AMERICAN NATIONAL STANDARD

Square and Hex Bolts and Screws Inch Series

ANSI B18.2.1 - 1981

(REVISION OF B18.2.1 — 1972)

Including Hex Cap Screws and Lag Screws

REAFFIRMED 1992

F CURRENT COMMITTEE PERSONNEL
ASE SEE ASME MANUAL AS-11

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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FOREWORD

American National Standards Committee B18 for the standardization of bolts, screws, nuts, rivets, and similar fasteners was organized in March 1922, as Sectional Committee B18, under the aegis of the American Engineering Standards Committee (later the American Standards Association, then the United States of America Standards Institute and, as of October 6, 1969, the American National Standards Institute, Inc.), with the Society of Automotive Engineers and the American Society of Mechanical Engineers as joint sponsors. Subcommittee 2 was subsequently established and charged with the responsibility for technical content of standards covering wrench head bolts and nuts.

Subcommittee 2, after appraisal of the requirements of industry, developed a proposed standard series of bolt head and nut dimensions. This proposal was finally approved and designated a Tentative American Standard in February 1927.

A first revision of the document was designated as an American Standard in March 1933, and was followed by a second revision which was granted approval as an American Standard in January 1941.

Following reorganization of the B18 Committee in 1947, Subcommittee 2 was asked to expand the standard on head proportions into a complete product standard. A proposal covering square and hexagon head bolts, and nuts, hexagon head cap screws and automotive hexagon head bolts was prepared and submitted to the B18 Committee in April 1950. While this draft was under consideration, the B18 Committee received a proposal from the British Standards Institution for unification of dimensions on products incorporating Unified screw threads. The Committee welcomed the opportunity of discussing the proposals and an American-British-Canadian Conference was held in New York, June 1-2, 1950.

It was agreed in the Conference that the essentials of unification could be accomplished by selection of mutually satisfactory across-the-flats dimensions, since this would permit the use of the same wrenches and because other features would rarely affect interchangeability. After due consideration, suitable existing across-the-flats dimensions were selected for the hexagon products affected.

In its meeting of October 13, 1950, Subcommittee 2 agreed to incorporate in the proposed standard the conference recommendations on 1/4 in. hexagon head bolts, 5/8 in. hexagon head cap screws and automotive hexagon head bolts, 5/16 and 3/8 in. regular hexagon and square nuts, and 7/16 in. light and regular hexagon and square nuts. At a subsequent meeting of Subcommittee 2, further changes were adopted in order to combine the light and regular series of nuts and to combine the automotive hexagon head bolt, hexagon head cap screw, and regular hexagon head close tolerance bolt.

In view of the progress made in the United States and the urgency of standardization for mutual defense, the British Standards Institution sponsored a second Conference in London in April 1951, to complete the unification of certain hexagon bolts and nuts.

At a meeting on June 8, 1951, Subcommittee 2 reaffirmed its acceptance of the unified dimensions, which corresponded with those in the March 1951 draft, but attempted to select better nomenclature for the unified products. A final draft incorporating the nomenclature *Finished Hexagon Bolts and Nuts* and containing numerous editorial changes was submitted for letter ballot in September 1951. Following approval by the B18 Committee and the sponsors, the proposal was presented to the American Standards Association for approval and designation as an American Standard. This was granted on March 24, 1952.

Recognizing the standard was in need of additional refinements, Subcommittee 2 began immediately to revise it, removing inconsistencies with respect to fillets, improving the length tolerances on heavy hexagon bolts, and incorporating numerous other corrections and clarifications. The most noteworthy

editorial change was a decision to combine the coverage for hexagon cap screws and square head set screws from the B18.2 standard with the coverage for slotted head cap screws and slotted headless set screws from the B18.6 standard and publish them in a separate document. The requirements for the unified hexagon cap screws and finished hexagon bolts being identical in the overlapping sizes, this data would now be available in two publications. Following approvals by the B18 Committee and sponsor organizations, the proposal was submitted to the American Standards Association and declared an American Standard on February 2, 1955.

A revision of this document comprised of numerous editorial corrections and inclusion of an appendix for grade markings was duly approved and designated an American Standard on April 18, 1960.

At a meeting in February 1960, Subcommittee 2 approved a recommendation to reduce the head heights for heavy, heavy semi-finished, and heavy finished hexagon bolts which was subsequently approved by letter ballot of the B18 Committee on August 16, 1960. A proposed standard for heavy hexagon structural bolts submitted and accepted by Subcommittee 2 at its October 17, 1960 meeting was approved by letter ballot of the B18 Committee on May 9, 1961. To meet the urgent needs of the steel construction industry, it was considered necessary to publish the standard for the structural bolts immediately. Consequently, Appendix IV to ASA B18.2–1960 containing coverage for the revised heavy hexagon bolts and the new heavy hexagon structural bolts was released in 1962.

In October of 1961, Subcommittee 2 appointed a subgroup to review all product standards for square and hexagon bolts, screws, and nuts, and to recommend simplifications which would be compatible with technical, production, and distribution advances that had occurred over the prior several years. The subgroup presented its recommendations at a meeting of Subcommittee 2 in October of 1962. It was agreed that the internally and externally threaded products should be published in separate documents as suggested, and draft proposals for each were completed.

The proposed revision for square and hex bolts and screws incorporated the following subgroup recommendations: consolidation of hexagon head cap screws and finished hexagon bolts into a single product; consolidation of heavy semifinished hexagon bolts and heavy finished hexagon bolts into a single product; elimination of regular semifinished hexagon bolts; a new length tolerancing pattern for all bolts and screws; documentation of a positive identification procedure for determining whether an externally threaded product should properly be designated a bolt or a screw; and an abbreviated and purified set of product nomenclature reflecting application of the identification procedure. Letter ballot of this proposal to the B18 Committee in March, 1964 resulted in several comments which were resolved to the satisfaction of the Committee in June of 1964. Following acceptance by the sponsor organizations, the revision was submitted to the American Standards Association and was designated American Standard ASA B18.2.1 on September 8, 1965.

Subcommittee 2 continued to further develop refinements initiated by the simplification subgroup and revisions reflecting changes in manufacturing practices and consumer requirements. This work culminated in Subcommittee acceptance of a 1970 proposal incorporating, in addition to numerous editorial changes, revisions in the following significant areas: addition of coverage for askew head bolts and hex head lag screws; addition of straightness requirements to applicable products; addition of minimum fillet to square and hex bolts and lag screws; application of UNR threads and new concepts for controlling thread length on products having Unified threads; and clarification of grade markings, thread runout gages and formulas for dimensions. Also included were refinements to hex cap screw and heavy hex screw requirements consisting of addition of wrenching height and revision of underhead fillets, washer face thicknesses and controls on angularity of bearing face. The proposed revision, after approval by letter ballot of the B18 Committee in March, 1970, was subsequently approved by the sponsors and submitted to the American National Standards Institute for designation as an American National Standard. This was granted on January 18, 1972.

Numerous user complaints on interference of the elliptical fillet added in the 1972 revision resulted in appointment of a subcommittee to study the problem. They recommended reverting back to the max/min

radius fillet specified in the 1965 version with the elliptical fillet retained for use when specified by the user. Further refinements in the definition of the fillet for short length screws were added to Hex Cap and Heavy Hex Screws. Geometric tolerancing was updated to conform to American National Standard Y14.5 dimensioning and tolerancing methods. The transition length of the hex cap screw was changed to equal 5 coarse (UNC) threads. Few, if any, users accepted the 1972 values that were designed to reduce tooling by providing the same body length for adjacent lengths. On screws, separate straightness requirements have been deleted and the combination thread runout and straightness gage described in Appendix I is specified. Straightness as a variable based on length has been applied to bolts with gaging described in Appendix II. Acceptability of screw threads based on gaging systems established by American National Standard B1.3-1979 has been added to each type of screw or bolt, except lag screws. This proposal was approved by letter ballot of the subcommittee and B18 in January, 1980. Following acceptance by the secretariat organizations, the revision was referred to the American National Standards Institute and granted recognition as an American National Standard on June 24, 1981.

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AMERICAN NATIONAL STANDARD

SQUARE AND HEX BOLTS AND SCREWS
INCH SERIES

1 Introductory Notes

1.1 Scope

1.1.1 This Standard is intended to cover the complete general and dimensional data for the various types of inch series square and hex bolts and screws recognized as American National Standard. Also included are appendixes covering thread runout sleeve gages, gaging procedure for checking bolt and screw straightness, grade markings for steel bolts and screws, formulas on which dimensional data are based, wrench openings for bolts and screws, and a specification to assist in identifying a product as being a screw or a bolt. It should be understood, however, that where questions arise concerning acceptance of product, the dimensions in the tables shall govern over recalculation by formula.

1.1.2 The inclusion of dimensional data in this Standard is not intended to imply that all of the products described herein are stock production sizes. Consumers are requested to consult with manufacturers concerning lists of stock production sizes.

1.2 Dimensions

All dimensions in this Standard are in inches, unless stated otherwise.

1.3 Options

Options, where specified, shall be at the discretion of the manufacturer unless otherwise agreed upon by the manufacturer and the purchaser.

1.4 Terminology

For definitions of terms relating to fasteners or component features thereof used in this Standard, refer to American National Standard, Glossary of Terms for Mechanical Fasteners, ANSI B18.12.

1.5 Related Standards

It should be noted that standards for square and hex nuts, machine screws and machine screw nuts, tapping screws, socket cap screws, round head bolts, and other related fasteners are published under separate cover as listed on the back sheet of this Standard.

1.6 Referenced Standards

Copies of referenced ASTM standards may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

Copies of referenced SAE standards may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

2 General Data

2.1 Heads

2.1.1 Width Across Flats. The width across flats of head shall be the distance measured perpendicular to the axis of product, overall between two opposite sides of the head in accordance with the notes on respective dimensional tables.

2.1.2 Head Height. The head height shall be 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.

2.2 Bolt or Screw Length

The bolt or screw length shall be 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 point, if the product is pointed.

2.3 Threads

Threads on all products except lag screws shall be Unified Standard, Class 2A, of the series specified in the notes on respective dimensional tables as documented in American National Standard, Unified Inch Screw Threads (UN and UNR Thread Form) ANSI B1.1. For threads with additive finish, the maximum

daimeter of Class 2A may be exceeded by the amount of the allowance; that is, the Class 2A maximum diameters apply to an unplated or uncoated part or to a part before plating or coating, whereas the basic diameters (Class 2A maximum diameters plus the allowance) apply to a part after plating or coating.

2.4 Body Diameter, Minimum

The minimum body diameter on products for which no minimum limits are shown in the dimensional tables shall not be less than the minimum pitch diameter of the thread.

2.5 Finish

Unless otherwise specified, bolts and screws shall be supplied with a natural (as processed) finish, unplated or uncoated.

2.6 Workmanship

Bolts and screws shall be free from burrs, seams, laps, loose scale, irregular surfaces, and any defects affecting their serviceability.

2.7 Designation

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

3/8-16 x 1-1/2 Square Bolt, Steel, Zinc Plated

1/2-13 x Hex Cap Screw, SAE Grade 8 Steel

.75 x 5.00 Hex Lag Screw, Steel

Table 1 is on the following page.

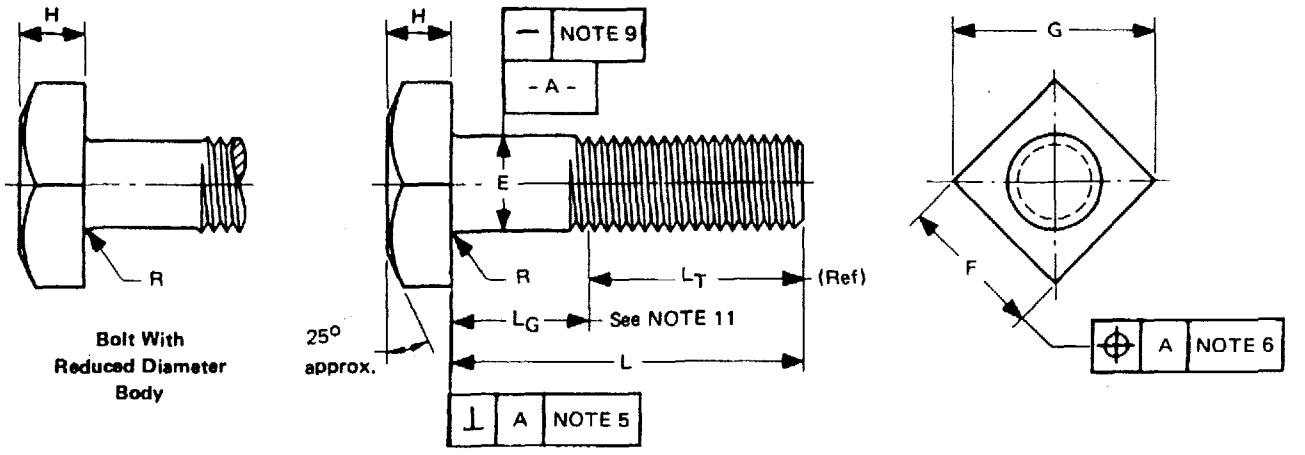


TABLE 1 DIMENSIONS OF SQUARE BOLTS

Nominal Size or Basic Product Dia (17)		E	F			G		H			R		L_T	
		Body Dia (7), (14)	Width Across Flats (4)			Width Across Corners		Height			Radius of Fillet		Thread Length For Bolt Lengths (11)	
													6 in. and shorter	over 6 in.
		Max	Basic	Max	Min	Max	Min	Basic	Max	Min	Max	Min	Basic	Basic
1/4	0.2500	0.260	3/8	0.375	0.362	0.530	0.498	11/64	0.188	0.156	0.03	0.01	0.750	1.000
5/16	0.3125	0.324	1/2	0.500	0.484	0.707	0.665	13/64	0.220	0.186	0.03	0.01	0.875	1.125
3/8	0.3750	0.388	9/16	0.562	0.544	0.795	0.747	1/4	0.268	0.232	0.03	0.01	1.000	1.250
7/16	0.4375	0.452	5/8	0.625	0.603	0.884	0.828	19/64	0.316	0.278	0.03	0.01	1.125	1.375
1/2	0.5000	0.515	3/4	0.750	0.725	1.061	0.995	21/64	0.348	0.308	0.03	0.01	1.250	1.500
5/8	0.6250	0.642	15/16	0.938	0.906	1.326	1.244	27/64	0.444	0.400	0.06	0.02	1.500	1.750
3/4	0.7500	0.768	1 1/8	1.125	1.088	1.591	1.494	1/2	0.524	0.476	0.06	0.02	1.750	2.000
7/8	0.8750	0.895	1 5/16	1.312	1.269	1.856	1.742	19/32	0.620	0.568	0.06	0.02	2.000	2.250
1	1.0000	1.022	1 1/2	1.500	1.450	2.121	1.991	21/32	0.684	0.628	0.09	0.03	2.250	2.500
1 1/8	1.1250	1.149	1 11/16	1.688	1.631	2.386	2.239	3/4	0.780	0.720	0.09	0.03	2.500	2.750
1 1/4	1.2500	1.277	1 7/8	1.875	1.812	2.652	2.489	27/32	0.876	0.812	0.09	0.03	2.750	3.000
1 3/8	1.3750	1.404	2 1/16	2.062	1.994	2.917	2.738	29/32	0.940	0.872	0.09	0.03	3.000	3.250
1 1/2	1.5000	1.531	2 1/4	2.250	2.175	3.182	2.986	1	1.036	0.964	0.09	0.03	3.250	3.500

Notes to Table 1:

Additional requirements in General Data on pp. 1 and 2.

(1) **Unification.** Bold type indicates products unified dimensionally with British and Canadian standards.

(2) **Surface Condition.** Bolts need not be finished on any surface except threads.

(3) **Top of Head.** Top of head shall be full form and 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 minus 15%.

(4) **Head Taper.** Maximum width across flats shall not be exceeded. No transverse section through the head between 25 and 75% of actual head height as measured from the bearing surface shall be less than the minimum width across flats.

(5) **Bearing Surface.** A die seam across the bearing surface is permissible. Bearing surface shall be perpendicular to the axis of the body within a tolerance of 3 deg. for 1 in. size and smaller, and 2 deg. for sizes larger than 1 in. Angularity measurement shall be taken at a location to avoid interference from a die seam.

(6) **True Position of Head.** The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats, regardless of feature size.

(7) **Body Diameter.** There may be a reasonable swell or fin under the head or die seam on the body not to exceed the basic bolt diameter by the following:

0.030 in. for sizes up to ½ in.
0.050 in. for sizes ⅝ and ¾ in.
0.060 in. for sizes over ¾ in. to 1¼ in.
0.090 in. for sizes over 1¼ in. to 1½ in.

(8) **Point.** Bolts need not be pointed.

(9) **Straightness.** Shanks of bolts shall be straight within the following limits: for bolts with nominal lengths to and including 12 in., the maximum camber shall be 0.006 in. per inch of bolt length. Bolts with nominal lengths over 12 in. to and including 24 in., the maximum camber shall be 0.008 in. per inch of length. A suggested gage and gaging procedure for checking bolt straightness is given in Appendix II.

(10) **Length Tolerances.** Bolt length tolerances are given in Table 10. Tolerances for non-pointed products shall apply.

(11) **Thread Length.** The length of thread on bolts shall be controlled by the grip gaging length L_G max as set forth in the following:

Grip gaging length L_G max is the distance measured parallel to the axis of bolt from the underhead bearing surface to the face of a non-counterbored or non-countersunk standard GO thread ring gage assembled by hand as far as the thread will permit. It shall be used as the criterion for inspection. 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 basic thread length (L_G max = L nom - L_T). For bolts which 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. L_G max represents the minimum design grip length of the bolt and shall be used for determining thread availability when selecting bolt lengths even though usable threads may extend beyond this point.

All bolts of nominal lengths equal to or shorter than the basic 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.

Basic 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. Basic thread length equals twice the basic thread diameter plus 0.25 in. for nominal bolt lengths up to and including 6 in., and twice the basic thread diameter plus 0.50 in. for nominal lengths over 6 in.

(12) **Incomplete Thread Diameter.** The major diameter of incomplete thread shall not exceed the actual major diameter of the full form thread.

(13) **Threads.** Threads, when rolled, shall be Unified Inch coarse, fine, or 8 thread series (UNRC, UNRF, or 8 UNR Series), Class 2A. Threads produced by other methods may be Unified Inch coarse, fine, or 8 thread series (UNC, UNF, or 8 UN Series), Class 2A. Acceptability of screw threads shall be determined based on System 21, ANSI B1.3 Screw Thread Gaging Systems for Dimensional Acceptability.

(14) **Reduced Diameter Body.** Bolts may be obtained in "reduced diameter body." Where "reduced

diameter body" is specified, the body diameter may be duced to approximately the pitch diameter of the thread. A shoulder of full body diameter under the head may be supplied at option of the manufacturer.

(15) **Identificaton Symbols.** Identification marking symbols on the tops of heads for bolt sizes 5/8 in. and smaller shall project not less than 0.005 in. above the surface nor more than 0.015 in. over the specified maximum head height. Bolt sizes larger than 5/8 in. shall project not less than the equivalent in inches of 0.0075 times the basic bolt diameter above the surface nor more than 0.030 in. over the specified maximum head height. ASTM and SAE grade markings for steel bolts are given in Appendix III.

(16) **Material.** Unless otherwise specified, chemical and mechanical properties of steel bolts shall conform to ASTM A307, Grade A. (See Appendix III.) Other materials shall be as agreed upon by manufacturer and purchaser.

(17) **Nominal Size.** Where specifying nominal size in decimals, zeros preceding decimal and in the fourth decimal place shall be omitted.

Table 2 is on the following page.

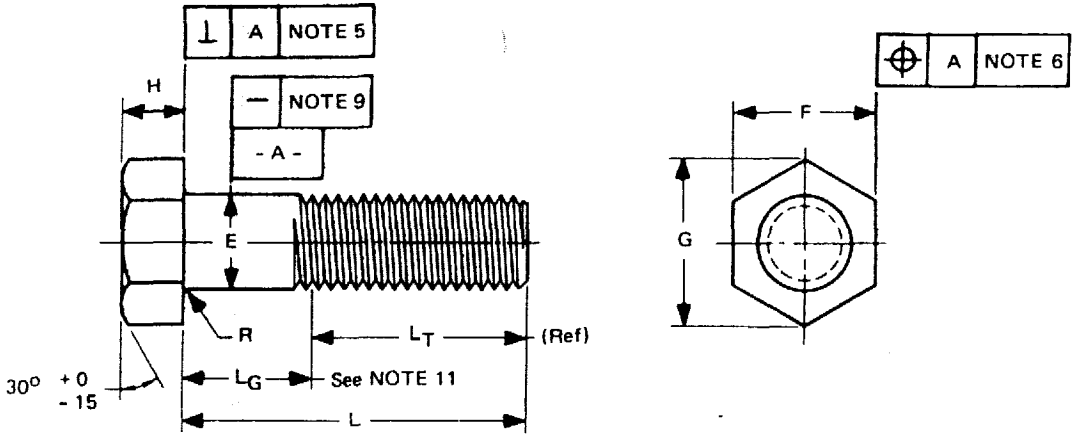


TABLE 2 DIMENSIONS OF HEX BOLTS

Nominal Size or Basic Product Dia (17)		E	F			G		H			R		L_T	
		Body Dia (7)	Width Across Flats (4)			Width Across Corners		Height			Radius of Fillet		Thread Length For Bolt Lengths (11)	
													6 in. and shorter	over 6 in.
		Max	Basic	Max	Min	Max	Min	Basic	Max	Min	Max	Min	Basic	Basic
1/4	0.2500	0.260	7/16	0.438	0.425	0.505	0.484	11/64	0.188	0.150	0.03	0.01	0.750	1.000
5/16	0.3125	0.324	1/2	0.500	0.484	0.577	0.552	7/32	0.235	0.195	0.03	0.01	0.875	1.125
3/8	0.3750	0.388	9/16	0.562	0.544	0.650	0.620	1/4	0.268	0.226	0.03	0.01	1.000	1.250
7/16	0.4375	0.452	5/8	0.625	0.603	0.722	0.687	19/64	0.316	0.272	0.03	0.01	1.125	1.375
1/2	0.5000	0.515	3/4	0.750	0.725	0.866	0.826	11/32	0.364	0.302	0.03	0.01	1.250	1.500
5/8	0.6250	0.642	15/16	0.928	0.906	1.083	1.033	27/64	0.444	0.378	0.06	0.02	1.500	1.750
3/4	0.7500	0.768	1 1/8	1.125	1.088	1.299	1.240	1/2	0.524	0.455	0.06	0.02	1.750	2.000
7/8	0.8750	0.895	1 5/16	1.312	1.269	1.516	1.447	37/64	0.604	0.531	0.06	0.02	2.000	2.250
1	1.0000	1.022	1 1/2	1.500	1.450	1.732	1.653	43/64	0.700	0.591	0.09	0.03	2.250	2.500
1 1/8	1.1250	1.149	1 11/16	1.688	1.631	1.949	1.859	3/4	0.780	0.658	0.09	0.03	2.500	2.750
1 1/4	1.2500	1.277	1 7/8	1.875	1.812	2.165	2.066	27/32	0.876	0.749	0.09	0.03	2.750	3.000
1 3/8	1.3750	1.404	2 1/16	2.062	1.994	2.382	2.273	29/32	0.940	0.810	0.09	0.03	3.000	3.250
1 1/2	1.5000	1.531	2 1/4	2.250	2.175	2.598	2.480	1	1.036	0.902	0.09	0.03	3.250	3.500
1 3/4	1.7500	1.785	2 5/8	2.625	2.538	3.031	2.893	1 5/32	1.196	1.054	0.12	0.04	3.750	4.000
2	2.0000	2.039	3	3.000	2.900	3.464	3.306	1 11/32	1.388	1.175	0.12	0.04	4.250	4.500
2 1/4	2.2500	2.305	3 3/8	3.375	3.262	3.897	3.719	1 1/2	1.548	1.327	0.19	0.06	4.750	5.000
2 1/2	2.5000	2.559	3 3/4	3.750	3.625	4.330	4.133	1 21/32	1.708	1.479	0.19	0.06	5.250	5.500
2 3/4	2.7500	2.827	4 1/8	4.125	3.988	4.763	4.546	1 13/16	1.869	1.632	0.19	0.06	5.750	6.000
3	3.0000	3.081	4 1/2	4.500	4.350	5.196	4.959	2	2.060	1.815	0.19	0.06	6.250	6.500
3 1/4	3.2500	3.335	4 7/8	4.875	4.712	5.629	5.372	2 3/16	2.251	1.936	0.19	0.06	6.750	7.000
3 1/2	3.5000	3.589	5 1/4	5.250	5.075	6.062	5.786	2 5/16	2.380	2.057	0.19	0.06	7.250	7.500
3 3/4	3.7500	3.858	5 5/8	5.625	5.437	6.495	6.198	2 1/2	2.572	2.241	0.19	0.06	7.750	8.000
4	4.0000	4.111	6	6.000	5.800	6.928	6.612	2 11/16	2.764	2.424	0.19	0.06	8.250	8.500

Notes to Table 2:

Additional requirements in General Data on pp. 1 and 2.

(1) **Unification.** Bold type indicates products unified dimensionally with British and Canadian standards.

(2) **Surface Condition.** Bolts need not be finished on any surface except threads.

(3) **Top of Head.** Top of head shall be full form and 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 minus 15%.

(4) **Head Taper.** Maximum width across flats shall not be exceeded. No transverse section through the head between 25 and 75% of actual head height as measured from the bearing surface shall be less than the minimum width across flats.

(5) **Bearing Surface.** A die seam across the bearing surface is permissible. Bearing surface shall be perpendicular to the axis of the body within a tolerance of 3 deg. for 1 in. size and smaller, and 2 deg. for sizes larger than 1 in. Angularity measurement shall be taken at a location to avoid interference from a die seam.

(6) **True Position of Head.** The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats, regardless of feature size.

(7) **Body Diameter.** There may be a reasonable swell or fin under the head or die seam on the body not to exceed the basic bolt diameter by the following:

0.030 in. for sizes up to ½ in.
0.050 in. for sizes ⅝ and ¾ in.
0.060 in. for sizes over ¾ in. to 1¼ in.
0.090 in. for sizes over 1¼ in. to 2 in.
0.120 in. for sizes over 2 in. to 3 in.
0.190 in. for sizes over 3 in.

(8) **Point.** Bolts need not be pointed.

(9) **Straightness.** Shanks of bolts shall be straight within the following limits: for bolts with nominal lengths to and including 12 in., the maximum camber shall be 0.006 in. per inch of bolt length. Bolts with nominal lengths over 12 in. to and including 24 in., the maximum camber shall be 0.008 in. per inch of length. A suggested gage and gaging procedure for checking bolt straightness is given in Appendix II.

(10) **Length Tolerances.** Bolt length tolerances are given in Table 10. Tolerances for non-pointed products shall apply.

(11) **Thread Length.** The length of thread on bolts shall be controlled by the grip gaging length L_G max as set forth in the following:

Grip gaging length L_G max is the distance measured parallel to the axis of bolt from the underhead bearing surface to the face of a non-counterbored or non-countersunk standard GO thread ring gage assembled by hand as far as the thread will permit. It shall be used as the criterion for inspection. 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 basic thread length (L_G max = L nom - L_T). For bolts which 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. L_G max represents the minimum design grip length of the bolt and shall be used for determining thread availability when selecting bolt lengths even though usable threads may extend beyond this point.

All bolts of nominal lengths equal to or shorter than the basic 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.

Basic 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. Basic thread length equals twice the basic thread diameter plus 0.25 in. for nominal bolt lengths up to and including 6 in., and twice the basic thread diameter plus 0.50 in. for nominal lengths over 6 in.

(12) **Incomplete Thread Diameter.** The major diameter of incomplete thread shall not exceed the actual major diameter of the full form thread.

(13) **Threads.** Threads, when rolled, shall be Unified Inch coarse, fine, or 8 thread series (UNRC, UNRF or 8 UNR Series). Class 2A. Threads produced by other methods may be Unified Inch coarse, fine, or 8 thread series (UNC, UNF or 8 UN Series), Class 2A. Acceptability of screw threads shall be determined based on System 21, ANSI B1.3 Screw Thread Gaging Systems for Dimensional Acceptability.

(14) **Reduced Diameter Body.** Bolts may be obtained in "reduced diameter body." Where "reduced diameter body" is specified, the body diameter may be reduced to approximately the pitch diameter of the thread. A shoulder of full body diameter under the head may be supplied at option of the manufacturer.

(15) **Identification Symbols.** Identification marking symbols on the tops of heads for bolt sizes 5/8 in. and smaller shall project not less than 0.005 in. above the surface nor more than 0.015 in. over the specified maximum head height. Bolt sizes larger than 5/8 in. shall project not less than the equivalent in inches of 0.0075 times the basic bolt diameter above the surface nor more than 0.030 in. over the specified maximum head height. ASTM and SAE grade markings for steel bolts are given in Appendix III.

(16) **Material.** Unless otherwise specified, chemical and mechanical properties of steel bolts shall conform to ASTM A307, Grade A (see Appendix III). Other materials shall be as agreed upon by manufacturer and purchaser.

(17) **Nominal Size.** Where specifying nominal size in decimals, zeros preceding the decimal and in the fourth decimal place shall be omitted.

Table 3 is on the following page.

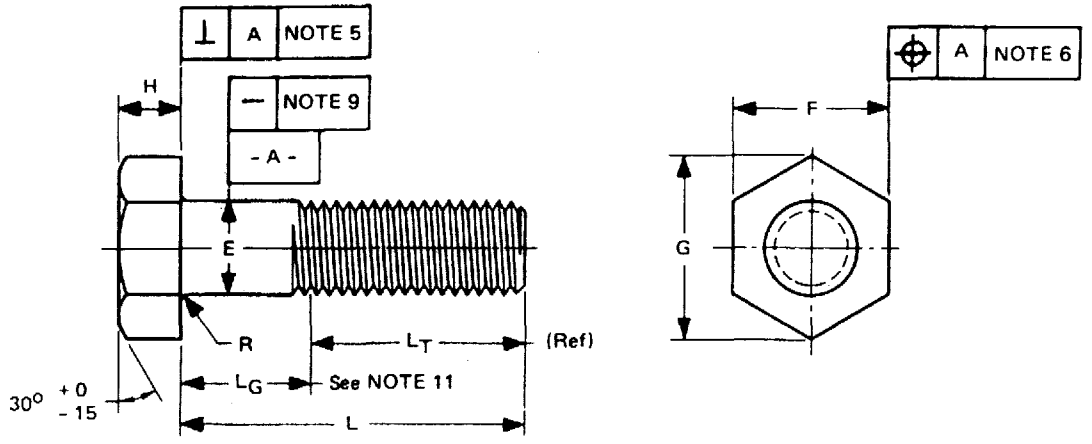


TABLE 3 DIMENSIONS OF HEAVY HEX BOLTS

Nominal Size or Basic Product Dia (17)		E	F			G		H			R		L_T	
		Body Dia (7)	Width Across Flats (4)			Width Across Corners		Height			Radius of Fillet		Thread Length For Bolt Lengths (11)	
													6 in. and shorter	over 6 in.
		Max	Basic	Max	Min	Max	Min	Basic	Max	Min	Max	Min	Basic	Basic
1/2	0.5000	0.515	7/8	0.875	0.850	1.010	0.969	11/32	0.364	0.302	0.03	0.01	1.250	1.500
5/8	0.6250	0.642	1 1/16	1.062	1.031	1.227	1.175	27/64	0.444	0.378	0.06	0.02	1.500	1.750
3/4	0.7500	0.768	1 1/4	1.250	1.212	1.443	1.383	1/2	0.524	0.455	0.06	0.02	1.750	2.000
7/8	0.8750	0.895	1 7/16	1.438	1.394	1.660	1.589	37/64	0.604	0.531	0.06	0.02	2.000	2.250
1	1.0000	1.022	1 5/8	1.625	1.575	1.876	1.796	43/64	0.700	0.591	0.09	0.03	2.250	2.500
1 1/8	1.1250	1.149	1 13/16	1.812	1.756	2.093	2.002	3/4	0.780	0.658	0.09	0.03	2.500	2.750
1 1/4	1.2500	1.277	2	2.000	1.938	2.309	2.209	27/32	0.876	0.749	0.09	0.03	2.750	3.000
1 3/8	1.3750	1.404	2 3/16	2.188	2.119	2.526	2.416	29/32	0.940	0.810	0.09	0.03	3.000	3.250
1 1/2	1.5000	1.531	2 3/8	2.375	2.300	2.742	2.622	1	1.036	0.902	0.09	0.03	3.250	3.500
1 3/4	1.7500	1.785	2 3/4	2.750	2.662	3.175	3.035	1 5/32	1.196	1.054	0.12	0.04	3.750	4.000
2	2.0000	2.039	3 1/8	3.125	3.025	3.608	3.449	1 11/32	1.388	1.175	0.12	0.04	4.250	4.500
2 1/4	2.2500	2.305	3 1/2	3.500	3.388	4.041	3.862	1 1/2	1.548	1.327	0.19	0.06	4.750	5.000
2 1/2	2.5000	2.559	3 7/8	3.875	3.750	4.474	4.275	1 21/32	1.708	1.479	0.19	0.06	5.250	5.500
2 3/4	2.7500	2.827	4 1/4	4.250	4.112	4.907	4.688	1 13/16	1.869	1.632	0.19	0.06	5.750	6.000
3	3.0000	3.081	4 5/8	4.625	4.475	5.340	5.102	2	2.060	1.815	0.19	0.06	6.250	6.500

Notes to Table 3:

Additional requirements in General Data on pp. 1 and 2.

(1) **Unification.** Bold type indicates products unified dimensionally with British and Canadian standards.

(2) **Surface Condition.** Bolts need not be finished on any surface except threads.

(3) **Top of Head.** Top of head shall be full form and 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 minus 15%.

(4) **Head Taper.** Maximum width across flats shall not be exceeded. No transverse section through the head between 25 and 75% of actual head height as measured from the bearing surface shall be less than the minimum width across flats.

(5) **Bearing Surface.** A die seam across the bearing surface is permissible. Bearing surface shall be perpendicular to the body within a tolerance of 3 deg. for 1 in. size and smaller, and 2 deg. for sizes larger than 1 in. Angularity measurement shall be taken at a location to avoid interference from a die seam.

(6) **True Position of Head.** The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats, regardless of feature size.

(7) **Body Diameter.** There may be a reasonable swell or fin under the head or die seam on the body not to exceed the basic bolt diameter by the following:

0.030 in. for sizes up to ½ in.
0.050 in. for sizes ⅝ and ¾ in.
0.060 in. for sizes over ¾ in. to 1¼ in.
0.090 in. for sizes over 1¼ in. to 2 in.
0.120 in. for sizes over 2 in. to 3 in.

(8) **Point.** Bolts need not be pointed.

(9) **Straightness.** Shanks of bolts shall be straight within the following limits: for bolts with nominal lengths to and including 12 in., the maximum camber shall be 0.006 in. per inch of bolt length. Bolts with nominal lengths over 12 in. to and including 24 in., the maximum camber shall be 0.008 in. per inch of length. A suggested gage and gaging procedure for checking bolt straightness is given in Appendix II.

(10) **Length Tolerances.** Bolt length tolerances are given in Table 10. Tolerances for non-pointed products shall apply.

(11) **Thread Length.** The length of thread on bolts shall be controlled by the grip gaging length L_G max as set forth in the following:

Grip gaging length L_G max is the distance measured parallel to the axis of bolt from the underhead bearing surface to the face of a non-counterbored or non-countersunk standard GO thread ring gage assembled by hand as far as the thread will permit. It shall be used as the criterion for inspection. 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 basic thread length (L_G max = L nom - L_T). For bolts which 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. L_G max represents the minimum design grip length of the bolt and shall be used for determining thread availability when selecting bolt lengths even though usable threads may extend beyond this point.

All bolts of nominal lengths equal to or shorter than the basic 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.

Basic 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. Basic thread length equals twice the basic thread diameter plus 0.25 in. for nominal bolt lengths up to and including 6 in., and twice the basic thread diameter plus 0.50 in. for nominal lengths over 6 in.

(12) **Incomplete Thread Diameter.** The major diameter of incomplete thread shall not exceed the actual major diameter of the full form thread.

(13) **Threads.** Threads, when rolled, shall be Unified Inch coarse, fine, or 8 thread series (UNRC, UNRF or 8 UNR Series), Class 2A. Threads produced by other methods may be Unified Inch coarse, fine, or 8 thread series (UNC, UNF or 8 UN Series), Class 2A. Acceptability of screw threads shall be determined based on System 21, ANSI B1.3 Screw Thread Gaging Systems for Dimensional Acceptability.

(14) **Reduced Diameter Body.** Bolts may be obtained in "reduced diameter body." Where "reduced diameter body" is specified, the body diameter may be reduced to approximately the pitch diameter of the thread. A shoulder of full body diameter under the head may be supplied at option of the manufacturer.

(15) **Identification Symbols.** Identification marking symbols on the tops of heads for bolt sizes 5/8 in. and smaller shall project not less than 0.005 in. above the surface nor more than 0.015 in. over the specified maximum head height. Bolt sizes larger than 5/8 in. shall project not less than the equivalent in inches of 0.0075 times the basic bolt diameter above the surface nor more than 0.030 in. over the specified maximum head height. ASTM and SAE grade markings for steel bolts are given in Appendix III.

(16) **Material.** Unless otherwise specified, chemical and mechanical properties of steel bolts shall conform to ASTM A307, Grade A (see Appendix III). Other materials shall be as agreed upon by manufacturer and purchaser.

(17) **Nominal Size.** Where specifying nominal size in decimals, zeros preceding the decimal and in the fourth decimal place shall be omitted.

Table 4 is on the following page.

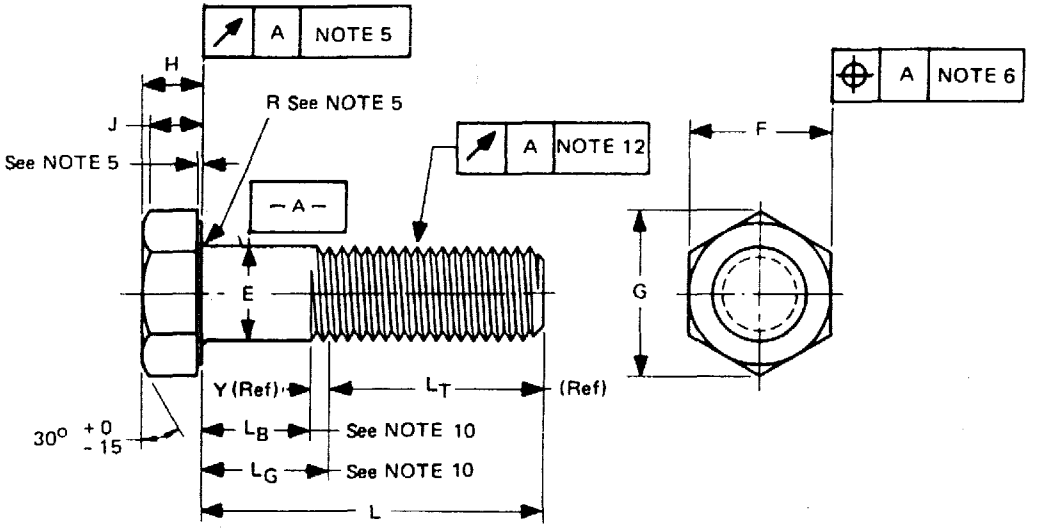


TABLE 4 DIMENSIONS OF HEX CAP SCREWS (FINISHED HEX BOLTS)

Nominal Size or Basic Product Dia (18)		E		F			G		H			J	L_T		Y	Runout of Bearing Surface FIM (5)
		Body Dia (8)		Width Across Flats			Width Across Corners (4)		Height			Wrenching Height (4)	Thread Length For Screw Lengths (10)		Transition Thread Length (10)	
													6 in. and Shorter	Over 6 in.		
		Max	Min	Basic	Max	Min	Max	Min	Basic	Max	Min	Min	Basic	Basic	Max	Max
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	1.000	0.250	0.010
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	1.125	0.278	0.011
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	1.250	0.312	0.012
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	1.375	0.357	0.013
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	1.500	0.385	0.014
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	1.625	0.417	0.015
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	1.750	0.455	0.017
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	2.000	0.500	0.020
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	2.250	0.556	0.023
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	2.500	0.625	0.026
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	2.750	0.714	0.029
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	3.000	0.714	0.033
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	3.250	0.833	0.036
1 1/2	1.5000	1.5000	1.4880	2 1/4	2.230	2.175	2.598	2.480	1 5/16	0.974	0.902	0.640	3.250	3.500	0.833	0.039
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	4.000	1.000	0.046
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	4.500	1.111	0.052
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	4.750	5.000	1.111	0.059
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	5.250	5.500	1.250	0.065
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	5.750	6.000	1.250	0.072
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	6.250	6.500	1.250	0.07°

Notes to Table 4:

Additional requirements in General Data on pp. 1 and 2.

(1) **Consolidation.** This product is a consolidation of two separate products (hex cap screws and finished hex bolts) which were each recognized in the American National Standards prior to 1961. To facilitate identification by consuming and producing interests during a transition period, both former product names are continued. However, in conjunction with this consolidation, a guide to assist nomenclature selection is provided in Appendix VI: analysis therein designates the product as a screw.

(2) **Unification.** Bold type indicates products unified dimensionally with British and Canadian standards. Unification of fine thread products is limited to sizes 1 in. and smaller.

(3) **Top of Head.** Top of head shall be full form and 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 minus 15%.

(4) **Wrenching Height J.** Wrenching height is a distance measured from the bearing surface up the side of the head at the corners. The width across corners shall be within specified limits for the full wrenching height.

(5) **Bearing Surface.** Bearing surface shall be flat and washer faced. Diameter of bearing surface shall be equal to the maximum width across flats within a tolerance of minus 10%.

Thickness of the washer face shall be not less than 0.015 in. nor greater than 0.025 in. for screw sizes 3/4 in. and smaller, and not less than 0.015 in. nor greater than 0.035 in. for sizes larger than 3/4 in.

Runout of the bearing surface with respect to the axis of the body shall be within the FIM limits specified. Measurement of FIM shall be made as close to the periphery of the bearing surface as possible while the screw is held in a collet or other gripping device at a distance of one screw diameter from the underside of the head.

(6) **True Position of Head.** The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone whose diameter is equivalent to 6% of the maximum width across flats, regardless of feature size.

(7) **Fillet.** Two styles of head to shank fillets are provided for screws in lengths to which the minimum body length L_B is applicable.

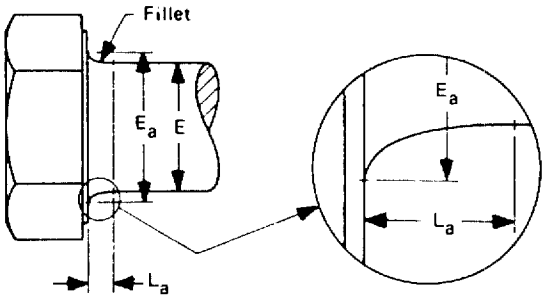
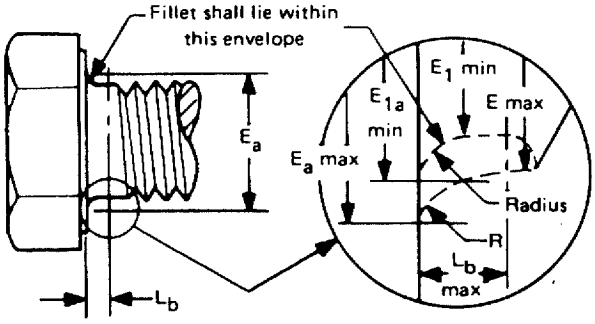


FIG. 1 STYLE 2 ELLIPTICAL SHAPED FILLET



Where:

$$E_{1a}\ \text{MIN} = E_a\ \text{MIN} - \frac{E_a\ \text{MAX} - E_1\ \text{MIN}}{2}$$

$$L_b\ \text{MAX} = \frac{E_a\ \text{MAX} - E_1\ \text{MIN}}{2}$$

E_1 MIN = Minimum specifed pitch diameter of thread

FIG. 2 UNDERHEAD FILLET FOR SCREWS THREADED FULL LENGTH

Style 1 is a radius in accordance with the maximum – minimum limits for R shown in Table 4A. Style 1 will be supplied unless Style 2 is specified by the purchaser.

Style 2 has an elliptical shape defined as a smooth, multi-radius concave curve tangent to the under head bearing surface at a point no greater than one-half of E_a max or less than one-half of E_a min from the axis of the screw, and tangent to the shank at a distance from the underhead bearing surface within the limits specified for L_a. No radius in the fillet shall be less than R min. See Fig. 1 and Table 4A.

For screws threaded full length, to which the minimum body length dimension L_b is not applicable, the

TABLE 4A DIMENSIONS OF UNDERHEAD FILLETS

Nominal Size or Basic Product Dia		E_a Fillet Transition Dia		L_a Fillet Length		R Radius of Fillet	
		Max	Min	Max	Min	Max	Min
1/4	0.2500	0.300	0.280	0.037	0.043	0.025	0.015
5/16	0.3125	0.362	0.342	0.087	0.043	0.025	0.015
3/8	0.3750	0.425	0.405	0.087	0.043	0.025	0.015
7/16	0.4375	0.488	0.468	0.087	0.043	0.025	0.015
1/2	0.5000	0.550	0.530	0.087	0.043	0.025	0.015
9/16	0.5625	0.652	0.602	0.157	0.078	0.045	0.020
5/8	0.6250	0.715	0.665	0.157	0.078	0.045	0.020
3/4	0.7500	0.840	0.790	0.157	0.078	0.045	0.020
7/8	0.8750	1.005	0.955	0.227	0.113	0.065	0.040
1	1.0000	1.190	1.120	0.332	0.166	0.095	0.060
1 1/8	1.1250	1.315	1.245	0.332	0.166	0.095	0.060
1 1/4	1.2500	1.440	1.370	0.332	0.166	0.095	0.060
1 3/8	1.3750	1.565	1.495	0.332	0.166	0.095	0.060
1 1/2	1.5000	1.690	1.620	0.332	0.166	0.095	0.060
1 3/4	1.7500	1.940	1.870	0.332	0.166	0.095	0.060
2	2.0000	2.190	2.120	0.332	0.166	0.095	0.060
2 1/4	2.2500	2.440	2.370	0.332	0.166	0.095	0.060
2 1/2	2.5000	2.690	2.620	0.332	0.166	0.095	0.060
2 3/4	2.7500	2.940	2.870	0.332	0.166	0.095	0.060
3	3.0000	3.190	3.120	0.332	0.166	0.095	0.060

fillet shall be a smooth concave curve lying within the envelope established by: 1) a true radius tangent to the underhead bearing surface at a point no less than one-half E_{1a} min from the axis of screw and to the minimum shank diameter; and 2) a multi-radius curve tangent to the underhead bearing surface at a point no greater than one-half E_a max from the axis of screw and blending into the maximum shank diameter at a distance not exceeding L_b max from the head. No radius in the fillet shall be less than R min. See Fig. 2 and Table 4A.

(8) **Body Diameter.** The diameter of body over the L_b minimum length shall conform to the limits for E given in Table 4. On screws threaded for full length, the diameter of the unthreaded shank shall not exceed the tabulated E max body diameter nor be less than the specified minimum pitch diameter of the thread.

(9) **Point.** Point shall be chamfered or rounded at manufacturer's option from approximately 0.016 in. below the minor diameter of the thread, the length of point to be from 1/2 to 1 1/2 threads.

(10) **Length Tolerances.** Screw length tolerances are given in Table 10. Tolerances for pointed products shall apply.

(11) **Thread Length.** The length of thread on screws shall be controlled by the grip gaging length L_G max and body length L_B min as set forth in the following:

Grip gaging length L_G max is the distance measured parallel to the axis of screw from the underhead bearing surface to the face of a non-counterbored or non-countersunk standard GO thread ring gage assembled by hand as far as the thread will permit. It shall be used as the criterion for inspection. The maximum grip gaging length, as calculated and rounded to two decimal places for any screw not threaded full length, shall be equal to the nominal screw length minus the basic thread length (L_G max = L nom - L_T). For screws which are threaded full length, L_G max defines the unthreaded length under the head and shall conform to the values listed in Table 4B for the respective nominal screw lengths, L_G max represents the minimum design grip length of the screw

TABLE 4B LIMITATIONS FOR PRODUCTS THREADED FULL LENGTH

Nominal Size	Unthreaded Length Under Head						
	For Nominal Product Lengths (1)	L_G Max (2)	For Nominal Product Lengths		L_G Max (3)		
	≤ Than	All Thread Series	> Than	≤ Than	Coarse (UNC) Thd	Fine (UNF) Thd	8 (UN) Thd
1/4	1/2	0.075	1/2	1.125	0.125	0.089	...
5/16	5/8	0.083	5/8	1.375	0.139	0.104	...
3/8	3/4	0.094	3/4	1.500	0.156	0.104	...
7/16	7/8	0.107	7/8	1.750	0.179	0.125	...
1/2	1	0.115	1	1.875	0.192	0.125	...
9/16	1 1/8	0.125	1 1/8	2.000	0.208	0.139	...
5/8	1 1/4	0.136	1 1/4	2.250	0.227	0.139	...
3/4	1 1/2	0.150	1 1/2	2.250	0.250	0.156	...
7/8	...	...	...	2.875	0.278	0.179	...
1	...	...	...	3.250	0.312	0.208	...
1 1/8	...	...	...	3.625	0.357	0.208	0.312
1 1/4	...	...	...	3.875	0.357	0.208	0.312
1 3/8	...	...	...	4.250	0.417	0.208	0.312
1 1/2	...	...	...	4.500	0.417	0.208	0.312
1 3/4	...	...	...	5.250	0.500	...	0.312
2	...	...	...	6.000	0.556	...	0.312
2 1/4	...	...	...	6.500	0.556	...	0.312
2 1/2	...	...	...	7.125	0.625	...	0.312
2 3/4	...	...	...	7.625	0.625	...	0.312
3	...	...	...	8.125	0.625	...	0.312

NOTES:

(1) Tabulated values are equal to 2 times the basic product diameter.

(2) Tabulated values are equal to 1.5 times the coarse thread (UNC) pitch.

(3) Tabulated values are equal to 2.5 times the thread pitch.

and shall be used for determining thread availability when selecting screw lengths even though usable threads may extend beyond this point.

Basic thread length L_T is a reference dimension, intended for calculation purposes only, which represents the distance from the extreme end of the screw to the last complete (full form) thread. Basic thread length equals twice the basic thread diameter plus 0.25 in. for nominal screw lengths up to and including 6 in., and twice the basic thread diameter plus 0.50 in. for nominal lengths over 6 in.

Body length L_B min is the distance measured parallel to the axis of screw from the underhead bearing surface to the last scratch of thread or to the top of the extrusion angle. It shall be used as a criterion for inspection. The minimum body length as calculated and rounded to two decimal places shall be equal to the maximum grip gaging length minus the maximum transition thread length (L_B min = L_G max - Y max). Screws of nominal lengths which have a calculated L_B min length equal to or shorter than the length of 2.5 times the coarse thread (UNC) pitch (see nominal lengths listed in the fifth column of Table 4B) shall be threaded for full length. The distance from underhead bearing surface

to the last scratch of thread shall not be less than L_b max.

Transition thread length Y is a reference dimension equal to five coarse (UNC) pitches intended for calculation purposes only, which includes the length of incomplete threads, the extrusion angle on rolled threads, and tolerances on grip length.

(12) **Incomplete Thread Diameter.** The major diameter of incomplete thread shall not exceed the actual major diameter of the full form thread.

(13) **Thread Runout and Screw Straightness.** The runout of the thread in relation to screw body and the shank straightness shall be such that screw will meet the requirements set forth in Appendix I, Thread Runout and Straightness Sleeve Gages and Gaging.

(14) **Threads.** Threads, when rolled, shall be Unified Inch coarse, fine, or 8 thread series (UNRC, UNRF, or 8 UNR Series), Class 2A. Threads produced by other methods shall preferably be UNRC, UNRF, or 8 UNR, but at manufacturer's option, may be Unified Inch coarse, fine, or 8 thread series (UNC, UNF, or 8 UN Series), Class 2A. Acceptability of screw threads shall be determined based on System 21, ANSI B1.3 Screw Thread Gaging Systems for Dimensional Acceptability.

(15) **Identification Symbols.** Identification marking symbols on the tops of heads for screw sizes 5/8 in. and smaller shall project not less than 0.005 in. above the surface nor more than 0.015 in. over the specified maximum head height. Screw sizes larger than 5/8 in. shall project not less than the equivalent in inches of 0.0075 times the basic screw diameter above the surface nor more than 0.030 in. over the specified maximum head height. ASTM and SAE grade markings for steel screws are given in Appendix III.

(16) **Material.** Chemical and mechanical properties of steel screws normally conform to Grades 2, 5, or 8 of SAE J429, ASTM A449, or ASTM A354 Grade BD (see Appendix III). Where specified, screws may also be made from brass, bronze, corrosion-resisting steel, aluminum alloy, or other materials.

(17) **Nominal Size.** Where specifying nominal size in decimals, zeros preceding the decimal and in the fourth decimal place shall be omitted.

Table 5 is on the following page.

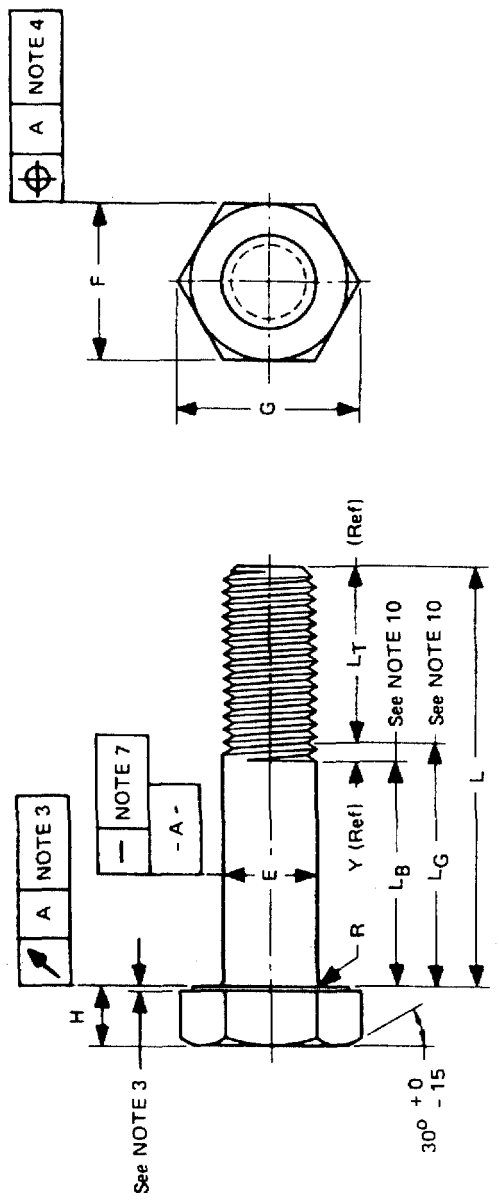


TABLE 5 DIMENSIONS OF HEAVY HEX STRUCTURAL BOLTS

Nominal Size or Basic Product Dia (15)		E		F			G		H			R		L_T	Y	Runout of Bearing Surface FIM (3)
		Body Dia (5)		Width Across Flats (2)			Width Across Corners		Height			Radius of Fillet		Thread Length (10)	Transition Thread Length (10)	
		Max	Min	Basic	Max	Min	Max	Min	Basic	Max	Min	Max	Min	Basic	Max	Max
1/2	0.5000	0.515	0.482	7/8	0.875	0.850	1.010	0.969	5/16	0.323	0.302	0.031	0.009	1.00	0.19	0.016
5/8	0.6250	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	0.22	0.019
3/4	0.7500	0.768	0.729	1 1/4	1.250	1.212	1.443	1.383	15/32	0.483	0.455	0.062	0.021	1.38	0.25	0.022
7/8	0.8750	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	1.50	0.28	0.025
1	1.0000	1.022	0.976	1 5/8	1.625	1.575	1.876	1.796	39/64	0.627	0.591	0.093	0.062	1.75	0.31	0.028
1 1/8	1.1250	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	0.34	0.032
1 1/4	1.2500	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	0.38	0.035
1 3/8	1.3750	1.404	1.345	2 3/16	2.188	2.119	2.526	2.416	27/32	0.878	0.810	0.093	0.062	2.25	0.44	0.038
1 1/2	1.5000	1.531	1.470	2 3/8	2.375	2.300	2.742	2.622	15/16	0.974	0.902	0.093	0.062	2.25	0.44	0.041

Notes to Table 5:

Additional requirements in General Data on pp. 1 and 2.

(1) **Top of Head.** Top of head shall be full form and 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 minus 15%.

(2) **Head Taper.** Maximum width across flats shall not be exceeded. No transverse section through the head between 25 and 75% of actual head height as measured from the bearing surface shall be less than the minimum width across flats.

(3) **Bearing Surface.** Bearing surface shall be flat and washer faced. Diameter of bearing surface shall be equal to the maximum width across flats within a tolerance of minus 10%.

Thickness of the washer face shall be not less than 0.015 in. nor greater than 0.025 in. for bolt 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 plane of the bearing surface shall be perpendicular to the axis of the body within the FIM limits specified. Measurement of FIM shall be made as close to the periphery of the bearing surface as possible while the bolt is being held in a collet or other gripping device at a distance of one bolt diameter from the underside of the head.

(4) **True Position of Head.** The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats, regardless of feature size.

(5) **Body Diameter.** There may be a reasonable swell or fin under the head, or die seam on the body not to exceed the basic bolt diameter by the following:

0.030 in. for sizes ½ in.
0.050 in. for sizes ⅝ and ¾ in.
0.060 in. for sizes over ¾ in. to 1¼ in.
0.090 in. for sizes over 1¼ in.

(6) **Point.** Point shall be chamfered or rounded at manufacturer's option. Length of point to first complete thread shall not exceed 1½ threads.

(7) **Straightness.** Shanks of bolts shall be straight within the following limits: for bolts with nominal lengths to and including 12 in. the maximum camber shall be 0.006 in. per inch of bolt length, and for bolts with nominal lengths over 12 in. to and including 24 in. the maximum camber shall be 0.008 in. per inch of length. A suggested gage and gaging procedure for checking bolt straightness is given in Appendix II.

(8) **Bolt Length.** Bolts are normally supplied in ¼ in. length increments, all lengths.

(9) **Length Tolerance.** Bolt length tolerances shall be as tabulated below:

Nominal Bolt Size	1/2	5/8	3/4 thru 1	1-1/8 thru 1-1/2
Nominal Bolt Length	Tolerance on Length			
Thru 6 in.	−0.12	−0.12	−0.19	−0.25
Over 6 in.	−0.19	−0.25	−0.25	−0.25

(10) **Thread Length.** The length of thread on bolts shall be controlled by the grip gaging length L_G max and body length L_B min as set forth in the following:

Grip gaging length L_G max is the distance measured parallel to the axis of bolt from the underhead bearing surface to the face of a non-counterbored or non-countersunk standard GO thread ring gage assembled by hand as far as the thread will permit. It shall be used as the criterion for inspection. 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 basic thread length (L_G max = L nom − L_T). For bolts which are threaded full length, L_B 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. L_G max represents the minimum design grip length of the bolt and shall be used for determining thread availability when selecting bolt lengths even though usable threads may extend beyond this point.

Basic 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.

Body length L_B min is the distance measured parallel to the axis of bolt from the underhead bearing surface to the last scratch of thread or to the top of the extrusion angle. It shall be used as a criterion for inspection. The minimum body length as calculated and rounded to

two decimal places shall be equal to the maximum grip gaging length minus the maximum transition thread length ($L_B$min = L_G max - Y max). Bolts of nominal lengths which have a calculated L_B min length equal to or shorter than 2.5 times the thread pitch for sizes 1 in. and smaller, and 3.5 times the thread pitch for sizes larger than 1 in. shall be threaded for full length.

Transition thread length Y is a reference dimension, intended for calculation purposes only, which represents the length of incomplete threads and tolerance on grip gaging length.

(11) **Incomplete Thread Diameter.** The major diameter of incomplete thread shall not exceed the actual major diameter of the full form thread.

(12) **Threads.** Threads, when rolled, shall be in the Unified Inch coarse or 8 thread series (UNRC or 8 UNR Series), Class 2A. Threads produced by other methods may be Unified Inch coarse or 8 thread series (UNC or 8 UN Series), Class 2A. Acceptability of screw threads shall be determined based on System 21, ANSI B1.3 Screw Thread Gaging Systems for Dimensional Acceptability.

(13) **Identification Symbols.** Identification marking symbols on the tops of heads for bolt sizes 5/8 in. and smaller shall project not less than 0.005 in. above the surface nor more than 0.015 in. over the specified maximum head height. Bolt sizes larger than 5/8 in. shall project not less than the equivalent in inches of 0.0075 times the basic bolt diameter above the surface nor more than 0.030 in. over the specified maximum head height. ASTM grade markings for steel bolts are given in Appendix III.

(14) **Material.** Chemical and mechanical properties of steel bolts shall conform to ASTM A325 or ASTM A490 (see Appendix III).

(15) **Nominal Size.** Where specifying nominal size in decimals, zeros preceding the decimal and in the fourth decimal place shall be omitted.

Table 6 is on the following page.

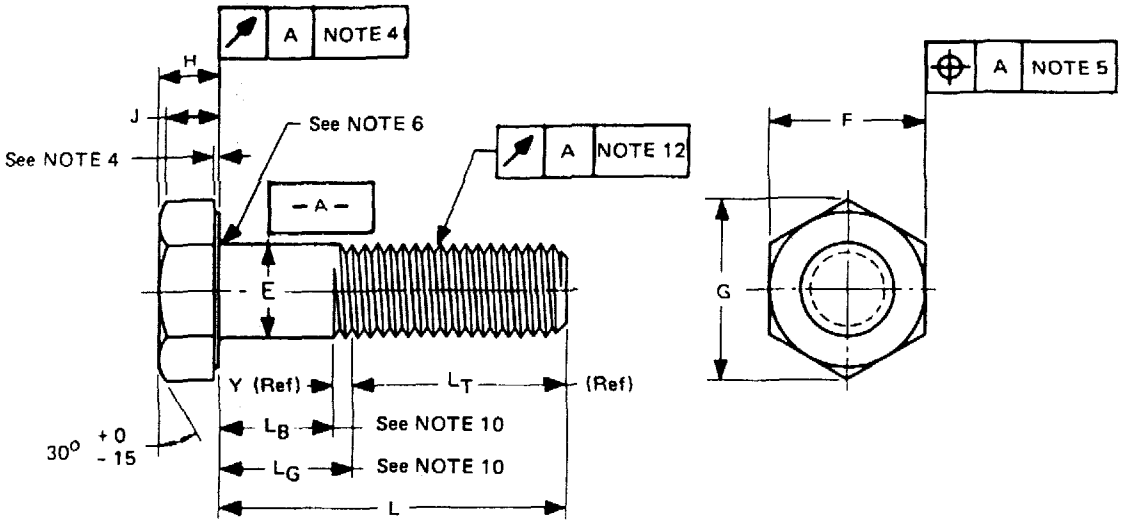


TABLE 6 DIMENSIONS OF HEAVY HEX SCREWS

Nominal Size or Basic Product Dia (17)		E		F			G		H			J	L_T		Y	Runout of Bearing Surface FIM (4)
		Body Dia (7)		Width Across Flats			Width Across Corners (3)		Height			Wrenching Height (3)	Thread Length For Screw Lengths (11)		Transition Thread Length (11)	
													6 in. and Shorter	Over 6 in.		
		Max	Min	Basic	Max	Min	Max	Min	Basic	Max	Min	Min	Basic	Basic	Max	Max
1/2	0.5000	0.5000	0.482	7/8	0.875	0.850	1.010	0.969	5/16	0.323	0.302	0.215	1.250	1.500	0.385	0.016
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	1.750	0.455	0.019
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	2.000	0.500	0.022
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	2.250	0.556	0.025
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	2.500	0.625	0.028
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	2.750	0.714	0.032
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	3.000	0.714	0.035
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	3.250	0.833	0.038
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	3.500	0.833	0.041
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	4.000	1.000	0.048
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	4.500	1.111	0.055
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	4.750	5.000	1.111	0.061
2 1/2	2.5000	2.5000	2.461	3 7/8	3.875	3.750	4.474	4.275	1 17/32	1.583	1.479	1.042	5.250	5.500	1.250	0.068
2 3/4	2.7500	2.7500	2.711	4 1/4	4.250	4.112	4.907	4.688	1 11/16	1.744	1.632	1.151	5.750	6.000	1.250	0.074
3	3.0000	3.0000	2.961	4 5/8	4.625	4.475	5.340	5.102	1 7/8	1.935	1.815	1.290	6.250	6.500	1.250	0.081

Notes to Table 6:

Additional requirements in General Data on pp. 1 and 2.

(1) **Unification.** Bold type indicates product features unified dimensionally with British and Canadian standards. Unification of fine thread products is limited to sizes 1 in. and smaller.

(2) **Top of Head.** Top of head shall be full form and 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 minus 15%.

(3) **Wrenching Height J.** Wrenching height is a distance measured from the bearing surface up the side of the head at the corners. The width across corners shall be within the specified limits for minimum wrenching height.

(4) **Bearing Surface.** Bearing surface shall be flat and washer faced. Diameter of bearing surface shall be equal to the maximum width across flats within a tolerance of minus 10%.

Thickness of the washer face shall be not less than 0.015 in. nor 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.

Runout of the bearing surface with respect to the axis of the body shall be within the FIM limits specified. Measurement of FIM shall be made as close to the periphery of the bearing surface as possible while the screw is being held in a collet or other gripping device at a distance of one screw diameter from the underside of the head.

(5) **True Position of Head.** The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats, regardless of feature size.

(6) **Fillet.** Two styles of head to shank fillets are provided for screws in length to which the minimum body length L_b is applicable.

Style 1 is a radius in accordance with the maximum-minimum limits for R shown in Table 6A. Style 1 will be supplied unless Style 2 is specified by the purchaser.

Style 2 has an elliptical shape defined as a smooth, multiradius, concave curve tangent to the under head bearing surface at a point no greater than one-half of E_a max or less than one half of E_a min from the axis of the screw, and tangent to the shank at a distance from the underhead bearing surface within the limits specified for L_a. No radius in the fillet shall be less than R min. See Fig. 3 and Table 6A.

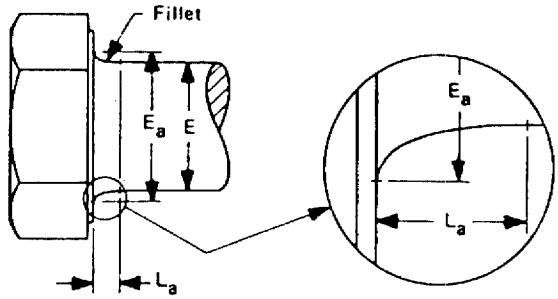
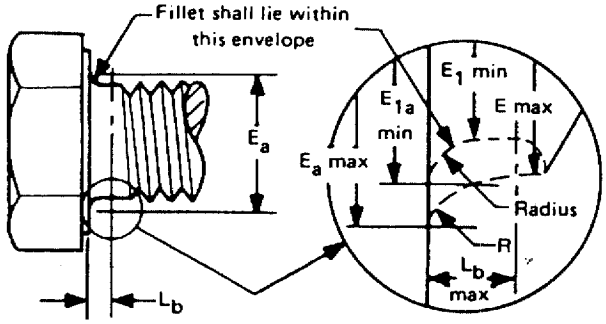


FIG. 3 STYLE 2 ELLIPTICAL SHAPED FILLET



where:

$$E_{1a}\,\text{MIN} = E_a\,\text{MIN} - \frac{E_a\,\text{MAX} - E_1\,\text{MIN}}{2}$$

$$L_b\,\text{MAX} = \frac{E_a\,\text{MAX} - E_1\,\text{MIN}}{2}$$

E_1 MIN = Minimum specified pitch diameter of thread

FIG. 4 UNDERHEAD FILLET FOR SCREWS THREADED FULL LENGTH

For screws threaded full length, to which the minimum body length dimension L_b is not applicable, the fillet shall be a smooth concave curve lying within the envelope established by (1), a true radius tangent to the underhead bearing surface at a point no less than one-half E_{1a} minimum from the axis of screw and to the

TABLE 6A DIMENSIONS OF UNDERHEAD FILLETS

Nominal Size or Basic Product Dia		E_a Fillet Transition Dia		L_a Fillet Length		R Radius of Fillet	
		Max	Min	Max	Min	Max	Min
1/2	0.5000	0.550	0.530	0.087	0.043	0.025	0.015
5/8	0.6250	0.715	0.665	0.157	0.078	0.045	0.020
3/4	0.7500	0.840	0.790	0.157	0.078	0.045	0.020
7/8	0.8750	1.005	0.955	0.227	0.113	0.065	0.040
1	1.0000	1.190	1.120	0.332	0.166	0.095	0.060
1 1/8	1.1250	1.315	1.245	0.332	0.166	0.095	0.060
1 1/4	1.2500	1.440	1.370	0.332	0.166	0.095	0.060
1 3/8	1.3750	1.565	1.493	0.332	0.166	0.095	0.060
1 1/2	1.5000	1.690	1.620	0.332	0.166	0.095	0.060
1 3/4	1.7500	1.940	1.870	0.332	0.166	0.095	0.060
2	2.0000	2.190	2.120	0.332	0.166	0.095	0.060
2 1/4	2.2500	2.440	2.370	0.332	0.166	0.095	0.060
2 1/2	2.5000	2.690	2.620	0.332	0.166	0.095	0.060
2 3/4	2.7500	2.940	2.870	0.332	0.166	0.095	0.060
3	3.0000	3.190	3.120	0.332	0.166	0.095	0.060

minimum shank diameter; and (2) a multi-radius curve tangent to the underhead bearing surface at a point no greater than one half E_a max from the axis of screw and blending into the maximum shank diameter at a distance not exceeding L_b min from the head. No radius in the fillet shall be less than R min. See Fig. 2 and Table 4A.

(7) **Body Diameter.** The diameter of body over the L_B min length shall conform to the limits for E given in Table 4. On screws threaded for full length, the diameter of the unthreaded shank shall not exceed the tabulated E max body diameter nor be less than the specified minimum pitch diameter of the thread.

(8) **Point.** Point shall be chamfered or rounded at manufacturer's option. Length of point of first complete thread shall not exceed 1 1/2 threads.

(9) **Length Tolerances.** Screw length tolerances are given in Table 10. Tolerances for pointed products shall apply.

(10) **Thread Length.** The length of thread on screws shall be controlled by the grip gaging length L_G max and body length L_B min as set forth in the following:

Grip gaging length L_G max is the distance measured parallel to the axis of bolt from the underhead bearing surface to the face of a non-counterbored or non-countersunk standard GO thread ring gage assembled by hand as far as the thread will permit. It shall be used as the criterion for inspection. 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 basic thread length (L_G max = L nom - L_T). For bolts which 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. L_G max represents the minimum design grip length of the bolt and shall be used for determining thread availability when selecting bolt lengths even though usable threads may extend beyond this point.

All bolts of nominal lengths equal to or shorter than the basic 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.

Basic 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

TABLE 6B LIMITATIONS FOR PRODUCTS THREADED FULL LENGTH

Nominal Size	Unthreaded Length Under Head						
	For Nominal Product Lengths (1)	L_G Max (2)	For Nominal Product Lengths		L_G Max (3)		
	≤ Than	All Thread Series	> Than	≤ Than	Coarse (UNC) Thd	Fine (UNF) Thd	8 (UN) Thd
1/2	1	0.115	1	1.875	0.192	0.125	...
9/16	1 1/8	0.125	1 1/8	2.000	0.208	0.139	...
5/8	1 1/4	0.136	1 1/4	2.250	0.227	0.139	...
3/4	1 1/2	0.150	1 1/2	2.250	0.250	0.156	...
7/8	...	...	...	2.875	0.278	0.179	...
1	...	...	...	3.250	0.312	0.208	...
1 1/8	...	...	...	3.625	0.357	0.208	0.312
1 1/4	...	...	...	3.875	0.357	0.208	0.312
1 3/8	...	...	...	4.250	0.417	0.208	0.312
1 1/2	...	...	...	4.500	0.417	0.208	0.312
1 3/4	...	...	...	5.250	0.500	...	0.312
2	...	...	...	6.000	0.556	...	0.312
2 1/4	...	...	...	6.500	0.556	...	0.312
2 1/2	...	...	...	7.125	0.625	...	0.312
2 3/4	...	...	...	7.625	0.625	...	0.312
3	...	...	...	8.125	0.625	...	0.312

NOTES:
(1) Tabulated values are equal to 2 times the basic product diameter.
(2) Tabulated values are equal to 1.5 times the coarse thread (UNC) pitch.
(3) Tabulated values are equal to 2.5 times the thread pitch.

the last complete (full form) thread. Basic thread length equals twice the basic thread diameter plus 0.25 in. for nominal bolt lengths up to and including 6 in., and twice the basic thread diameter plus 0.50 in. for nominal lengths over 6 in.

Transition thread length Y is a reference dimension equal to five coarse (UNC) pitches, intended for calculation purposes only, which includes the length of incomplete threads, the extrusion angle on rolled threads, and the tolerances on grip length.

(11) **Incomplete Thread Diameter.** The major diameter of incomplete thread shall not exceed the actual major diameter of the full form thread.

(12) **Thread Runout and Screw Straightness.** The runout of the thread in relation to screw body and the shank straightness shall be such that screw will meet the requirements set forth in Appendix I, Thread Runout and Straightness Sleeve Gages and Gaging.

(13) **Threads.** Threads, when rolled, shall be Unified Inch coarse, fine, or 8 thread series (UNRC, UNRF, or 8 UNR Series), Class 2A. Threads produced by other methods shall preferably be UNRC, UNRF, or 8 UNR, but at manufacturer's option, may be Unified Inch coarse, fine, or 8 thread series (UNC, UNF, or UN Series), Class 2A. Acceptability of screw threads shall be determined based on System 21, ANSI B1.3 Screw Thread Gaging Systems for Dimensional Acceptability.

(14) **Identification Symbols.** Identification marking symbols on the tops of heads for screw sizes 5/8 in. and smaller shall project not less than 0.005 in. above the surface nor more than 0.015 in. over the specified maximum head height. Screw sizes larger than 5/8 in. shall project not less than the equivalent in inches of 0.0075 times the basic screw diameter above the surface

nor more than 0.030 in. over the specified maximum head height. ASTM and SAE grade markings for steel screws are given in Appendix III.

(15) **Material.** Chemical and mechanical properties of steel screws normally conform to Grades 2, 5, or 8 of SAE J429, ASTM A449 or ASTM A354 Grade BD (see Appendix III). Where specified, screws may also be made from brass, bronze, corrosion-resisting steel, aluminum alloy, or other materials.

(16) **Nominal Size.** Where specifying nominal size in decimals, zeros preceding the decimal and in the fourth decimal place shall be omitted.

Table 7 is on the following page.

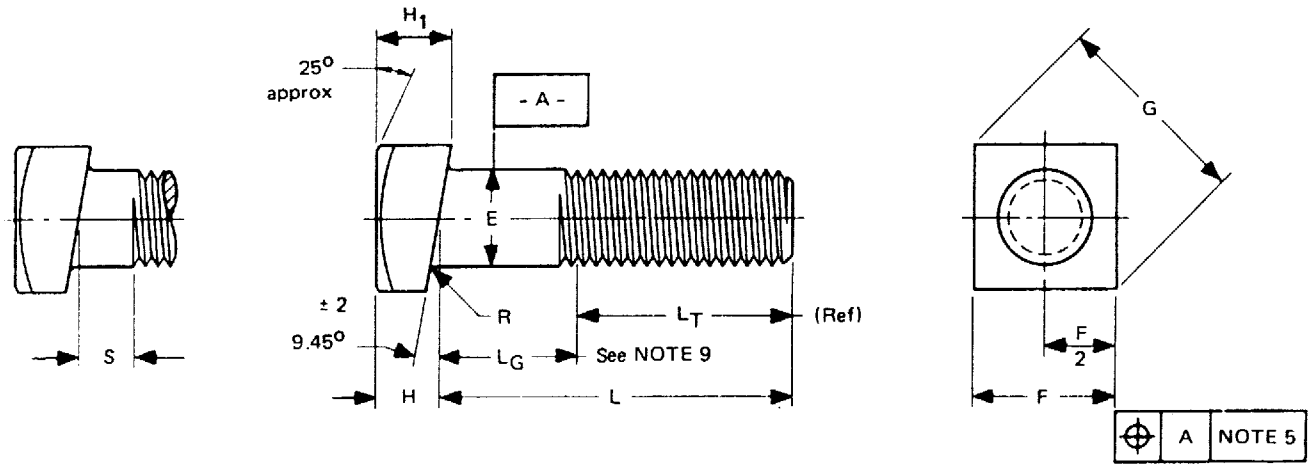


TABLE 7 DIMENSIONS OF ASKEW HEAD BOLTS

Nominal Size or Basic Bolt Diameter (12)		E		F			G		H_1		H	R		S	L_T	
		Body Dia (6)		Width Across Flats			Width Across Corners		Height (3)		Mid Height (3)	Radius of Fillet		Un-threaded Length (9)	Thread Length For Bolt Lengths (9)	
															6 in. and Shorter	Over 6 in.
		Max	Min	Basic	Max	Min	Max	Min	Max	Min	Ref	Max	Min	Max	Basic	Basic
3/8	0.3750	0.388	0.360	9/16	0.562	0.544	0.795	0.747	0.317	0.277	0.250	0.03	0.01	0.250	1.000	1.250
1/2	0.5000	0.515	0.482	3/4	0.750	0.725	1.061	0.995	0.411	0.371	0.328	0.03	0.01	0.312	1.250	1.500
5/8	0.6250	0.642	0.605	15/16	0.938	0.906	1.326	1.244	0.520	0.480	0.422	0.06	0.02	0.344	1.500	1.750
3/4	0.7500	0.768	0.729	1 1/8	1.125	1.088	1.591	1.494	0.614	0.574	0.500	0.06	0.02	0.406	1.750	2.000
7/8	0.8750	0.895	0.852	1 5/16	1.312	1.269	1.856	1.742	0.723	0.683	0.594	0.06	0.02	0.438	2.000	2.250
1	1.0000	1.022	0.976	1 1/2	1.500	1.450	2.121	1.991	0.801	0.761	0.656	0.09	0.03	0.500	2.250	2.500

Notes to Table 7:

Additional requirements in General Data on pp. 1 and 2.

(1) **Surface Condition.** Bolts need not be finished on any surface except threads.

(2) **Top of Head.** Top of head shall be full form and 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 minus 15%.

(3) **Head Height.** Mid height H is a reference dimension and equals the basic head height of square bolts as given in Table 1. Head height H_1 is computed as mid height H plus 0.0833 times the specified maximum width across flats F. Tolerance on head height, H_1 is plus and minus 0.020 in. from computed head height.

(4) **Bearing Surface.** A die seam across the bearing surface is permissible. Angle of bearing surface with respect to shank is based on the 2 in 12 slope of the inner flange of American Standard beams and channels.

(5) **True Position of Head.** The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats, regardless of feature size.

(6) **Body Diameter.** There may be a reasonable swell or fin under the head or die seam on the body not to exceed the basic bolt diameter by the following:

0.030 in. for sizes 3/8 and 1/2 in.
0.050 in. for sizes 5/8 and 3/4 in.
0.060 in. for sizes 7/8 and 1 in.

(7) **Point.** Bolt need not be pointed.

(8) **Length Tolerances.** Bolt length tolerances are given in Table 10. Tolerances for non-pointed products shall apply.

(9) **Thread Length.** The length of thread on bolts shall be controlled by the grip gaging length L_G max as set forth in the following:

Grip gaging length L_G max is the distance measured parallel to the axis of bolt from the underhead bearing surface to the face of a non-counterbored or non-countersunk standard GO thread ring gage assembled by hand as far as the thread will permit. The maximum grip gaging length, as calculated and rounded to two decimal places, for any bolt length shall be equal to the nominal bolt length minus the basic thread length (L_G max = L nom - L_T). It represents the minimum design grip length of the bolt and shall be used as the criterion for inspection and for determining thread availability when selecting bolt lengths even though usable threads may extend beyond this point.

All bolts of nominal lengths equal to or shorter than the basic thread length L_T, plus the unthreaded length S, shall be threaded for full length. The distance from the bearing surface of the head as measured at mid-height of head to the last scratch of thread shall not exceed the unthreaded length S. The distance from the bearing surface of the head as measured at mid-height to the first complete (full form) thread, as measured with a GO thread ring gage assembled by hand as far as the thread will permit, shall not exceed the unthreaded length S plus a length of 2½ threads.

Basic 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. Basic thread length equals twice the basic thread diameter plus 0.25 in. for lengths up to and including 6 in., and twice the basic diameter plus 0.50 in. for lengths over 6 in.

(10) **Threads.** Threads shall be Unified Inch coarse thread series (UNC Series), Class 2A. Acceptability of screw threads shall be determined based on System 21, ANSI B1.3 Screw Thread Gaging Systems for Dimensional Acceptability.

(11) **Material.** Unless otherwise specified, chemical and mechanical properties of steel bolts shall conform to ASTM A307, Grade A (see Appendix III). Other materials shall be as agreed upon by manufacturer and purchaser.

(12) **Nominal Size.** Where specifying nominal size in decimals, zeros preceding decimal and in the fourth decimal place shall be omitted.

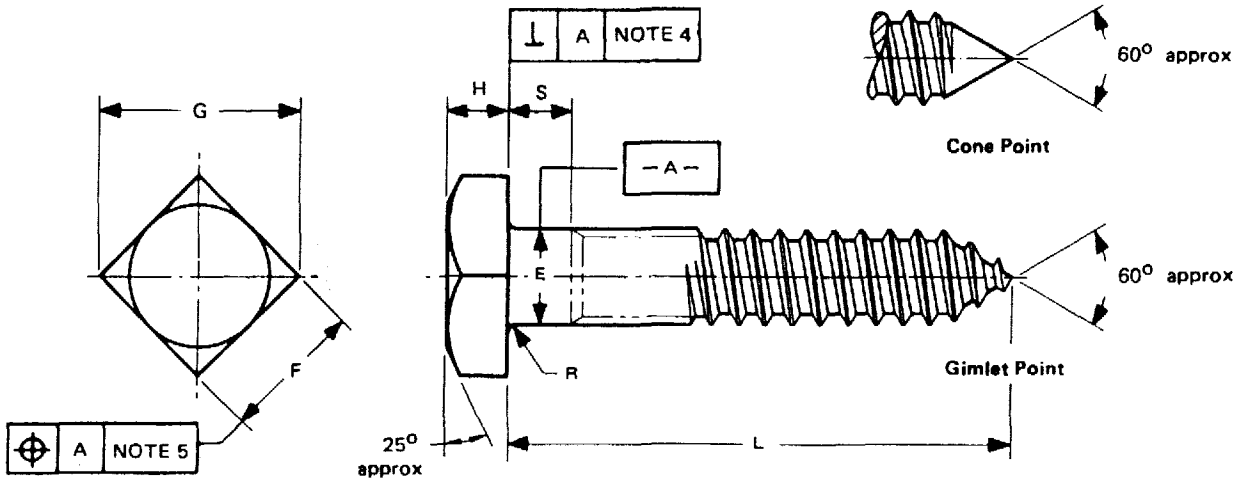


TABLE 8 DIMENSIONS OF SQUARE LAG SCREWS

Nominal Size or Basic Product Dia (12)		E		F			G		H			S	R	
		Body or Shoulder Dia (6), (7)		Width Across Flats (3)			Width Across Corners		Height			Shoulder Length (7)	Radius of Fillet	
		Max	Min	Basic	Max	Min	Max	Min	Basic	Max	Min	Min	Max	Min
No. 10	0.1900	0.199	0.178	9/32	0.281	0.271	0.398	0.372	1/8	0.140	0.110	0.094	0.03	0.01
1/4	0.2500	0.260	0.237	3/8	0.375	0.362	0.530	0.498	11/64	0.188	0.156	0.094	0.03	0.01
5/16	0.3125	0.324	0.298	1/2	0.500	0.484	0.707	0.665	13/64	0.220	0.186	0.125	0.03	0.01
3/8	0.3750	0.388	0.360	9/16	0.562	0.544	0.795	0.747	1/4	0.268	0.232	0.125	0.03	0.01
7/16	0.4375	0.452	0.421	5/8	0.625	0.603	0.884	0.828	19/64	0.316	0.278	0.156	0.03	0.01
1/2	0.5000	0.515	0.482	3/4	0.750	0.725	1.061	0.995	21/64	0.348	0.308	0.156	0.03	0.01
5/8	0.6250	0.642	0.605	1 5/16	0.938	0.906	1.326	1.244	27/64	0.444	0.400	0.312	0.06	0.02
3/4	0.7500	0.768	0.729	1 1/8	1.125	1.088	1.591	1.494	1/2	0.524	0.476	0.375	0.06	0.02
7/8	0.8750	0.895	0.852	1 5/16	1.312	1.269	1.856	1.742	19/32	0.620	0.568	0.375	0.06	0.02
1	1.0000	1.022	0.976	1 1/2	1.500	1.450	2.121	1.991	21/32	0.684	0.628	0.625	0.09	0.03
1 1/8	1.1250	1.149	1.098	1 11/16	1.688	1.631	2.386	2.239	3/4	0.780	0.720	0.625	0.09	0.03
1 1/4	1.2500	1.277	1.223	1 7/8	1.875	1.812	2.652	2.489	27/32	0.876	0.812	0.625	0.09	0.03

Notes to Tables 8 and 9 on p. 36

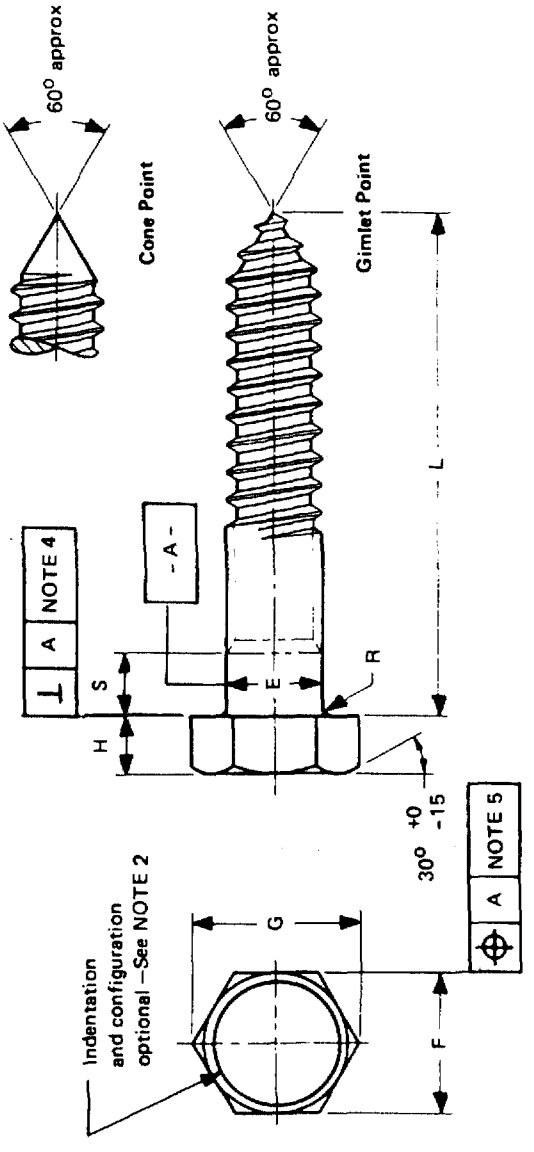


TABLE 9 DIMENSIONS OF HEX LAG SCREWS

Nominal Size or Basic Product Dia (12)		E		F		G		H		S	R	
		Body or Shoulder Dia (6), (7)		Width Across Flats (3)		Width Across Corners		Height		Shoulder Length (7)	Radius of Fillet	
		Max	Min	Basic	Max	Min	Max	Min	Basic	Max	Min	Max	Min
No. 10	0.1900	0.199	0.178	9/32	0.281	0.271	0.323	0.309	1/8	0.140	0.110	0.094	0.03	0.01
1/4	0.2500	0.260	0.237	7/16	0.438	0.425	0.505	0.484	11/64	0.188	0.150	0.094	0.03	0.01
5/16	0.3125	0.324	0.298	1/2	0.500	0.484	0.577	0.552	7/32	0.235	0.195	0.125	0.03	0.01
3/8	0.3750	0.388	0.360	9/16	0.562	0.544	0.650	0.620	1/4	0.268	0.226	0.125	0.03	0.01
7/16	0.4375	0.452	0.421	5/8	0.625	0.603	0.722	0.687	19/64	0.316	0.272	0.156	0.03	0.01
1/2	0.5000	0.515	0.482	3/4	0.750	0.725	0.866	0.826	11/32	0.364	0.302	0.156	0.03	0.01
5/8	0.6250	0.642	0.605	1 5/16	0.938	0.906	1.083	1.033	27/64	0.444	0.378	0.312	0.06	0.02
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	0.375	0.06	0.02
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	0.375	0.06	0.02
1	1.0000	1.022	0.976	1 1/2	1.500	1.450	1.732	1.653	43/64	0.700	0.591	0.625	0.09	0.03
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	0.625	0.09	0.03
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	0.625	0.09	0.03

Notes to Tables 8 and 9 on p. 36

Notes to Tables 8 and 9:
Additional requirements in General Data on pp. 1 and 2.

(1) **Surface Condition.** Screws need not be finished on any surface except threads.

(2) **Top of Head.** Top of square head shall be full form but top of hex head may be either full form or indented at the manufacturer's option. The top of head shall be chamfered or rounded. The diameter of the chamfer circle or start of rounding shall be equal to the maximum width across flats within a tolerance of minus 15%.

(3) **Head Taper.** Maximum width across flats shall not be exceeded. No transverse section through the head between 25 and 75% of actual head height as measured from the bearing surface shall be less than minimum width across flats.

(4) **Bearing Surface.** A die seam across the bearing surface is permissible. Bearing surface shall be perpendicular to the axis of the body within a tolerance of 3 deg. for 1 in. size and smaller, and 2 deg. for sizes larger than 1 in. Angularity measurement shall be taken at a location to avoid interference from a die seam.

(5) **True Position of Head.** The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats, regardless of feature size.

(6) **Body Diameter.** There may be a reasonable fillet or fin under the head, or die seam on the body not to exceed the basic screw diameter by the following.

0.030 in. for sizes up to ½ in.
0.050 in. for sizes ⅝ and ¾ in.
0.060 in. for sizes over ¾ in. to 1¼ in.

(7) **Reduced Diameter Body.** Screws may be obtained in "reduced diameter body." Where "reduced diameter body" is specified, the body diameter may be reduced to the blank diameter before threading and a shoulder of full body diameter under the head shall be provided.

(8) **Length Tolerance.** Screw length tolerances shall be as tabulated below:

Nominal Screw Size	½ and Smaller	Over ½
Nominal Screw Length	Tolerance on Length	
Thru 6 in.	±0.12	±0.25
Over 6 in.	±0.25	±0.25

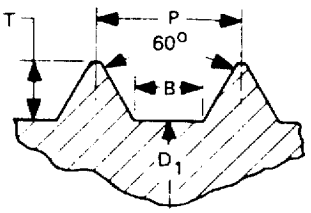


FIG. 5 DETAIL OF THREADS

TABLE 9A DIMENSIONS OF LAG SCREW THREADS

Nominal Size or Basic Product Dia		Threads per Inch	P	B	T	D_1
			Pitch	Flat at Root	Depth of Thread	Root Dia
No. 10	0.1900	11	0.091	0.039	0.035	0.120
1/4	0.2500	10	0.100	0.043	0.039	0.173
5/16	0.3125	9	0.111	0.048	0.043	0.227
3/8	0.3750	7	0.143	0.062	0.055	0.265
7/16	0.4375	7	0.143	0.062	0.055	0.328
1/2	0.5000	6	0.167	0.072	0.064	0.371
5/8	0.6250	5	0.200	0.086	0.077	0.471
3/4	0.7500	4 1/2	0.222	0.096	0.085	0.579
7/8	0.8750	4	0.250	0.108	0.096	0.683
1	1.0000	3 1/2	0.286	0.123	0.110	0.780
1 1/8	1.1250	3 1/4	0.308	0.133	0.119	0.887
1 1/4	1.2500	3 1/4	0.308	0.133	0.119	1.012

GENERAL NOTE:
Thread formulas are as follows:

$$\text{Pitch} = \frac{1}{\text{No. of threads per inch}}$$

Flat at root = pitch x 0.4305
Depth of single thread = pitch x 0.385

(9) **Thread Length.** The minimum thread length shall be equal to one-half of the nominal screw length plus 0.50 in., or 6.00 in., whichever is shorter. Screws too short for the formula thread length shall be threaded as close to the head or shoulder as practicable.

(10) **Threads.** Threads on lag screws shall conform with Fig. 5 and Table 9A.

(11) **Material.** Chemical and mechanical requirements shall be as agreed upon by manufacturer and purchaser.

(12) **Nominal Size.** Where specifying nominal size in decimals, zeros preceding the decimal and in the fourth decimal place shall be omitted.

TABLE 10 LENGTH TOLERANCES FOR SQUARE AND HEX BOLTS AND SCREWS [NOTE (3)]

NON-POINTED PRODUCTS (1)

Nominal Length	Nominal Size					
	1/4 to 3/8	7/16 and 1/2	9/16 to 3/4	7/8 and 1	1 1/8 to 1 1/2	Over 1 1/2
Up to 1 in., incl.	+0.02 −0.03	+0.02 −0.03	+0.02 −0.03	....	....	....
Over 1 in. to 2 1/2 in., incl.	+0.02 −0.04	+0.04 −0.06	+0.06 −0.08	+0.08 −0.10	+0.12 −0.12	+0.18 −0.18
Over 2 1/2 in. to 4 in., incl.	+0.04 −0.06	+0.06 −0.08	+0.08 −0.10	+0.10 −0.14	+0.16 −0.16	+0.20 −0.20
Over 4 in. to 6 in., incl.	+0.06 −0.10	+0.08 −0.10	+0.10 −0.10	+0.12 −0.16	+0.18 −0.18	+0.22 −0.22
Longer than 6 in.	+0.10 −0.18	+0.12 −0.18	+0.14 −0.18	+0.16 −0.20	+0.22 −0.22	+0.24 −0.24

POINTED PRODUCTS (2)

Nominal Length	Nominal Size					
	1/4 to 3/8	7/16 and 1/2	9/16 to 3/4	7/8 and 1	1 1/8 to 1 1/2	Over 1 1/2
Up to 1 in., incl.	−0.03	−0.03	−0.03	....	....	....
Over 1 in. to 2 1/2 in., incl.	−0.04	−0.06	−0.08	−0.10	−0.12	−0.18
Over 2 1/2 in. to 4 in., incl.	−0.06	−0.08	−0.10	−0.14	−0.16	−0.20
Over 4 in. to 6 in., incl.	−0.10	−0.10	−0.10	−0.16	−0.18	−0.22
Longer than 6 in.	−0.18	−0.18	−0.18	−0.20	−0.22	−0.24

NOTES:

(1) Non-pointed products are square, hex, heavy hex, and askew head bolts.

(2) Pointed products are hex cap screws (finished hex bolts) and heavy hex screws.

(3) Length tolerances for heavy hex structural bolts and lag screws are given in the respective product standards.

APPENDIX I

THREAD RUNOUT AND STRAIGHTNESS SLEEVE GAGES AND GAGING

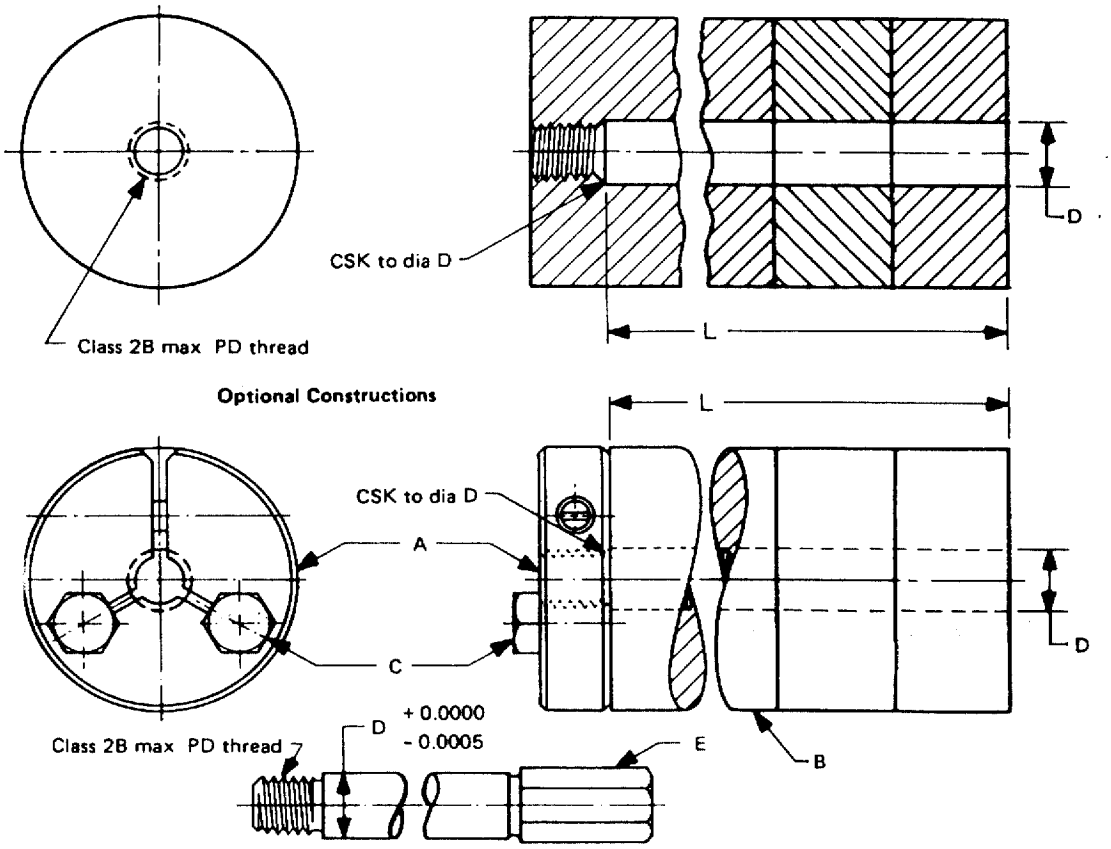
Gages capable of simultaneously checking thread runout and screw straightness are illustrated below for all screws with lengths 10 in. and shorter.

Both constructions can accommodate different lengths of screws through the combination of various lengths of sleeves to build up the required length L. When two or more sections are combined, care must be exercised to assure accurate alignment of the internal hole.

In the lower construction, thread ring gage A is centered on the sleeve B by means of positioning plug E and is secured in position by attachment screws C. The ring gage is set to class 2B maximum pitch diameter by use of the positioning plug E. The maximum length of the sleeve gage B for any diameter and length of screw will be 9 in. The hole diameter of the sleeve will be the nominal screw diameter plus 0.031 in. when inspecting screws of sizes 3/4 in. and smaller with lengths 6 in. and shorter; and plus 0.062 in. when inspecting screws of larger sizes and/or longer lengths.

To insure adequate service life, gages and sleeve sections should be suitably hardened.

Failure of the product to enter the threads of the gage freely by hand for a minimum of two complete threads indicates excessive thread runout and/or out-of-straightness.



D = Equals maximum bolt or screw diameter plus diametral clearance allowance.

L = Depth of counterbore or length of sleeve shall encompass the screw body to within 0.50 in. for screw lengths to and including 6 in. and to within 1.00 in. for lengths over 6 in.

APPENDIX II

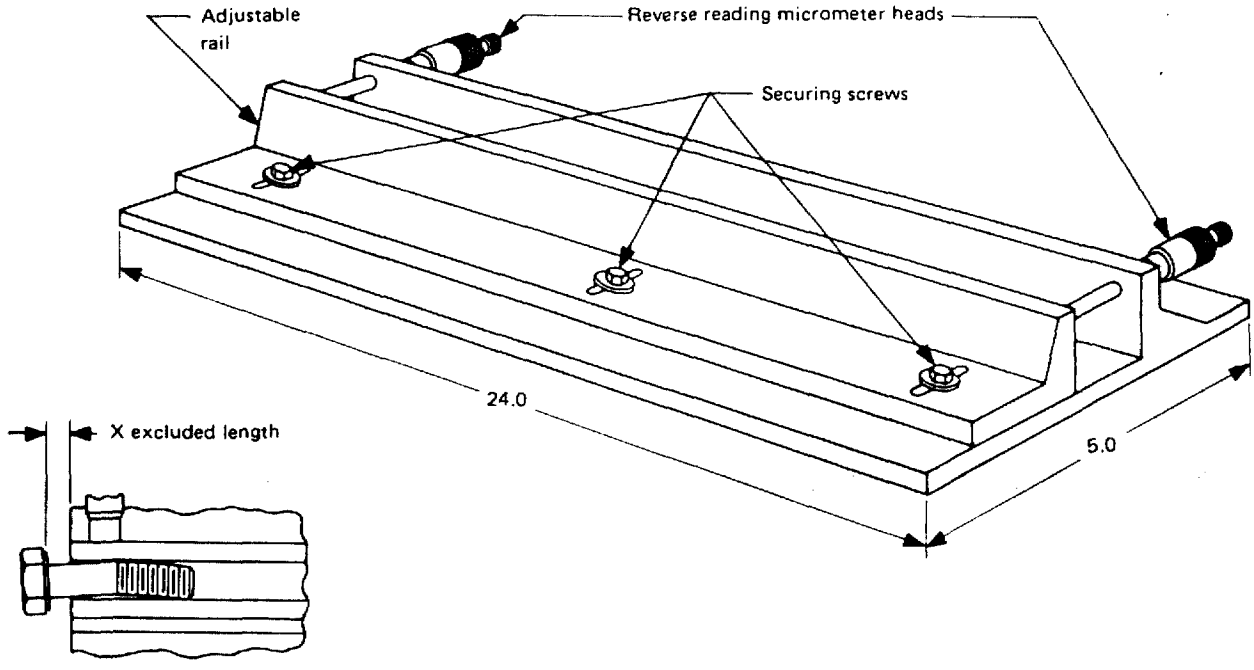
STRAIGHTNESS GAGE AND GAGING

The conformance of bolts to shank straightness or camber limitations set forth in the respective product standards may be checked by the use of the typical gage illustrated below in accordance with the following procedures:

All screws with lengths 10 in. and shorter shall be gaged in accordance with Appendix I requirements. All screws with lengths longer than 10 in. shall be gaged in accordance with Appendix I requirements using the 9 in. length of sleeve, and additionally shall be gaged in accordance with the gaging described in this Appendix and to the straightness requirements now specified for bolts.

Allowable total camber on the product to be inspected shall be calculated by multiplying the specified permissible camber per inch of length by the product length expressed as a two place decimal. The total camber thus derived shall be added to the specified maximum body diameter exclusive of allowance for swell or fin under head, and the adjustable rail of gage shall be adjusted to provide a parallel space between the rails equal to this distance by obtaining common readings on both micrometer heads. The adjustable rail shall then be locked in place by tightening securing screws.

The product shall then be inserted between rails, excluding from the gage any permissible length of swell or fillet under the head. The product shall be rotated by hand through full 360 deg. Any interference occurring between the product and the gage which is sufficient to prevent rotation shall indicate excessive camber.



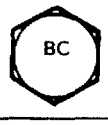
TYPICAL STRAIGHTNESS GAGE

Excluded lengths applicable to the various products shall be as designated below:

X = Two times the basic bolt diameter to allow for permissible swell under the head for Square Bolts (Table 1), Hex Bolts (Table 2), Heavy Hex Bolts (Table 3), and Heavy Hex Structural Bolts (Table 5).

APPENDIX III

ASTM AND SAE GRADE MARKINGS FOR STEEL BOLTS AND SCREWS

Grade Marking	Specification	Material
 NO MARK	SAE–Grade 1	Low or Medium Carbon Steel
	ASTM–A307	Low Carbon Steel
	SAE–Grade 2	Low or Medium Carbon Steel
	SAE–Grade 5	Medium Carbon Steel, Quenched and Tempered
	ASTM–A 449	
	SAE–Grade 5.2	Low Carbon Martensite Steel, Quenched and Tempered
	ASTM–A 325 Type 1	Medium Carbon Steel, Quenched and Tempered Radial dashes optional
	ASTM–A 325 Type 2	Low Carbon Martensite Steel, Quenched and Tempered
	ASTM–A 325 Type 3	Atmospheric Corrosion (Weathering) Steel, Quenched and Tempered
	ASTM–A 354 Grade BC	Alloy Steel, Quenched and Tempered
	SAE–Grade 7	Medium Carbon Alloy Steel, Quenched and Tempered, Roll Threaded After Heat Treatment
	SAE–Grade 8	Medium Carbon Alloy Steel, Quenched and Tempered
	ASTM–A 354 Grade BD	Alloy Steel, Quenched and Tempered
	SAE–Grade 8.2	Low Carbon Martensite Steel, Quenched and Tempered
	ASTM–A 490 Type 1	Alloy Steel, Quenched and Tempered
	ASTM–A 490 Type 3	Atmospheric Corrosion (Weathering) Steel, Quenched and Tempered

APPENDIX IV

FORMULAS FOR BOLT AND SCREW HEAD DIMENSIONS

Product	Size	Width Across Flats		Head Height		Width Across Corners
		Basic (1)	Tolerance (Minus)	Basic (2)	Tolerance (Plus or Minus)	Limits
Square Bolt and Square Lag Screw	No. 10	F = 1.500 D - 0.004	0.050 D	H = 0.667 D	0.016 D + 0.012	Max G = 1.4142 (Max F) Min G = 1.373 (Min F)
	1/4 thru 1 1/2	F = 1.500 D	0.050 D	H = 0.667 D	0.016 D + 0.012	
Hex Bolt and Hex Lag Screw	1/4	F = 1.500 D + 0.062	0.050 D	H = 0.625 D + 0.016	0.016 D + 0.012 (3)	Max G = 1.1547 (Max F) Min G = 1.14 (Min F)
	5/16 thru 7/16	F = 1.500 D	0.050 D	H = 0.625 D + 0.016	0.016 D + 0.012 (3)	
	1/2 thru 7/8	F = 1.500 D	0.050 D	H = 0.625 D + 0.031	0.016 D + 0.012 (3)	
	1 thru 1 7/8	F = 1.500 D	0.050 D	H = 0.625 D + 0.062	0.016 D + 0.012 (3)	
	2 thru 3 3/4	F = 1.500 D	0.050 D	H = 0.625 D + 0.125	0.016 D + 0.012 (3)	
	4	F = 1.500 D	0.050 D	H = 0.625 D + 0.188	0.016 D + 0.012 (3)	
Hex Cap Screw (Finished Hex Bolt)	1/4	F = 1.500 D + 0.062	0.015 D + 0.006	H = 0.625 D	0.015 D + 0.003	Max G = 1.1547 (Max F) Min G = 1.14 (Min F)
	5/16 thru 5/8	F = 1.500 D	0.015 D + 0.006	H = 0.625 D	0.015 D + 0.003	
	3/4 thru 7/8	F = 1.500 D	0.025 D + 0.006	H = 0.625 D	0.015 D + 0.003	
	1	F = 1.500 D	0.025 D + 0.006	H = 0.625 D - 0.016	0.015 D + 0.003	
	1 1/8 thru 1 7/8	F = 1.500 D	0.050 D	H = 0.625 D - 0.016	0.016 D + 0.012	
	2 thru 2 3/4	F = 1.500 D	0.050 D	H = 0.625 D - 0.031	0.016 D + 0.012	
	3	F = 1.500 D	0.050 D	H = 0.625 D	0.016 D + 0.012	
·avy Hex Bolt	1/2 thru 3	F = 1.500 D + 0.125	0.050 D	Same as for Hex Bolt (4)	Same as for Hex Bolt (4)	Max G = 1.1547 (Max F) Min G = 1.14 (Min F)
·eavy Hex Screw and Heavy Hex Structural Bolt	1/2 thru 3	F = 1.500 D + 0.125	0.050 D	Same as for Hex Cap Screw (5)	Same as for Hex Cap Screw (5)	Max G = 1.1547 (Max F) Min G = 1.14 (Min F)

NOTES:

(1) Adjusted to sixteenths.

(2) Size to 1 in. adjusted to sixty-fourths. 1 1/8 thru 2 1/2 in. sizes adjusted upward to thirty-seconds. 2 3/4 thru 4 in. sizes adjusted upward to sixteenths.

(3) Plus tolerance only. Minus tolerance adjusted so that minimum head height is equal to minimum head height of corresponding Hex Cap Screw (Finished Hex Bolt). For sizes 3 1/4 thru 4 in., minimum head height is equal to 0.625 D - (0.016 D + 0.012).

(4) In 1960, head heights for heavy hex bolts were reduced. Prior to 1960, head heights were 0.750 D + 0.062 in. Plus tolerance was 0.016 D + 0.012 in. Minus tolerance was adjusted so that minimum head height was same as minimum head height of heavy hex screw.

(5) In 1960, head heights for heavy hex screws were reduced. Prior to 1960, head heights were 0.750 D + 0.031 in. for sizes 1/2 thru 7/8 in.; 0.750 D for sizes 1 thru 1 7/8 in.; and 0.750 D - 0.062 in. for sizes 2 thru 3 in. Tolerance on head height for all sizes was plus and minus 0.016 D + 0.012 in.

Where: D = Basic (Nominal) bolt or screw diameter.
F = Width across flats.
G = Width across corners.

APPENDIX V

WRENCH OPENINGS FOR SQUARE AND HEX BOLTS AND SCREWS

Nominal Size of Wrench (1) also Basic (Maximum) Width Across Flats of Bolt and Screw Heads		Allowance between Bolt or Screw Head and Jaws of Wrench (2)	Wrench Openings			Square Bolts / Hex Bolt / Hex Cap Screw (Finished Hex Bolt) / Lag Screw	Heavy Hex Bolt / Heavy Hex Screw / Heavy Hex Structural Bolt
			Min	Tol (2)	Max	Nominal Product Sizes	
1/8	0.1250	0.002	0.127	0.005	0.132	...	...
5/32	0.1562	0.002	0.158	0.005	0.163	...	...
3/16	0.1875	0.002	0.190	0.005	0.195	...	...
7/32	0.2188	0.002	0.220	0.005	0.225	...	...
1/4	0.2500	0.002	0.252	0.005	0.257	...	...
9/32	0.2812	0.002	0.283	0.005	0.288	No. 10	...
5/16	0.3125	0.003	0.316	0.006	0.322	...	...
11/32	0.3438	0.003	0.347	0.006	0.353	...	...
3/8	0.3750	0.003	0.378	0.006	0.384	1/4 (3)	...
7/16	0.4375	0.003	0.440	0.006	0.446	1/4	...
1/2	0.5000	0.004	0.504	0.006	0.510	5/16	...
9/16	0.5625	0.004	0.566	0.007	0.573	3/8	...
5/8	0.6250	0.004	0.629	0.007	0.636	7/16	...
11/16	0.6875	0.004	0.692	0.007	0.699	...	...
3/4	0.7500	0.005	0.755	0.008	0.763	1/2	...
13/16	0.8125	0.005	0.818	0.008	0.826	9/16	...
7/8	0.8750	0.005	0.880	0.008	0.888	...	1/2
15/16	0.9375	0.006	0.944	0.009	0.953	5/8	...
1	1.0000	0.006	1.006	0.009	1.015	...	...
1 1/16	1.0625	0.006	1.068	0.009	1.077	...	5/8
1 1/8	1.1250	0.007	1.132	0.010	1.142	3/4	...
1 1/4	1.2500	0.007	1.257	0.010	1.267	...	3/4
1 5/16	1.3125	0.008	1.320	0.011	1.331	7/8	...
1 3/8	1.3750	0.008	1.383	0.011	1.394	...	...
1 7/16	1.4375	0.008	1.446	0.011	1.457	...	7/8
1 1/2	1.5000	0.008	1.508	0.012	1.520	1	...
1 5/8	1.6250	0.009	1.634	0.012	1.646	...	1
1 11/16	1.6875	0.009	1.696	0.012	1.708	1 1/8	...
1 13/16	1.8125	0.010	1.822	0.013	1.835	...	1 1/8
1 7/8	1.8750	0.010	1.885	0.013	1.898	1 1/4	...
2	2.0000	0.011	2.011	0.014	2.025	...	1 1/4
2 1/16	2.0625	0.011	2.074	0.014	2.088	1 3/8	...
2 3/16	2.1875	0.012	2.200	0.015	2.215	...	1 3/8
2 1/4	2.2500	0.012	2.262	0.015	2.277	1 1/2	...
2 3/8	2.3750	0.013	2.388	0.016	2.404	...	1 1/2
2 7/16	2.4375	0.013	2.450	0.016	2.466	1 5/8	...

APPENDIX V (CONT'D)

WRENCH OPENINGS FOR SQUARE AND HEX BOLTS AND SCREWS

Nominal Size of Wrench (1) also Basic (Maximum) Width Across Flats of Bolt and Screw Heads		Allowance between Bolt or Screw Head and Jaws of Wrench (2)	Wrench Openings			Square Bolts / Hex Bolt / Hex Cap Screw (Finished Hex Bolt) / Lag Screw	Heavy Hex Bolt / Heavy Hex Screw / Heavy Hex Structural Bolt
			Min	Tol (2)	Max	Nominal Product Sizes	
2 9/16	2.5625	0.014	2.576	0.017	2.593	...	1 5/8
2 5/8	2.6250	0.014	2.639	0.017	2.656	1 3/4	...
2 3/4	2.7500	0.014	2.766	0.017	2.783	...	1 3/4
2 13/16	2.8125	0.015	2.827	0.018	2.845	1 7/8	...
2 15/16	2.9375	0.016	2.954	0.019	2.973	...	1 7/8
3	3.0000	0.016	3.016	0.019	3.035	2	...
3 1/8	3.1250	0.017	3.142	0.020	3.162	...	2
3 3/8	3.3750	0.018	3.393	0.021	3.414	2 1/4	...
3 1/2	3.5000	0.019	3.518	0.022	3.540	...	2 1/4
3 3/4	3.7500	0.020	3.770	0.023	3.793	2 1/2	...
3 7/8	3.8750	0.020	3.895	0.023	3.918	...	2 1/2
4 1/8	4.1250	0.022	4.147	0.025	4.172	2 3/4	...
4 1/4	4.2500	0.022	4.272	0.025	4.297	...	2 3/4
4 1/2	4.5000	0.024	4.524	0.026	4.550	3	...
4 5/8	4.6250	0.024	4.649	0.027	4.676	...	3
4 7/8	4.8750	0.025	4.900	0.028	4.928	3 1/4	...
5	5.0000	0.026	5.026	0.029	5.055	...	...
5 1/4	5.2500	0.027	5.277	0.030	5.307	3 1/2	...
5 3/8	5.3750	0.028	5.403	0.031	5.434	...	...
5 5/8	5.6250	0.029	5.654	0.032	5.686	3 3/4	...
5 3/4	5.7500	0.030	5.780	0.033	5.813	...	...
6	6.0000	0.031	6.031	0.034	6.065	4	...
6 1/8	6.1250	0.032	6.157	0.035	6.192	...	...

NOTES:

(1) Wrenches shall be marked with the "Nominal Size of Wrench" which is equal to the basic (maximum) width across flats of the corresponding bolts or screw head.

(2) Allowance (minimum clearance) between maximum width across flats of bolt or screw head and jaws of wrench equals (0.005W + 0.001). Tolerance on wrench opening equals plus (0.005W + 0.004 from minimum). W equals nominal size of wrench.

(3) Square bolt and square lag screw only.

APPENDIX VI

SPECIFICATIONS FOR IDENTIFICATION OF BOLTS AND SCREWS

1 Scope

This specification establishes a recommended procedure for determining the identity of an externally threaded fastener as a bolt or as a screw.

2 Definitions

2.1 Bolt

A bolt is an externally threaded fastener designed for insertion through holes in assembled parts, and is normally intended to be tightened or released by torquing a nut.

2.2 Screw

A screw is an externally threaded fastener capable of being inserted into holes in assembled parts, of mating with a preformed internal thread or forming its own thread, and of being tightened or released by torquing the head.

3 Explanatory Data

A bolt is designed for assembly with a nut. A screw has features in its design which makes it capable of being used in a tapped or other preformed hole in the work. Because of basic design, it is possible to use certain types of screws in combination with a nut. Any externally threaded fastener which has a majority of the design characteristics which assist its proper use in a tapped or other preformed hole is a screw, regardless of how it is used in its service application.

4 Procedure

To identify an externally threaded fastener as a bolt or as a screw, two sets of criteria – Primary and Supplementary – shall be applied. The Primary Criteria (5.1 thru 5.4) shall be applied first. Any fastener which satisfies one of the Primary Criteria shall be identified accordingly, and no further examination need be made. The Supplementary Criteria (6.1 thru 6.9, and not listed in order of importance or priority of application) shall be applied to a fastener which does not satisfy completely any one of the Primary Criteria. The Supplementary Criteria detail the principal features in the design of an externally threaded fastener which contribute to its proper use as a screw. A fastener having a majority of these characteristics shall be identified as a screw.

5 Primary Criteria

5.1 An externally threaded fastener which, because of head design or other feature, is prevented from being turned during assembly, and which can be tightened or released only by torquing a nut, is a bolt. (Example: round head bolts, track bolts, plow bolts)

5.2 An externally threaded fastener which has a thread form which prohibits assembly with a nut having a straight thread of multiple pitch length, is a screw. (Example: wood screws, tapping screws)

5.3 An externally threaded fastener, which must be assembled with a nut to perform its intended service, is a bolt. (Example: heavy hex structural bolt)

5.4 An externally threaded fastener, which must be torqued by its head into a tapped or other preformed hole to perform its intended service, is a screw. (Example: square head set screw)

6 Supplementary Criteria

6.1 Under Head Fillet

A screw should have a controlled fillet at the junction of the head with the body. Because of the severe combined torsion and tension stresses at this junction when torquing the head, the minimum limits of the fillet radius should be specified. Because the screw must be capable of being turned through a minimum clearance hole and into an immovable tapped hole, the maximum limits of the fillet radius should be specified to assure solid seating of the head, and to prevent interference at the top of the hole with the junction of head to body.

6.2 Bearing Surface

The under head bearing surface of a screw should be smooth and flat to minimize frictional resistance during tightening, to prevent scoring of the surface against which the head is turned, and to produce uniform clamping loads.

6.3 Head Angularity

The angularity (squareness) of the under head bearing surface with the shank of a screw should be controlled to minimize eccentric loading in the screw or assembled parts, and to assure complete seating and uniform under head bearing pressure.

6.4 Body

The body of a screw should be closely controlled in accuracy of size and roundness. To fit effectively through a minimum clearance hole, the body diameter must have close tolerances, preferably unilateral on the minus side.

6.5 Shank Straightness

The shank of a screw should be particularly straight to permit ready engagement with the internal thread, to prevent eccentric loading in the fastener or in the assembled parts, and to minimize interference with the walls of a minimum clearance hole.

6.6 Thread Concentricity

The threads of a screw should be concentric with the body axis within close limits to permit assembly into a tapped hole (which usually has a length of thread engagement longer than a nut) without binding of the body against the walls of a minimum clearance hole.

6.7 Thread Length

The length of thread on a screw must be sufficient to develop the full strength of the fastener in tapped holes in various materials.

6.8 Point

A screw should have a chamfered, or other specially prepared point at its end to facilitate entry into the hole and easy start with the internal thread, which may be distant from the top of the hole. The point also protects the first thread, which, if damaged, may gall or scar the internal thread throughout its entire length.

6.9 Length

The length of a screw should be closely toleranced, with variance preferably unilateral on the minus side to prevent bottoming of the fastener in a tapped hole.