *b***				v_1 min	d_s		d_p		***s***		***z***			
		Short		**Long**												
		nominal	max	nominal	max		max	min	max	min	max	min	nominal	max	min	
M12	1,75	21	23,5	23	25,5	13,5	12	11,82	8	7,78	7	6,82	4	4,24	3,76	
M16	2	25	28	28	31	17	16	15,82	12	11,73	10	9,78	5	5,24	4,76	
M20	2,5	30	34	34	37	21	20	19,79	14	13,73	11	10,73	6	6,24	5,76	
M24	3	36	40,5	40	44,5	25	24	23,79	14	13,73	11	10,73	6	6,24	5,76	
M27	3	38	42,5	43	47,5	28	27	26,79	18	17,73	13	12,73	6	6,24	5,76	
M30	3,5	42	47	47	52	31	30	29,79	18	17,73	13	12,73	6	6,24	5,76	
M33	3,5	44	49	50	55	33	33	32,75	25	24,67	22	21,67	9	9,29	8,71	
M36	4	50	56	55	61	37	36	35,75	25	24,67	22	21,67	9	9,29	8,71	
M39	4	52	58	58	64	39	39	38,75	28	27,67	24	23,67	10	10,29	9,71	

DIN 2510: Bolted Connection with Reduced Shank Stud-bolts

In DIN 2510 bolted connections, the use of DIN 2510 stud with reduced (waisted) shank ensure top-notch performance under high pressure and high impact conditions. When combined with high resistance material in compliance, they show excellent durability and superior functionality in working operations. Part 3 of the standard covers dimensions of various type of studs (M12 to M180). DIN 2510 studs are generally supplied with DIN 2510 NF Nuts. Part 5 of the standard gives information about NF and TF type hexagon nuts.



Type L with Long Thread up to M52

Type Z with Long Thread up to M56

Type K with Short Thread up to M56

Type KU with Short Thread and Spacer Point up to M56

Type ZU with Long Thread and Spacer Point up to M56

Dimensions of Double End Studs as per DIN 2510

Following table shows some dimensions of stud sizes from M12 to M56. For larger studs, please see the standard. It may be noted that larger studs, stud sizes from M64 and upwards are provided with a hole in their center (d_4, not shown in above figure).

Dimensions of Double End Studs as per DIN 2510 (All dimensions are in mm)														
d_1*	M12	M16	M20	M24	M27	M30	M33	M36	M39	M42	M45	M48	M52	M56
Pitch	1,75	2	2,5	3	3	3,5	3,5	4	4	4,5	4,5	5	5	5,5
d_2	8,5	12	15	18	20,5	23	25,5	27,5	30,5	32,5	35,5	37,5	41	44
d_3	8	12	14	14	18	18	25	25	28	28	32	32	36	40
d_7	8	12	13	16	18	21	24	26	30	32	34	37	40	45
b_1	20	23	28	32	35	39	42	45	48	52	55	58	62	-
b_2	13	16	20	24	27	30	33	36	39	42	45	48	52	56
b_3	27	31	36	42	47	50	53	57	60	64	66	70	74	79
SW	7	10	11	11	13	13	22	22	24	24	27	27	30	32

* Thread size d_1 according to DIN 2510 Part 2

Designation Example

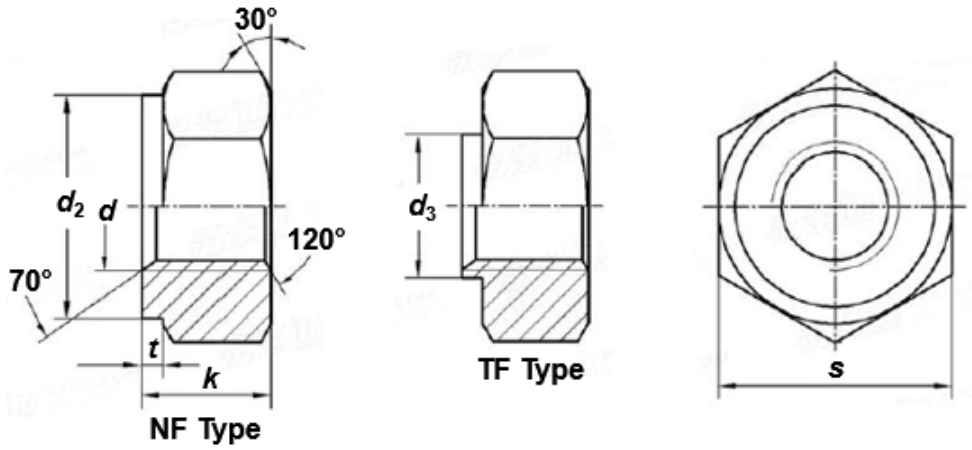
Designation of a stud-bolt type L with thread d_1 = M30 and nominal length l = 200 mm in 24CrMo5:

Stud-bolt L M30 × 200 DIN 2510 - 24CrMo5

If stud-bolt of types K, KU, Z or ZU for M64 DIN 2510 and upwards are required without hole d_4, then the letter O should be inserted in the designation, e.g.:

Stud-bolt KO M100 × 6 × 600 DIN 2510 - 24CrMo5

NF and TF Type Hexagon Nuts



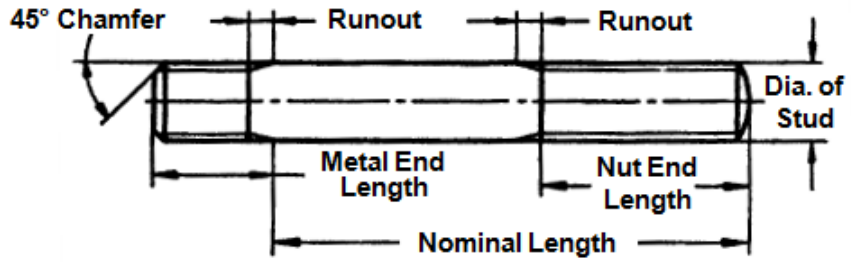
NF and TF Type Hexagon Nuts

Following table shows some dimensions of NF and TF Type Hexagon Nuts (DIN 2510).

Dimensions of NF and TF Type Hexagon Nuts as per DIN 2510 (All dimensions are in mm)														
Thread Size, *d*	M12	M16	M20	M24	M27	M30	M33	M36	M39	M42	M45	M48	M52	M56
Pitch, *P*	1,75	2	2,5	3	3	3,5	3,5	4	4	4,5	4,5	5	5	5,5
d_2	21	26	31	35	40	45	49	53,5	58,5	63,5	68,5	73,5	78,5	83,5
d_3	14,5	18,5	22,5	26,5	30,5	33,5	36,5	39,5	42,5	45,5	49,5	53,5	57,5	63
k	12	16	20	24	27	30	33	36	39	42	45	48	52	56
s	22	27	32	36	41	46	50	55	60	65	70	75	80	85
t	2	2	2	3	3	3	3	3	3	3	3	4	4	4

IS 1862-1975: Specification for Studs

IS: 1862-1975 covers the requirements for studs in the diameter range from 3 to 39 mm.



Nomenclature of Stud as per IS 1862

Definitions

Metal End - The end of the stud which is screwed into the component.

Nut End - The end of the stud which is not screwed into the component.

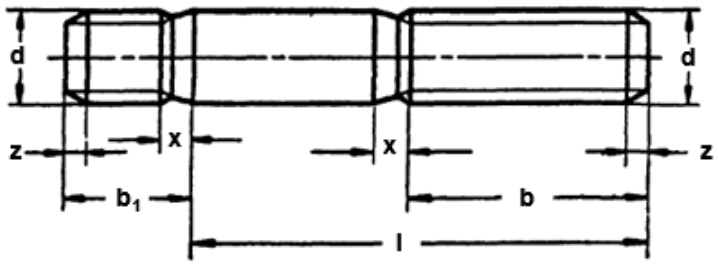
Stud Types

Type A - $b_1 \approx 1.0\ d$, suitable for use in steel.
Type B - $b_1 \approx 1.5\ d$, suitable for use in cast iron.
Type C - $b_1 \approx 2.0\ d$, suitable for use in aluminium alloys.

Grade

Studs are made to Grade A as specified in IS: 1367 (Part II) - 1979 'Technical supply conditions for threaded steel fasteners: Part II Product grades and tolerances'.

Dimensions



Dimensions of Studs as per IS 1862

d - Nominal size of stud
z - according to IS: 1368-1967 Dimensions of ends of bolts and screws
x - according to IS: 1369-1975 Dimensions of screw thread runouts and undercuts

Screw Threads

The screw thread dimensions for the metal end of the stud shall conform to those specified in IS: 2186 – 1967 'Dimensions for external interference fit threads'. Screw threads for nut end of the stud shall conform to 6g tolerance class as specified in IS: 4218-1976 'ISO metric screw threads'.

Mechanical Properties

Type A and Type B studs, made from steel, shall conform to property classes 4.6, 6.6, 8.8 and 10.9 of IS: 1367-1967 'Technical supply conditions for threaded fasteners'.

Type C studs, made from steel, shall conform to property classes 4.6, 6.6 and 8.8 of IS: 1367-1967

Designation

Studs shall be designated by the name, type, size, nominal length, number of this standard and symbol for mechanical property class.

Example: A stud of Type A, size M5, nominal length 25 mm and made of steel having property class 8.8 shall be designated as under.

Stud A M5 × 25 IS: 1862 8.8

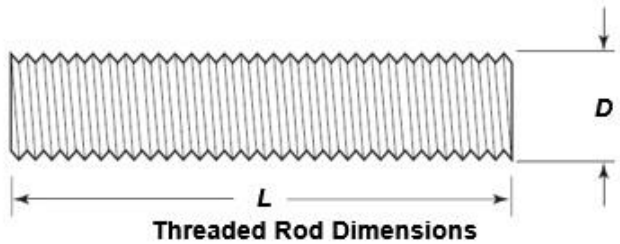
For information on nut end length and preferred length-size combinations, please see the specification.

AWHEM Recommendation

AWHEM (Association of Well Head Equipment Manufacturers) recommendation establishes definite dimensions for stud bolts and tap end studs for use with API Spec 6A flanges/studded flange connections and provides for dimensionally interchangeable stud bolts and tap end studs for API Spec 6A flanges/studded flange connections. For more information, please see their recommendation.

ASME B18.31.3: Threaded Rods

ASME B18.31.3 covers the complete general and dimensional data for inch series threaded rods recognized as American National Standard. Included are diameters #4 through 4 in. UNC, UNF, 8UN, and ACME in both right- and left-handed threads.



Threaded Rod Dimensions

Threaded rods are commonly produced in, but not limited to, 3-ft, 6-ft, 10-ft, and 12-ft lengths. The length of the threaded rod shall be measured, overall, from end to end.

There are four primary designations for threaded rod materials: Steel (ASTM A 307, Grade A), A36 (ASTM F 1554, Grade 36), B7 (ASTM A 193/A 193M, Grade B7) and CRES [corrosion resistant steel of either 18-8 (302, 303, or 304) or 316 as designated by the purchaser]. Nonferrous materials shall conform to ASTM F 468.

For more information about threaded rods, please see ASME B18.31.3.

Product Standards for Prevailing Torque Type Nuts

Usually nuts are free-running, but prevailing torque type nuts have a self-contained feature that causes resistance to nut turning. This resistance is called "prevailing torque". Prevailing torque is the torque required to turn the nut. None of the prevailing torque goes toward tightening/tensioning the bolt. There are various self-contained features, with the common principle being to bind (or wedge) the nut thread to the bolt threads. Prevailing torque type nuts can be divided into two main types, namely all metal type and non-metallic insert type. All metal prevailing torque nuts get the feature of prevailing torque when the threads are distorted at the top of the nut. On the other hand, the non-metallic inserts type prevailing torque nuts have nylon or any other polymer insert that helps achieve a prevailing torque.

Prevailing torque type nuts can be reused only for a limited number of times because each time the nut is used, there is a decline in its prevailing torque quality. Hence, the nut user should consider the implications of decreased performance prior to its reuse. These nuts are used as a lock nut to withstand shock loads and vibrations. Information about various ISO and ASME product standards for prevailing torque type nuts and ISO 2320, standard for functional properties of prevailing torque steel nuts is given in this chapter.

ISO 2320: Fasteners - Prevailing Torque Steel Nuts - Functional Properties

ISO 2320 specifies the functional properties for prevailing torque steel nuts when tested at an ambient temperature range of +10°C to +35°C. It includes a combined test method to determine the prevailing torque properties and the torque/clamp force properties at the same time. It applies to prevailing torque all metal type nuts and prevailing torque non-metallic insert type nuts with coarse pitch thread M5 to M39 or with fine pitch thread M8 × 1 to M39 × 3. All metal type nuts conforming to the requirements of this Standard are used in applications ranging from −50°C to +150°C. All non-metallic insert type nuts conforming to the requirements of this Standard are used in applications ranging from −50 °C to +120 °C.

Note

The fifth edition (ISO 2320:2015) cancels and replaces the fourth edition (ISO 2320:2008), which has been technically revised. The following changes have been made:

- property class 9 has been deleted;
- prevailing torques for nuts M3 and M4 have been moved to Annex C;
- in the test fixture, the thread protrusion through the prevailing torque feature has been changed to 3 to 5 pitches;
- the reference surface condition for the test bolt has been specified in accordance with ISO 16047 (plain surface, uncoated and degreased, unless otherwise agreed);
- the determination of the prevailing-off torque has been changed from the upper value to the minimum value (new point 5 in Figure 2 of the standard), which changes the acceptance conditions.

Terms and Definitions

Prevailing torque nut

Nut which is not free-running on a mating thread by virtue of a self-contained prevailing torque feature, and which provides resistance to rotation independent of clamping or compression forces.

Prevailing torque developed by the nut

Torque necessary to rotate the nut on its mating externally threaded component and without clamp force.

Prevailing-on torque ($T_{FV, max}$)

Torque to rotate the nut on its mating externally threaded component with the torque measured while the nut is in motion and without clamp force.

Prevailing-off torque ($T_{Fd, min}$)

Torque to rotate after backing off the nut until the removal of the clamp force in the following 360° rotation of the nut.

Prevailing torque all metal type nut

Nut which has a one piece or a multiple piece metal construction and derives its prevailing torque characteristics from a controlled distortion of the nut thread and/or body and/or from metallic insert(s).

Prevailing torque non-metallic insert type nut

Nut which has a multiple piece construction and derives its prevailing torque characteristics from insert(s) of non-metallic material retained in the nut.

Seating point

Point in the tightening process where clamp force first appears.

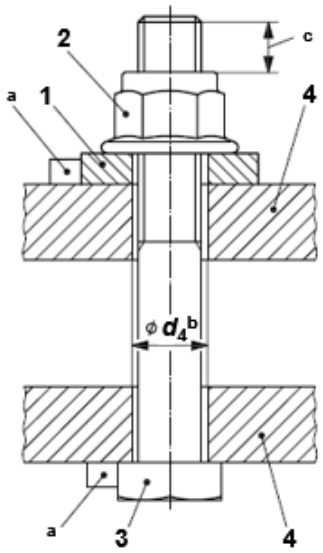
Symbols

For the purpose of this standard, the following symbols apply together with those defined in ISO 16047.

d - nominal diameter
d_4 - diameter of the hole of the fixture
F_P - proof load
F_{65} - lower load limit for the evaluation of the coefficient of total friction at 65 % of F_P
F_{75} - upper load limit for the evaluation of the coefficient of total friction at 75 % of F_P
F_{80} - test clamp force (shut-down force for the tightening process) at 80 % of F_P
P - pitch of the thread
T_{Fv} - prevailing-on torque, in newton metres
T_{Fd} - prevailing-off torque, in newton metres
T_{65} - lower torque limit for the evaluation of the coefficient of total friction at F_{65}
T_{75} - upper torque limit for the evaluation of the coefficient of total friction at F_{75}
T_{80} - test torque corresponding to 80 % of the proof load, in newton metres (see Tables in the standard)
μ_{tot} - coefficient of total friction

Test Apparatus and Test Procedure as per ISO 2320: 2008

For better understanding of terms and definitions, general information about test apparatus and test procedure as per ISO 2320: 2008 is given in this section. Please note that this information is revised in the fifth edition (ISO 2320:2015) and you are requested to see the fifth edition.



Key
1 test-bearing plate/washer
2 nut to be tested
3 test bolt/screw
4 load cell

[a] Test-bearing plate or test washer and bolt head shall be fixed by suitable means to prevent rotation and shall be aligned.
[b] *d*4 shall be in accordance with ISO 273:1979, fine series.
[c] 4 to 7 pitches.

Test Setup and Nut When Seated

Above figure (Test Setup and Nut When Seated, called Figure 1 in ISO 2320:2008) shows the test setup. For test apparatus, please see ISO 16047.

Test Procedure

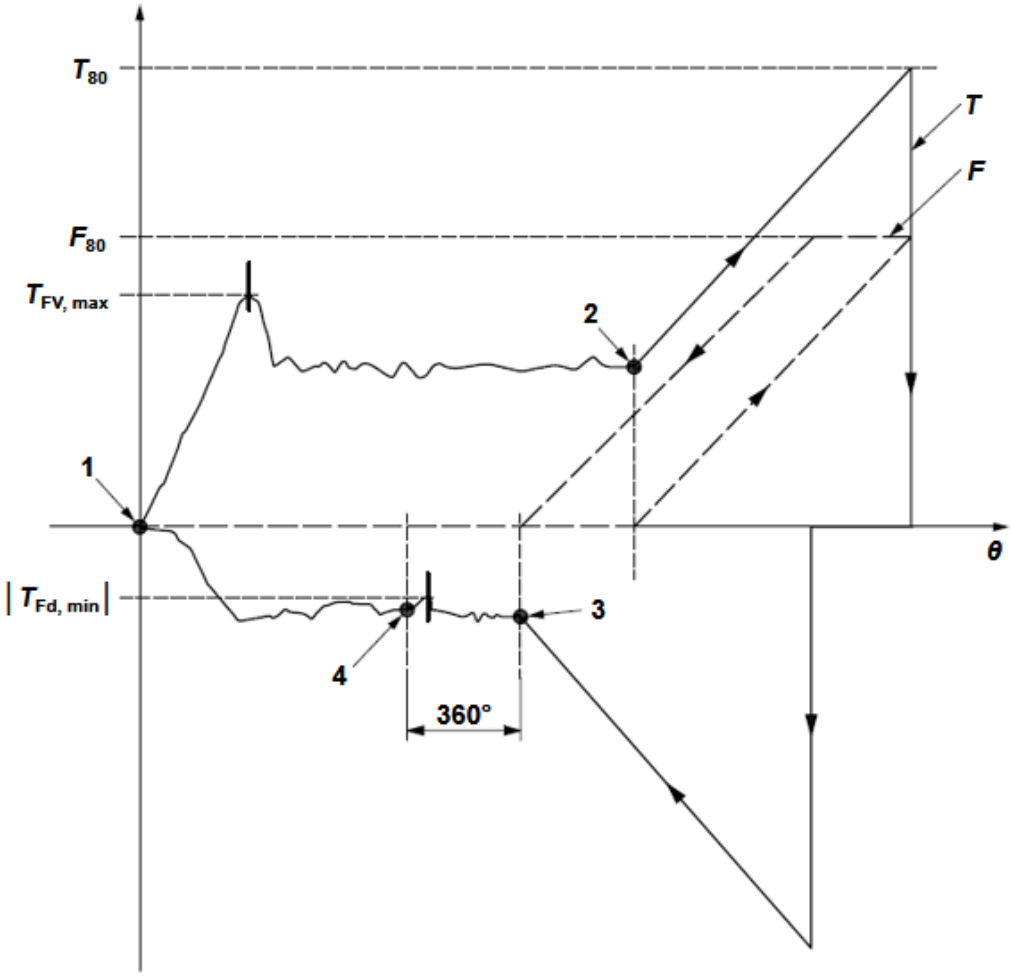
The purpose of this test procedure is to obtain the performance properties (prevailing torques developed by the nut) of prevailing torque type nuts. Following is the test procedure.

The test bolt/screw is placed in the testing device such that the protrusion through the prevailing torque feature of the nut after seating is according to above figure (Figure 1).

The nut to be tested is engaged by hand on the bolt/screw thread until the prevailing torque feature is engaged. The end of the test bolt/screw shall not protrude through the nut before testing. The threaded length for tightening shall be four to seven pitches according to above figure.

The starting point of the installation phase corresponds to the start-up of the tightening device (see point 1 in the following figure, Torque/Clamp Force/Angle Curve called Figure 2).

The rotation shall be continuous and uniform from point 1 until the test clamp force, F_{80}, is reached. Values for F_{80} are given in the standard (for values of F_{80}, tables are given in the standard for nuts of various property class - for tables, please see the standard). Torque at clamp force F_{75} shall be recorded and evaluated.



Key

F **clamp force**	**1 point where prevailing-on torque occurs first and measurement of T_{Fv} starts**
T **torque**	**2 seating point, end of measurement of T_{Fv}**
θ **angle**	**3 no contact with the test plate/ washer, beginning of measurement of T_{Fd}**
	4 end of measurement of T_{Fd}

Torque/Clamp Force/Angle Curve

The seating point (see point 2 in above figure, Fig. 2 of ISO 2320:2008) shall be determined. Between point 1 and point 2, the prevailing-on torque, $T_{Fv, max}$, shall be measured.

It may be noted that the test apparatus does not generate clamp force during prevailing torque testing.

The nut is then rotated off by the application of a reverse torque until the clamp force in the test bolt/screw is reduced to zero (see point 3 in above figure, Figure 2 of ISO 2320:2008). The prevailing-off torque, $T_{Fd, min}$, occurring while the nut is rotated through the next 360° of rotation (see point 4 in above figure, Figure 2 of ISO 2320:2008) shall be measured. Point 4 corresponds to the angular position of point 3 minus 360°.

The nut is then disassembled until the initial angular position has reached the starting point (see point 1).

During the removal of the nut, the rotating shall be continuous and uniform from the test clamp force, F_{80}, to point 1.

After the complete removal of the nut, the nut and bolt threads shall not be damaged.

For determination of the values for the 5th removal, the above procedure will be performed four more times between point 1 and point 2 only.

During the 5th removal, the prevailing-off torque occurring while the nut is being rotated through the first 360° shall be measured. This torque shall be equal to, or higher than, the 5th removal prevailing torque value as specified in the tables given in the standard.

To give an idea of information contained in various tables in the standard, following figure shows a snap shot of Table 5 (small part of the table) from ISO 2320: 2008. Please note that as mentioned earlier, the fifth edition (ISO 2320: 2015) cancels and replaces the fourth edition (ISO 2320: 2008), which has been technically revised.

Table 5 — Test clamp force and prevailing torques for prevailing torque type nuts of property class 8

Thread $d\ P$	Test clamp force F_{80}[a] N	Clamp force for evaluation of total friction coefficient μ_{tot}[b]		Prevailing torque N·m		
		Upper limit F_{75}[c] N	Lower limit F_{65}[d] N	1st installation $T_{Fv,max}$[e]	1st removal $T_{Fd,min}$[f]	5th removal $T_{Fd,min}$[f]
M3	2 336	2 190	1 898	0,43	0,12	0,08
M4	4 080	3 825	3 315	0,9	0,18	0,12
M5	6 584	6 173	5 350	1,6	0,29	0,2
M6	9 280	8 700	7 540	3	0,45	0,3
M7	13 440	12 600	10 920	4,5	0,65	0,45
M8	16 960	15 900	13 780	6	0,85	0,6
M8×1	18 160	17 025	14 755			
M10	26 960	25 275	21 905	10,5	1,5	1
M10×1,25	28 400	26 625	23 075			
M10×1	29 920	28 050	24 310			

a The clamp force for property class 8 nuts is equal to 80 % of the proof load of property class 8.8 bolts. Proof loads for bolts are given in ISO 898-1.

e The prevailing torques for first assembly apply for all metal type nuts only. For prevailing torque non-metallic insert type nuts, the maximum torques shall be 50 % of the values.

Snap Shot of Table 5 (Part) ISO 2320: 2008

Performance Requirements for Prevailing Torque Properties

The prevailing-on torque shall not exceed the value specified for the applicable nut in the tables given in the standard.

The prevailing-off torque shall exceed the value specified for the applicable nut in in the tables given in the standard.

For delivery inspection, the 1st installation/removal test applies, unless otherwise agreed.

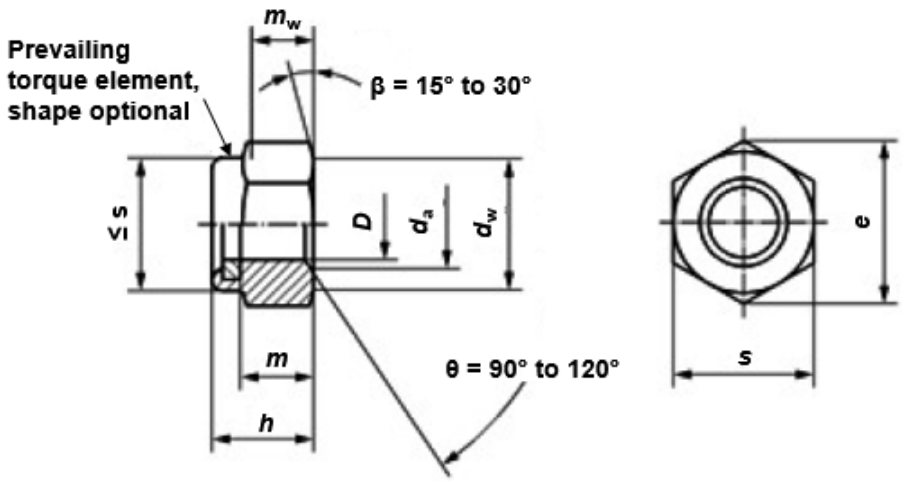
By request of the customer, a temperature resistance test for prevailing torque non-metallic insert type nuts as given in Annex A of the standard may be carried out.

ISO 7040: Prevailing Torque Type Hexagon Regular Nuts (with non-metallic insert) - Property Classes 5, 8 and 10

ISO 7040 specifies the characteristics of prevailing torque type hexagon regular (style 1) nuts (with non-metallic insert), with threads from M3 up to and including M36, in product grade A for threads up to and including M16 and product grade B for threads above M16, and with property classes 5, 8 and 10.

Dimensions

Symbols and designations of dimensions are specified in ISO 225



Dimensions of Prevailing Torque Type Hexagon Regular Nuts with Non-Metallic Insert (as per ISO 7040)

It may be noted that the dimensions of the nuts correspond to those given in ISO 4032 plus prevailing torque feature.

Following table shows dimensions of the nuts.

Dimensions of Prevailing Torque Type Hexagon Regular Nuts with Non-Metallic Insert (in mm)														
Thread, *D*		M3	M4	M5	M6	M8	M10	M12	(M14)*	M16	M20	M24	M30	M36
P	Pitch	0,5	0,7	0,8	1	1,25	1,5	1,75	2	2	2,5	3	3,5	4
d_a	max	3,45	4,6	5,75	6,75	8,75	10,8	13	15,1	17,3	21,6	25,9	32,4	38,9
	min	3	4	5	6	8	10	12	14	16	20	24	30	36
d_w	min	4,57	5,88	6,88	8,88	11,63	14,63	16,63	19,64	22,49	27,7	33,25	42,75	51,11
e	min	6,01	7,66	8,79	11,05	14,38	17,77	20,03	23,36	26,75	32,95	39,55	50,85	60,79
h	max	4,5	6,00	6,8	8,00	9,5	11,9	14,9	17,00	19,1	22,8	27,1	32,6	38,9
	min	4,02	5,52	6,22	7,42	8,92	11,2	14,2	15,9	17,8	20,7	25,0	30,1	36,4
m	min	2,15	2,9	4,4	4,9	6,44	8,04	10,37	12,1	14,1	16,9	20,2	24,3	29,4
m_w	min	1,72	2,32	3,52	3,92	5,15	6,43	8,3	9,68	11,28	13,52	16,16	19,44	23,52
s	max	5,5	7	8	10	13	16	18	21	24	30	36	46	55
	min	5,32	6,78	7,78	9,78	12,73	15,73	17,73	20,67	23,67	29,16	35	45	53,8

* The size in brackets should be avoided if possible.

Requirements

The nuts shall meet mechanical and performance properties as per ISO 2320.

Designation

Example - A prevailing torque type hexagon regular nut with non-metallic insert, thread M10 and property class 8 is designated as follows:

Prevailing torque type hexagon regular nut ISO 7040 - M10 - 8

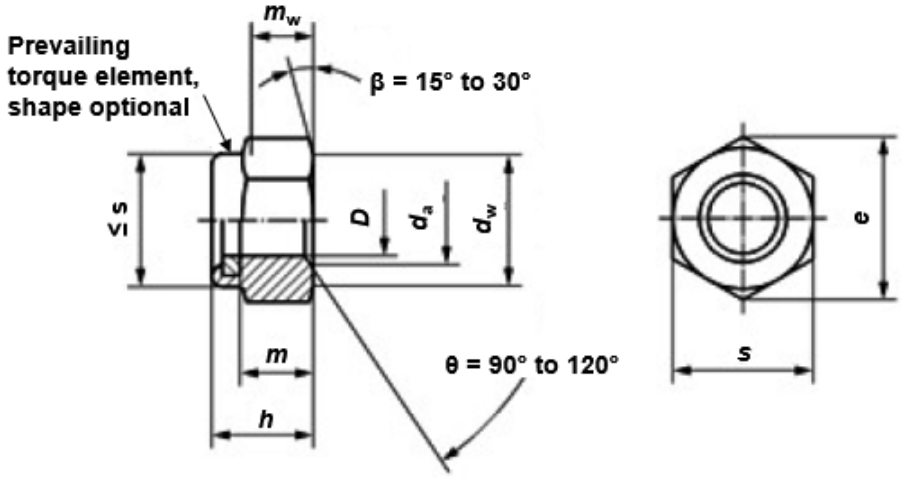
Note

It may be noted that Indian Standard **IS 1367, Part 8** is identical with ISO 2320 and Indian Standard **IS 7002** is identical with ISO 7040.

ISO 7041: Prevailing Torque Type Hexagon Nuts (with non-metallic insert), Style 2 - Property Classes 9 and 12

ISO 7041 specifies the characteristics of prevailing torque type hexagon nuts (with non-metallic insert), style 2, with threads from M5 up to and including M36, in product grade A for threads up to and including M16, and product grade B for threads above M16, and with property classes 9 and 12

Dimensions



Dimensions of Prevailing Torque Type Hexagon Nuts with Non-Metallic Insert, Style 2 (as per ISO 7041)

The dimensions of the nuts correspond to those given in ISO 4033 plus prevailing torque feature. Following table shows dimensions of the nuts.

Dimensions of Prevailing Torque Type Hexagon Nuts with Non-Metallic Insert, Style 2 (in mm)												
Thread, *D*		M5	M6	M8	M10	M12	(M14)*	M16	M20	M24	M30	M36
P	Pitch	0,8	1	1,25	1,5	1,75	2	2	2,5	3	3,5	4
d_a	max	5,75	6,75	8,75	10,8	13	15,1	17,3	21,6	25,9	32,4	38,9
	min	5	6	8	10	12	14	16	20	24	30	36
d_w	min	6,88	8,88	11,63	14,63	16,63	19,64	22,49	27,7	33,25	42,75	51,11
e	min	8,79	11,05	14,38	17,77	20,03	23,36	26,75	32,95	39,55	50,85	60,79
h	max	7,2	8,5	10,2	12,8	16,1	18,3	20,7	25,1	29,5	35,6	42,6
	min	6,62	7,92	9,5	12,1	15,4	17	19,4	23	27,4	33,1	40,1
m	min	4,8	5,4	7,14	8,94	11,57	13,4	15,7	19	22,6	27,3	33,1
m_w	min	3,84	4,32	5,71	7,15	9,26	10,7	12,6	15,2	18,1	21,8	26,5
s	max	8	10	13	16	18	21	24	30	36	46	55
	min	7,78	9,78	12,73	15,73	17,73	20,67	23,67	29,16	35	45	53,8

* The size in brackets should be avoided if possible.

Requirements

The nuts shall meet mechanical and performance properties as per ISO 2320.

Designation

Example - A prevailing torque type hexagon nut, style 2, with non-metallic insert, thread M10 and property class 12 is designated as follows:

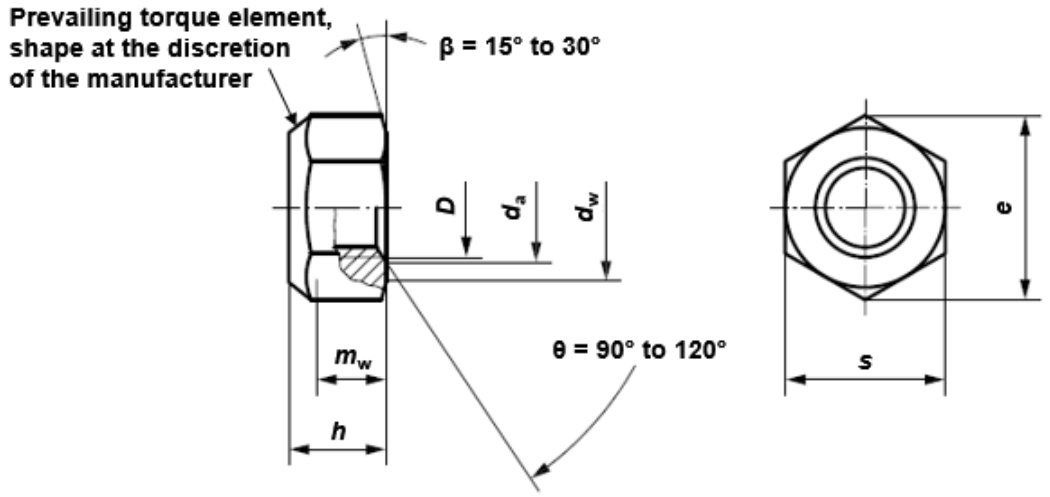
Prevailing torque type hexagon nut, ISO 7041 - M10 - 12

ISO 7042: Prevailing Torque Type All-Metal Hexagon High Nuts - Property Classes 5, 8, 10 and 12

ISO 7042 specifies the characteristics of prevailing torque type all-metal hexagon high nuts with threads from M5 up to and including M36, in product grade A for threads up to and including M16 and product grade B for threads above M16, and with property classes 5, 8, 10 and 12.

It may be noted that nuts of property class 9 are dealt with in ISO 7720.

Dimensions



Dimensions of Prevailing Torque Type All-Metal Hexagon High Nuts (as per ISO 7044)

The dimensions of the nuts with the exception of the dimensions m_w and h_{max} correspond to those given in ISO 4033. Following table shows dimensions of the nuts.

Dimensions of Prevailing Torque Type All-Metal Hexagon High Nuts (in mm)												
Thread, *D*		M5	M6	M8	M10	M12	(M14)*	M16	M20	M24	M30	M36
P	Pitch	0,8	1	1,25	1,5	1,75	2	2	2,5	3	3,5	4
d_a	max	5,75	6,75	8,75	10,8	13	15,1	17,3	21,6	25,9	32,4	38,9
	min	5,00	6,00	8,00	10,00	12,00	14,00	16,00	20,00	24,00	30,00	36,00
d_w	min	6,88	8,88	11,63	14,63	16,63	19,64	22,49	27,7	33,25	42,75	51,11
e	min	8,79	11,05	14,38	17,77	20,03	23,36	26,75	32,95	39,55	50,85	60,79
h	max	5,1	6	8	10	13,3	14,1	16,4	20,3	23,9	30	36
	min	4,8	5,4	7,14	8,94	11,57	13,4	15,7	19	22,6	27,3	33,1
s	max	8	10	13	16	18	21	24	30	36	46	55
	min	7,78	9,78	12,73	15,73	17,73	20,67	23,67	29,16	35	45	53,8
m_w	min	3,52	3,92	5,15	6,43	8,30	9,68	11,28	13,52	16,16	19,44	23,52

* The size in brackets should be avoided if possible.

Requirements

The nuts shall meet mechanical and performance properties as per ISO 2320.

Designation

Example - A prevailing torque type all-metal hexagon high nut, thread M10 and property class 12 is designated as follows:
Prevailing torque type hexagon nut, ISO 7042 - M10 - 12

ISO Standards on Prevailing Torque Type Nuts

Following is a list of ISO standards on prevailing torque type nuts not covered in this chapter. For information on them, please see ISO standards.

ISO 7043: Prevailing torque type hexagon nuts with flange (with non-metallic insert), style 2 - Product grades A and B
ISO 7044: Prevailing torque type all-metal hexagon nuts with flange, style 2 - Product grades A and B
ISO 7719: Prevailing torque type all-metal hexagon regular nuts - Property classes 5, 8 and 10
ISO 7720: Prevailing torque type all-metal hexagon nuts, style 2 - Property class 9
ISO 10511: Prevailing torque type hexagon thin nuts (with non-metallic insert)
ISO 10512: Prevailing torque type hexagon regular nuts (with non-metallic insert) with metric fine pitch thread - Property classes 6, 8 and 10
ISO 10513: Prevailing torque type all-metal hexagon high nuts with metric fine pitch thread - Property classes 8, 10 and 12
ISO 12125: Prevailing torque type hexagon nuts with flange (with non-metallic insert) with metric fine pitch thread, style 2 - Product grades A and B
ISO 12126: Prevailing torque type all-metal hexagon nuts with flange with metric fine pitch thread, style 2 - Product grades A and B

ASME B18.16.6: Prevailing Torque Locknuts (Inch Series)

ASME B18.16.6 covers the complete general, dimensional, mechanical, and performance requirements (proof load, prevailing torque, and torque-tension) for carbon steel, inch series nylon insert locknuts of grades N2, N5, and N8 in styles NE (¼ in. to 1½ in.), NTE (¼ in. to 1½ in.), NU (¼ in. to 3 in.), NTU (¼ in. to 3 in.), NM (#2 to #12), NTM (#2 to #12), and hex flange (¼ in. to ¾ in.). This Standard also includes all-metal hex (#4 to 1½ in.) and hex flange (¼ in. to ¾ in.) locking nuts of grades A, B, C, F, and G. These nut designs are designated as American National Standards.

Nut Designs and Property Grades

Nylon Insert Locknuts

Nylon insert locknuts are two-piece construction hex nuts and hex flange nuts. They derive their prevailing torque characteristics from a full ring of nylon material installed in the nut under its top surface. They are available in configuration styles NE, NTE, NU, NTU, NM, NTM and hex flange. They are designated as property grades N2, N5, and N8 with chemical composition and hardness requirements as shown in the following tables.

All-Metal Locknuts

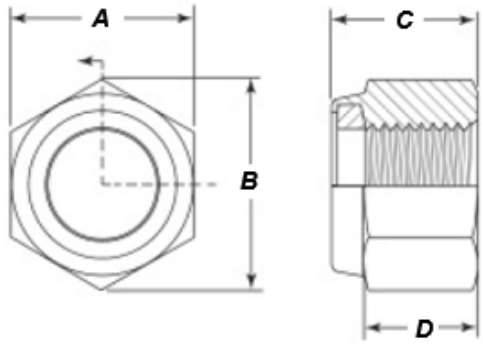
All-metal locknuts are one-piece construction hex and hex flange nuts. They derive their prevailing torque performance from controlled distortion of the nut threads and/or body. Hex locknuts are designated as grades A, B, and C. Hex flange locknuts are designated as grades F and G. The chemical composition and hardness requirements for the various grades are as shown in the following tables.

Chemical Composition Requirements for Nylon Insert Locknuts and All-Metal Locknuts*				
Nut Grade	C, Max.	Mn, Min.	P, Max.	S, Max.
N2, A	0.47	-	0.12	0.15
N5, B, F	0.55	0.30	0.05	0.15
N8, C, G	0.55	0.30	0.04	0.05

* For general notes please see the standard

Hardness Requirements for Nylon Insert Locknuts and All-Metal Locknuts		
Nut Grade	Locknut Size	Rockwell Hardness
N2, N5, A, B and F	¼ to 1½	C28, max.
N8, C and G	¼ to ⅝	C24 to C32
	¾ to 1	C26 to C34
	1⅛ to 1½	C26 to C36

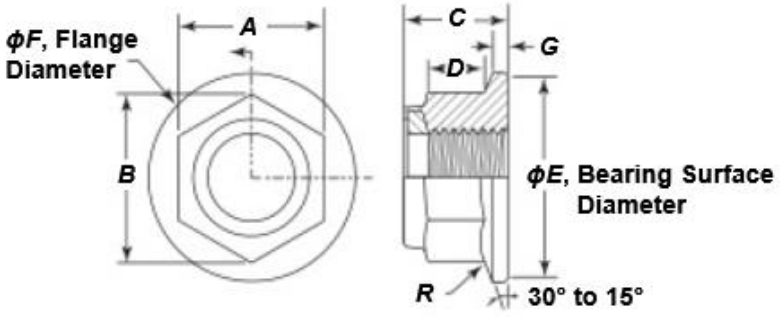
Construction and Dimensions of Nylon Insert Locknuts



Construction of Nylon Insert Locknuts

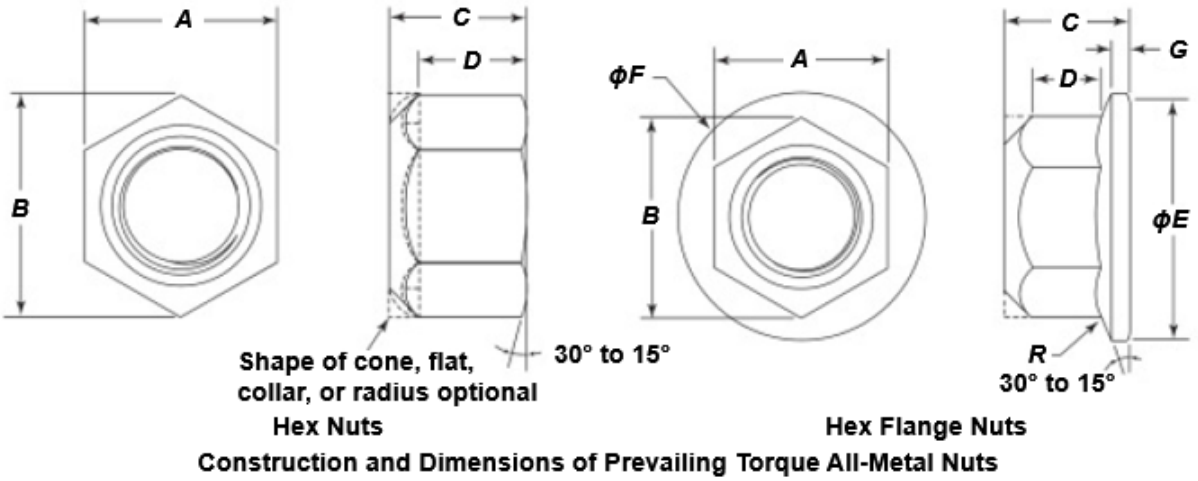
Above figure shows construction of nylon insert locknuts. It may be noted that construction of all configuration styles (NE, NTE, NU, NTU, NM and NTM) is same, i.e. as shown in above figure. They differ in dimensions. To give an idea about difference in their dimensions, following table shows dimensions of ½ in. nuts of various configuration styles.

Dimensions of ½ in. Nylon Insert Nuts of Various Configuration Styles (dimensions are in inch)						
Configuration Styles	Width Across Flats, A		Minimum Width Across Corners, B	Thickness, C		Minimum Hex Height, D
	Max.	Min.		Max.	Min.	
NE	0.752	0.736	0.837	0.609	0.579	0.464
NTE	0.752	0.741	0.837	0.328	0.298	0.190
NU	0.879	0.861	0.969	0.718	0.688	0.544
NTU	0.877	0.865	0.978	0.546	0.516	0.360
NM and NTM	These nuts are not made in ½ in. size (They are made in sizes from #2 to #12)					



Construction and Dimensions of Nylon Insert Hex Flange Nuts

Above figure shows construction and dimensions of nylon insert hex flange nuts. For dimensions, please see the standard.



Construction and Dimensions of Prevailing Torque All-Metal Nuts

Above figure shows construction and dimensions of prevailing torque all-metal hex nuts and hex flange nuts. For dimensions, please see the standard.

Locknut Lubrication

All nuts may be provided with an additional supplementary lubricant that shall be clean and dry to the touch as defined in ASTM F1137.

Mechanical Requirements

Locknuts shall have a hardness conforming to the limits specified for the applicable grade and shall withstand the proof load specified for the applicable grade and thread series as specified in the standard.

Performance Requirements for Steel Locknuts

All steel locknuts shall meet proof loads, clamp loads and prevailing torques as specified in the performance requirements tables. Performance requirements tables for coarse thread locknuts, fine thread locknuts and 8-UN series thread locknuts are given in the standard.

The prevailing torque developed by nuts during their first installation, or any subsequent installation or removal, shall not exceed the maximum first installation torque specified for the applicable grade in the tables given in the standard. In addition, minimum prevailing torque generated by nuts during their first and third removals shall not be les than the respective removal torque values specified for the applicable grade in the tables.

Prevailing Torque Test

The prevailing torque test shall be conducted at room temperature using a load-measuring device. A test bolt and/or hardened mandrel shall be inserted in the load-measuring device and hardened washer placed on the bolt or mandrel and the sample nut then assembled on the bolt or mandrel. The nut shall be advanced until a minimum of three and a maximum of five full bolt or mandrel threads protrude through the top of the nut. At that time, the maximum torque shall be recorded. This torque shall not exceed the first installed prevailing torque value as specified for the applicable grade and thread series in tables.

Tightening shall be continued until the nut is seated against the hardened washer. The length of the test bolt or mandrel should be such that seating of the nut shall occur at or before a length equivalent to a maximum of nine thread pitches of the test bolt or mandrel protruding through the top of the nut, as measured from the end of the bolt or mandrel. The nut shall then be tightened until a tensile load equal to the clamp load, as specified for the applicable grade and thread series in the tables, is developed in the bolt or mandrel. The hardened washer shall be prevented from turning during nut tightening. The nut shall then be backed off by the application of reverse torque until the tensile load in the bolt or mandrel has been reduced to zero. The lowest numerical torque occurring while the nut is being backed off throughout the next 360 degree of rotation shall be recorded as the minimum first removal torque. This minimum torque shall not be less than the first removal prevailing torque value as specified in the tables. The nut shall then be backed off until the prevailing torque element is disengaged from the bolt or mandrel thread. The nut shall be reassembled and removed two more times. On each reassembly, the nut shall be assembled to the initial first removal position, but no clamp load shall be induced in the bolt or mandrel. The test washer shall not be removed during these additional cycles.

At no time during the two additional installations and removals should the prevailing torque exceed the maximum, first install prevailing torque value as specified for the applicable grade and thread series in the tables. During the third removal, the minimum torque occurring while the nut is being backed off throughout the first 360 degree of rotation shall be recorded. The minimum torque shall not be less than the third removal value as specified in the tables. Sufficient time shall elapse between installation and removal cycles to prevent overheating of the test assembly.

The speed of installation and removal of the nut shall not exceed 30 rpm and shall be continuous and uniform.

Following table shows the proof loads, clamp loads and prevailing torques for coarse thread locknuts (regardless of finish).

Proof Loads, Clamp Loads and Prevailing Torques for Coarse Thread Locknuts									
Nut Size and Threads per Inch	**Grades N2 and A Nuts**		**Grades N5, B and F Nuts**		**Grades N8, C and G Nuts**		**Prevailing Torque**		
	Proof Load, lb	Clamp Load, lb	Proof Load, lb	Clamp Load, lb	Proof Load, lb	Clamp Load, lb	**Max. First Install, in.-lb**	**Min. First Removal, in.-lb**	**Min. Third Removal, in.-lb**
No. 4-40	540	250	720	380	910	550	4	1.0	0.2
No. 6-32	820	370	1,100	580	1,350	810	8	1.5	0.5
No. 8-32	1,250	580	1,700	900	2,100	1,250	12	2.0	0.5
No. 10-24	1,550	720	2,100	1,100	2,600	1,550	17	2.5	1.0
No. 12-24	2,200	1,000	2,900	1,550	3,650	2,200	27	3.5	1.0
¼-20	2900	1300	3800	2000	4750	2850	40	5.0	1.5
5⁄16-18	4700	2150	6300	3350	7850	4700	80	8.0	2.5
⅜-16	7000	3200	9300	4950	11,600	6950	110	12.0	4.0
7⁄16-14	9550	4400	12,800	6800	15,900	9600	135	17.0	5.0
½-13	12,800	5850	17,000	9050	21,300	12,800	204	22.0	7.5
9⁄16-12	16,400	7550	21,800	11,600	27,300	16,400	300	30.0	10.0
⅝-11	20,300	9300	27,200	14,500	33,900	20,300	420	39.0	12.5
¾-10	30,000	13800	40,100	21,300	50,100	30,100	540	58.0	20.0
⅞-9	41,600	12400	55,400	29,500	69,300	41,600	840	88.0	30.0
1-8	54,500	15000	72,700	38,700	90,900	54,600	1080	120.0	40.0
1⅛-7	68,700	18900	80,100	42,100	115,000	69,000	1200	150.0	50.0
1¼-7	87,200	24000	101,700	53,500	145,000	87,000	1320	188.0	60.0
1⅜-6	104,000	28700	121,300	63,800	173,000	104,000	1620	220.0	70.0
1½-6	126,000	34800	147,500	77,600	211,000	127,000	1800	260.0	90.0

It may be noted that proof loads for Grade N2, Grade N5 and Grade N8 are same as for nut Grade 2, 5 and 8 as per SAE J995 respectively.

For informatio about performance requirements (proof loads, clamp loads and prevailing torques) of fine thread locknuts and 8-UN series thread locknuts; proof load test; test devices, washers, bolts and test mandrels for testing, please see the standard.

Designation

Nylon Insert Nuts

Nylon insert locknuts shall be designated by the following data preferably in the sequence as follows:

- product name
- designation of standard (i.e., ASME B18.16.6)
- nominal diameter and threads per inch
- style of locknut (NM, NU, etc.)
- steel property grade or material identification
- protective coating, if required
- torque-tension data per IFI-101, if required

Example - Nylon insert locknut, ASME B18.16.6, ½-13, NE, grade N8, zinc plated per ASTM F1941/F1941M, Fe/Zn 5C.

All-Metal Locknuts

All-metal locknuts shall be designated by the following data preferably in the sequence as follows:

- product name and type
- designation of standard (i.e., ASME B18.16.6)
- nominal diameter and threads per inch
- steel grade or material identification
- protective coating, if required
- torque-tension data per IFI-101, if required

Example - All-metal hex flange locknut, ASME B18.16.6, ⅝-11, grade F, zinc plated per ASTM F1941/F1941M, Fe/Zn 5C.

Product Standards for Plain (Flat) Washers

At high preloads the force under the head of a bolt or nut can exceed the compressive yield strength of the clamped material. If this occurs, excessive embedding and deformation can result in bolt preload loss. Washers serve to minimize embedding and to aid tightening.

In practice, washers are used for oversized holes or slots (for example, on enlarged holes in base plate to accommodate foundation bolt to overcome interference due to misalignment of foundation bolts with holes in the base plate). In such cases, care shall be taken to select a large and thick washer (or a thick plate with a hole of required size having large outside diameter to adequately cover enlarged hole) which will not deform during tightening.

In view of above, information about ASME, ISO and IS product standards for plain washers is given in this chapter.

ASME B18.21.1: Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

B18.21.1 covers the dimensional requirements, physical properties, and related test methods for helical spring-lock washers (#0 through 3 inches), tooth-lock washers (#2 through 1¼ inches), and plain washers (#0 through 3 inches).

This Standard covers plain (flat) washers of three constructions designated Type A, Type B, and Fender washers. Information about them is given in this chapter.

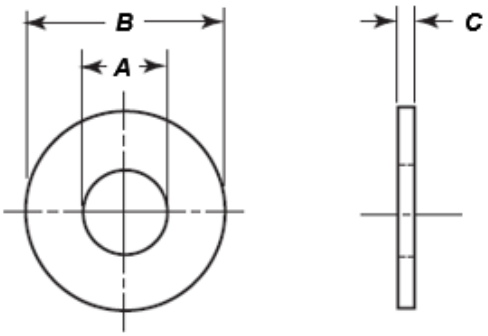
Application of Plain Washers

The Type A plain washers covered in this standard are intended for general application. The Type A plain washers serve to minimize embedding and to aid tightening.

The Type B plain washers covered in this standard are intended for general application. The Type B plain washers fulfill the purpose of distributing load over larger areas of lower strength materials.

The Fender washers covered in this standard are intended for use in covering oversized holes or slots or for distributing load over very larger areas of extremely low strength materials.

Dimensions of Preferred Sizes of Type A and Type B Plain Washers



Dimensions of Preferred Sizes of Type A and Type B Plain Washers

Selection of the Type A plain washers should be made from the preferred sizes shown in the following table (Only basic sizes are shown. For tolerance, please see the standard).

It may be noted that sometimes Type A narrow washers are referred to as SAE and Type A wide washers are referred to as USS washers even though they are not covered by SAE or USS standards.

Dimensions of Preferred Sizes of Type A Plain Washers (All dimensions are in inch)					
Nominal Washer Size		Series*	Inside Diameter, *A*	Outside Diameter, *B*	Thickness, *C*
No. 0	-	-	0.078	0.188	0.020
No. 2	-	-	0.094	0.250	0.020
No. 4	-	-	0.125	0.312	0.032
No. 6	0.138	-	0.156	0.375	0.049
No. 8	0.164	-	0.188	0.438	0.049
No. 10	0.190	-	0.219	0.500	0.049
3/16	0.188	-	0.250	0.562	0.049
No. 12	0.216	-	0.250	0.562	0.065
1/4	0.250	N	0.281	0.625	0.065
1/4	0.250	W	0.312	0.734#	0.065
5/16	0.312	N	0.344	0.688	0.065
5/16	0.312	W	0.375	0.875	0.083
3/8	0.375	N	0.406	0.812	0.065
3/8	0.375	W	0.438	1.000	0.083
7/16	0.438	N	0.469	0.922	0.065
7/16	0.438	W	0.500	1.250	0.083
1/2	0.500	N	0.531	1.062	0.095
1/2	0.500	W	0.562	1.375	0.109
9/16	0.562	N	0.594	1.156#	0.095
9/16	0.562	W	0.625	1.469#	0.109
5/8	0.625	N	0.656	1.312	0.095
5/8	0.625	W	0.688	1.750	0.134
3/4	0.750	N	0.812	1.469	0.134
3/4	0.750	W	0.812	2.000	0.148
7/8	0.875	N	0.938	1.750	0.134
7/8	0.875	W	0.938	2.250	0.165
1	1.000	N	1.062	2.000	0.134
1	1.000	W	1.062	2.500	0.165
1 1/8	1.125	N	1.250	2.250	0.134
1 1/8	1.125	W	1.250	2.750	0.165
1 1/4	1.250	N	1.375	2.500	0.165
1 1/4	1.250	W	1.375	3.000	0.165
1 3/8	1.375	N	1.500	2.750	0.165
1 3/8	1.375	W	1.500	3.250	0.180
1 1/2	1.500	N	1.625	3.000	0.165
1 1/2	1.500	W	1.625	3.500	0.180
1 5/8	1.625	-	1.750	3.750	0.180
1 3/4	1.750	-	1.875	4.000	0.180
1 7/8	1.875	-	2.000	4.250	0.180
2	2.000	-	2.125	4.500	0.180
2 1/4	2.250	-	2.375	4.750	0.220
2 1/2	2.500	-	2.625	5.000	0.238
2 3/4	2.750	-	2.875	5.250	0.259
3	3.000	-	3.125	5.500	0.284

* Preferred sizes are for the most part from series previously designated “Standard Plate” and “SAE.” Where common sizes existed in the two series, the SAE site is designated “N” (narrow) and the Standard Plate “W” (wide). These sizes as well as all other sizes of Type A Plain Washers are to be ordered by I.D., O.D., and thickness dimensions.

Avoid the 0.734 in., 1.156 in., and 1.469 in. outside diameter washers which could be used in coin operated devices.

The Type B plain washers are designated as narrow, regular and wide series. Suitable washer selection can be made by selecting the appropriate width series for the application from the following table. (Nominal washer sizes up to 2.0 in. and only basic sizes are shown in the table. For washers larger than nominal size 2.0 in. and tolerance on basic sizes, please see the standard).

Dimensions of Type B Plain Washers (All dimensions are in inch)					
Nominal Washer Size		Series*	Inside Diameter, *A*	Outside Diameter, *B*	Thickness, *C*
No. 0	0.060	N	0.068	0.125	0.025
		R	0.068	0.188	0.025
		W	0.068	0.250	0.025
No. 1	0.073	N	0.084	0.156	0.025
		R	0.084	0.219	0.025
		W	0.084	0.281	0.032
No. 2	0.086	N	0.094	0.188	0.025
		R	0.094	0.250	0.032
		W	0.094	0.344	0.032
No. 3	0.099	N	0.109	0.219	0.025
		R	0.109	0.312	0.032
		W	0.109	0.406	0.040
No. 4	0.112	N	0.125	0.250	0.032
		R	0.125	0.375	0.040
		W	0.125	0.438	0.040
No. 5	0.125	N	0.141	0.281	0.032
		R	0.141	0.406	0.040
		W	0.141	0.500	0.040
No. 6	0.138	N	0.156	0.312	0.032
		R	0.156	0.438	0.040
		W	0.156	0.562	0.040
No. 8	0.164	N	0.188	0.375	0.040
		R	0.188	0.500	0.040
		W	0.188	0.625	0.063
No. 10	0.190	N	0.203	0.406	0.040
		R	0.203	0.562	0.040
		W	0.203	0.734#	0.063
No. 12	0.216	N	0.234	0.438	0.040
		R	0.234	0.625	0.063
		W	0.234	0.875	0.063
1/4	0.250	N	0.281	0.500	0.063
		R	0.281	0.734#	0.063
		W	0.281	1.000	0.063
5/16	0.312	N	0.344	0.625	0.063
		R	0.344	0.875	0.063
		W	0.344	1.125	0.063
3/8	0.375	N	0.406	0.734#	0.063
		R	0.406	1.000	0.063
		W	0.406	1.250	0.100
7/16	0.438	N	0.469	0.875	0.063
		R	0.469	1.125	0.063
		W	0.469	1.469#	0.100
1/2	0.500	N	0.531	1.000	0.063
		R	0.531	1.250	0.100
		W	0.531	1.750	0.100
9/16	0.562	N	0.594	1.125	0.063
		R	0.594	1.469#	0.100
		W	0.594	2.000	0.100

⅝	0.625	N	0.656	1.250	0.100
		R	0.656	1.750	0.100
		W	0.656	2.250	0.160
¾	0.750	N	0.812	1.375	0.100
		R	0.812	2.000	0.100
		W	0.812	2.500	0.160
⅞	0.875	N	0.938	1.469[#]	0.100
		R	0.938	2.250	0.160
		W	0.938	2.750	0.160
1	1.000	N	1.062	1.750	0.100
		R	1.062	2.500	0.160
		W	1.062	3.000	0.160
1⅛	1.125	N	1.188	2.000	0.100
		R	1.188	2.750	0.160
		W	1.188	3.250	0.160
1¼	1.250	N	1.312	2.250	0.160
		R	1.312	3.000	0.160
		W	1.312	3.500	0.250
1⅜	1.375	N	1.438	2.500	0.160
		R	1.438	3.250	0.160
		W	1.438	3.750	0.250
1½	1.500	N	1.562	2.750	0.160
		R	1.562	3.500	0.250
		W	1.562	4.000	0.250
1⅝	1.625	N	1.750	3.000	0.160
		R	1.750	3.750	0.250
		W	1.750	4.250	0.250
1¾	1.750	N	1.875	3.250	0.160
		R	1.875	4.000	0.250
		W	1.875	4.500	0.250
1⅞	1.875	N	2.000	3.500	0.250
		R	2.000	4.250	0.250
		W	2.000	4.750	0.250
2	2.000	N	2.125	3.750	0.250
		R	2.125	4.500	0.250
		W	2.125	5.000	0.250

* N indicates Narrow; R, Regular; and W, Wide Series.
[#] Avoid the 0.734 in. and 1.469 in. outside diameter washers which could be used in coin operated devices.

The Fender washers are available in one series with multiple outside diameters. For an example, following table shows ¼ in. Fender washers. For other sizes and tolerance on basis sizes, please see the standard.

Dimensions of ¼ in. Fender Washers (All dimensions are in inch)			
Size	Inside Diameter, *A*	Outside Diameter, *B*	Thickness, *C*
¼ × 1	0.285	1.000	0.065
¼ × 1¼	0.285	1.250	0.065
¼ × 1½	0.285	1.500	0.065
¼ × 1¾	0.285	1.761	0.065
¼ × 2	0.285	2.000	0.065

Materials

Plain and Fender washers shall be made of low carbon steel, stainless steel, non-ferrous metal, plastic, or other material as specified by the purchaser. Hardened plain washers shall conform to the chemical and mechanical requirements in ASTM F436.

Designation

Nominal washer sizes are intended for use with comparable screw or nut sizes. Washers conforming to this standard shall be designated by the following data, in the sequence shown.

1. product name and type
2. ASME document number (ASME B18.21.1)
3. nominal size (number, fraction, or decimal equivalent)
4. basic washer inside diameter
5. basic washer outside diameter
6. basic washer thickness
7. material (include alloy or UNS number if required)
8. surface protective finish standard number and thickness, if applicable

Examples:

Plain Washer, Type A, ASME B18.21.1, ½ N, 0.531 × 1.062 × 0.095, 302 Stainless Steel, Passivation per ASTM A 380.

Plain Washer, Type B, ASME B18.21.1, ¾ W, 0.812 × 2.500 × 0.160. Steel (UNS 105000), hardened as per ASTM A 436.

Fender Washer, ASME B18.21.1, ¼ × 1½ × 0.065, Low Carbon Steel, Zinc as per ASTM F1941, Fe/Zn 3A.

ISO 7089: Plain Washers - Normal Series - Product Grade A

ISO 7089 specifies the characteristics of normal-series, product-grade-A plain washers in the 200 HV and 300 HV hardness classes and of nominal sizes (nominal thread diameters) ranging from 1,6 mm to 64 mm inclusive.

Washers of hardness class 200 HV are suitable for the following.

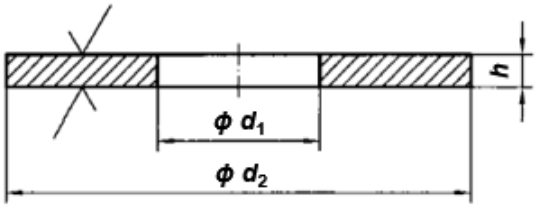
- hexagon bolts and screws of product grades A and B in property classes up to and including 8.8;
- hexagon nuts of product grades A and B in property classes up to and including 8;
- hexagon bolts, screws and nuts of stainless steel of similar chemical composition;
- case-hardened thread rolling screws.

Washers of hardness class 300 HV are suitable for the following.

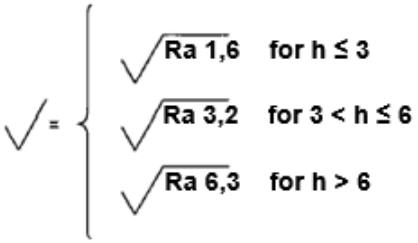
- hexagon bolts and screws of product grades A and B in property classes up to and including 10.9;
- hexagon nuts of product grades A and B in property classes up to and including 10.

Washer Dimensions

Following tables show the preferred dimensions and non-preferred dimensions. If dimensions other than those listed in this standard (ISO 7089) are required, they should be selected from those given in ISO 887. ISO 887 specifies the full range of the nominal dimensions of product-grade-A and -C plain washers for general-purpose bolts, screws and nuts of nominal thread diameters ranging from 1 mm to 150 mm inclusive.



Dimensions in millimeters
Surface roughness values in micrometers.



Plain Washers ISO Normal Series - Product Grade A

Preferred Dimensions (Dimensions in millimeters)							
Nominal Size (Nominal Thread Diameter *d*)	Clearance Hole d_1		Outside Diameter d_2		Thickness *h*		
	nom. (min.)	max.	nom. (max.)	min.	nom.	max.	min.
1,6	1,7	1,84	4	3,7	0,3	0,35	0,25
2	2,2	2,34	5	4,7	0,3	0,35	0,25
2,5	2,7	2,84	6	5,7	0,5	0,55	0,45
3	3,2	3,38	7	6,64	0,5	0,55	0,45
4	4,3	4,48	9	8,64	0,8	0,9	0,7
5	5,3	5,48	10	9,64	1	1,1	0,9
6	6,4	6,62	12	11,57	1,6	1,8	1,4
8	8,4	8,62	16	15,57	1,6	1,8	1,4
10	10,5	10,77	20	19,48	2	2,2	1,8
12	13	13,27	24	23,48	2,5	2,7	2,3
16	17	17,27	30	29,48	3	3,3	2,7
20	21	21,33	37	36,38	3	3,3	2,7
24	25	25,33	44	43,38	4	4,3	3,7
30	31	31,39	56	55,26	4	4,3	3,7
36	37	37,62	66	64,8	5	5,6	4,4
42	45	45,62	78	76,8	8	9	7
48	52	52,74	92	90,6	8	9	7
56	62	62,74	105	103,6	10	11	9
64	70	70,74	115	113,6	10	11	9

Non-preferred Dimensions (Dimensions in millimeters)							
Nominal Size (Nominal Thread Diameter *d*)	Clearance Hole d_1		Outside Diameter d_2		Thickness *h*		
	nom. (min.)	max.	nom. (max.)	min.	nom.	max.	min.
3,5	3,7	3,88	8	7,64	0,5	0,55	0,45
14	15	15,27	28	27,48	2,5	2,7	2,3
18	19	19,33	34	33,38	3	3,3	2,7
22	23	23,33	39	38,38	3	3,3	2,7
27	28	28,33	50	49,38	4	4,3	3,7
33	34	34,62	60	58,8	5	5,6	4,4
39	42	42,62	72	70,8	6	6,6	5,4
45	48	48,62	85	83,6	8	9	7
52	56	56,74	98	96,6	8	9	7
60	66	66,74	110	106,6	10	11	9

Requirements and International Standards of Reference

Specifications and International Standards of reference for material, mechanical properties and surface finish shall be as per the following table.

Material		Steel		Stainless Steel
	Grade	-		A2, A4, F1 C1, C4
	International Standard	-		ISO 3506-1
Mechanical Properties	Hardness Class	200 HV	300 HV	200 HV
	Hardness Range*	200 HV to 300 HV	300 HV to 370 HV	200 HV to 300 HV
Surface Finish		Plane: i.e. washers shall be supplied in natural finish, treated with a protective lubricant or with other coatings as agreed by customer and supplier. Requirements for electroplating covered in ISO 4042. Requirements for non-electrolytically applied zinc flake coatings covered in ISO 10683. For hardened and tempered washers, appropriate plating or coating processes should be employed to avoid hydrogen embrittlement. When washers are electroplated or phosphate, they shall be suitably treated immediately after plating or coating to obviate detrimental hydrogen embrittlement. All tolerances shall apply prior to the application of a plating or coating.		Plane: i.e. washers shall be supplied in natural finish.

* - Hardness testing according to ISO 6507-1.
Test force: HV 2 for nominal thickness h ≤ 0,6 mm
HV 10 for nominal thickness 0,6 < h ≤ 1,2 mm
HV 30 for nominal thickness h > 1,2 mm

Designation Examples

A normal-series, product-grade-A plain washer made of steel, of nominal size 10 mm and hardness class 200 MV is designated as follows.

Washer ISO 7089-10-200 HV

A normal-series, product-grade-A plain washer made of grade A2 stainless steel, of nominal size 10 mm and hardness class 200 HV is designated as follows:

Washer ISO 7089-10-200 HV-A2

Other ISO Standards on Washers

Following are other ISO standards on washers.

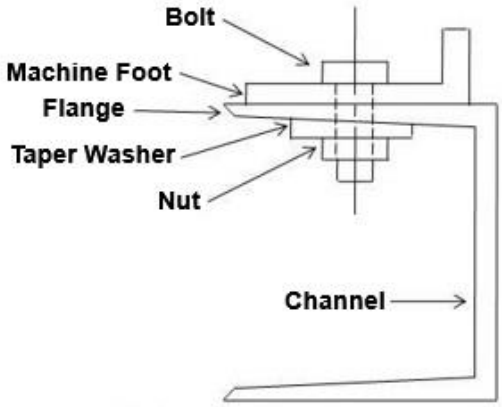
ISO 887: Plain washers for metric bolts, screws and nuts for general purposes - General plan
ISO 7090: Plain washers, chamfered - Normal series - Product grade A
ISO 7091: Plain washers - Normal series - Product grade C
ISO 7092: Plain washers - Small series - Product grade A
ISO 7093-1: Plain washers - Large series - Part 1: Product grade A
ISO 7093-2: Plain washers - Large series - Part 2: Product grade C

Plain washers - Large series are commonly referred to as fender washers. O.D. of these washers is approximately 3 × the screw size diameter.

ISO 7094: Plain washers - Extra large series - Product grade C

ISO 7094 specifies the characteristics of extra-large-series, product-grade-C plain washers in the 100 H class, of nominal sizes (nominal thread diameters) ranging from 5 mm to 36 mm inclusive. These washers are suitable for hexagon bolts and screws of product grade C in property classes up to and including 6.8, and hexagon nuts of product grade C in property classes up to and including 6 used in timber structures.

Taper Washers

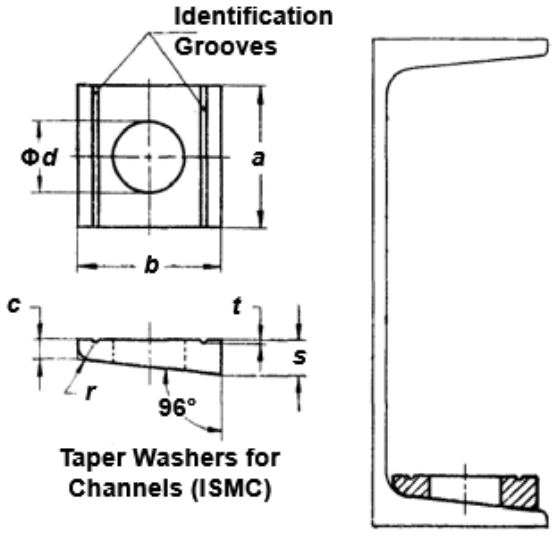


Use of Taper Washer in Base Frame made from Channel

Flange thickness of a rolled beam or channel is not constant. Due to this, when base frames are made from rolled steel beams and channels, a taper washer is required to make surfaces between bolt head and nut parallel as shown in above figure. Following is the information about taper washers used with base frames as per IS standards.

IS: 5372 - 1975 (Reaffirmed 2001)
Specification for Taper Washers for Channels (ISMC)

This specification covers the requirements for taper washers for use with Indian Standard Medium Weight Channels (ISMC) with bolts in the diameter range of 10 to 39 mm.



Dimensions of Taper Washers for Channels (ISMC)

Dimensions

Following table shows dimensions of taper washers for channels (ISMC).

Dimensions of Taper Washers for Channels - ISMC (All dimensions in millimetres)							
Nominal Size, *d*	**For Bolt Size**	***a***	***b***	***c***	***r***	***s***	***t* Approx.**
11	M10	22	22	2	2.4	4.3	0.5
14	M12	26	30	2.5	2.4	5.7	0.7
18	M16	32	36	3	2.4	6.8	0.8
22	M20	40	44	3.5	3.2	8.1	0.9
(24)	(M22)	44	50	4	3.2	9.2	1
26	M24	56	56	4	4.0	9.9	1
(30)	(M27)	56	56	4	4.0	9.9	1
33	M30	62	62	4	4.0	10.5	1.2
(36)	(M33)	68	68	4	4.0	11.2	1.2
39	M36	75	75	4	4.8	11.9	1.2
(42)	(M39)	80	80	4	4.8	12.4	1.2

Note: Sizes in brackets are of second preference.

Material

The taper washers shall be made from any suitable low carbon steel.

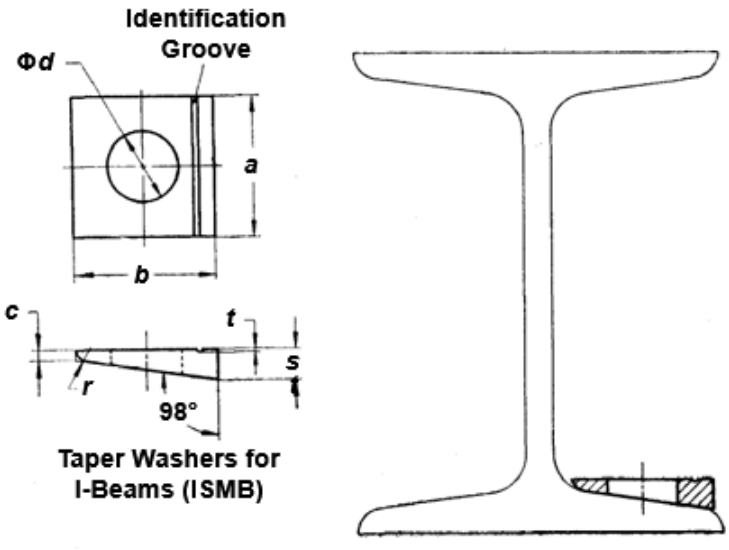
Designation

Washers shall be designated by the name, size and the number of this standard.

Example: A taper washer of nominal size 18 mm shall be designated as - Taper Washer 18 IS: 5372.

IS: 5374 - 1975 (Reaffirmed 2001)
Specification for Taper Washers for I-Beams (ISMB)

IS: 5374 covers the requirements for taper washers for use with Indian Standard Medium Weight Beams (ISMB) with bolts in the diameter range 10 to 39 mm.



Dimensions of Taper Washers for I-Beams (ISMB)

Dimensions

Following table shows dimensions of taper washers for I-Beams (ISMB).

Dimensions of Taper Washers for I-Beams - ISMB (All dimensions in millimetres)							
Nominal Size, *d*	**For Bolt Size**	***a***	***b***	***c***	***r***	***s***	***t* Approx.**
11	M10	22	22	1.5	2.4	4.6	0.5
14	M12	26	30	2	2.4	6.2	0.7
18	M16	32	36	2.5	2.4	7.6	0.8
22	M20	40	44	3	3.2	9.2	0.9
(24)	(M22)	44	50	3	3.2	10.0	1
26	M24	56	56	3	4.0	10.3	1
(30)	(M27)	56	56	3	4.0	10.8	1
33	M30	62	62	3	4.0	11.7	1.2
(36)	(M33)	68	68	3	4.0	12.6	1.2
39	M36	75	75	3	4.8	13.6	1.2
(42)	(M39)	80	80	3	4.8	14.2	1.2

Note: Sizes in brackets are of second preference.

Material

The taper washers shall be made from any suitable low carbon steel.

Designation

Washers shall be designated by the name, size and the number of this standard.

Example: A taper washer of nominal size 18 mm shall be designated as - Taper Washer 18 IS: 5374

Caution:

When taper washers are used, use correct type of washer, i.e. use of washer for I-Beams with I-Beam (type of a washer can be identified by number of grooves for identification on it).

When taper washers are used, check for correctness of their installation (thin edge of washer should be on thick edge of the channel/beam) as many times they are installed wrongly by inexperienced technicians.

IS 2016 - 1967 (Reaffirmed 2001): Specification for Plain Washers

IS 2016 lays down the requirements for plain washers of the following types:

- Machined washers, for precision and semi-precision grade (grade A and Grade B) of general purpose bolts and screws, in the diameter range 1.7 to 155 mm;
- Punched washers, type A, for black grade (grade C) general purpose bolts and screws, in the diameter range 1.8 to 52 mm; and
- Punched washers, type B, for slotted head screws in the diameter range 1.8 to 22 mm.

For more information, please see the standard.

Product Standards for Spring Washers

A typical helical spring washer shown in the following figure is made of rectangular or square section wire formed into a helix of one coil so that the free height is approximately twice the thickness of the washer cross section. Spring washer are usually made of hardened carbon steel, but they are also available in aluminum, silicon-bronze, phosphor-bronze. stainless steel and K-Monel.

Spring Washers

Since these washers are not highly reliable, they are generally used for non-critical applications only. The section on lock washers in NASA Reference Publication 1228 (1990) - "Fastener Design Manual" states the following.

"The helical spring washer serves as a spring while the bolt is being tightened. However, the washer is normally flat by the time the bolt is fully torqued. At this time, it is equivalent to a solid flat washer, and its locking ability is nonexistent. In summary, a lock washer of this type is useless for locking."

Spring Washers with Bent Ends

As shown in above figure, some spring washers are having bent (deflected or tang) ends. When the washer is tightened, the sharp edges of the washer are supposed to dig into the nut and mounting surface to prevent counter-clockwise rotation. In practice bent end is unable to dig into hard surfaces and does not actually prevent rotation.

Information about ASME, IS and DIN product standards on spring washers is given in this chapter.

ASME B18.21.1: Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

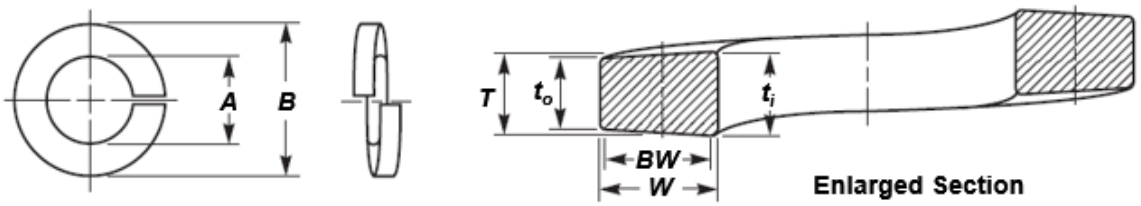
B18.21.1 covers the dimensional requirements, physical properties, and related test methods for helical spring-lock washers (#0 through 3 inches), tooth-lock washers (#2 through 1¼ inches), and plain washers (#0 through 3 inches).

This standard covers helical spring-lock washers of regular, heavy, extra duty and high-collar sections.

The helical spring-lock washers covered in this standard are intended for general applications. These washers compensate for developed looseness between component parts of an assembly and provide a hardened bearing surface.

The section of finished washer shall be slightly trapezoidal with thickness at the inner periphery greater than the thickness at the outer periphery by a minimum of 0.0005 in. to a maximum of 0.001 in. per 0.0156 in. of the section width. It may be noted that after the single-coil spring closes to the flat condition, due to the trapezoidal section, further loading results in additional deformation of the washer.

Dimensions



Dimensions of Helical Spring-Lock Washers

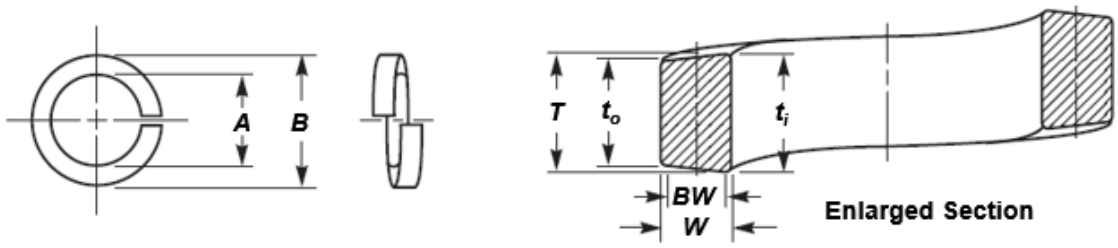
Dimensions of regular, heavy and extra duty helical spring lock washers shall be as shown in the following table.

Dimensions of Regular, Heavy and Extra Duty Helical Spring Lock Washers
(All dimensions are in inches)

Nominal Washer Size		Inside Diameter, *A*		Regular			Heavy			Extra Duty		
		Max.	Min.	O.D., *B* Max.	Width, *W*	Minimum Mean Thickness, *T*#	O.D., *B* Max.	Width, *W*	Minimum Mean Thickness, *T*#	O.D., *B* Max.	Width, *W*	Minimum Mean Thickness, *T*#
No. 2	0.086	0.094	0.088	0.172	0.035	0.020	0.182	0.040	0.025	0.208	0.053	0.027
No. 3	0.099	0.107	0.101	0.195	0.040	0.025	0.209	0.047	0.031	0.239	0.062	0.034
No. 4	0.112	0.120	0.114	0.209	0.040	0.025	0.223	0.047	0.031	0.253	0.062	0.034
No. 5	0.125	0.133	0.127	0.236	0.047	0.031	0.252	0.055	0.040	0.300	0.079	0.045
No. 6	0.138	0.148	0.141	0.250	0.047	0.031	0.266	0.055	0.040	0.314	0.079	0.045
No. 8	0.164	0.174	0.167	0.293	0.055	0.040	0.307	0.062	0.047	0.375	0.096	0.057
No. 10	0.190	0.200	0.193	0.334	0.062	0.047	0.350	0.070	0.056	0.434	0.112	0.068
No. 12	0.216	0.227	0.220	0.377	0.070	0.056	0.391	0.077	0.063	0.497	0.130	0.080
1/4	0.250	0.060	0.252	0.487	0.109	0.062	0.489	0.110	0.077	0.533	0.132	0.084
5/16	0.3125	0.322	0.314	0.583	0.125	0.078	0.593	0.130	0.097	0.619	0.143	0.108
3/8	0.375	0.385	0.377	0.680	0.141	0.094	0.688	0.145	0.115	0.738	0.170	0.123
7/16	0.4375	0.450	0.440	0.776	0.156	0.109	0.784	0.160	0.133	0.836	0.186	0.143
1/2	0.500	0.512	0.502	0.869	0.171	0.125	0.879	0.176	0.151	0.935	0.204	0.162
9/16	0.5625	0.574	0.564	0.965	0.188	0.141	0.975	0.193	0.170	1.035	0.223	0.182
5/8	0.625	0.641	0.628	1.073	0.203	0.156	1.087	0.210	0.189	1.151	0.242	0.202
11/16	0.6875	0.704	0.691	1.170	0.219	0.172	1.186	0.227	0.207	1.252	0.260	0.221
3/4	0.750	0.766	0.753	1.265	0.234	0.188	1.285	0.244	0.226	1.355	0.279	0.241
13/16	0.8125	0.832	0.816	1.363	0.250	0.203	1.387	0.262	0.246	1.458	0.298	0.261
7/8	0.875	0.894	0.878	1.459	0.266	0.219	1.489	0.281	0.266	1.571	0.322	0.285
15/16	0.9375	0.958	0.941	1.556	0.281	0.234	1.590	0.298	0.284	1.684	0.345	0.308
1	1.000	1.024	1.003	1.656	0.297	0.250	1.700	0.319	0.306	1.794	0.366	0.330
1 1/16	1.0625	1.087	1.066	1.751	0.312	0.266	1.803	0.338	0.326	1.905	0.389	0.352
1 1/8	1.125	1.153	1.129	1.847	0.328	0.281	1.903	0.356	0.345	2.013	0.411	0.375
1 3/16	1.1875	1.217	1.192	1.943	0.344	0.297	2.001	0.373	0.364	2.107	0.431	0.396
1 1/4	1.250	1.280	1.254	2.036	0.359	0.312	2.104	0.393	0.384	2.222	0.452	0.417
1 5/16	1.3125	1.344	1.317	2.133	0.375	0.328	2.203	0.410	0.403	2.327	0.472	0.438
1 3/8	1.375	1.408	1.379	2.219	0.391	0.344	2.301	0.427	0.422	2.429	0.491	0.458
1 7/16	1.4375	1.472	1.442	2.324	0.406	0.359	2.396	0.442	0.440	2.530	0.509	0.478
1 1/2	1.500	1.534	1.504	2.419	0.422	0.375	2.491	0.458	0.458	2.627	0.526	0.496

- *T* = mean section thickness = $(t_i + t_o) \div 2$.
BW = Bearing Width

Please see the standard for sizes over 1½ in. to 3 in., inclusive, for regular and heavy helical spring lock washers and over 1½ in. to 2 in., inclusive, for extra duty helical spring lock washers.



Dimensions of High-Collar Helical Spring-Lock Washers

Dimensions of Hi-Collar helical spring lock washers shall be as shown in the following table.

Dimensions of Hi-Collar Helical Spring-Lock Washers (All dimensions are in inches)						
Nominal Washer Size		Inside Diameter, *A*		Maximum Outside Diameter, *B*	Minimum Mean Section Thickness, *T*[#]	Minimum Section Width, *W*
		Max.	Min.			
No. 4	0.112	0.120	0.114	0.173	0.022	0.022
No. 5	0.125	0.133	0.127	0.202	0.030	0.030
No. 6	0.138	0.148	0.141	0.216	0.030	0.030
No. 8	0.164	0.174	0.167	0.267	0.047	0.042
No. 10	0.190	0.200	0.193	0.294	0.047	0.042
¼	0.250	0.260	0.252	0.363	0.078	0.047
5⁄16	0.3125	0.322	0.314	0.457	0.093	0.062
⅜	0.375	0.385	0.377	0.550	0.125	0.076
7⁄16	0.4375	0.450	0.440	0.644	0.140	0.090
½	0.500	0.512	0.502	0.733	0.172	0.103
⅝	0.625	0.641	0.628	0.917	0.203	0.125
¾	0.750	0.766	0.753	1.105	0.218	0.154
⅞	0.875	0.894	0.878	1.291	0.234	0.182
1	1.000	1.024	1.003	1.478	0.250	0.208
1⅛	1.125	1.153	1.129	1.663	0.313	0.236
1¼	1.250	1.280	1.254	1.790	0.313	0.236
1⅜	1.375	1.408	1.379	2.031	0.375	0.292
1½	1.500	1.534	1.504	2.159	0.375	0.292
1¾	1.750	1.789	1.758	2.596	0.469	0.383
2	2.000	2.039	2.008	2.846	0.469	0.383
2¼	2.250	2.293	2.262	3.345	0.508	0.508
2½	2.500	2.543	2.512	3.595	0.508	0.508
2¾	2.750	2.793	2.762	4.095	0.633	0.633
3	3.000	3.043	3.012	4.345	0.633	0.633

[#] - Mean section thickness, T = (inside thickness, t_i + outside thickness, t_o) ÷ 2.

Material and Hardness

Washers shall be made from material shown in the following table meeting the chemical composition requirements of the material as per shown material standards and shall meet hardness requirements applicable to the respective materials.

Material	Material Standard	Hardness
Carbon Steel	SAE J403 1055-1065 (UNS G10550-G10650)	38 to 46 HRC, 372 to 458 HV
Boron Steel	SAE J411 10B55-10B65	38 to 46 HRC, 372 to 458 HV
Stainless Steel	SAE J405 302-305 (UNS S30200-S30500) or SAE J405 316 (UNS S31600)	35 to 43 HRC, 345 to 423 HV for lock washers up to and including ⅝ in., for larger sizes 32 to 43 HRC, 318 to 423 HV
Aluminum Alloy	ASTM B 211, Alloy 7075 (UNS A97075)	75 to 97 HRB, 137 to 222 HV

Phosphor-Bronze	ASTM B 159, Copper Alloy No. 510 (UNS C51000)	90 min. HRB, 185 min. HV, or equivalent.
Silicon-Bronze	ASTM B 99, Copper Alloy No. 651 or 655 (UNS C65100 or C65500)	90 min. HRB, 185 min. HV, or equivalent
Nickel-Copper-Aluminum	Federal Specification QQ-N-286 (UNS N05500)	33 to 40 HRC, 327 to 392 HV
Alloy Steel	SAE J404 4037 (UNS G40370) or other alloy steel having at least 0.35% carbon.	38 to 46 HRC, 372 to 458 HV

Designation

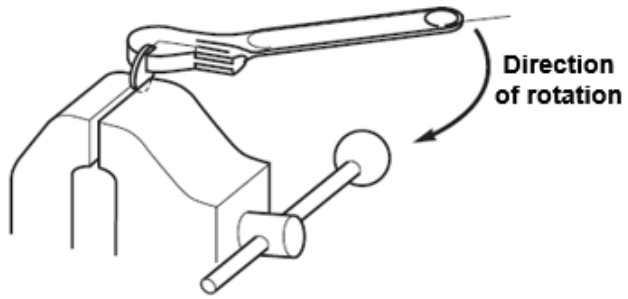
Nominal washer sizes are intended for use with comparable nominal screw or nut sizes.

These washers are designated by the following data in the sequence shown.

Product name and style where applicable, ASME document number (ASME B18.21.1), nominal size, series, material (alloy or UNS number if required) and surface protective finish standard number and thickness, if applicable.

For example: Helical spring lock washer, ASME B18.21.1, ¾ in., Extra Duty, Carbon Steel, Mechanical Zinc as per ASTM B695, Class 55.

Twist Tests



Washer Twist Test

The washer shall be gripped in vise jaws. The ends of the washer shall be free, and an axis passing through the slot shall be parallel to and slightly above the top of the vise so less than 50% of the washer is gripped. A 90° maximum segment of the free end of the washer shall be gripped in wrench jaws so at least 25% of the washer is exposed when twisting, as shown in above figure. Edges of the wrench jaws shall be in a plane parallel to the vise. Movement of the wrench that increases the free height of the spring lock washer shall twist carbon steel, boron steel and alloy steel washers through an angle approximating 90°, and corrosion resistant steel and nonferrous washers through an angle approximating 45° with no sign of fracture.

IS 3063: 1994 (Reaffirmed 2004): Fasteners - Single Coil Rectangular Section Spring Lock Washers - Specification

Note: In preparation of this standard assistance has been derived from DIN 127-1987 'Spring lock washers with square ends or tang ends'.

This standard covers requirements for single coil rectangular section spring lock washers suitable for use with bolt/nut assemblies involving fasteners of property class 5.8 or less in the size range 2 to 100 mm.

For higher property classes other sections such as waveform, conical, etc. are generally used.

Steel spring lock washers serve to counteract the loss in inherent tension caused by setting or creep of a bolt/nut assembly provided that they are sufficiently resilient to increase the overall resilience of the assembly and that their inherent springiness can compensate for any loss in tension so that the clamping force required to ensure the reliability of the assembly is maintained.

Types

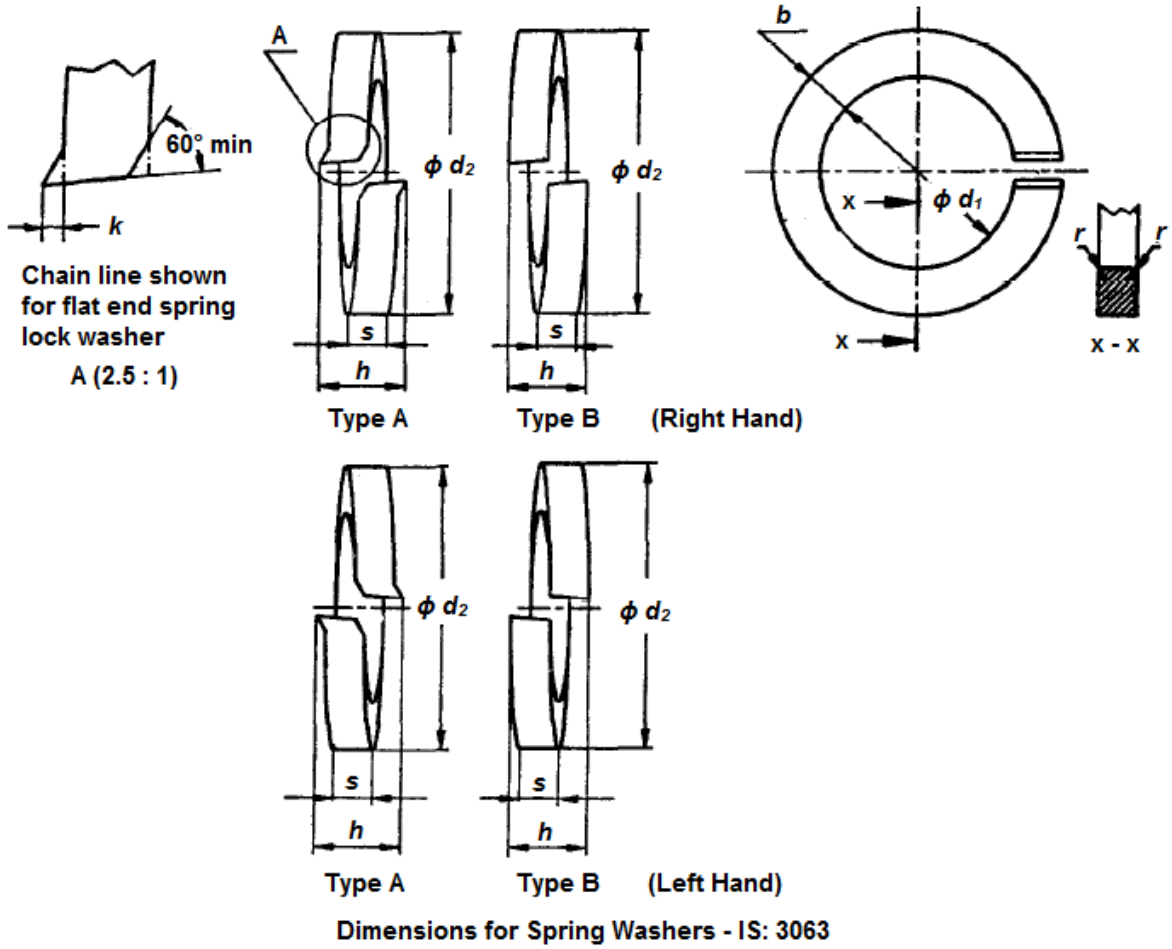
The spring lock washers shall be of following two types.

Type A - Spring lock washers with bent (deflected or tang) ends.
Type B - Spring lock washers with flat (square) ends.

Heat Treatment

The spring lock washers after coiling shall be suitably heat treated to a hardness of HV 430 to 530.

Dimensions



Dimensions for Spring Washers - IS: 3063

The dimensions of the spring lock washers shall be as given in the following table.

Dimensions for Spring Washers (All dimensions in millimetres)										
Nominal Size	d_1 Basic	d_2 Max.	b Basic	s Basic	r Nom.	k*	h			
							Type A		Type B	
							Min	Max	Min	Max
2	2.1	4.4	0.9	0.5	0.1	-	-	-	1	1.2
2.2	2.3	4.8	1	0.6	0.1	-	-	-	1.2	1.4
2.5	2.6	5.1	1	0.6	0.1	-	-	-	1.2	1.4
3	3.1	6.2	1.3	0.8	0.2	0.15	1.9	2.1	1.6	1.9
4	4.1	7.6	1.5	0.9	0.2	0.15	2.1	2.5	1.8	2.1
5	5.1	9.2	1.8	1.2	0.2	0.15	2.7	3.2	2.4	2.8
6	6.1	11.8	2.5	1.6	0.3	0.2	3.6	4.2	3.2	3.8
8	8.1	14.8	3	2	0.5	0.2	4.6	5.4	4	4.7
10	10.2	18.1	3.5	2.2	0.5	0.3	5	5.9	4.4	5.2
12	12.2	21.1	4	2.5	1.0	0.4	5.8	6.8	5	5.9
16	16.2	27.4	5	3.5	1.0	0.4	7.8	9.2	7	8.3
20	20.2	33.6	6	4	1.0	0.4	8.8	10.4	8	9.4
24	24.5	40	7	5	1.6	0.5	11	13	10	11.8
30	30.5	48.2	8	6	1.6	0.8	13.6	16.1	12	14.2
36	36.5	58.2	10	6	1.6	0.8	13.6	16.1	12	14.2
42	42.5	68.2	12	7	2	0.8	15.6	18.4	14	16.5
48	49	75	12	7	2	0.8	15.6	18.4	14	16.5
52	53	83	14	8	2	1	18	21.2	16	18.9
56	57	87	14	8	2	1	18	21.2	16	18.9
60	61	91	14	8	2	1	18	21.2	16	18.9
64	65	95	14	8	2	1	18	21.2	16	18.9
68	69	99	14	8	2	1	18	21.2	16	18.9
72	73	103	14	8	2	1	18	21.2	16	18.9
80	81	111	14	8	2	1	18	21.2	16	18.9
90	91	121	14	8	2	1	18	21.2	16	18.9
100	101	131	14	8	2	1	18	21.2	16	18.9

* - The bend *k* shall be made on the last tenth of the washer circumference without any sharp angle.

Note: For amount of tolerance, please see the standard.

Washers having nominal sizes 3.5, 7, 14, 18, 22, 27, 33, 39 and 45 are non-preferred sizes. For information on their dimensions, please see the standard.

Finish

Spring lock washers shall be supplied in natural finish unless otherwise specified by the purchaser. At the request of the purchaser washers may be phosphate coated, nickel plated, tinned, electrogalvanized, copper plated or cadmium plated.

The use of hot dip galvanized spring lock washers is not recommended as it entails the loss of physical properties during the process of galvanizing.

Designation

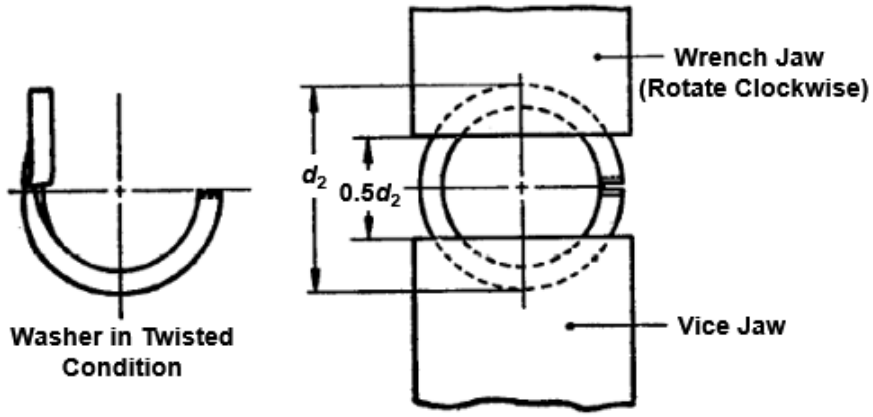
The spring lock washers shall be designated by the nomenclature, type, nominal size, the number of this standard and the surface protection, if any.

Example:

A spring lock washer of nominal size 10 mm, Type A and with phosphate coating shall be designated as: Spring Lock Washer A10 - IS 3063 Phosphate coated.

In case the spring washer is intended for use with LH thread, the designation shall be modified as: Spring Lock Washer LH-A 10 IS 3063 Phosphate coated.

Twist Test



Twist Test of Spring Washers

A portion of the washer shall be gripped in vice jaws and then equal portion shall be gripped in wrench jaws as shown in above figure. Edges of the wrench jaws shall be sharp and parallel to the vice jaws. The wrench shall then be rotated in a direction that increases the free height of the spring lock washer till the washer is, twisted through an angle of 90°. The washer shall show no sign of fracture.

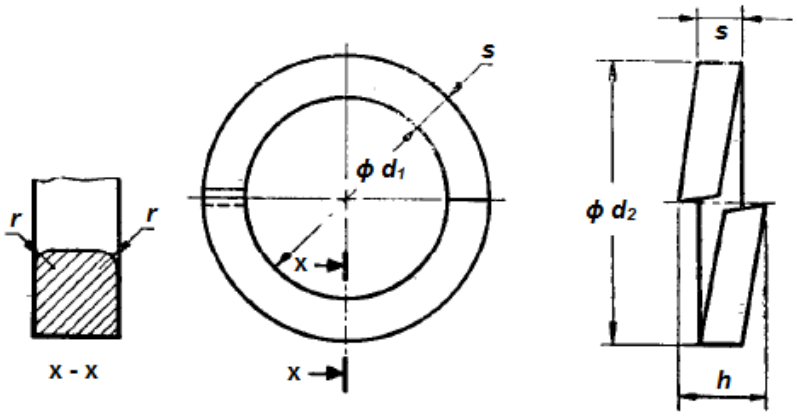
IS 6735: 1994 (Reaffirmed 2004)
Spring Lock Washers for Screws with Cylindrical Heads - Specification

Note: In the preparation of this standard assistance has been derived from DIN 7980: 1987 'Spring lock washers with square ends for cheese head screws'.

These washers are designed for use with cheese head screws and socket head cap screws because of the smaller outside diameter.

This standard covers requirement for spring lock washers suitable for use with bolt/nut assemblies involving fasteners of property classes less than 8.8 in the size range 3 to 48 mm.

Dimensions



Dimensions for Spring Washers - IS: 6735

The dimensions of the spring lock washers shall be as given in the following table.

Dimensions for Spring Lock Washers for Screws with Cylindrical-Heads (All dimensions in millimetres)							
Nominal Size	***d₁***		***d₂***	***s***	***h***		***r***
	Min	**Max**			**Min**	**Max**	
3	3.1	3.4	5.6	1	2	2.36	0.2
4	4.1	4.4	7	1.2	2.4	2.83	0.2
5	5.1	5.4	8.8	1.6	3.2	3.78	0.2
6	6.1	6.5	9.9	1.6	3.2	3.78	0.3
8	8.1	8.5	12.7	2	4	4.72	0.5
10	10.2	10.7	16	2.5	5	5.9	0.8
12	12.2	12.7	18	2.5	5	5.9	0.8
16	16.2	17	24.4	3.5	7	8.25	1
20	20.2	21.2	30.6	4.5	9	10.6	1
24	24.5	25.5	35.9	5	10	11.8	1.6
30	30.5	31.7	44.1	6	12	14.2	1.6
36	36.5	37.7	52.2	7	14	16.5	1.6
42	42.5	43.7	60.2	8	16	18.9	2
48	49	50.5	67	8	16	18.9	2

Note: For amount of tolerance, please see the standard.

Washers having nominal sizes 3.5, 14, 18, 22, 27 and 33 are non-preferred sizes. For information on their dimensions, please see the standard.

Heat Treatment

The spring lock washers after coiling shall be suitably heat treated to a hardness of HV 430 to 530.

Designation

The spring lock washers shall be designated by the nomenclature, nominal size, the number of this standard and the surface protection, if any.

Example:

A spring lock washer of nominal size 10 mm, and with phosphate coating shall be designated as: Spring Lock Washer 10 - IS 6735 Phosphate coated.

The designation for LH spring lock washers shall be modified as: Spring Lock Washer LH - 10 IS 6735 Phosphate coated.

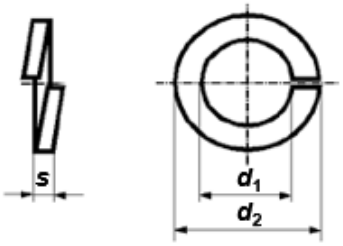
DIN Standards for Spring Lock Washers

Following are the DIN Standards for spring lock washers.

DIN 127 - Spring lock washers with square ends or tang ends
DIN 7980 - Spring lock washer with square ends for cheese head screws
DIN 128 - Split spring washers, Curved Type A and Waved Type B.
DIN 137 - Spring lock washers, Curved Type A and Waved Type B.
DIN 6796 - Conical spring washers for bolt/nut assemblies

DIN 127 and DIN 7980

For information on spring lock washers as per DIN 127 with tang ends, Type A please see the standard (or IS 3063). Following is the information about important dimensions of spring lock washers as per DIN 127 with square ends, Type B, and DIN 7980 with square ends.



Dimensions of Spring Lock Washers as per DIN 127, Type B and DIN 7980

Dimensions of Spring Lock Washers as per DIN 127, Type B (in mm)					
Screw Size	Hole Diameter d_1		Outside Diameter d_2 max.	Thickness s	Thickness Tolerance
	min.	max.			
2	2.1	2.4	4.4	0.5	+/-0.1
2.2	2.3	2.6	4.8	0.6	+/-0.1
2.5	2.6	2.9	5.1	0.6	+/-0.1
3	3.1	3.4	6.2	0.8	+/-0.1
(3.5)	3.6	3.9	6.7	0.8	+/-0.1
4	4.1	4.4	7.6	0.9	+/-0.1
5	5.1	5.4	9.2	1.2	+/-0.1
6	6.1	6.5	11.8	1.6	+/-0.1
7	7.1	7.5	12.8	1.6	+/-0.1
8	8.1	8.5	14.8	2	+/-0.1
10	10.2	10.7	18.1	2.2	+/-0.15
12	12.2	12.7	21.1	2.5	+/-0.15
14	14.2	14.7	24.1	3	+/-0.15
16	16.2	17	27.4	3.5	+/-0.2
(18)	18.2	19	29.4	3.5	+/-0.2
20	20.2	21.2	33.6	4	+/-0.2
(22)	22.5	23.5	35.9	4	+/-0.2
24	24.5	25.5	40	5	+/-0.2
(27)	27.5	28.5	43	5	+/-0.2
30	30.5	31.7	48.2	6	+/-0.2
(33)	33.5	34.7	55.2	6	+/-0.2
36	36.5	37.7	58.2	6	+/-0.2
(39)	39.5	40.7	61.2	6	+/-0.2
42	42.5	43.7	68.2	7	+/-0.25
(45)	45.5	46.7	71.2	7	+/-0.25
48	49	50.5	75	7	+/-0.25
52	53	54.5	83	8	+/-0.25
56	57	58.5	87	8	+/-0.25
(60)	61	62.5	91	8	+/-0.25
64	65	66.5	95	8	+/-0.25
68	69	70.5	99	8	+/-0.25
72	73	74.5	103	8	+/-0.25
80	81	82.5	111	8	+/-0.25
90	91	92.5	121	8	+/-0.25
100	101	102.5	131	8	+/-0.25

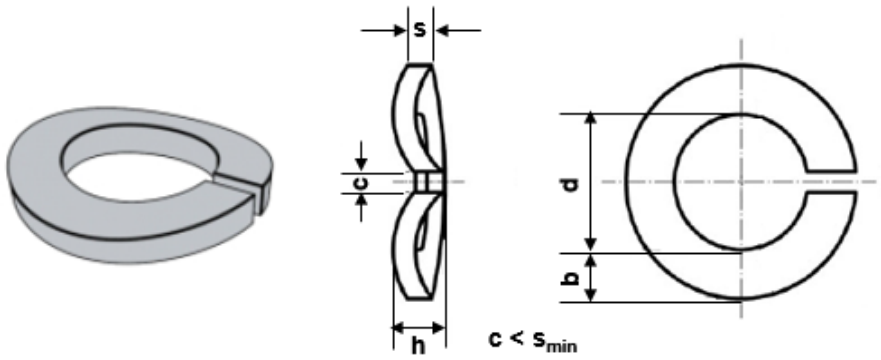
Note: sizes with ( ) should be avoided for new design.

Dimensions of Spring Lock Washers as per DIN 7980 (All dimensions in millimetres)					
Screw Size	**Hole Diameter d_1**		**Outside Diameter d_2 max.**	**Thickness s**	**Thickness Tolerance**
	min.	**max.**			
3	3.1	3.4	5.6	1	+/-0.1
(3.5)	3.6	3.9	6.1	1	+/-0.1
4	4.1	4.4	7	1.2	+/-0.1
5	5.1	5.4	8.8	1.6	+/-0.1
6	6.1	6.5	9.9	1.6	+/-0.1
8	8.1	8.5	12.7	2	+/-0.1
10	10.2	10.7	16	2.5	+/-0.15
12	12.2	12.7	18	2.5	+/-0.15
14	14.2	14.7	21.1	3	+/-0.2
16	16.2	17	24.4	3.5	+/-0.2
(18)	18.2	19	26.4	3.5	+/-0.2
20	20.2	21.2	30.6	4.5	+/-0.2
(22)	22.5	23.5	32.9	4.5	+/-0.2
24	24.5	25.5	35.9	5	+/-0.2
(27)	27.5	28.5	38.9	5	+/-0.2
30	30.5	31.7	44.1	6	+/-0.2
(33)	33.5	34.7	47.1	6	+/-0.2
36	36.5	37.7	52.2	7	+/-0.25
42	42.5	43.7	60.2	8	+/-0.25
48	49	50.5	67	8	+/-0.25

Note: sizes with ( ) should be avoided for new design.

DIN 128

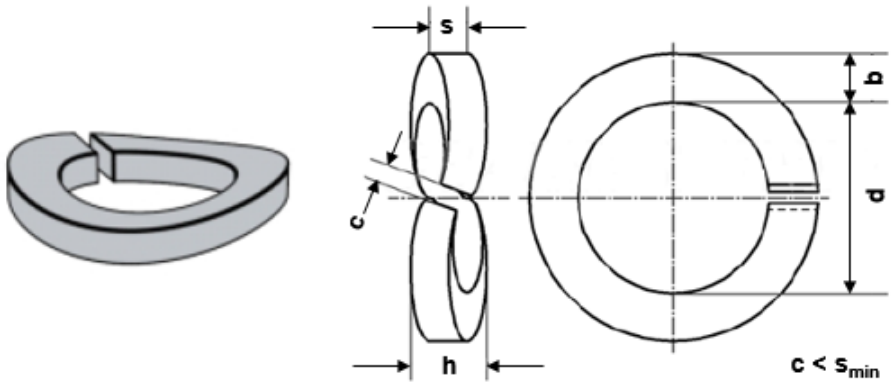
DIN 128 is for split spring washers; Curved, Type A and Waved Type B. Unlike standard split spring lock washers, DIN 128 lock washers are non-directional, allowing the screw or nut to be tightened in a clockwise or counter clockwise manner. When compressed by tightening the nut, DIN 128 lock washer exert a spring force between the tightened bolt and the substrate creating frictional resistance to rotation. Following is the information about their important dimensions.



Dimensions of Split Spring Washers as per DIN 128, Curved, Type A

Dimensions of Split Spring Washers as per DIN 128, Curved, Type A (in mm)						
Screw Size	**d**		**b**	**s**	**h**	
	min.	max.			min.	max.
2	2.1	2.4	0.9±0.1	0.5±0.1	0.7	0.9
2.5	2.6	2.9	1±0.1	0.6±0.1	0.9	1.1
3	3.1	3.4	1.3±0.1	0.7±0.1	1.1	1.3
3.5	3.6	3.9	1.3±0.1	0.7±0.1	1.1	1.3
4	4.1	4.4	1.5±0.1	0.8±0.1	1.2	1.4

5	5.1	5.4	1.8±0.1	1±0.1	1.5	1.7
6	6.1	6.5	2.5±0.15	1.3±0.1	2	2.2
7	7.1	7.5	2.5±0.15	1.3±0.1	2	2.2
8	8.1	8.5	3±0.15	1.6±0.1	2.45	2.75
10	10.2	10.7	3.5±0.2	1.8±0.1	2.85	3.15
12	12.2	12.7	4±0.2	2.1±0.15	3.35	3.65
14	14.2	14.7	4.5±0.2	2.4±0.15	3.9	4.3
16	16.2	17	5±0.2	2.8±0.15	4.5	5.1
18	18.2	19	5±0.2	2.8±0.15	4.5	5.1
20	20.2	21.2	6±0.2	3.2±0.2	5.1	5.9
22	22.5	23.5	6±0.2	3.2±0.2	5.1	5.9
24	24.5	25.5	7±0.25	4±0.2	6.5	7.5
27	27.5	28.5	7±0.25	4±0.2	6.5	7.5
30	30.5	31.7	8±0.25	6±0.2	9.5	10.5
36	36.5	37.7	10±0.25	6±0.2	10.3	11.3



Dimensions of Split Spring Washers as per DIN 128, Waved, Type B

Dimensions of Split Spring Washers as per DIN 128, Waved, Type B (in mm)															
Screw Size		2	2.5	3	3.5	4	5	6	7	8	10	12	14	16	18
d	min	2.1	2.6	3.1	3.6	4.1	5.1	6.1	7.1	8.1	10.2	12.2	14.2	16.2	18.2
	max	2.4	2.9	3.4	3.9	4.4	5.4	6.5	7.5	8.5	10.7	12.7	14.7	17	19
b	Nominal Size	0.9	1	1.3	1.3	1.5	1.8	2.5	2.5	3	3.5	4	4.9	5	5
	min	0.8	0.9	1.2	1.2	1.4	1.7	2.4	2.35	2.85	3.3	3.8	4.7	4.8	4.8
	max	1	1.1	1.4	1.4	1.6	1.9	2.6	2.65	3.15	3.7	4.2	5.1	5.2	5.2
s	Nominal Size	0.5	0.6	0.7	0.7	0.8	1	1.3	1.3	1.6	1.8	2.1	2.4	2.8	2.8
	min	0.4	0.5	0.6	0.6	0.7	0.9	1.2	1.2	1.5	1.7	1.95	2.25	2.65	2.65
	max	0.6	0.7	0.8	0.8	0.9	1.1	1.4	1.4	1.7	1.9	2.25	2.55	2.95	2.95
h	min	0.7	0.9	1.1	1.1	1.2	1.5	2	2	2.45	2.85	3.35	3.9	4.5	4.5
	max	0.9	1.1	1.3	1.3	1.4	1.7	2.2	2.2	2.75	3.15	3.65	4.3	5.1	5.1

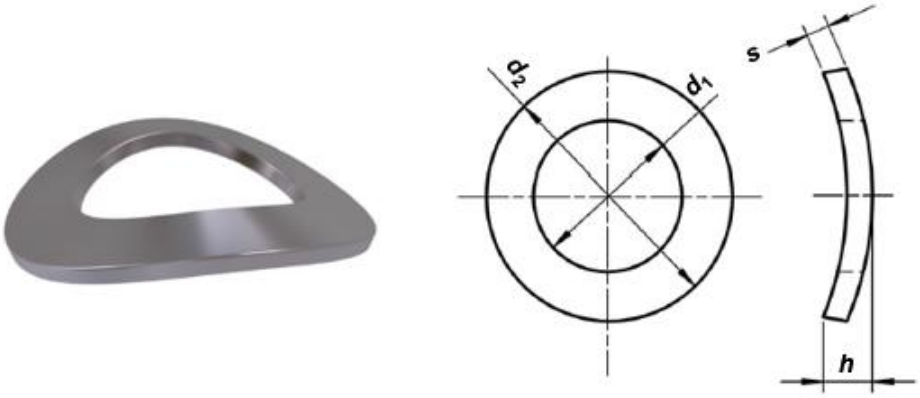
Note: For screw sizes from 20 mm to 100 mm, please see the standard

DIN 137

DIN 137 is for spring lock washers, Curved Type A and Waved Type B.

DIN 137 Type A and B spring lock washers are specialty spring lock washers. Unlike standard split helical spring lock washers, the DIN 137 lock washers are uninterrupted formed disks in either a curved or waved configuration that are non-directional allowing the screw and or nut to be tightened in a clockwise or counter-clockwise manner. When compressed by tightening the nut, the DIN 137 lock washers exert a spring force between the tightened bolt and the substrate creating frictional resistance to rotation.

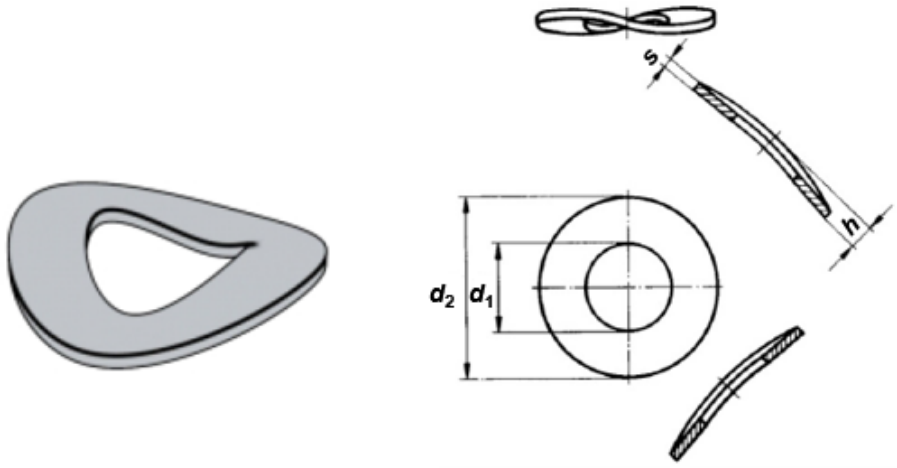
Following is the information about their important dimensions.



Dimensions of Spring Lock Washers as per DIN 137, Curved Type A

Following table shows dimensions of spring lock washers as per DIN 137, Curved Type A

Dimensions of Spring Lock Washers as per DIN 137, Curved Type A (in mm)							
Nominal Size	For Bolt Size	d_1 H14	d_2 js16	*s*		*h*	
				Nominal Size	tolerance	min.	max.
3	M3	3.2	8	0.5	±0.05	0.8	1.6
3.5	M3.5	3.7	8	0.5	±0.05	0.9	1.8
4	M4	4.3	9	0.5	±0.05	1	2
5	M5	5.3	11	0.5	±0.05	1.1	2.2
6	M6	6.4	12	0.5	±0.05	1.3	2.6
7	M7	7.4	14	0.8	±0.06	1.5	3
8	M8	8.4	15	0.8	±0.06	1.5	3
10	M10	10.5	21	1	±0.07	2.1	4.2
12	M12	13	24	1.2	±0.07	2.5	5
14	M14	15	28	1.6	±0.08	3	6
16	M16	17	30	1.6	±0.08	3.2	6.4
18	M18	19	34	1.6	±0.08	3.3	6.6
20	M20	21	36	1.6	±0.08	3.7	7.4
22	M22	23	40	1.8	±0.1	3.9	7.8
24	M24	25	44	1.8	±0.1	4.1	8.2
27	M27	28	50	2	±0.1	4.7	9.4
30	M30	31	56	2.2	±0.1	5	10
33	M33	34	60	2.2	±0.1	5.3	10.6
36	M36	37	68	2.5	±0.15	5.8	11.6



Dimensions of Spring Lock Washers as per DIN 137, Waved Type B

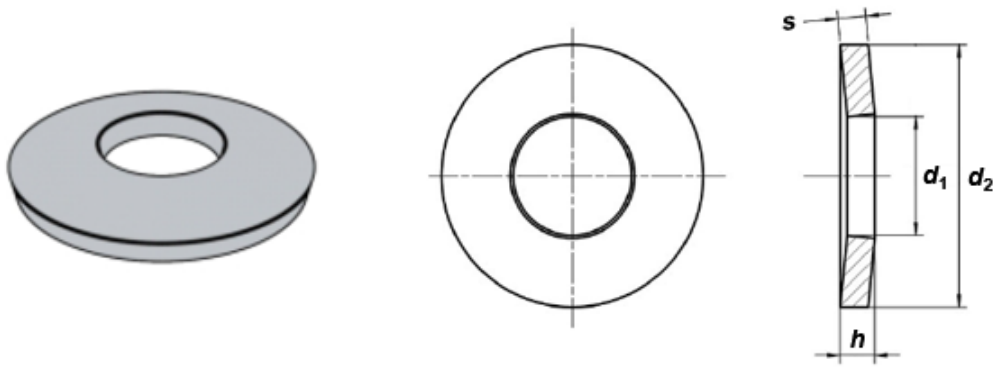
Following table shows dimensions of spring lock washers as per DIN 137, Waved Type B

Dimensions of Spring Lock Washers as per DIN 137, Waved Type B (in mm)						
Nominal Size	For Bolt Size	d_1 H14	d_2 js16	s	h	
					min.	max.
3	M3	3.2	8.0	0.5 ± 0.05	0.8	1.6
3.5	M3.5	3.7	8.0	0.5 ± 0.05	0.9	1.8
4	M4	4.3	9.0	0.5 ± 0.05	1.0	2.0
5	M5	5.3	11.0	0.5 ± 0.05	1.1	2.2
6	M6	6.4	12.0	0.5 ± 0.05	1.3	2.6
7	M7	7.4	14.0	0.8 ± 0.06	1.5	3.0
8	M8	8.4	15.0	0.8 ± 0.06	1.5	3.0
10	M10	10.5	21.0	1 ± 0.07	2.1	4.2
12	M12	13.0	24.0	1.2 ± 0.07	2.5	5.0
14	M14	15.0	28.0	1.6 ± 0.08	3.0	6.0
16	M16	17.0	30.0	1.6 ± 0.08	3.2	6.4
18	M18	19.0	34.0	1.6 ± 0.08	3.3	6.6
20	M20	21.0	36.0	1.6 ± 0.08	3.7	7.4
22	M22	23.0	40.0	1.8 ± 0.1	3.9	7.8
24	M24	25.0	44.0	1.8 ± 0.1	4.1	8.2
27	M27	28.0	50.0	2 ± 0.1	4.7	9.4
30	M30	31.0	56.0	2.2 ± 0.1	5.0	10.0
33	M33	34.0	60.0	2.2 ± 0.1	5.3	10.6
36	M36	37.0	68.0	2.5 ± 0.15	5.8	11.6

DIN 6796

DIN 6796 is for conical spring washers for bolt/nut assemblies. Conical spring washers are also known by their alternative names such as Belleville washers or cupped spring washer. Conical spring washers covered in this standard are deemed to be spring washers designed for use for bolt/nut assemblies involving bolts of property classes 8.8 to 10.9 as specified in ISO 898 Part I. They are intended to counteract the effect of setting which results in bolt/nut assemblies working loose (see DIN 267 Part 26). They do not effectively prevent loosening of the assembly under varying radial load and are designed for use with short bolts predominantly subject to thrust. These washers are used for heavy duty bolted section such as bus bars, transformers, rectifiers, heat exchangers, etc.

Following is the information about their important dimensions.



Dimensions of Conical Spring Washers as per DIN 6796

Dimensions of Conical Spring Washers as per DIN 6796 (in mm)						
Nominal Size	d_1 H14	d_2 h14	s	h		For Thread Size
				max.	min.	
2	2.2	5	0.4	0.6	0.5	M2
2.5	2.7	6	0.5	0.72	0.61	M2.5
3	3.2	7	0.6	0.85	0.72	M3
3.5	3.7	8	0.8	1.06	0.92	M3.5
4	4.3	9	1	1.3	1.12	M4
5	5.3	11	1.2	1.55	1.35	M5
6	6.4	14	1.5	2	1.7	M6
7	7.4	17	1.75	2.3	2	M7
8	8.4	18	2	2.6	2.4	M8
10	10.5	23	2.5	3.2	2.8	M10
12	13	29	3	3.95	3.43	M12
14	15	35	3.5	4.65	4.04	M14
16	17	39	4	5.25	4.58	M16
18	19	42	4.5	5.6	5.08	M18
20	21	45	5	6.4	5.6	M20
22	23	49	5.5	7.05	6.15	M22
24	25	56	6	7.75	6.77	M24
27	28	60	6.5	8.35	7.3	M27
30	31	70	7	9.2	8	M30

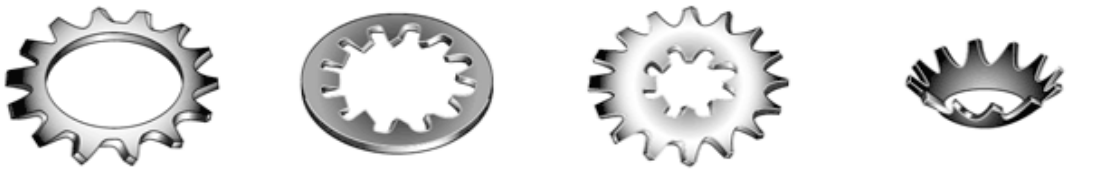
Designation of a conical spring washer of nominal size 8 made of spring steel (FSt): Conical spring washer DIN 6796 - 8 - FSt.

Withdrawn DIN Standards

It may be noted that DIN 127, DIN 7980, DIN 128 and DIN 137 have been withdrawn. These standards do not have ISO counterparts or replacements as all of them are considered ineffective.

Product Standards for Tooth (Star) Lock Washers

As shown in the following figure, tooth lock washer, also known as serrated washer or star washer has tooth or serrations that extend radially inward and/or outward. There are of four types: external tooth, internal tooth, external-internal type (combination type) and countersunk type.



Tooth Lock Washers

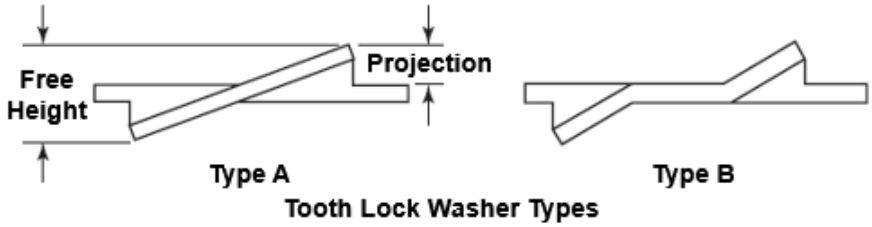
Tooth lock washers are used with screws and nuts for some spring action but mostly for locking action. They serve to increase the friction between the screw and the assembly. The teeth are formed in a twisted configuration with sharp edges. One edge bites into the bolt/screw head (or nut) while the other edge bites into the mating surface. Although this washer does provide some locking action, it damages the mating surfaces. These scratches can cause crack formation in highly stressed fasteners, in mating parts, or both, as well as increased corrosion susceptibility.

Externally toothed lock washers are used with normal hexagon head and other screws where projection or teeth beyond screw head or nut is not objectionable. The external type also provides better holding power because of the greater circumference. Internally toothed lock washers are preferred where it is desirable to provide a smooth periphery. The teeth along the inner edge of the washer also make them more aesthetically pleasing. The combination type has serrations on both edges, for maximum holding power. The countersunk type is designed to be used with flat countersunk or oval countersunk screws.

Information about product standards for tooth lock washer as per ASME, IS and DIN is given in this chapter.

ASME B18.21.1: Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

ASME B18.21.1 covers the dimensional requirements, physical properties, and related test methods for helical spring-lock washers (# 0 through 3 in.), tooth-lock washers (# 2 through 1¾ in.), and plain washers (# 0 through 3 in.).



Tooth Lock Washer Types

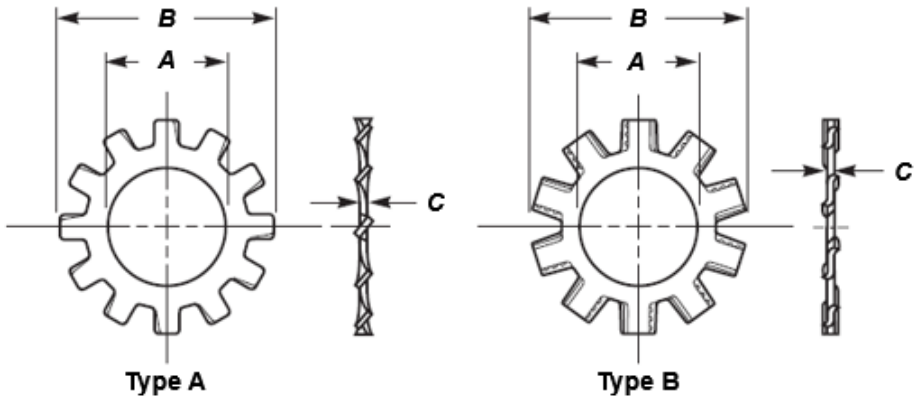
The standard covers tooth lock washers of internal tooth, external tooth, internal/external tooth and countersunk external tooth types and of two constructions, designated Types A and B as shown in above figure.

Material and Hardness Requirements

Washers shall be made from material meeting the chemical composition requirements for the material as per the standards shown in the following table and shall also meet hardness requirements as shown in the table.

Material	Material Standard	Hardness
Carbon Steel	SAE J403 1050-1065 (UNS G10500-G10650)	40 to 50 HRC, 392 to 513 HV
Stainless Steel	SAE J405 301-305 (UNS S30100-S30500) or SAE J405 316 (UNS S31600)	Annealed 88 minimum HRB, ¼ hard through full hard 20 to 45 HRC
Stainless Steel	SAE J405 410 (UNS S41000)	40 to 50 HRC, 392 to 513 HV
Copper Alloy	ASTM B 591 Type 425 (UNS C42500)	Temper H06 minimum.

Dimensions of External Tooth Lock Washers



Dimensions of External Tooth Lock Washers

Dimensions for External Tooth Lock Washers as per ASME B18.21.1 (All dimensions are in inches)						
Nominal Size	Inside Diameter, *A*		Outside Diameter, *B*		Thickness, *C*	
	Max.	Min.	Max.	Min.	Max.	Min.
No. 3 (0.099)	0.109	0.102	0.235	0.220	0.0 16	0.010
No. 4 (0.112)	0.123	0.115	0.260	0.245	0.018	0.012
No. 5 (0.125)	0.136	0.129	0.285	0.270	0.020	0.014
No. 6 (0.138)	0.150	0.141	0.320	0.305	0.022	0.016
No. 8 (0.164)	0.176	0.168	0.381	0.365	0.023	0.018
No. 10 (0.190)	0.204	0.195	0.410	0.395	0.024	0.018
No. 12 (0.216)	0.231	0.221	0.475	0.460	0.027	0.020
¼ (0.250)	0.267	0.256	0.510	0.494	0.028	0.023
5⁄16 (0.3125)	0.332	0.320	0.610	0.588	0.034	0.028
⅜ (0.375)	0.398	0.384	0.694	0.670	0.040	0.032
7⁄16 (0.4375)	0.464	0.448	0.760	0.74	0.040	0.032
½ (0.500)	0.530	0.513	0.900	0.880	0.045	0.037
9⁄16 (0.5625)	0.596	0.576	0.985	0.960	0.045	0.037
⅝ (0.625)	0.663	0.641	1.070	1.045	0.050	0.042
11⁄16 (0.6875)	0.728	0.704	1.155	1.130	0.050	0.042
¾ (0.750)	0.795	0.768	1.260	1.220	0.055	0.047
13⁄16 (0.8125)	0.861	0.833	1.315	1.290	0.055	0.047
⅞ (0.875)	0.927	0.897	1.410	1.380	0.060	0.052
1 (1.000)	1.060	1.025	1.620	1.590	0.067	0.059

For dimensions of other types of washers, internal tooth lock washers, heavy internal tooth lock washers, external tooth countersunk washers and internal/external tooth lock washers, please see the standard.

Designation

Nominal washer sizes are intended for use with comparable screw or nut sizes.

Tooth lock washers conforming to this standard shall be designated by the following data, in the sequence:

Product style, tooth type if purchaser has preference, ASME document number (ASME B18.21.1), nominal size (number, fraction, or decimal equivalent), maximum washer outside diameter (internal/external tooth washers only), type, material and surface protective finish standard number and thickness, if applicable.

For examples:

Internal Tooth Lock Washer, ASME B18.21.1. ¼ in., Type A, Stainless Steel.

Internal/External Tooth Lock Washer, ASME B18.21.1, No. 12 (0.900 O.D.), Type A, Carbon Steel, Mechanical Zinc per ASTM B 695, Class 55.

IS 5371-1982 (Reaffirmed 2001): Specification for Multi-Tooth Lock Washers

In the preparation of this standard, assistance has been taken from DIN 6797-1971 ‘Toothed lock washers’.

This standard covers the requirements for multi-tooth lock washers for use with screws in the diameter range 1.6 to 30 mm.

Types

The multi-tooth lock washers shall be of the following three types:

Type A - Externally toothed
Type B - Internally toothed
Type C - Countersunk

Hardness

The multi-tooth lock washers made of spring steel shall be suitably hardened and tempered to result in a hardness range of 410 to 490 HV or 42 to 49 HRC.

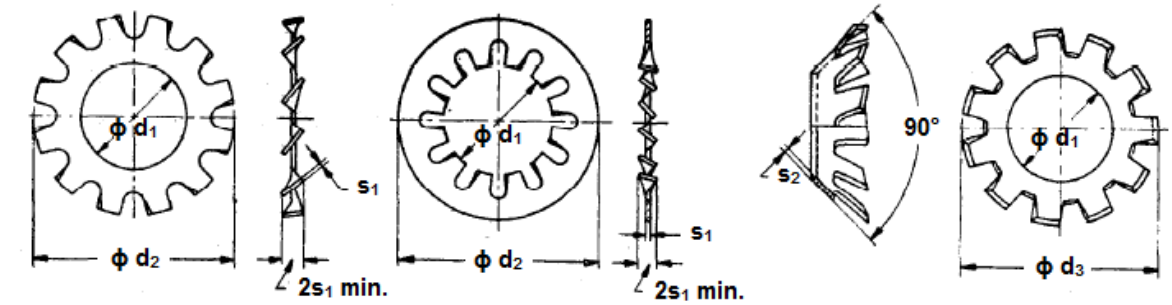
Designation

The multi-tooth lock washers shall be designated by the name, type, nominal size, number of the standard, and the surface protection, if any. For example,

A multi-tooth lock washer of type A, nominal size 10.5 mm, and phosphate coated shall be designated as: Multi-Tooth lock washer A 10.5 IS: 5371 Phosphate Coated.

In case the lock washer is intended for screws with left hand threads, the designation shall be Multi-Tooth lock washer A 10.5 LH IS: 5371 Phosphate Coated.

Dimensions



Type A - Externally Toothed Type B - Internally Toothed Type C - Countersunk

Dimensions for Multi-Tooth Lock Washers - IS: 5371

Dimensions of multi-tooth lock washers shall be as given in the following table.

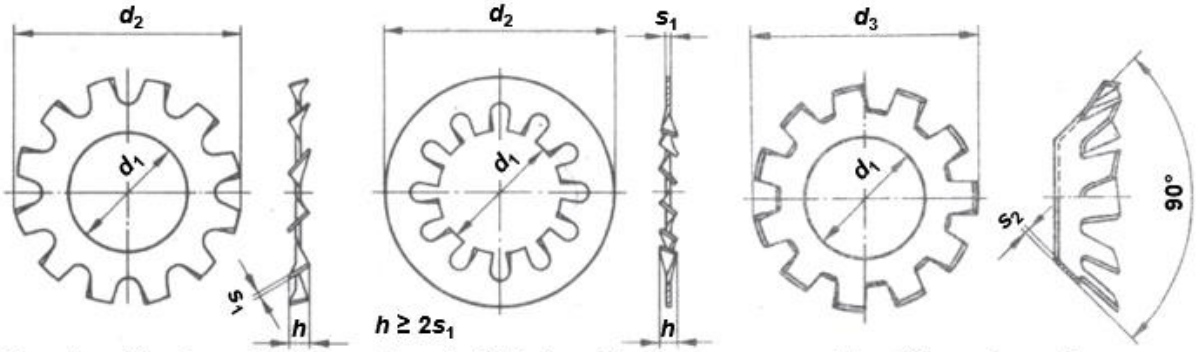
Dimensions of Multi-Tooth Lock Washers as per IS 5371 (All dimensions in millimetres)							
Nominal Size, d_1, H13	**d_2, h14**	**d_3**	**s_1**	**s_2**	**Number of Teeth, Min.**		**Suitable for Screw Size**
					Types A and B	**Type C**	
1.7	3.6	-	0.3	-	6	-	M1.6
(1.9)	4	-	0.3	-	6	-	M1.8
2.2	4.5	4.2	0.3	0.2	6	6	M2
2.7	5.5	5.1	0.4	0.2	6	6	M2.5
3.2	6	6	0.4	0.2	6	6	M3
(3.7)	7	7	0.5	0.25	6	6	M3.5
4.3	8	8	0.5	0.25	8	8	M4
5.1*	9	-	0.5	-	8	-	M5
5.3	10	9.8	0.6	0.3	8	8	M5
6.4	11	11.8	0.7	0.3	8	10	M6
(7.4)	12.5	-	0.8	-	8	-	M7
8.2*	14	-	0.8	-	8	-	M8
8.4	15	15.3	0.8	0.4	8	10	M8
10.5	18	19	0.9	0.5	9	10	M10
12.5	20.5	23	1	0.5	10	10	M12
(14.5)	24	26.2	1	0.6	10	12	M14
16.5	26	30.2	1.2	0.6	12	12	M16
(19)	30	-	1.4	-	12	-	M18
21	33	-	1.4	-	12	-	M20
(23)	36	-	1.5	-	14	-	M22
25	38	-	1.5	-	14	-	M24
(28)	44	-	1.6	-	14	-	M27
31	48	-	1.6	-	14	-	M30

* - Only for hexagon head bolts.
Note: Sizes shown within the brackets are non-preferred.

DIN 6797 (1988)

The main purpose of toothed lock washers is to permit the flow of electric current between components coated by varnish, anti-corrosive agents or similar materials, the bent ends of the washers piercing the coating when such components are joined. For such applications, the effectiveness of toothed lock washers shall be verified in accordance with the relevant DIN standards. Where such washers are intended to keep fasteners of a low property class from working loose, their effectiveness shall be checked for the application concerned.

Dimensions



Type A, with external teeth | Type J with internal teeth | Type V, countersunk

Dimensions of Toothed Lock Washers

Dimensions of toothed lock washers, Type A (with external teeth) and Type J (with internal teeth) as per DIN 6797 shall be as given in the following table. For dimensions of toothed lock washers, Type V, please see the standard.

Dimensions of Type A and Type J Toothed Lock Washers as per DIN 6797
(All dimensions in millimetres)

Nominal Size	Hole Diameter d_1		Outside Diameter d_2		Material Thickness, s_1	Min. No. of Teeth	For Nominal Screw Size
	min. = nominal	max.	max. = nominal	min.			
1.7	1.7	1.84	3.6	3.3	0.3	6	1.6
2.2	2.2	2.34	4.5	4.2	0.3	6	2
2.7	2.7	2.84	5.5	5.2	0.4	6	2.5
3.2	3.2	3.38	6	5.7	0.4	6	3
3.7	3.7	3.88	7	6.64	0.5	6	3.5
4.3	4.3	4.48	8	7.64	0.5	8	4
5.3	5.3	5.48	10	9.64	0.6	8	5
6.4	6.4	6.62	11	10.57	0.7	8	6
7.4	7.4	7.62	12.5	12.07	0.8	8	7
8.4	8.4	8.62	15	14.57	0.8	8	8
10.5	10.5	10.77	18	17.57	0.9	9	10
13	13	13.27	20.5	19.98	1	10	12
15	15	15.27	24	23.48	1	10	14
17	17	17.27	26	25.48	1.2	12	16
19	19	19.33	30	29.48	1.4	12	18
21	21	21.33	33	32.38	1.4	12	20
23	23	23.33	36	35.38	1.5	14	22
25	25	25.33	38	37.38	1.5	14	24
28	28	28.33	44	43.38	1.6	14	27
31	31	31.39	48	47.38	1.6	14	30

Material and Hardness

Toothed lock washers shall be made of spring steel and shall have hardness in the range of 350 to 425 HV.

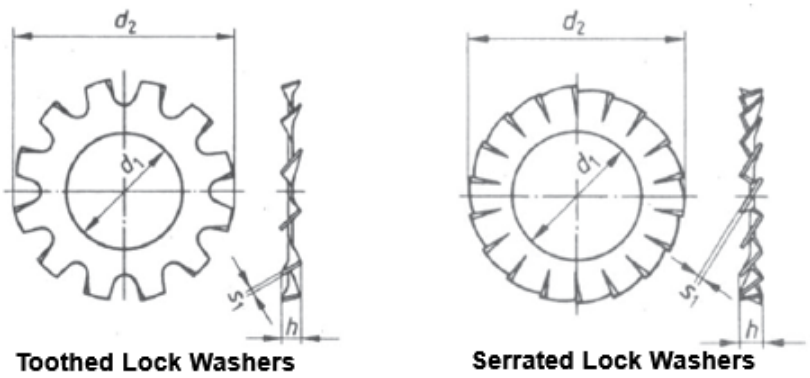
Designation

Designation of a type A toothed lock washer of nominal size 8.4, made from spring steel (FSt): Toothed lock washer DIN 6797 - A 8.4 - FSt.

Where toothed lock washers for left-hand thread bolts are required, symbol LH shall be included in the designation: Toothed lock washer DIN 6797 - A 8.4 - LH - FSt.

Difference between DIN 6797 and DIN 6798

DIN 6797 is for toothed lock washers whereas DIN 6798 is for serrated lock washers. The following figure shows difference in construction of toothed lock washers and serrated lock washers. It may be noted that though DIN 6797 and DIN 6798 cover Type A, with external teeth; Type J with internal teeth and Type V, countersunk, only Type A washers are shown in the figure. For more information on DIN 6798 please see the standard.



Toothed Lock Washers **Serrated Lock Washers**

Construction of Toothed and Serrated Lock Washers

Note

It may be noted that the DIN standards DIN 6797 (toothed lock washers) and DIN 6798 (serrated lock washers) have been withdrawn by DIN (DIN stands for "Deutsches Institut für Normung", which means "German Institute for Standardization"). They do not have ISO counterparts or replacements.

References

Machinery's Handbook by Industrial Press Inc., New York, NY.

Engineering Guide by Unbrako Group (www.unbrako.com)

Technical Manual by Lindstrom Fasteners (www.lindstromfasteners.com)

Internet Sites:

www.fasteners.eu/standards

www.globalfastener.com/standards