

ASME B18.2.6-2010
(Revision of ASME B18.2.6-2006)

Fasteners for Use in Structural Applications

AN AMERICAN NATIONAL STANDARD



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Fasteners for Use in Structural Applications

AN AMERICAN NATIONAL STANDARD



Three Park Avenue • New York, NY • 10016 USA

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FOREWORD

The B18 Standards Committee for the standardization of bolts, screws, nuts, rivets, and similar fasteners was organized in March 1922 as the B18 Sectional Committee 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. B18 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 and 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.

In its meeting on October 13, 1950, Subcommittee 2 agreed to incorporate in the proposed standard the conference recommendations on $\frac{1}{4}$ in. hexagon head bolts, $\frac{5}{8}$ in. hexagon head cap screws and automotive hexagon head bolts, $\frac{5}{16}$ in. and $\frac{3}{8}$ in. regular hexagon and square nuts, and $\frac{7}{16}$ 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 inclusions 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 semifinished, 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 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, new length tolerancing values 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 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 in 1992 recognized the value of having all structural products in a single standard. In a revision initiated for the B18.2.1 Standard in that year, it was proposed to remove the heavy hex structural bolt from the B18.2.1 Standard, the heavy hex nut from the B18.2.2 Standard and combine these with the dimensions of hardened steel washers from ASTM F 436 and the compressible-washer-type direct tension indicator dimensions of ASTM F 959. This new Standard would then provide all standardized dimensions for the fasteners intended for use in structural applications. The first draft of this Standard was submitted to Subcommittee 2 at its May 1993 meeting. It was subsequently approved as an American National Standard on December 4, 1996.

In December of 2008 the B18.2 Subcommittee agreed to begin the updating of ASME B18.2.6. The document's format was revised to meet the new guidelines for B18 Standards. The inside diameters of the hardened washer were revised to match the revised size indicated in ASTM F 436. An alternative design for the $\frac{5}{8}$ in. size compressible-washer-type direct tension indicator was introduced to simplify production tooling for some washer manufacturers. References to platings and coatings in the various product sections were removed and the users of this Standard are directed to the appropriate ASTM material standard to determine finish requirements in addition to other physical and mechanical properties. The quality assurance section was simplified by removing the reference to ASME B18.18.1 and the list of designated inspection characteristics. Instead, users are directed to ASME B18.18.2 for the quality assurance requirements and sampling plans for all product characteristics.

The revision of Section 2.1.6, Bearing Surface, was the final resolved issue. It was learned that a significant amount of ASTM A 325 and A 490 bolts have always been produced by the hot

heading method, which leaves a die seam across the bolt bearing surface. A sentence was added to the section specifically stating that die seams are permissible. Even though no problems had ever been reported relative to the presence of the die seams, one concerned party raised an objection to the addition of this statement. It was decided that this issue should be resolved by conducting a testing program to objectively determine if die seams on structural bolt bearing surfaces cause any detrimental performance in application. Several lots of ASTM A 325 and A 490 bolts were tested in an ISO 17025 accredited laboratory. Bolts and nuts were assembled in tension testing equipment with the tightening torque applied through the rotation of the nut in one set of lots and then by rotating the bolts by their heads in another series of lots. An 88 page report was created, including details on the testing of all lots, bolt chemical and physical certificates, photographs of each stage of testing, and the accreditation certificate for the testing laboratory. The report was submitted to Professor Emeritus Dr. John Fisher of Lehigh University for review and comment. In his conclusion Dr. Fisher stated, "Hence I do not see any reason to consider the installation of bolts with or without seams to differ in achieving the desired preload thereby providing the desired slip resistance. The torque variability is consistent with past studies. Seams are not a significant factor as demonstrated by this study." The Standard was published containing the statement permitting die seams on structural bolt bearing surfaces.

This edition was approved by the American National Standards Institute on July 8, 2010.

ASME B18 COMMITTEE

Standardization of Bolts, Nuts, Rivets, Screws, Washers, and Similar Fasteners

(The following is the roster of the Committee at the time of approval of this Standard.)

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General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B18 Standards Committee
The American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5990
<http://go.asme.org/Inquiry>

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued for the purpose of providing alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee Web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the standard, the paragraph, figure or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the standard to which the proposed Case applies.

Interpretations. Upon request, the B18 Standards Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the B18 Standards Committee.

The request for an interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The B18 Standards Committee regularly holds meetings, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the B18 Standards Committee.

FASTENERS FOR USE IN STRUCTURAL APPLICATIONS

1 INTRODUCTORY NOTES

1.1 Scope

1.1.1 This Standard covers the complete general and dimensional data for five products in the inch series recognized as an American National Standard. These five structural products include

- (a) Heavy Hex Structural Bolts: ASTM A 325 and ASTM A 490
- (b) Heavy Hex Nuts: ASTM A 563 and ASTM A 194
- (c) Hardened Steel Washers; Circular, Circular Clipped, and Beveled: ASTM F 436
- (d) Compressible Washer-Type Direct Tension Indicators: ASTM F 959
- (e) Twist-Off-Type Tension Control Structural Bolts: Heavy Hex and Round: ASTM F 1852 and ASTM F 2280

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

1.2 Dimensions

All dimensions in this Standard are in inches, unless stated otherwise, and apply to an unplated or uncoated product. When plating or coating is specified, the finished product dimensions shall be as agreed upon between supplier and purchaser. Symbols specifying geometric characteristics are in accord with ASME Y14.5.

1.3 Options

Options, where specified, shall be at the discretion of the supplier, unless otherwise agreed upon by the purchaser with the manufacturer or distributor.

1.4 Terminology

For definitions of terms relating to fastener dimensional or component features used in this Standard, refer to ASME B18.12.

1.5 Referenced Standards

Unless otherwise specified, the referenced Standard shall be the most recent issue at the time of order placement. The following is a list of publications referenced in this Standard.

ASME B1.1, Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B1.2, Gages and Gaging for Unified Inch Screw Threads

ASME B1.3, Screw Thread Gaging Systems for Dimensional Acceptability — Inch and Metric Screw Threads (UN, UNR, UNJ, M, and MJ)

ASME B18.2.1, Square and Hex Bolts and Screws (Inch Series)

ASME B18.2.2, Square and Hex Nuts (Inch Series)

ASME B18.2.9, Straightness Gage and Gaging for Bolts and Screws

ASME B18.12, Glossary of Terms for Mechanical Fasteners

ASME B18.18.2, Inspection and Quality Assurance for High-Volume Machine Assembly Fasteners

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

ASME Y14.5, Dimensioning and Tolerancing

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300 (www.asme.org)

ASTM A 194/A 194M, Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service or Both

ASTM A 325, Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

ASTM A 490, Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

ASTM A 563M, Carbon and Alloy Steel Nuts [Metric]

ASTM B 695, Coatings of Zinc Mechanically Deposited on Iron and Steel

ASTM F 436, Hardened Steel Washers

ASTM F 788/F 788M, Surface Discontinuities of Bolts, Screws, and Studs

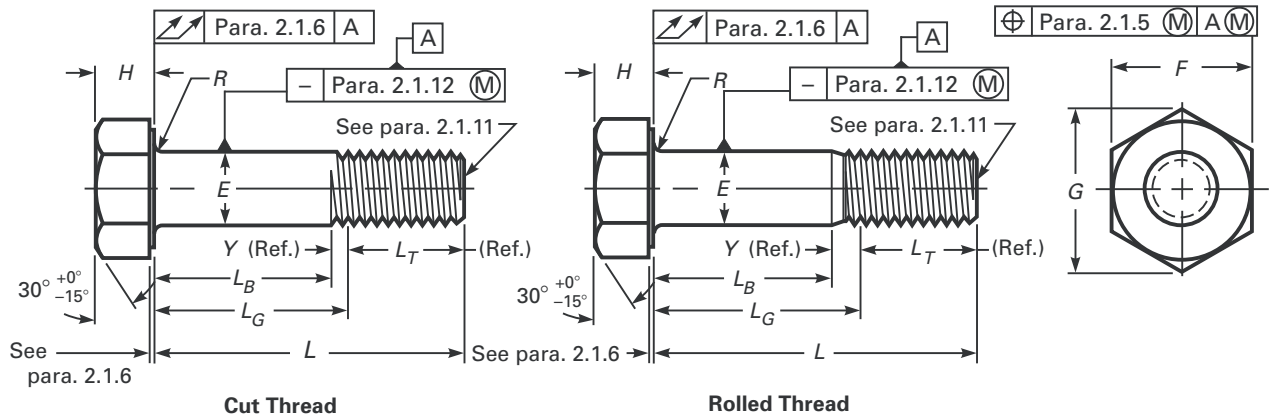
ASTM F 812/F 812M, Surface Discontinuities of Nuts, Inch and Metric

ASTM F 959, Compressible-Washer-Type Direct Tension Indicators for Use With Structural Fasteners

ASTM F 1852, "Twist Off" Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

ASTM F 2280, "Twist Off" Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 150 ksi Minimum Tensile Strength

ASTM F 2329, Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

Table 1 Dimensions of Heavy Hex Structural Bolts

Nominal Size or Basic Product Diameter [Note (1)]	Maximum Total Runout of Bearing Surface FIM															
	Body Diameter, <i>E</i>			Width Across Flats, <i>F</i> [Note (2)]			Width Across Corners, <i>G</i>		Head Height, <i>H</i> [Note (3)]			Radius of Fillet, <i>R</i>		Thread	Transition	
														Length, <i>L_T</i>	Thread Length, <i>Y</i>	
	Max.	Min.	Nominal	Max.	Min.	Max.	Min.	Nominal	Max.	Min.	Max.	Min.	Ref.	Ref.	[Note (5)]	
1/2	0.500	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	0.625	0.642	0.605	1 1/16	1.062	1.031	1.227	1.175	25/64	0.403	0.378	0.062	0.021	1.25	0.22	0.019
3/4	0.750	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	0.875	0.895	0.852	1 7/16	1.438	1.394	1.660	1.589	35/64	0.563	0.531	0.062	0.031	1.50	0.28	0.025
1	1.000	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	1.125	1.149	1.098	1 13/16	1.812	1.756	2.093	2.002	11/16	0.718	0.658	0.093	0.062	2.00	0.34	0.032
1 1/4	1.250	1.277	1.223	2	2.000	1.938	2.309	2.209	25/32	0.813	0.749	0.093	0.062	2.00	0.38	0.035
1 3/8	1.375	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	1.500	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

GENERAL NOTE: See additional requirements in section 2.

NOTES:

- (1) See para. 2.4.1.
- (2) See paras. 2.1.2 and 2.1.3.
- (3) See para. 2.1.4.
- (4) See para. 2.1.10.2.
- (5) See para. 2.1.6.

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2 HEAVY HEX STRUCTURAL BOLTS: ASTM A 325 AND ASTM A 490

2.1 Heavy Hex Structural Bolt Dimensions

Bolts shall conform to the dimensions given in Table 1. Formulas for heavy hex structural bolts are given in the Appendix of ASME B18.2.1.

2.1.1 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 -15% of the maximum across flats dimension.

2.1.2 Width Across Flats. The width across flats of heads shall be the distance measured perpendicular to the axis of the overall product between the two opposite sides of the head.

2.1.3 Head Taper. The 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.

2.1.4 Head Height. The head height shall be that overall distance measured parallel to the axis of the product from the top of the head to the bearing surface

and shall include the thickness of the washer face. Raised grade and manufacturer's identification are excluded from head height.

2.1.5 True Position of Head. The head shall be located at true position with respect to the body within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats at maximum material condition. For measurement purposes, hold the body a distance under the head equal to one diameter.

2.1.6 Bearing Surface. Bearing surface shall be flat and washer faced. However, a die seam across the bearing face shall be permissible. Diameter of washer face shall be equal to the maximum width across flats within a tolerance of -10%.

Thickness of the washer face shall not be less than 0.015 in., nor greater than 0.025 in. for bolt sizes $\frac{3}{4}$ in. and smaller, and not less than 0.015 in. nor greater than 0.035 in. for sizes larger than $\frac{3}{4}$ in.

The plane of the bearing surface shall be perpendicular to the axis of the body within the full indicator movement (FIM) limits specified for total runout. Measurement of FIM shall extend 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. The angularity measurement shall be taken at a location to avoid interference from a die seam.

2.1.7 Bolt Length. The bolt length shall be the distance measured parallel to the axis of the product from the bearing surface of the head to the extreme end of the bolt including point. Bolts are normally furnished in $\frac{1}{4}$ in. length increments.

2.1.8 Length Tolerance. Bolt length tolerances shall be as tabulated below

Nominal Bolt Size, in.	Nominal Bolt Length Tolerance	
	Through 6 in.	Over 6 in.
$\frac{1}{2}$	-0.12	-0.19
$\frac{5}{8}$	-0.12	-0.25
$\frac{3}{4}$ through 1	-0.19	-0.25
$1\frac{1}{8}$ through $1\frac{1}{2}$	-0.25	-0.25

2.1.9 Threads. Threads shall be cut or rolled in accordance with ASME B1.1 Unified Coarse, Class 2A. Structural bolts shall not be undersized to accommodate heavy coatings. Threads that have been hot-dipped or mechanically zinc coated shall meet the maximum limit requirements specified in ASTM A 325.

2.1.9.1 Thread Acceptability. Unless otherwise specified by the purchaser, gaging for screw thread dimensional acceptability shall be in accordance with Gaging System 21, as specified in ASME B1.3.

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

Grip gaging length, L_G , is the distance measured parallel to the axis of bolt from the underhead bearing surface to the face of a noncounterbored or noncountersunk 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 thread length (L_G max. = L nom. - L_T). For bolts that are threaded full length, L_G max. defines the unthreaded length under the head and shall not exceed the length of 2.5 times the thread pitch for sizes up to and including 1 in., and 3.5 times the thread pitch for sizes larger than 1 in. L_G max. represents the minimum design grip length of the bolt and may be used for determining thread availability when selecting bolt lengths even though usable threads may extend beyond this point (see Table 2).

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

Body length, L_B , is the distance measured parallel to the axis of the 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 transition thread length (L_T min. = L_G max. - Y). Bolts of nominal lengths that 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 (see Table 2).

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

2.1.9.3 Incomplete Thread Diameter. The major diameter of incomplete thread shall not exceed the actual major diameter of the full form thread.

2.1.10 Point. Point shall be chamfered or rounded at the manufacturer's option from approximately 0.016 in. below the minor diameter of the thread. The first full formed thread at major diameter is located a distance no greater than 2 times the pitch measured from the end of the bolt. This distance is to be determined by measuring how far the point enters into a cylindrical NOT GO major diameter ring gage (reference Gage, ASME B1.2).

2.1.11 Straightness. Shanks of bolts shall be straight within the following limits at MMC:

**Table 2 Maximum Grip Gaging Lengths and Minimum Body Lengths
for Heavy Hex Structural Bolts**

Nominal Length, L	Nominal Diameter and Thread Pitch																	
	$\frac{1}{2}$ -13		$\frac{5}{8}$ -11		$\frac{3}{4}$ -10		$\frac{7}{8}$ -9		1-8		$1\frac{1}{8}$ -7		$1\frac{1}{4}$ -7		$1\frac{3}{8}$ -6		$1\frac{1}{2}$ -6	
	L_G Max.	L_B Min.	L_G Max.	L_B Min.	L_G Max.	L_B Min.	L_G Max.	L_B Min.	L_G Max.	L_B Min.	L_G Max.	L_B Min.	L_G Max.	L_B Min.	L_G Max.	L_B Min.	L_G Max.	L_B Min.
$1\frac{1}{2}$	0.50	0.31	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$1\frac{3}{4}$	0.75	0.56	0.50	0.28	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	1.00	0.81	0.75	0.53	0.62	0.37	...	...	...	...	...	...	...	...	...	...	...	...
$2\frac{1}{4}$	1.25	1.06	1.00	0.78	0.87	0.62	0.75	0.47	...	...	...	...	...	...	...	...	...	...
$2\frac{1}{2}$	1.50	1.31	1.25	1.03	1.12	0.87	1.00	0.72	0.75	0.44	...	...	...	...	...	...	...	...
$2\frac{3}{4}$	1.75	1.56	1.50	1.28	1.37	1.12	1.25	0.97	1.00	0.69	...	...	...	...	...	...	...	...
3	2.00	1.81	1.75	1.53	1.62	1.37	1.50	1.22	1.25	0.94	1.00	0.66	1.00	0.62	...	...	...	...
$3\frac{1}{4}$	2.25	2.06	2.00	1.78	1.87	1.62	1.75	1.47	1.50	1.19	1.25	0.91	1.25	0.87	1.00	0.56	1.00	0.56
$3\frac{1}{2}$	2.50	2.31	2.25	2.03	2.12	1.87	2.00	1.72	1.75	1.44	1.50	1.16	1.50	1.12	1.25	0.81	1.25	0.81
$3\frac{3}{4}$	2.75	2.56	2.50	2.28	2.37	2.12	2.25	1.97	2.00	1.69	1.75	1.41	1.75	1.37	1.50	1.06	1.50	1.06
4	3.00	2.81	2.75	2.53	2.62	2.37	2.50	2.22	2.25	1.94	2.00	1.66	2.00	1.62	1.75	1.31	1.75	1.31
$4\frac{1}{4}$	3.25	3.06	3.00	2.78	2.87	2.62	2.75	2.47	2.50	2.19	2.25	1.91	2.25	1.87	2.00	1.56	2.00	1.56
$4\frac{1}{2}$	3.50	3.31	3.25	3.03	3.12	2.87	3.00	2.72	2.75	2.44	2.50	2.16	2.50	2.12	2.25	1.81	2.25	1.81
$4\frac{3}{4}$	3.75	3.56	3.50	3.28	3.37	3.12	3.25	2.97	3.00	2.69	2.75	2.41	2.75	2.37	2.50	2.06	2.50	2.06
5	4.00	3.81	3.75	3.53	3.62	3.37	3.50	3.22	3.25	2.94	3.00	2.66	3.00	2.62	2.75	2.31	2.75	2.31
$5\frac{1}{4}$	4.25	4.06	4.00	3.78	3.87	3.62	3.75	3.47	3.50	3.19	3.25	2.91	3.25	2.87	3.00	2.56	3.00	2.56
$5\frac{1}{2}$	4.50	4.31	4.25	4.03	4.12	3.87	4.00	3.72	3.75	3.44	3.50	3.16	3.50	3.12	3.25	2.81	3.25	2.81
$5\frac{3}{4}$	4.75	4.56	4.50	4.28	4.37	4.12	4.25	3.97	4.00	3.69	3.75	3.41	3.75	3.37	3.50	3.06	3.50	3.06
6	5.00	4.81	4.75	4.53	4.62	4.37	4.50	4.22	4.25	3.94	4.00	3.66	4.00	3.62	3.75	3.31	3.75	3.31
$6\frac{1}{4}$	5.25	5.06	5.00	4.78	4.87	4.62	4.75	4.47	4.50	4.19	4.25	3.91	4.25	3.87	4.00	3.56	4.00	3.56
$6\frac{1}{2}$	5.50	5.31	5.25	5.03	5.12	4.87	5.00	4.72	4.75	4.44	4.50	4.16	4.50	4.12	4.25	3.81	4.25	3.81
$6\frac{3}{4}$	5.75	5.56	5.50	5.28	5.37	5.12	5.25	4.97	5.00	4.69	4.75	4.41	4.75	4.37	4.50	4.06	4.50	4.06
7	6.00	5.81	5.75	5.53	5.62	5.37	5.50	5.22	5.25	4.94	5.00	4.66	5.00	4.62	4.75	4.31	4.75	4.31
$7\frac{1}{4}$	6.25	6.06	6.00	5.78	5.87	5.62	5.75	5.47	5.50	5.19	5.25	4.91	5.25	4.87	5.00	4.56	5.00	4.56
$7\frac{1}{2}$	6.50	6.31	6.25	6.03	6.12	5.87	6.00	5.72	5.75	5.44	5.50	5.16	5.50	5.12	5.25	4.81	5.25	4.81
$7\frac{3}{4}$	6.75	6.56	6.50	6.28	6.37	6.12	6.25	5.97	6.00	5.69	5.75	5.41	5.75	5.37	5.50	5.06	5.50	5.06
8	7.00	6.81	6.75	6.53	6.62	6.37	6.50	6.22	6.25	5.94	6.00	5.66	6.00	5.62	5.75	5.31	5.75	5.31
$8\frac{1}{4}$	7.25	7.06	7.00	6.78	6.87	6.62	6.75	6.47	6.50	6.19	6.25	5.91	6.25	5.87	6.00	5.56	6.00	5.56
$8\frac{1}{2}$	7.50	7.31	7.25	7.03	7.12	6.87	7.00	6.72	6.75	6.44	6.50	6.16	6.50	6.12	6.25	5.81	6.25	5.81
$8\frac{3}{4}$	7.75	7.56	7.50	7.28	7.37	7.12	7.25	6.97	7.00	6.69	6.75	6.41	6.75	6.37	6.50	6.06	6.50	6.06
9	8.00	7.81	7.75	7.53	7.62	7.37	7.50	7.22	7.25	6.94	7.00	6.66	7.00	6.62	6.75	6.31	6.75	6.31
$9\frac{1}{4}$	8.25	8.06	8.00	7.78	7.87	7.62	7.75	7.47	7.50	7.19	7.25	6.91	7.25	6.87	7.00	6.56	7.00	6.56
$9\frac{1}{2}$	8.50	8.31	8.25	8.03	8.12	7.87	8.00	7.72	7.75	7.44	7.50	7.16	7.50	7.12	7.25	6.81	7.25	6.81
$9\frac{3}{4}$	8.75	8.56	8.50	8.28	8.37	8.12	8.25	7.97	8.00	7.69	7.75	7.41	7.75	7.37	7.50	7.06	7.50	7.06
10	9.00	8.81	8.75	8.53	8.62	8.37	8.50	8.22	8.25	7.94	8.00	7.66	8.00	7.62	7.75	7.31	7.75	7.31

(a) for bolts with nominal lengths to and including 12 in., the maximum camber shall be 0.006 in. per inch (0.006L) of bolt length.

(b) for bolts with nominal lengths over 12 in. to and including 24 in., the maximum camber shall be 0.008 in. per inch (0.008L) of length.

A suggested gage and gaging procedure for checking bolt straightness is given in ASME B18.2.9.

2.2 Materials and Processing

Chemical and mechanical properties of steel bolts shall conform to ASTM A 325 or ASTM A 490.

2.3 Finish

Unless otherwise specified, bolts shall be supplied with a plain (as-processed) finish, unplated or uncoated. If a finish is required, it shall conform to those approved in the applicable material standard.

2.4 Designation

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

EXAMPLES:

(1) Heavy Hex Structural Bolt, ASME B18.2.6, $\frac{3}{4}$ – 10 × 2 $\frac{1}{4}$, ASTM A 325 Type 1, Hot-Dip Zinc Coated per ASTM F 2329.

(2) Heavy Hex Structural Bolt, ASTM A 325 Type 1, $\frac{3}{4}$ – 10 × 2 $\frac{1}{4}$, Hot-Dip Zinc Coated per ASTM F 2329.

(b) For a part identifying number (PIN), refer to ASME B18.24.

2.4.1 Nominal Size. Where specifying nominal size in decimals, zeros preceding the decimal shall be used and the fourth decimal place shall be omitted.

EXAMPLES:

(1) Heavy Hex Structural Bolt, ASME B18.2.6, 0.750 – 10 × 2.25, ASTM A 325 Type 1, Hot-Dip Zinc Coated per ASTM F 2329.

(2) Heavy Hex Structural Bolt, ASTM A 325 Type 1, 0.750 – 10 × 2.25, Hot-Dip Zinc Coated per ASTM F 2329.

2.5 Identification Symbols

Identification marking symbols on the tops of heads for bolt sizes $\frac{5}{8}$ 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 $\frac{5}{8}$ 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.

2.5.1 Grade Symbols. Each bolt shall be marked in accordance with the requirements of the applicable specification, ASTM A 325 or ASTM A 490.

2.5.2 Source Symbols. Each bolt shall be marked to identify the source (manufacturer or private label distributor) accepting the responsibility for conformance to this and other applicable specifications.

2.6 Workmanship

The allowable limits, inspection, and evaluation of the surface discontinuities, quench cracks, forging cracks, head bursts, sheer bursts, seams, folds, thread laps, voids, tool marks, nicks, and gouges shall be in accordance with ASTM F 788/F 788M.

2.7 Quality Assurance

Unless otherwise specified, products shall be furnished in accordance with ASME B18.18.2.

3 HEAVY HEX NUTS: ASTM A 563 AND ASTM A 194

3.1 Nut Dimensions

Nuts shall conform to the dimensions given in Table 3. Heavy hex nut formulas for thickness, width across flats, and width across corners are given in Appendix II of ASME B18.2.2.

3.1.1 Width Across Flats. The width across flats of heavy hex nuts shall be the overall distance measured, perpendicular to the axis of the nut, between two opposite sides of the nut in accordance with Table 3. For milled-from-bar hex nuts, the nominal bar size used shall be the closest commercially available size to the specified basic width across flats of the nut. If the bar dimensions will not conform to the dimensions in Table 3, the manufacturers must obtain approval from the purchaser prior to manufacturing.

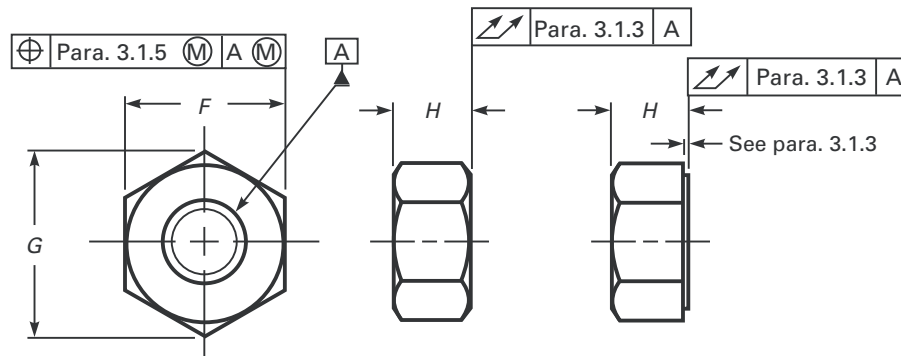
Maximum width across flats shall not be exceeded (except as stated in the previous paragraph). No transverse section through the nut between 25% and 75% of the actual nut thickness, as measured from the bearing surface, shall be less than the minimum width across flats.

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

3.1.3 Tops and Bearing Surfaces. Nuts may be double chamfered or have a washer faced bearing surface and chamfered top.

The diameter of chamfer circle on double chamfered nuts and diameter of washer face shall be within the limits of the maximum width across flats and 95% of the minimum width across flats.

The tops of washer faced nuts shall be flat and the diameter of chamfer circle shall be equal to the maximum width across flats within a tolerance of –15%. The length of chamfer at hex corners shall be 5% to 15% of

Table 3 Dimensions of Heavy Hex Nuts for Use With Structural Bolts

Nominal Size or Basic Major Diameter of Thread [Note (1)]		Width Across Flats, <i>F</i> [Note (2)]			Width Across Corners, <i>G</i> [Note (3)]		Thickness, <i>H</i> [Note (4)]			Total Runout of Bearing Face FIM, Heavy Hex Nuts, Specified Proof Load [Note (5)]	
		Nominal	Max.	Min.	Max.	Min.	Nominal	Max.	Min.	< 150,000	≥ 150,000
										psi	psi
$\frac{1}{2}$	0.500	$\frac{7}{8}$	0.875	0.850	1.010	0.969	$\frac{31}{64}$	0.504	0.464	0.023	0.016
$\frac{5}{8}$	0.625	$1\frac{1}{16}$	1.062	1.031	1.227	1.175	$\frac{39}{64}$	0.631	0.587	0.025	0.018
$\frac{3}{4}$	0.750	$1\frac{1}{4}$	1.250	1.212	1.443	1.382	$\frac{47}{64}$	0.758	0.710	0.027	0.020
$\frac{7}{8}$	0.875	$1\frac{7}{16}$	1.438	1.394	1.660	1.589	$\frac{55}{64}$	0.885	0.833	0.029	0.022
1	1.000	$1\frac{5}{8}$	1.625	1.575	1.876	1.796	$\frac{63}{64}$	1.012	0.956	0.031	0.024
$1\frac{1}{8}$	1.125	$1\frac{13}{16}$	1.812	1.756	2.093	2.002	$1\frac{7}{64}$	1.139	1.079	0.033	0.027
$1\frac{1}{4}$	1.250	2	2.000	1.938	2.309	2.209	$1\frac{7}{32}$	1.251	1.187	0.035	0.030
$1\frac{3}{8}$	1.375	$2\frac{3}{16}$	2.188	2.119	2.526	2.416	$1\frac{11}{32}$	1.378	1.310	0.038	0.033
$1\frac{1}{2}$	1.500	$2\frac{3}{8}$	2.375	2.300	2.742	2.622	$1\frac{15}{32}$	1.505	1.433	0.041	0.036

GENERAL NOTE: See additional requirements in section 3. Complete table included in ASME B18.2.2.

NOTES:

- (1) See para. 2.4.1.
- (2) See para. 3.1.1.
- (3) See para. 3.1.4.
- (4) See para. 3.1.2.
- (5) See para. 3.1.3.

the basic thread diameter. The surface of chamfer may be slightly convex or rounded.

Bearing surfaces shall be flat and, unless otherwise specified, shall be perpendicular to the axis of the threaded hole within the total runout (FIM) tabulated for the respective nut size, type, and strength level.

3.1.4 Corner Fill. A rounding or lack of fill at junction of hex corners with chamfer shall be permissible, provided the width across corners is within specified limits at and beyond a distance equal to 17.5% of the basic thread diameter from the chamfered faces.

3.1.5 Position of Hexagon to Tapped Hole. At maximum material condition, the nut body shall be located at true position with respect to the thread pitch diameter within a tolerance zone having a diameter equivalent to 4% of the maximum width across flats for $1\frac{1}{2}$ in. nominal size nuts or smaller.

3.1.6 Countersink. Tapped hole shall be countersunk on the bearing face or faces. The maximum countersink diameter shall be 1.08 times the thread basic (nominal) major diameter. No part of the threaded portion shall project beyond the bearing surface.

3.1.7 Threads. Threads shall be Class 2B in accordance with ASME B1.1.

3.1.7.1 Thread Gaging. Unless otherwise specified by the purchaser, gaging for screw thread dimensional acceptability shall be in accordance with Gaging System 21 as specified in ASME B1.3.

3.1.7.2 Overtapping. When nuts are zinc coated, they shall be overtapped after coating in accordance with the provisions of ASTM A 563.

3.2 Materials

Chemical and mechanical properties of heavy hex nuts shall conform to ASTM A 563 grades or ASTM A 194/A 194M, Grade 2H. The nut's grade shall have a proof load capacity equal to or greater than the ultimate tensile strength of the bolt it will be used with.

3.3 Finish

Unless otherwise specified, nuts shall be supplied with a plain (as-processed) finish, unplated or uncoated. If a finish is required, it shall conform to those approved in the applicable material standard.

3.4 Designation

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

EXAMPLE: Heavy Hex Nut, ASME B18.2.6, $\frac{1}{2}$ – 13, ASTM A 563, Grade C, Plain Finish.

(b) For a part identifying number (PIN), refer to ASME B18.24.

3.5 Identification Symbols

3.5.1 Grade Symbols. Each nut shall be marked in accordance with the requirements of ASTM A 563 or ASTM A 194/A 194M, Grade 2H, as applicable.

3.5.2 Source Symbols. Each nut shall be marked to identify the source (manufacturer or private label distributor) accepting the responsibility for conformance to this and other applicable specifications.

3.6 Workmanship

Surface discontinuity limits shall be in accordance with ASTM F 812/F 812M.

3.7 Quality Assurance

Unless otherwise specified, products shall be furnished in accordance with ASME B18.18.2.

4 HARDENED STEEL WASHERS

4.1 Circular and Circular Clipped Washers

4.1.1 Circular and Circular Clipped Washer Dimensions. All circular and circular clipped washers shall conform to the dimensions given in Table 4.

4.1.2 Tolerances. Washer inside diameter, outside diameter, thickness, and edge distance shall be in accordance with Table 4. The deviation from flatness shall not exceed 0.010 in. per inch as the maximum deviation from a straight edge placed on the cut side. Circular runout of the outside diameter with respect to the hole

shall not exceed 0.030 FIM. Burrs shall not project above immediately adjacent washer surface more than 0.010 in.

4.1.3 Finish. Unless otherwise specified, washers shall be supplied with a plain (as-processed) finish. If a finish is required, it shall conform to those approved in the applicable material standard.

4.1.4 Materials and Mechanical Properties. Materials and properties shall conform to the requirements specified in ASTM F 436.

4.1.5 Workmanship. Washers shall be free of excess mill scale, excess coatings, and foreign material on bearing surfaces. Arc and gas cut washers shall be free of metal splatter.

4.1.6 Designation

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

EXAMPLES:

(1) Hardened Steel Circular Washer, ASME B18.2.6, $1\frac{1}{8}$, ASTM F 436, Mechanical Zinc, ASTM B 695 Class 55, Type 1.

(2) Hardened Steel Circular Washer, ASME B18.2.6, ASTM F 436, Type 1, $1\frac{1}{8}$, Mechanical Zinc per ASTM B 695 Class 55.

(b) For a part identifying number (PIN), refer to ASME B18.24.

4.1.7 Identification Symbols. Grade and source marking and symbols shall conform to the requirements of ASTM F 436. The source marking is intended to identify the source accepting the responsibility for the conformance to this and other applicable specifications.

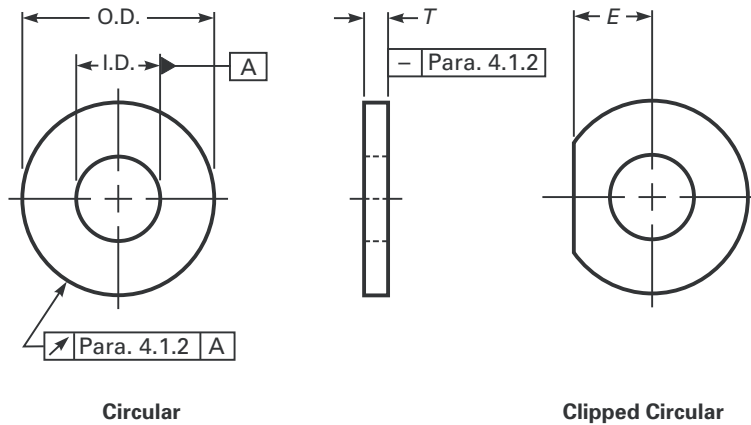
4.1.8 Quality Assurance. Unless otherwise specified, products shall be furnished in accordance with ASME B18.18.2.

4.2 Square and Clipped Square Beveled Washers

4.2.1 Square Beveled Washer Dimensions. All square beveled and clipped square beveled washers shall conform to the dimensions given in Table 5.

4.2.2 Tolerances. Tolerances for inside diameter for beveled washers shall be in accordance with Table 5. The flatness shall not exceed 0.010 in. as the maximum deviation from a straight edge placed on the cut side. Burrs shall not project above immediately adjacent washer surface more than 0.010 in. for smaller than 1 in. and 0.015 in. for 1 in to $1\frac{1}{2}$ in. The slope or taper in thickness shall be 0.98:6 to 1.02:6.

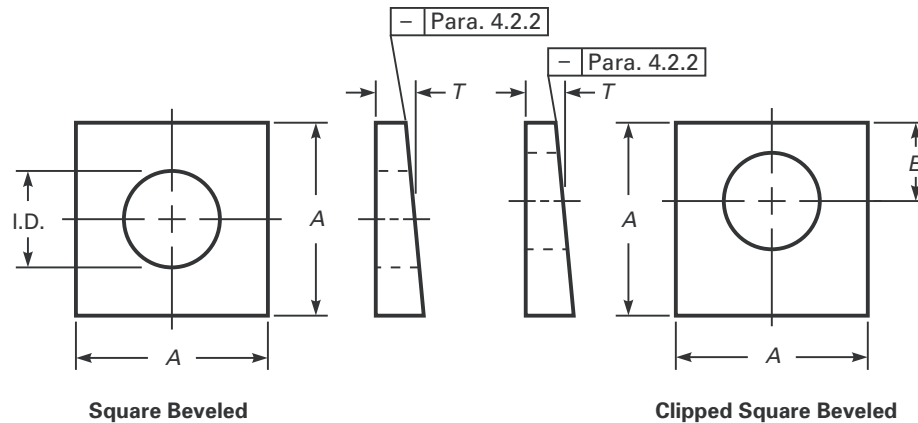
4.2.3 Finish. Unless otherwise specified, washers shall be supplied with a plain (as-processed) finish. If a finish is required, it shall conform to those approved in the material standard.

Table 4 Dimensions for Hardened Steel Circular and Circular Clipped Washers

Basic Size or Nominal Washer Size, in. [Note (1)]	Inside Diameter, I.D.			Outside Diameter, O.D.			Thickness, <i>T</i>		Minimum Edge Distance, <i>E</i> [Note (2)]
	Nominal	Min.	Max.	Nominal	Min.	Max.	Min.	Max.	
$\frac{1}{2}$	0.531	0.531	0.563	1.063	1.031	1.095	0.097	0.177	0.438
$\frac{5}{8}$	0.688	0.688	0.720	1.313	1.281	1.345	0.122	0.177	0.547
$\frac{3}{4}$	0.813	0.813	0.845	1.469	1.437	1.501	0.122	0.177	0.656
$\frac{7}{8}$	0.938	0.938	0.970	1.750	1.718	1.782	0.136	0.177	0.766
1	1.063	1.063	1.085	2.000	1.937	2.063	0.136	0.177	0.875
$1\frac{1}{8}$	1.188	1.188	1.251	2.250	2.187	2.313	0.136	0.177	0.984
$1\frac{1}{4}$	1.375	1.375	1.438	2.500	2.437	2.563	0.136	0.177	1.094
$1\frac{3}{8}$	1.500	1.500	1.563	2.750	2.687	2.813	0.136	0.177	1.203
$1\frac{1}{2}$	1.625	1.625	1.688	3.000	2.937	3.063	0.136	0.177	1.313

NOTES:

- (1) Nominal washer sizes are intended for use with comparable nominal bolt diameters.
 (2) Clipped edge, *E*, shall not be closer than 0.875 times the nominal bolt diameter from the center of the washer.

Table 5 Dimensions of Hardened Beveled Washers With Slope or Taper in Thickness 1:6

Nominal Washer Size [Note (1)]		Inside Diameter, I.D.			Minimum Side Length, A [Note (2)]	Thickness, T (Ref.) [Note (3)]	Minimum Edge Distance, E [Note (4)]
		Nominal	Min.	Max.			
$\frac{1}{2}$	0.500	0.531	0.531	0.563	1.750	0.313	0.438
$\frac{5}{8}$	0.625	0.688	0.688	0.720	1.750	0.313	0.547
$\frac{3}{4}$	0.750	0.813	0.813	0.845	1.750	0.313	0.656
$\frac{7}{8}$	0.875	0.938	0.938	0.970	1.750	0.313	0.766
1	1.000	1.125	1.125	1.188	1.750	0.313	0.875
$1\frac{1}{8}$	1.125	1.250	1.250	1.313	2.250	0.313	0.984
$1\frac{1}{4}$	1.250	1.375	1.375	1.438	2.250	0.313	1.094
$1\frac{3}{8}$	1.375	1.500	1.500	1.563	2.250	0.313	1.203
$1\frac{1}{2}$	1.500	1.625	1.625	1.688	2.250	0.313	1.313

NOTES:

- (1) Nominal washer sizes are intended for use with comparable nominal bolt diameters.
- (2) Nonclipped washers may be rectangular providing neither side dimension is less than A.
- (3) The thickness is measured on the centerline of the hole from the sloped to the flat surface.
- (4) Clipped edge, E, shall not be closer than 0.875 times the nominal bolt diameter from the center of the washer.

4.2.4 Materials and Mechanical Properties. Materials and properties shall conform to the requirements established by ASTM F 436.

4.2.5 Workmanship. Washers shall be free from seams, laps, loose scale, irregular surfaces, and any defects affecting serviceability.

4.2.6 Designation

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

EXAMPLES:

(1) Hardened Steel Square Washer, ASME B18.2.6, $1\frac{1}{8}$, ASTM F 436 Type 1, Mechanical Zinc, ASTM B 695 Class 55.

(2) Hardened Steel Square Washer, ASME B18.2.6, ASTM F 436 Type 1, $1\frac{1}{8}$, Mechanical Zinc, ASTM B 695 Class 55.

(b) For a part identifying number (PIN), refer to ASME B18.24.

4.2.7 Identification Symbols. Grade and source marking and symbols shall conform to the requirements of ASTM F 436. The source marking is intended to identify the source accepting the responsibility for conformance to this and other applicable specifications.

4.2.8 Quality Assurance. Unless otherwise specified, products shall be furnished in accordance with ASME B18.18.2.

5 COMPRESSIBLE WASHER-TYPE DIRECT TENSION INDICATORS

5.1 Direct Tension Indicator Dimensions

All washer-type direct tension indicators, Type 325 and 490, shall conform to the dimensions given in Table 6. Additional characteristics to accommodate the necessary features for silicone emitting type indicator washers are permissible.

5.2 Finish

Unless otherwise specified, direct tension indicators shall be supplied with a plain (as-processed) finish, unplated or uncoated. If a finish is required, it shall conform to those approved in the material standard.

5.3 Materials and Properties

Direct tension indicators shall conform to the requirements of ASTM F 959. Silicone emitting type indicator washers shall meet all of the performance requirements of ASTM F 959 and the dimensional requirements in this Standard.

5.4 Workmanship

The workmanship shall be smooth and free of burrs, laps, seams, excess mill scale, and foreign material on

bearing surfaces or in protrusions, or other defects that would make them unsuitable for intended application.

5.5 Designation

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

EXAMPLES:

(1) DTI, ASME B18.2.6, ASME B18.2.6, $\frac{1}{2}$, per ASTM F 959, Type 325 Plain Finish.

(2) DTI, ASME B18.2.6, ASTM F 959, $\frac{1}{2}$, Type 325, Plain Finish.

(b) For a part identifying number (PIN), refer to ASME B18.24.

5.6 Identification Symbols or Markings

Grade, lot number, and source marking symbols shall conform to the requirements of ASTM F 959.

5.7 Quality Assurance

Unless otherwise specified, products shall be furnished in accordance with ASME B18.18.2.

6 TWIST-OFF-TYPE TENSION CONTROL STRUCTURAL BOLTS: HEAVY HEX AND ROUND: ASTM F 1852 AND ASTM F 2280

6.1 Twist-Off-Type Tension Control Structural Bolt Dimensions

6.1.1 Heavy Hex Heads. Heavy hex head bolts shall conform to the dimensions included in Table 7.

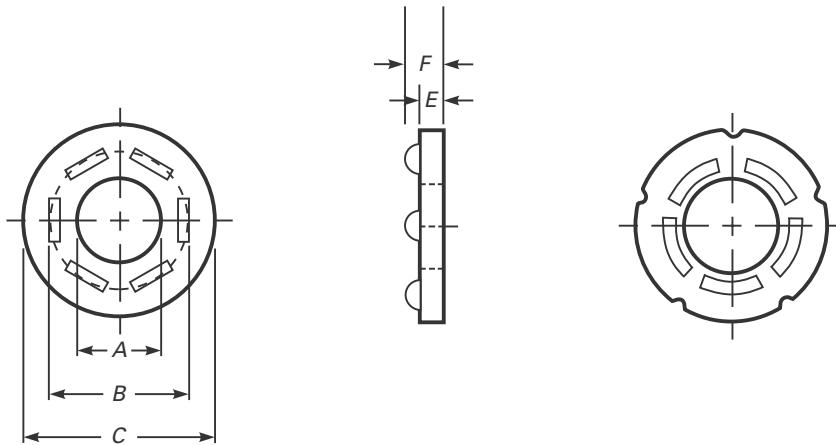
6.1.1.1 Top of Head. The top of head shall be full formed and chamfered or rounded with the diameter of the chamfer circle or start of rounding being equal to the maximum width across flats within a tolerance of -15% .

6.1.1.2 Width Across Flats. The width across flats of heads shall be the distance measured perpendicular to the axis of the product, overall between two opposite sides of the head.

6.1.1.3 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 the minimum width across flats.

6.1.1.4 Head Height. The head height shall be that overall distance measured parallel to the axis of the product from the top of the head to the bearing surface and shall include the thickness of the washer face. Raised grade and manufacturer's identification are excluded from head height.

6.1.2 Round Heads. Round head dimensions shall be in accordance with Table 7.

Table 6 Dimensions for Compressible Washer-Type Direct Tension Indicators**Straight-Side Protrusion Type****Curved Protrusion Type with
Optional Outside Notches**

Direct Tension Indicator Size, in. [Note (1)]	All Types		Type 325					Type 490					
	Inside Diameter, A, in.		Maximum Protrusion Tangential Diameter, B, in.	Outside Diameter, C, in.		Number of Protrusions (Equally Spaced)	Thickness, in.		Outside Diameter, C, in.		Number of Protrusions (Equally Spaced)	Thickness, in.	
							Without Protrusion, E	With Protrusion, F				Without Protrusion, E	With Protrusion, F
	Min.	Max.		Min.	Max.		Min.	Max.	Min.	Max.		Min.	Max.
1/2	0.523	0.527	0.788	1.167	1.187	4	0.104	0.180	1.355	1.375	5	0.104	0.180
5/8	0.654	0.658	0.956	1.355	1.375	4	0.126	0.220	1.605	1.625	5	0.126	0.220
5/8 option	0.654	0.658	0.956	NA	NA	NA	NA	NA	1.355	1.375	4	0.126	0.220
3/4	0.786	0.790	1.125	1.605	1.625	5	0.126	0.230	1.730	1.750	6	0.142	0.240
7/8	0.917	0.921	1.294	1.855	1.875	5	0.142	0.240	1.980	2.000	6	0.158	0.260
1	1.048	1.052	1.463	1.980	2.000	6	0.158	0.270	2.230	2.250	7	0.158	0.270
1 1/8	1.179	1.183	1.631	2.230	2.250	6	0.158	0.270	2.480	2.500	7	0.158	0.280
1 1/4	1.311	1.315	1.800	2.480	2.500	7	0.158	0.270	2.730	2.750	8	0.158	0.280
1 3/8	1.442	1.446	1.969	2.730	2.750	7	0.158	0.270	2.980	3.000	8	0.158	0.280
1 1/2	1.573	1.577	2.138	2.980	3.000	8	0.158	0.270	3.230	3.250	9	0.158	0.280

GENERAL NOTE: Additional requirements are in section 5.

NOTE:

(1) Nominal direct tension indicator sizes are intended for use with fasteners of the same nominal diameter.

6.1.2.1 Top of Head. The top of the round head shall be spherical and may be underfilled within a circle approximating the nominal bolt diameter.

6.1.2.2 Head Diameter. The round head configuration shall have a head diameter in accordance with Table 7. The heads are not normally machined or trimmed, thus the circumference may be irregular with a rounded or flat edge.

6.2 Bearing Surface

The hex head washer face diameter shall be equal to the maximum width across flats within a tolerance of -10% and have a thickness not less than 0.015 in. nor greater than 0.025 in. for bolt sizes $\frac{3}{4}$ in. and smaller, and not less than 0.015 in. nor greater than 0.035 in. for sizes larger than $\frac{3}{4}$ in.

The bearing surface shall be flat and perpendicular to the body within the FIM limits specified for total runout. Measurement of FIM shall extend 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.

A die seam across the bearing surface is not permissible.

6.3 Bolt Length

The bolt length shall be the distance measured parallel to the axis of the bolt from the bearing surface of the head to the center point of the groove through which shear will occur. Bolts are normally supplied in $\frac{1}{4}$ in. length increments.

6.4 Length Tolerance

Bolt length tolerances shall be as tabulated below:

Nominal Bolt Size, in.	Nominal Bolt Length Tolerance (There is no tolerance plus.)	
	Through 6 in.	Over 6 in.
$\frac{1}{2}$	-0.12	-0.19
$\frac{5}{8}$	-0.12	-0.25
$\frac{3}{4}$ through 1	-0.19	-0.25
$1\frac{1}{8}$ through $1\frac{1}{2}$	-0.25	-0.25

6.5 Straightness

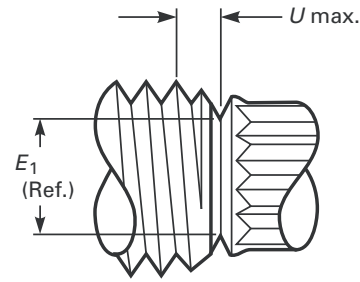
Shanks of bolts shall be straight within the following limits at MMC:

(a) for bolts with nominal lengths to and including 12 in., the maximum camber shall be 0.006 in. per inch (0.006L) of bolt length.

(b) for bolts with nominal lengths over 12 in. to and including 24 in., the maximum camber shall be 0.008 in. per inch (0.008L) of length.

A suggested gage and gaging procedure for checking bolt straightness is given in ASME B18.2.9.

Fig. 1 Groove Diameter



6.6 True Position of Head

The head shall be located at true position with respect to the body within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats at maximum material condition. For measurement purposes, hold the body a distance under the head equal to one diameter.

6.7 Spline

The 12 spline dimensions and groove dimensions are reference dimensions and shall be at the discretion of the manufacturer. Users should consult with the supplier to assure wrenchability. Reference dimensions for the spline length and width across flats are given in Table 7.

6.8 Point

Unless otherwise specified, bolts need not be pointed. The distance, U , given in Table 7, is from the center of the groove to the first fully formed thread crest. This shall be determined by measuring how far the point enters into a cylindrical NOT GO major diameter ring gage.

6.8.1 Groove Diameter. The groove diameter, E_1 , is approximately equal to 80% of the thread maximum minor diameter (see Fig. 1). The actual E_1 value shall be established by the manufacturer to assure proper function.

6.9 Threads

Threads shall be in the Unified Inch coarse series (UNRC Series), Class 2A. Acceptability of screw threads shall be determined based on System 21, ASME B1.3.

Unless otherwise specified, zinc coated bolts to be used with nuts that have been tapped oversize in accordance with ASTM A 563, shall have Class 2A threads before mechanically deposited zinc coating.

6.10 Thread Length

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

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 noncounterbored or noncountersunk 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 thread length ($L_G \text{ max.} = L \text{ nom.} - L_T$). For bolts that are threaded full length, $L_G \text{ max.}$ 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. $L_G \text{ max.}$ represents the minimum design grip length of the bolt and may be used for determining thread availability when selecting bolt lengths even though usable threads may extend beyond this point.

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

Body length, L_B , 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 transition thread length ($L_B = L_G \text{ max.} - Y$). Bolts of nominal lengths that have a calculated L_B 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, that represents the length of incomplete threads and tolerance on grip gaging length.

6.11 Incomplete Thread Diameter

The major diameter of incomplete thread shall not exceed the actual major diameter of the full form thread.

6.12 Material and Mechanical Properties

Chemical and mechanical properties shall conform to ASTM F 1852 or ASTM F 2280, as applicable.

6.13 Finish

Unless otherwise specified, bolts shall be supplied with a plain (as-processed) finish, unplated or uncoated.

If a finish is required, it shall conform to those approved in the material standard.

6.14 Workmanship

Surface discontinuities shall be in conformance with ASTM F 788/F 788M.

6.15 Designation

(a) Twist-off-type tension control bolt assemblies include a bolt, nut, and washer, and are designated in the following manner: quantity, size, including bolt diameter and length (without the spline end), name of product, head style, Type (1 or 3), specification, coating, and special requirements (if applicable).

EXAMPLES:

(1) 2,500 assemblies, $\frac{3}{4} \times 2$, twist-off tension control bolt/nut/washer assemblies, round head, ASME B18.2.6, ASTM F 1852 Type I, ASME B18.2.6, mechanically zinc coated to ASTM B 695 Class 55.

(2) 2,500 assemblies, ASME B18.2.6, ASTM F 1852 Type I, $\frac{3}{4} \times 2$, twist-off tension control bolt/nut/washer assemblies, round head, mechanically zinc coated to ASTM B 695 Class 55.

(b) For a part identifying number (PIN), refer to ASME B18.24.

6.16 Product Marking

All components shall be marked in accordance with ASTM F 1852 or ASTM F 2280, as applicable.

6.16.1 Identification Symbols. Identification marking symbols on bolt heads shall be raised or indented at the manufacturer's option, unless otherwise specified. Markings shall be legible to the unaided eye with the exception of corrective lenses. When raised, the height of the marking may not exceed 0.015 in. over the specified maximum head height for bolts $\frac{5}{8}$ in. and smaller. For bolts larger than $\frac{5}{8}$ in., the marking may not project more than 0.030 in. over the specified maximum head height. When indented, the depth of the marking shall not reduce the load-carrying capability of the fastener.

6.17 Quality Assurance

Unless otherwise specified, products shall be furnished in accordance with ASME B18.18.2.

B18 AMERICAN NATIONAL STANDARDS FOR BOLTS, NUTS, RIVETS, SCREWS, WASHERS, AND SIMILAR FASTENERS

Small Solid Rivets	B18.1.1-1972 (R2006)
Large Rivets	B18.1.2-1972 (R2006)
Metric Small Solid Rivets	B18.1.3M-1983 (R2006)
Square and Hex Bolts and Screws (Inch Series)	B18.2.1-1996 (R2005)
Square and Hex Nuts (Inch Series)	B18.2.2-1987 (R2005)
Metric Hex Cap Screws	B18.2.3.1M-1999 (R2005)
Metric Formed Hex Screws	B18.2.3.2M-2005
Metric Heavy Hex Screws	B18.2.3.3M-1979 (R2001)
Metric Hex Flange Screws	B18.2.3.4M-2001 (R2006)
Metric Hex Bolts	B18.2.3.5M-1979 (R2006)
Metric Heavy Hex Bolts	B18.2.3.6M-1979 (R2006)
Metric Heavy Hex Structural Bolts	B18.2.3.7M-1979 (R2006)
Metric Hex Lag Screws	B18.2.3.8M-1981 (R2005)
Metric Heavy Hex Flange Screws	B18.2.3.9M-2001 (R2006)
Metric Hex Nuts, Style 1	B18.2.4.1M-2002 (R2007)
Metric Hex Nuts, Style 2	B18.2.4.2M-2005
Metric Slotted Hex Nuts	B18.2.4.3M-1979 (R2006)
Metric Hex Flange Nuts	B18.2.4.4M-1982 (R2005)
Metric Hex Jam Nuts	B18.2.4.5M-2008
Metric Heavy Hex Nuts	B18.2.4.6M-1979 (R2003)
Metric Flanged 12-Point Head Screws	B18.2.5M-2009
Fasteners for Use in Structural Applications	B18.2.6-2010
Metric 12-Spline Flange Screws	B18.2.7.1M-2002 (R2007)
Clearance Holes for Bolt, Screws, and Studs	B18.2.8-1999 (R2005)
Straightness Gage and Gaging for Bolts and Screws	B18.2.9-2007
Socket Cap, Shoulder, and Set Screws, Hex and Spline Keys (Inch Series)	B18.3-2003 (R2008)
Socket Head Cap Screws (Metric Series)	B18.3.1M-1986 (R2008)
Metric Series Hexagon Keys and Bits	B18.3.2M-1979 (R2008)
Hexagon Socket Head Shoulder Screws (Metric Series)	B18.3.3M-1986 (R2008)
Hexagon Socket Button Head Cap Screws (Metric Series)	B18.3.4M-1986 (R2008)
Hexagon Socket Flat Countersunk Head Cap Screws (Metric Series)	B18.3.5M-1986 (R2008)
Metric Series Socket Set Screws	B18.3.6M-1986 (R2008)
Round Head Bolts (Inch Series)	B18.5-1990 (R2003)
Metric Round Head Short Square Neck Bolts	B18.5.2.1M-2006
Metric Round Head Square Neck Bolts	B18.5.2.2M-1982 (R2005)
Wood Screws (Inch Series)	B18.6.1-1981 (R2008)
Slotted Head Cap Screws, Square Head Set Screws, and Slotted Headless Set Screws (Inch Series)	B18.6.2-1998 (R2005)
Machine Screws and Machine Screw Nuts	B18.6.3-2003 (R2008)
Thread Forming and Thread Cutting Tapping Screws and Metallic Drive Screws (Inch Series)	B18.6.4-1998 (R2005)
Metric Thread-Forming and Thread-Cutting Tapping Screws	B18.6.5M-2000 (R2005)
Metric Machine Screws	B18.6.7M-1999 (R2005)
General Purpose Semi-Tubular Rivets, Full Tubular Rivets, Split Rivets and Rivet Caps	B18.7-2007
Metric General Purpose Semi-Tubular Rivets	B18.7.1M-2007
Clevis Pins and Cotter Pins (Inch Series)	B18.8.1-1994 (R2000)
Taper Pins, Dowel Pins, Straight Pins, Grooved Pins, and Spring Pins (Inch Series)	B18.8.2-2000
Spring Pins: Coiled Type, Spring Pins: Slotted, Machine Dowel Pins: Hardened Ground, and Grooved Pins (Metric Series)	B18.8.100M-2000 (R2005)
Cotter Pins, Headless Clevis Pins, and Headed Clevis Pins (Metric Series)	B18.8.200M-2000 (R2005)
Plow Bolts	B18.9-2007
Track Bolts and Nuts	B18.10-1982 (R2005)
Miniature Screws	B18.11-1961 (R2005)
Glossary of Terms for Mechanical Fasteners	B18.12-2001 (R2006)
Screw and Washer Assemblies — Sems (Inch Series)	B18.13-1996 (R2008)
Screw and Washer Assemblies: Sems (Metric Series)	B18.13.1M-1998 (R2003)
Forged Eyebolts	B18.15-1985 (R2008)
Prevailing-Torque Type Steel Metric Hex Nuts and Hex Flange Nuts	B18.16M-2004 (R2009)

Serrated Hex Flange Locknuts 90,000 psi (Inch Series)	B18.16.4-2008
Nylon Insert Locknuts (Inch Series)	B18.16.6-2008
Inspection and Quality Assurance for General Purpose Fasteners	B18.18.1-2007
Inspection and Quality Assurance for High-Volume Machine Assembly Fasteners	B18.18.2-2009
Inspection and Quality Assurance for Special Purpose Fasteners	B18.18.3M-1987 (R2005)
Inspection and Quality Assurance for Fasteners for Highly Specialized Engineered Applications	B18.18.4M-1987 (R2005)
Inspection and Quality Assurance Plan Requiring In-Process Inspection and Controls	B18.18.5M-1998 (R2009)
Quality Assurance Plan for Fasteners Produced in a Third Party Accreditation System	B18.18.6M-1998 (R2009)
Quality Assurance Plan for Fasteners Produced in a Customer Approved Control Plan	B18.18.7M-1998 (R2009)
Lock Washers (Inch Series)	B18.21.1-1999 (R2005)
Lock Washers (Metric Series)	B18.21.2M-1999 (R2005)
Double Coil Helical Spring Lock Washers for Wood Structures	B18.21.3-2008
Metric Plain Washers	B18.22M-1981 (R2005)
Plain Washers	B18.22.1-1965 (R2008)
Part Identifying Number (PIN) Code System for B18 Fastener Products	B18.24-2004
Square and Rectangular Keys and Keyways	B18.25.1M-1996 (R2008)
Woodruff Keys and Keyways	B18.25.2M-1996 (R2008)
Square and Rectangular Keys and Keyways: Width Tolerances and Deviations Greater Than Basic Size	B18.25.3M-1998 (R2008)
Tapered and Reduced Cross Section Retaining Rings (Inch Series)	B18.27-1998 (R2005)
Helical Coil Screw Thread Inserts — Free Running and Screw Locking (Inch Series)	B18.29.1-1993 (R2007)
Helical Coil Screw Thread Inserts: Free Running and Screw Locking (Metric Series)	B18.29.2M-2005
Open-End Blind Rivets With Break Mandrels (Metric Series)	B18.30.1M-2000 (R2005)
Metric Continuous and Double-End Studs	B18.31.1M-2008
Continuous and Double-End Studs	B18.31.2-2008

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