

ASME B18.2.1-2010

[Revision of ASME B18.2.1-1996 (R2005)]

Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)

AN AMERICAN NATIONAL STANDARD



INTENTIONALLY LEFT BLANK

ASME B18.2.1-2010

[Revision of ASME B18.2.1-1996 (R2005)]

**Square, Hex, Heavy
Hex, and Askew Head
Bolts and Hex, Heavy
Hex, Hex Flange,
Lobed Head, and Lag
Screws (Inch Series)**

AN AMERICAN NATIONAL STANDARD



Three Park Avenue • New York, NY • 10016 USA

Date of Issuance: October 13, 2010

This Standard will be revised when the Society approves the issuance of a new edition. There will be no addenda issued to this edition.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. Interpretations are published on the ASME Web site under the Committee Pages at <http://cstools.asme.org> as they are issued.

ASME is the registered trademark of The American Society of Mechanical Engineers.

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The Standards Committee that approved the code or standard was balanced to assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed code or standard was made available for public review and comment that provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

ASME does not “approve,” “rate,” or “endorse” any item, construction, proprietary device, or activity.

ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor assumes any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representative(s) or person(s) affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility for only those interpretations of this document issued in accordance with the established ASME procedures and policies, which precludes the issuance of interpretations by individuals.

No part of this document may be reproduced in any form,
in an electronic retrieval system or otherwise,
without the prior written permission of the publisher.

The American Society of Mechanical Engineers
Three Park Avenue, New York, NY 10016-5990

Copyright © 2010 by
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
All rights reserved
Printed in U.S.A.

CONTENTS

Foreword	iv
Committee Roster	vii
Correspondence With the B18 Committee	viii
1 Introduction	1
2 General Data for Both Bolts and Screws	2
3 Bolts	4
4 Screws	8
5 Lag Screws	20
Figures	
1 Underhead Fillet for Long Screws	15
2 Underhead Fillet for Short Screws Threaded Full Length	15
3 L_G , Maximum and L_B , Minimum for Short Screws Threaded Full Length	15
Tables	
1 Dimensions of Square Head Bolts	4
2 Dimensions of Hex Bolts	5
3 Dimensions of Heavy Hex Bolts	6
4 Dimensions of Askew Head Bolts	7
5 Length Tolerances for Bolts	7
6 Dimensions of Hex Cap Screws	9
7 Dimensions of Heavy Hex Screws	11
8 Dimensions of Hex Flange Screws	12
9 Dimensions of Lobe Head Screws	14
10 Dimensions of Underhead Fillets	15
11 L_G , Maximum and L_B , Minimum Limitations for Short Screws Threaded Full Length	16
12 Maximum Grip Gaging Lengths, L_G , and Minimum Body Lengths, L_B , for Screws	17
13 Length Tolerances for Screws	20
14 Dimensions of Square Lag Screws	21
15 Dimensions of Hex Lag Screws	22
16 Dimensions of Lag Screw Threads	22
Mandatory Appendix	
I Gage and Gaging Practices for External Lobed Head Drive System	23
Nonmandatory Appendices	
A Formulas for Bolt and Screw Head Dimensions	26
B Weight in Pounds of 100 Steel Hex Cap Screws for Given Diameter/Length Combination	28
C Countersunk Center Holes	29

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 that 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 affected.

In its meeting of 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, these 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 semifinished, and heavy finished hexagon bolts that 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 that 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 that 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 the 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 the 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. 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 11. 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.

In 1991, it was recognized that B18.2.1 required extensive revision to better meet the needs of conformance with Public Law 101-592. Included in these considerations were improved definition of a full body versus a reduced body and those dimensions that should be certified to ensure product fit, form, and function. Other dimensions given for each product would only be examined in the event of a dispute. Also, the term "finished hex bolt," which is today's cap screw, should be dropped. Additionally, a weight table has been included to assist users.

Furthermore, it was felt that the heavy hex structural bolt, heavy hex nut, hardened steel washers, and compressible washer-type direct tension indicators should be included in a new standard for fasteners intended for use in structural applications. For this reason, the heavy hex structural bolt was removed from this Standard. The new table for maximum grip gaging lengths and minimum body lengths for cap screws and heavy hex screws was included for the first time in the 1996 edition to assist users and is similar to the pattern used for metric bolts and screws.

The Subcommittee 2 agreed to undertake the revision of B18.2.1 during the first quarter of 2008. The Standard was updated to incorporate the new format and additional sections as refined in ASME B18.12.1. The notes that had followed every table were reorganized into the body of the Standard to eliminate the redundancy created by repeating the same table notes under numerous tables. This revision adds flange head and lobed head screws and extends the size range of heavy hex head cap screws from 3 in. to 6 in. in diameter. The thread details for lag screws were redefined to align with the way all other spaced threads are defined. Designated inspection characteristics were eliminated from each product type, and a general section on quality assurance was created stating that all products must meet the requirements in the Standard according to ASME B18.18.2. The title of the Standard was revised to indicate that the flange head and lobed head screws have been added to the Standard.

Suggestions for improvement of this Standard will be welcomed. They should be sent to The American Society of Mechanical Engineers, Secretary, B18 Main Committee, 3 Park Avenue, New York, NY 10016-5990.

This revision was approved as an American National Standard 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.)

STANDARDS COMMITTEE OFFICERS

J. Greenslade, *Chair*
D. S. George, *Vice Chair*
R. D. Strong, *Vice Chair*
C. J. Gomez, *Secretary*

STANDARDS COMMITTEE PERSONNEL

V. Cartina , Autocraft Industrial	W. H. Kopke , Consultant
D. A. Clever , Consultant	W. J. Lutkus , Emhart Technologies
A. P. Cockman , Ford Motor Co.	D. A. McCrindle , Canadian Fasteners Institute
C. A. D. de la Garza , TSP	M. D. Prasad , <i>Contributing Member</i> , Global M & F Solutions, Inc.
D. S. George , ND Industries	S. Savoji , ITW Medalist
C. J. Gomez , The American Society of Mechanical Engineers	W. R. Schevey , <i>Contributing Member</i> , BGM Fastener Co., Inc.
J. Greenslade , Industrial Fasteners Institute	Q. M. Smith III , Oregon DOT
J. J. Grey , <i>Contributing Member</i> , Fastener Consulting Services, Inc.	W. R. Stevens , Ramco
B. Hasiuk , <i>Contributing Member</i> , Defense Supply Center Philadelphia	R. D. Strong , GM Vehicle Engineering Center
A. Herskovitz , Consultant	S. W. Vass , Consultant
J. Hubbard , Leland-Powell Fasteners, Inc.	C. B. Wackrow , MNP Corp.
J. Jennings , <i>Contributing Member</i> , Naval Surface Warfare Center	W. K. Wilcox , Consultant
W. H. King , Porteous Fastener Co.	C. B. Williamson , Fastenal Co.
J. F. Koehl , <i>Contributing Member</i> , Spirol International Corp.	C. J. Wilson , Consultant
	R. B. Wright , <i>Contributing Member</i> , Wright Tool Co.
	J. G. Zeratsky , National Rivet and Manufacturing Co.

SUBCOMMITTEE 2 – EXTERNALLY DRIVEN FASTENERS

J. Greenslade , <i>Chair</i> , Industrial Fasteners Institute	J. F. McCarrick , Defense Supply Center Philadelphia
C. B. Williamson , <i>Vice Chair</i> , Fastenal Co.	D. A. McCrindle , Canadian Fasteners Institute
T. Anderson , Bay Bolt	R. B. Meade , Atrona Material Testing Laboratories, Inc.
V. Cartina , Autocraft Industrial	S. Savoji , ITW Medalist
L. Claus , ATF, Inc.	R. M. Serabin , Freundlich Supply Co.
D. A. Clever , Consultant	D. F. Sharp , GMS Structural Engineers
A. P. Cockman , Ford Motor Co.	G. M. Simpson , Semblex Corp.
C. A. D. de la Garza , TSP	Q. M. Smith III , Oregon DOT
B. A. Dusina , Federal Screw Works	D. J. Soscia , General Dynamics Electric Boat Corp.
M. A. Elmi , Consultant	W. R. Stevens , Ramco
J. S. Foote , Trade Association Management, Inc.	R. D. Strong , Consultant
M. C. Friel , Haydon Bolts, Inc.	R. L. Tennis , Consultant
D. S. George , ND Industries	S. W. Vass , Consultant
A. Herskovitz , Consultant	B. Vines , Birmingham Fastener
M. W. Holubecki , Electric Boat Corp.	C. B. Wackrow , MNP Corp.
J. Hubbard , Leland-Powell Fasteners, Inc.	K. Westphal , Kamax
J. Jennings , <i>Contributing Member</i> , Naval Surface Warfare Center	W. K. Wilcox , Consultant
W. H. King , Porteous Fastener Co.	C. J. Wilson , Consultant
R. Leemans , John Deere	D. Winn , Kamax

CORRESPONDENCE WITH THE B18 COMMITTEE

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

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 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.

SQUARE, HEX, HEAVY HEX, AND ASKEW HEAD BOLTS AND HEX, HEAVY HEX, HEX FLANGE, LOBED HEAD, AND LAG SCREWS (INCH SERIES)

1 INTRODUCTION

1.1 Scope

1.1.1 This Standard covers the dimensional requirements for nine product types of inch series bolts and screws recognized as American National Standard. Also included are appendices covering gaging procedures, grade markings for bolts and screws, formulas on which dimensional data are based, and a specification to assist in identifying a product as being a screw or a bolt. Where questions arise concerning acceptance of product, the dimensions in the tables shall govern over recalculation by formula. Heavy hex structural bolts, formerly covered in ASME B18.2.1, are now covered in ASME B18.2.6.

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 should consult with suppliers concerning lists of stock production sizes.

1.2 Comparison With ISO Standards

Since these are inch fastener standards, there are no comparable ISO standards.

1.3 Dimensions

All dimensions in this Standard are in inches and apply to unplated or uncoated product. When plating or coating is specified, the finished product dimensions shall be as agreed upon between supplier and purchaser. Where nominal sizes are expressed in decimals, zeros preceding the decimal and zeros in the fourth decimal place shall be omitted.

Symbols specifying geometric characteristics are in accord with ASME Y14.5.

1.4 Options

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

1.5 Terminology

As used in this Standard, "short bolt" or "short screw" means a bolt or screw of a diameter-length combination

that is required to be threaded for full length, whereas "long bolt" or "long screw" means a bolt or screw of a diameter-length combination that is not threaded for full length.

body length, L_B : the distance measured parallel to the axis of the bolt or screw from the underhead bearing surface to the last scratch of thread or, for rolled threads, to the top of the extrusion angle. Where specified, the minimum body length (L_B , min.) is a criterion for inspection.

grip gaging length, L_G : the distance measured parallel to the axis of the bolt or screw from the underhead bearing surface to the face of a noncounterbored, noncountersunk standard GO thread ring gage assembled by hand as far as the thread will permit. The maximum grip gaging length (L_G , max.) is a criterion for inspection.

point length: the length from the pointed end to the first fully formed thread at major diameter as determined by the distance that the point enters into a cylindrical NOT GO major diameter ring gage (refer to Gage 3.1 in ASME B1.2).

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

transition thread length, Y : the length that includes the length of incomplete threads, the extrusion angle on rolled threads, and tolerances on grip length. Where specified, transition thread length is a reference dimension intended for calculation purposes only.

For definitions of terminology not specified in this Standard, refer to ASME B18.12.

1.6 Referenced Standards

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 Acceptability: Inch and Metric Screw Threads (UN, UNR, UNJ, M, and MJ)

ASME B18.2.6, Fasteners for Use in Structural Applications

ASME B18.2.8, Clearance Holes for Bolts, Screws, and Studs

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 (QA) for High Volume Machine Assembly Fasteners

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

ASME B94.11M, Twist Drills

ASME Y14.5, Dimensioning and Tolerancing

Publisher: The American Society of Mechanical Engineers (ASME), 3 Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900 (www.asme.org)

ASTM A 6/A 6M, General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTM A 307, Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

ASTM A 354, Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners

ASTM A 449, Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use

ASTM F 468, Nonferrous Bolts, Hex Cap Screws, and Studs for General Use

ASTM F 593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

ASTM F 788/F 788M, Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series

ASTM F 1941, Standard Specification for Electrodeposited Coatings on Threaded Fasteners [Unified Inch Screw Threads (UN/UNR)]

Publisher: American Society for Testing and Materials (ASTM International), 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 (www.astm.org)

SAE J429, Mechanical and Material Requirements for Externally Threaded Fasteners

Publisher: Society of Automotive Engineers (SAE International), 400 Commonwealth Drive, Warrendale, PA 15096 (www.sae.org)

2 GENERAL DATA FOR BOTH BOLTS AND SCREWS

2.1 Heads

2.1.1 Top of Head. Top of head shall be full form and chamfered, with the diameter of chamfer circle equal to the maximum width across flats, on square or hex head products and the "B" dimension shown in Table 11 for lobed head screws with a tolerance of -15%.

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

2.1.3 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.

2.1.4 Position of Head. The runout of the flats or lobes of the head shall be no greater than 6% of the maximum width across flats or lobes. For reference purposes, the evaluation shall be made by indicating on the flats or outer surface of lobes while holding the body one bolt diameter from under the head and rotating the part.

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 the point if the product is pointed.

2.3 Body Diameter

The body diameter minimum/maximum limits are defined in each of the respective applicable tables. Unless otherwise specified by the purchaser, the body style supplied shall be full-size body.

NOTES:

- (1) Only bolts and lag screws are permitted to have die seams on their body that exceed the body diameter. Die seams on the body and all other styles of screws that exceed the body diameter are not permitted.
- (2) For recommended clearance of hole sizes for bolts and screws, refer to ASME B18.2.8.

2.4 Points

Unless otherwise specified, bolts need not be pointed. Products designated as screws, with the exception of lag screws, are required to have a chamfered point. The chamfer angle may vary depending on the manufacturing process. When specified, the chamfer angle should be considered a reference dimension only. The presence of a point is to reduce the possibility of damage to the leading threads and promote assembleability with a tapped hole or nut. Point features not defined in a given product standard are at the discretion of the manufacturer.

2.5 Threads

2.5.1 Thread Standard. Threads on all products in this Standard, except lag screws, shall meet the requirements of ASME B1.1. Lag screw thread dimensions are specified in Table 16.

2.5.2 Thread Class. Unless otherwise specified, size limits for standard external thread Class 2A apply prior to coating. The external thread allowance may be used to accommodate the coating thickness on plated or coated parts, provided that the maximum coating thickness is no more than one-fourth of the allowance. Thus, the thread after plating or coating is subject to acceptance using a basic size Class 3A GO size thread gage and a Class 2A NOT GO size thread gage.

2.5.3 Thread Series. Thread series on all bolts and screws may be coarse (UNC), fine (UNF), or 8 thread series (8 UN), except askew head bolts, which shall be unified coarse (UNC) only, and lag screws, which are specified in Table 16.

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

2.5.5 Thread Acceptability. Unless otherwise specified by the purchaser, dimensional acceptability of screw threads shall be determined using thread gaging System 21 in ASME B1.3.

2.6 Straightness

Shanks of bolts and screws shall be straight within the following limits at maximum material condition (MMC). For bolts with nominal lengths up to and including 12 in., the maximum camber shall be 0.006 in. per inch (0.006*L*) of bolt or screw length. For bolts and screws with nominal lengths over 12 in. up to and including 24 in., the maximum camber shall be 0.008 in. per inch (0.008*L*) of bolt or screw length. A typical gage and gaging procedure for checking bolt and screw straightness are given in ASME B18.2.9.

2.7 Countersunk Center Holes

For parts that require machining, it may be necessary to provide support with a countersunk center hole in the threaded end. Unless otherwise specified by the purchaser, the drill size and depth shall be in accordance with Nonmandatory Appendix C.

2.8 Materials

Standard materials for various configurations of bolts and screws are identified in paras. 3.9, 4.9, and 5.7. When materials and/or grades, other than those in the applicable notes, are required, the purchaser must clearly specify them in the purchase documents.

2.9 Finish

Unless otherwise specified, bolts and screws shall be supplied with a plain (as processed) finish, unplated, or uncoated. Light oil on the surface is permissible to avoid corrosion during transportation, packaging, and further handling.

2.10 Workmanship

Surface discontinuities shall be in accordance with the requirements of the applicable fastener material standard. The purchaser may specify additional surface discontinuity requirements for screws and bolts when tighter control of surface discontinuities is required or when discontinuity limits are not specified in the applicable fastener material standard.

2.11 Designation

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

EXAMPLES:

- (1) Square Bolt per ASME B18.2.1, $\frac{3}{8}$ – 16 × 1½. Steel per ASTM A 307 Grade A, Zinc plated per ASTM F 1941 Fe/Zn 3A
- (2) Hex Cap Screw per ASME B18.2.1. $\frac{1}{2}$ – 13 × 4. ASTM A 354 Grade BD, plain finish
- (3) Hex Lag Screw per ASME B18.2.1, 0.75 × 5.00, Stainless Steel per ASTM F 593, Group 1, Condition CW (304)

2.11.2 For a recommended part identification number (PIN) system for B18 fasteners, see ASME B18.24.

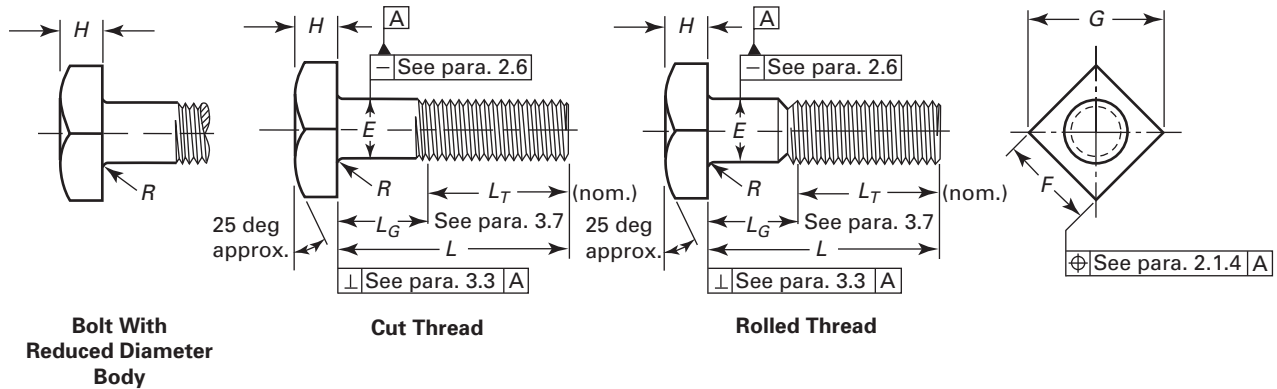
2.12 Grade and Manufacturer's Identification

2.12.1 Identification Symbols. Identification marking symbols on products included in this Standard 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 capacity of the fastener.

2.12.2 Grade Symbols. Each of the products included in this Standard shall be marked in accordance with the requirements of the applicable specification for its material, mechanical, or performance requirements.

2.12.3 Source Symbols. Each of the products included in this Standard shall be marked in accordance with the requirements of the applicable specification for

Table 1 Dimensions of Square Head Bolts



Nominal Size or Basic Product	Diameter	Full-Size Body Diameter, <i>E</i> (See Paras. 3.4 and 3.5)		Width Across Flats, <i>F</i> (See Para. 2.1.2)			Width Across Corners, <i>G</i>		Head Height, <i>H</i>			Radius of Fillet, <i>R</i>		Thread Length for Bolt Lengths, <i>L_T</i> (See Para. 3.7)	
		Max.	Min.	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.	Max.	Min.	6 in. and Shorter	Over 6 in.
														Nom.	Nom.
1/4	0.2500	0.260	0.237	3/8	0.375	0.362	0.530	0.498	11/64	0.188	0.156	0.03	0.01	0.750	1.000
5/16	0.3125	0.324	0.298	1/2	0.500	0.484	0.707	0.665	13/64	0.220	0.186	0.03	0.01	0.875	1.125
3/8	0.3750	0.388	0.360	9/16	0.562	0.544	0.795	0.747	1/4	0.268	0.232	0.03	0.01	1.000	1.250
7/16	0.4375	0.452	0.421	5/8	0.625	0.603	0.884	0.828	19/64	0.316	0.278	0.03	0.01	1.125	1.375
1/2	0.5000	0.515	0.482	3/4	0.750	0.725	1.061	0.995	21/64	0.348	0.308	0.03	0.01	1.250	1.500
5/8	0.6250	0.642	0.605	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	0.729	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	0.852	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	0.976	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	1.098	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	1.223	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	1.345	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	1.470	2 1/4	2.250	2.175	3.182	2.986	1	1.036	0.964	0.09	0.03	3.250	3.500

GENERAL NOTE: Refer to section 3 for further information.

its material, mechanical, or performance requirements to identify its source, manufacturer, or private label distributor.

2.13 Quality Assurance

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

3 BOLTS

Square head, hex, heavy hex, and askew head bolts are presented in Tables 1 through 4, respectively.

3.1 Surface Condition

Bolts need not be finished on any surface except threads.

3.2 Head Taper

Maximum width across flats and corners 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 across flats and corners requirements. (This is not applicable to askew head bolts.)

3.3 Bearing Surface

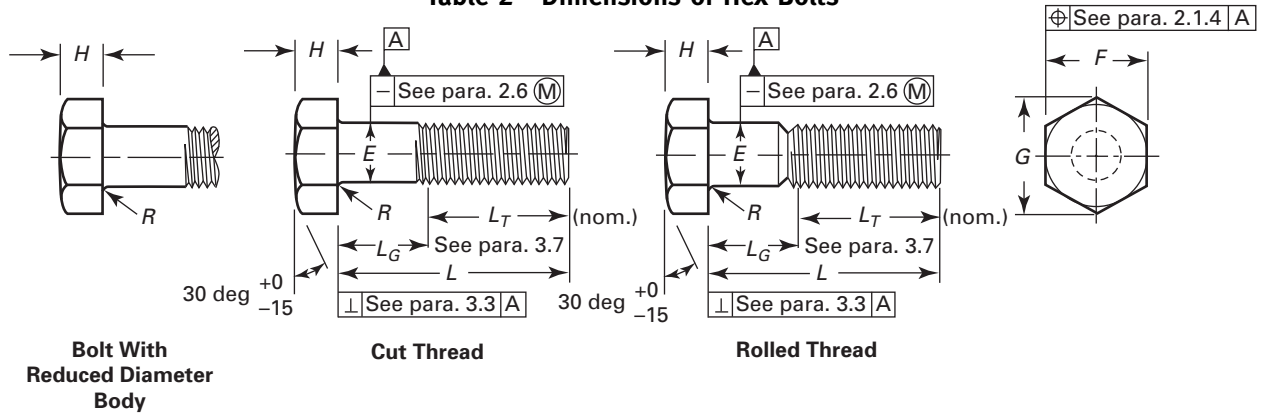
A die seam across the bearing surface of bolts is permissible. Bearing surface shall be perpendicular to the axis of the body within a tolerance of 3 deg for 1 in. size and smaller and 2 deg for sizes larger than 1 in. Angularity measurement shall be taken at a location to avoid interference with die seams. When specified by the purchaser, the die seam shall be removed. Upon completion of the machining, all dimensions and geometric requirements specified for the bearing surface and head shall be met. For askew head bolts, see Note (1) in Table 4.

3.4 Body Diameter

Any swell or fin under the head or any die seam on the body shall not exceed the basic bolt diameter by more than the following:

- (a) 0.030 in. for sizes up through 1/2 in.

Table 2 Dimensions of Hex Bolts



Nominal Size or Basic Product Diameter	Nominal Diameter	Full-Size Body Diameter, E (See Paras. 3.4 and 3.5)		Width Across Flats, F (See Para. 2.1.2)			Width Across Corners, G		Head Height, H			Radius of Fillet, R		Thread Length for Bolt Lengths, L_T (See Para. 3.7)	
		Max.	Min.	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.	Max.	Min.	6 in. and Shorter	Over 6 in.
															Nom.	Nom.
1/4	0.2500	0.260	0.237	7/16	0.438	0.425	0.505	0.484	11/64	0.188	0.150	0.03	0.01	0.750	1.000
5/16	0.3125	0.324	0.298	1/2	0.500	0.484	0.577	0.552	7/32	0.235	0.195	0.03	0.01	0.875	1.125
3/8	0.3750	0.388	0.360	9/16	0.562	0.544	0.650	0.620	1/4	0.268	0.226	0.03	0.01	1.000	1.250
7/16	0.4375	0.452	0.421	5/8	0.625	0.603	0.722	0.687	19/64	0.316	0.272	0.03	0.01	1.125	1.375
1/2	0.5000	0.515	0.482	3/4	0.750	0.725	0.866	0.826	11/32	0.364	0.302	0.03	0.01	1.250	1.500
5/8	0.6250	0.642	0.605	15/16	0.938	0.906	1.083	1.033	27/64	0.444	0.378	0.06	0.02	1.500	1.750
3/4	0.7500	0.768	0.729	1 1/8	1.125	1.088	1.299	1.240	1/2	0.524	0.455	0.06	0.02	1.750	2.000
7/8	0.8750	0.895	0.852	1 5/16	1.312	1.269	1.516	1.447	37/64	0.604	0.531	0.06	0.02	2.000	2.250
1	1.0000	1.022	0.976	1 1/2	1.500	1.450	1.732	1.653	43/64	0.700	0.591	0.09	0.03	2.250	2.500
1 1/8	1.1250	1.149	1.098	1 11/16	1.688	1.631	1.949	1.859	3/4	0.780	0.658	0.09	0.03	2.500	2.750
1 1/4	1.2500	1.277	1.223	1 7/8	1.875	1.812	2.165	2.066	27/32	0.876	0.749	0.09	0.03	2.750	3.000
1 3/8	1.3750	1.404	1.345	2 1/16	2.062	1.994	2.382	2.273	29/32	0.940	0.810	0.09	0.03	3.000	3.250
1 1/2	1.5000	1.531	1.470	2 1/4	2.250	2.175	2.598	2.480	1	1.036	0.902	0.09	0.03	3.250	3.500
1 5/8	1.6250	1.658	1.591	2 7/16	2.438	2.356	2.815	2.616	1 3/32	1.116	0.978	0.09	0.03	3.500	3.750
1 3/4	1.7500	1.785	1.716	2 5/8	2.625	2.538	3.031	2.893	1 5/32	1.196	1.054	0.12	0.04	3.750	4.000
1 7/8	1.8750	1.912	1.839	2 13/16	2.812	2.719	3.248	3.099	1 1/4	1.276	1.130	0.12	0.04	4.000	4.250
2	2.0000	2.039	1.964	3	3.000	2.900	3.464	3.306	1 11/32	1.388	1.175	0.12	0.04	4.250	4.500
2 1/4	2.2500	2.305	2.214	3 3/8	3.375	3.262	3.897	3.719	1 1/2	1.548	1.327	0.19	0.06	4.750	5.000
2 1/2	2.5000	2.559	2.461	3 3/4	3.750	3.625	4.330	4.133	1 21/32	1.708	1.479	0.19	0.06	5.250	5.500
2 3/4	2.7500	2.827	2.711	4 1/8	4.125	3.988	4.763	4.546	1 13/16	1.869	1.632	0.19	0.06	5.750	6.000
3	3.0000	3.081	2.961	4 1/2	4.500	4.350	5.196	4.959	2	2.060	1.815	0.19	0.06	6.250	6.500
3 1/4	3.2500	3.335	3.210	4 7/8	4.875	4.712	5.629	5.372	2 3/16	2.251	1.936	0.19	0.06	6.750	7.000
3 1/2	3.5000	3.589	3.461	5 1/4	5.250	5.075	6.062	5.786	2 5/16	2.380	2.057	0.19	0.06	7.250	7.500
3 3/4	3.7500	3.858	3.726	5 5/8	5.625	5.437	6.495	6.198	2 1/2	2.572	2.241	0.19	0.06	7.750	8.000
4	4.0000	4.111	3.975	6	6.000	5.800	6.928	6.612	2 11/16	2.764	2.424	0.19	0.06	8.250	8.500

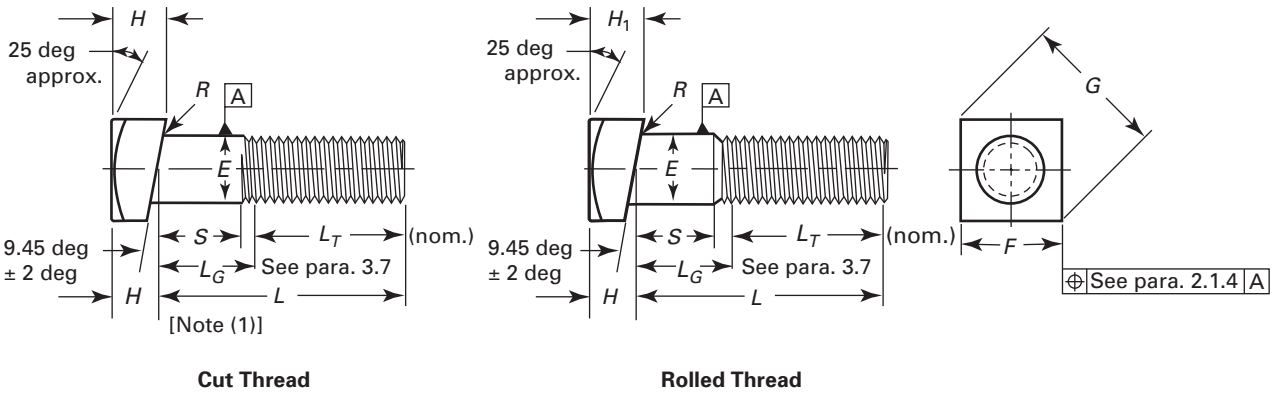
GENERAL NOTE: Refer to section 3 for further information.

Table 3 Dimensions of Heavy Hex Bolts

Nominal Size or Basic Product Diameter	Full-Size Body Diameter, <i>E</i> (See Paras. 3.4 and 3.5)		Width Across Flats, <i>F</i> (See Para. 2.1.2)			Width Across Corners, <i>G</i>		Head Height, <i>H</i>			Radius of Fillet, <i>R</i>		Thread Length for Bolt Lengths, <i>L_T</i> (See Para. 3.7)		
	Max.	Min.	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.	Max.	Min.	6 in. and Shorter	Over 6 in.	
													Nom.	Nom.	
$\frac{3}{8}$	0.3750	0.388	0.360	$\frac{11}{16}$	0.688	0.669	0.794	0.763	$\frac{1}{4}$	0.268	0.226	0.03	0.01	1.000	1.250
$\frac{1}{2}$	0.5000	0.515	0.482	$\frac{7}{8}$	0.875	0.850	1.010	0.969	$\frac{11}{32}$	0.364	0.302	0.03	0.01	1.250	1.500
$\frac{5}{8}$	0.6250	0.642	0.605	$\frac{11}{16}$	1.062	1.031	1.227	1.175	$\frac{27}{64}$	0.444	0.378	0.06	0.02	1.500	1.750
$\frac{3}{4}$	0.7500	0.768	0.729	$\frac{1}{4}$	1.250	1.212	1.443	1.383	$\frac{1}{2}$	0.524	0.455	0.06	0.02	1.750	2.000
$\frac{7}{8}$	0.8750	0.895	0.852	$\frac{7}{16}$	1.438	1.394	1.660	1.589	$\frac{37}{64}$	0.604	0.531	0.06	0.02	2.000	2.250
1	1.0000	1.022	0.976	$\frac{5}{8}$	1.625	1.575	1.876	1.796	$\frac{43}{64}$	0.700	0.591	0.09	0.03	2.250	2.500
$1\frac{1}{8}$	1.1250	1.149	1.098	$\frac{13}{16}$	1.812	1.756	2.093	2.002	$\frac{3}{4}$	0.780	0.658	0.09	0.03	2.500	2.750
$1\frac{1}{4}$	1.2500	1.277	1.223	2	2.000	1.938	2.309	2.209	$\frac{27}{32}$	0.876	0.749	0.09	0.03	2.750	3.000
$1\frac{3}{8}$	1.3750	1.404	1.345	$\frac{23}{16}$	2.188	2.119	2.526	2.416	$\frac{29}{32}$	0.940	0.810	0.09	0.03	3.000	3.250
$1\frac{1}{2}$	1.5000	1.531	1.470	$\frac{3}{8}$	2.375	2.300	2.742	2.622	1	1.036	0.902	0.09	0.03	3.250	3.500
$1\frac{5}{8}$	1.6250	1.658	1.591	$\frac{9}{16}$	2.562	2.481	2.959	2.829	$\frac{13}{32}$	1.116	0.978	0.09	0.03	3.500	3.750
$1\frac{3}{4}$	1.7500	1.785	1.716	$\frac{3}{4}$	2.750	2.662	3.175	3.035	$\frac{15}{32}$	1.196	1.054	0.12	0.04	3.750	4.000
$1\frac{7}{8}$	1.8750	1.912	1.839	$\frac{15}{16}$	2.938	2.844	3.392	3.242	$\frac{1}{4}$	1.276	1.130	0.12	0.04	4.000	4.250
2	2.0000	2.039	1.964	$\frac{3}{8}$	3.125	3.025	3.608	3.449	$\frac{11}{32}$	1.388	1.175	0.12	0.04	4.250	4.500
$2\frac{1}{4}$	2.2500	2.305	2.214	$\frac{1}{2}$	3.500	3.388	4.041	3.862	$\frac{1}{2}$	1.548	1.327	0.19	0.06	4.750	5.000
$2\frac{1}{2}$	2.5000	2.559	2.461	$\frac{7}{8}$	3.875	3.750	4.474	4.275	$\frac{21}{32}$	1.708	1.479	0.19	0.06	5.250	5.500
$2\frac{3}{4}$	2.7500	2.827	2.711	$\frac{1}{4}$	4.250	4.112	4.907	4.688	$\frac{13}{16}$	1.869	1.632	0.19	0.06	5.750	6.000
3	3.0000	3.081	2.961	$\frac{5}{8}$	4.625	4.475	5.340	5.102	2	2.060	1.815	0.19	0.06	6.250	6.500

GENERAL NOTE: Refer to section 3 for further information.

Table 4 Dimensions of Askew Head Bolts



Nominal Size or Basic Product Diameter [Note (2)]	Body Diameter, E (See Para. 3.5)		Width Across Flats, F (See Para. 2.1.2)			Width Across Corners, G		Head Height, H [Note (3)]		Mid-height, H [Note (3)] Ref.	Radius of Fillet, R		Maximum Unthreaded Length, S [Note (4)]	Thread Length for Bolt Lengths, L _T [Note (4)]		
	Max.	Min.	Basic	Max.	Min.	Max.	Min.	Max.	Min.		Max.	Min.		6 in. and Shorter Nom.	Over 6 in. Nom.	
	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 1/16	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:

- 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.
- Thread Series.** Askew head bolts are only available with unified course (UNC) threads.
- Head Height.** Midheight, H, is a reference dimension and equals the basic head height of square bolts as given in Table 2. Head height, H₁, is computed as midheight, H, + 0.0833 times the specified maximum width across flats, F. Tolerance on head height, H₁, is ±0.020 in. from computed head height.
- Thread Length.** All askew head bolts of nominal lengths equal to or shorter than the nominal 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 midheight 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 midheight, to the first complete (full form) thread, as measured with a nonchamfered 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 2 1/2 threads.

Table 5 Length Tolerances for Bolts

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	+0.02	+0.02	...	...	...
	-0.03	-0.03	-0.03	...	...	...
Over 1 in. to 2 1/2 in., incl.	+0.02	+0.04	+0.06	+0.08	+0.12	+0.18
	-0.04	-0.06	-0.08	-0.10	-0.12	-0.18
Over 2 1/2 in. to 4 in., incl.	+0.04	+0.06	+0.08	+0.10	+0.16	+0.20
	-0.06	-0.08	-0.10	-0.14	-0.16	-0.20
Over 4 in. to 6 in., incl.	+0.06	+0.08	+0.10	+0.12	+0.18	+0.22
	-0.10	-0.10	-0.10	-0.16	-0.18	-0.22
Longer than 6 in.	+0.10	+0.12	+0.14	+0.16	+0.22	+0.24
	-0.18	-0.18	-0.18	-0.20	-0.22	-0.24

- (b) 0.050 in. for sizes over $\frac{1}{2}$ in. through $\frac{3}{4}$ in.
- (c) 0.060 in. for sizes over $\frac{3}{4}$ in. through $1\frac{1}{4}$ in.
- (d) 0.090 in. for sizes over $1\frac{1}{4}$ in. through $1\frac{1}{2}$ in.
- (e) 0.090 in. for sizes over $1\frac{1}{2}$ in., unless otherwise agreed to between purchaser and supplier

The diameter of the unthreaded length on bolts that are threaded for full length shall not be less than the minimum pitch diameter of the thread nor greater than the maximum body diameter, E , max., specified in Tables 1 through 4.

3.5 Reduced Diameter Body

When specified by the purchaser, bolts may be supplied in the reduced diameter body style. These shall have a body diameter of not less than the minimum pitch diameter of the thread and not exceeding the minimum body diameter, E , min., shown in Tables 1 through 4. Any swell or fin under the head or any die seam on the body shall not exceed E , min. by more than the following:

- (a) 0.030 in. for sizes up through $\frac{1}{2}$ in.
- (b) 0.050 in. for sizes over $\frac{1}{2}$ in. through $\frac{3}{4}$ in.
- (c) 0.060 in. for sizes over $\frac{3}{4}$ in. through $1\frac{1}{4}$ in.
- (d) 0.090 in. for sizes over $1\frac{1}{4}$ in. through $1\frac{1}{2}$ in.
- (e) 0.090 in. for sizes over $1\frac{1}{2}$ in., unless otherwise agreed to between purchaser and supplier

3.6 Length Tolerance

Bolt length tolerances are given in Table 5.

3.7 Thread Length

Nominal thread length, L_T , is a reference dimension intended for calculation purposes only. Nominal thread length equals twice the basic thread diameter +0.25 in. for nominal bolt lengths up to and including 6 in. and twice the basic thread diameter +0.50 in. for nominal lengths over 6 in.

The length of thread on bolts shall be controlled by the grip gaging length. The maximum grip gaging length, L_G , as calculated and rounded to two decimal places for any bolt not threaded full length, shall be equal to the nominal bolt length minus the nominal thread length (L_G , max. = L , nom. - L_T) with a tolerance of minus a length equal to five coarse thread pitches. This represents the minimum design grip length of the joint and shall be used as the criterion for inspection and determining thread availability when selecting bolt lengths, even though usable threads may extend beyond this point.

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. It shall be used as the criterion for inspection.

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

3.8 Material

Unless otherwise specified, chemical and mechanical properties of steel bolts shall conform to ASTM A 307 Grade A, except for heavy hex bolts, which shall conform to ASTM A 307 Grade B. Other materials and grades shall be as agreed upon by supplier and purchaser.

3.9 Additional Requirements

For additional requirements, see sections 1 and 2.

4 SCREWS

4.1 General

Hex cap, heavy hex, hex flange, and lobe head screws are presented in Tables 6 through 9, respectively.

4.2 Top of Head

4.2.1 Hex Cap and Heavy Hex Cap Screws. Top of head shall be full form and chamfered, with the diameter of chamfer circle being equal to the maximum width across flats within a tolerance of -15%.

4.2.2 Hex Flange and Lobe Head Screws. Top of head may be full form or indented at the option of the manufacturer. If full form, the top of head shall be chamfered or rounded with the diameter of chamfer circle or start of rounding being equal to the maximum width across flats, within a tolerance of -15%. If the top of head is indented, the periphery may be rounded.

4.3 Washer Face

Thickness of the washer face shall be not less than 0.015 in. or greater than 0.025 in. for screw 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 washer face is not applicable to hex flange or lobe head screws.

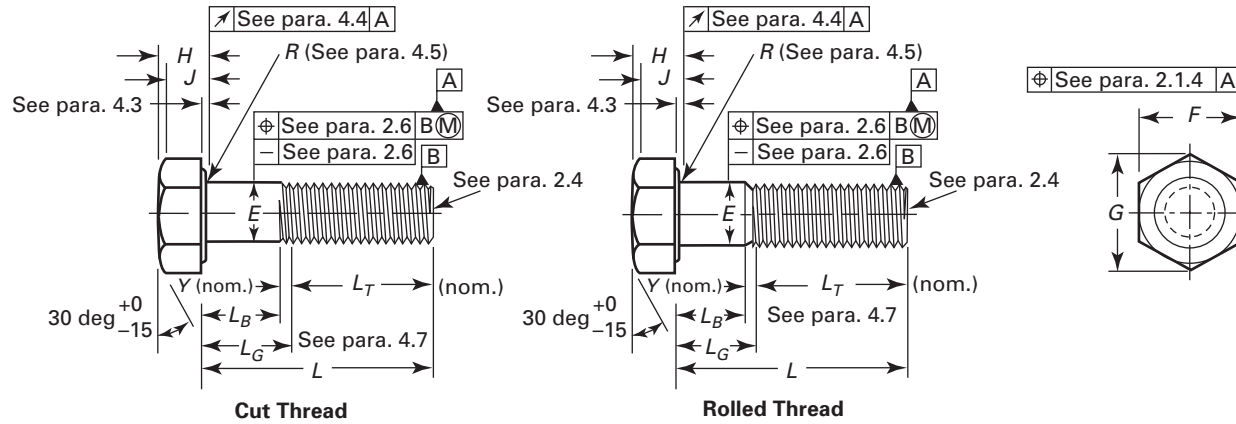
The washer face diameter shall be equal to the maximum width across flats with a tolerance of -10%. Measurement of the washer face diameter shall be taken 0.004 in. below the bearing surface plane toward the head of the screw.

Die seams are not allowed on the washer faces of screws.

4.4 Bearing Surface Runout

Runout of the bearing surface with respect to the axis of the body shall be within the full indicator measurement (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

Table 6 Dimensions of Hex Cap Screws



6

Nominal Size or Basic Product Diameter	Body Diameter, E (See Para. 4.6)		Width Across Flats, F (See Para. 2.1.2)			Width Across Corners, G		Head Height, H			Minimum Wrenching Height, J	Thread Length for Screw Lengths, L _T (See Para. 4.7)		Transition Thread Length, Y (See Para. 4.7) Reference	Maximum Total Runout of Bearing Surface FIM (See Para. 4.4)	
	Max.	Min.	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.		6 in. and Shorter	Over 6 in.			
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	2.250	2.175	2.598	2.480	15/16	0.974	0.902	0.640	3.250	3.500	0.833	0.039
1 5/8	1.6250	1.6250	1.6130	2 7/16	2.438	2.356	2.815	2.686	1	1.038	0.962	0.694	3.500	3.750	0.909	0.043

Table 6 Dimensions of Hex Cap Screws (Cont'd)

Nominal Size or Basic Product Diameter	Body Diameter, <i>E</i> (See Para. 4.6)		Width Across Flats, <i>F</i> (See Para. 2.1.2)			Width Across Corners, <i>G</i>		Head Height, <i>H</i>			Minimum Wrenching Height, <i>J</i>	Thread Length for Screw Lengths, <i>L_T</i> (See Para. 4.7)		Transition Thread Length, <i>Y</i> (See Para. 4.7) Reference	Maximum Total Runout of Bearing Surface FIM (See Para. 4.4)
	Max.	Min.	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.		6 in. and Shorter	Over 6 in.		
1 ³ / ₄	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
1 ⁷ / ₈	1.8750	1.8630	2 ¹³ / ₁₆	2.812	2.719	3.248	3.099	1 ⁵ / ₃₂	1.198	1.114	0.802	4.000	4.250	1.000	0.049
2	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	2.2380	3 ³ / ₈	3.375	3.262	3.897	3.719	1 ³ / ₈	1.423	1.327	0.933	...	5.000	1.111	0.059
2 ¹ / ₂	2.5000	2.4880	3 ³ / ₄	3.750	3.625	4.330	4.133	1 ¹⁷ / ₃₂	1.583	1.479	1.042	...	5.500	1.250	0.065
2 ³ / ₄	2.7500	2.7380	4 ¹ / ₈	4.125	3.988	4.763	4.546	1 ¹¹ / ₁₆	1.744	1.632	1.151	...	6.000	1.250	0.072
3	3.0000	2.9880	4 ¹ / ₂	4.500	4.350	5.196	4.959	1 ⁷ / ₈	1.935	1.815	1.290	...	6.500	1.250	0.079

GENERAL NOTE:

- (a) See Table 10 for underhead fillet dimensions and Table 11 for *L_G*, max. and *L_B*, min. dimensions for fully threaded short screws.
- (b) Refer to section 4 for further information.

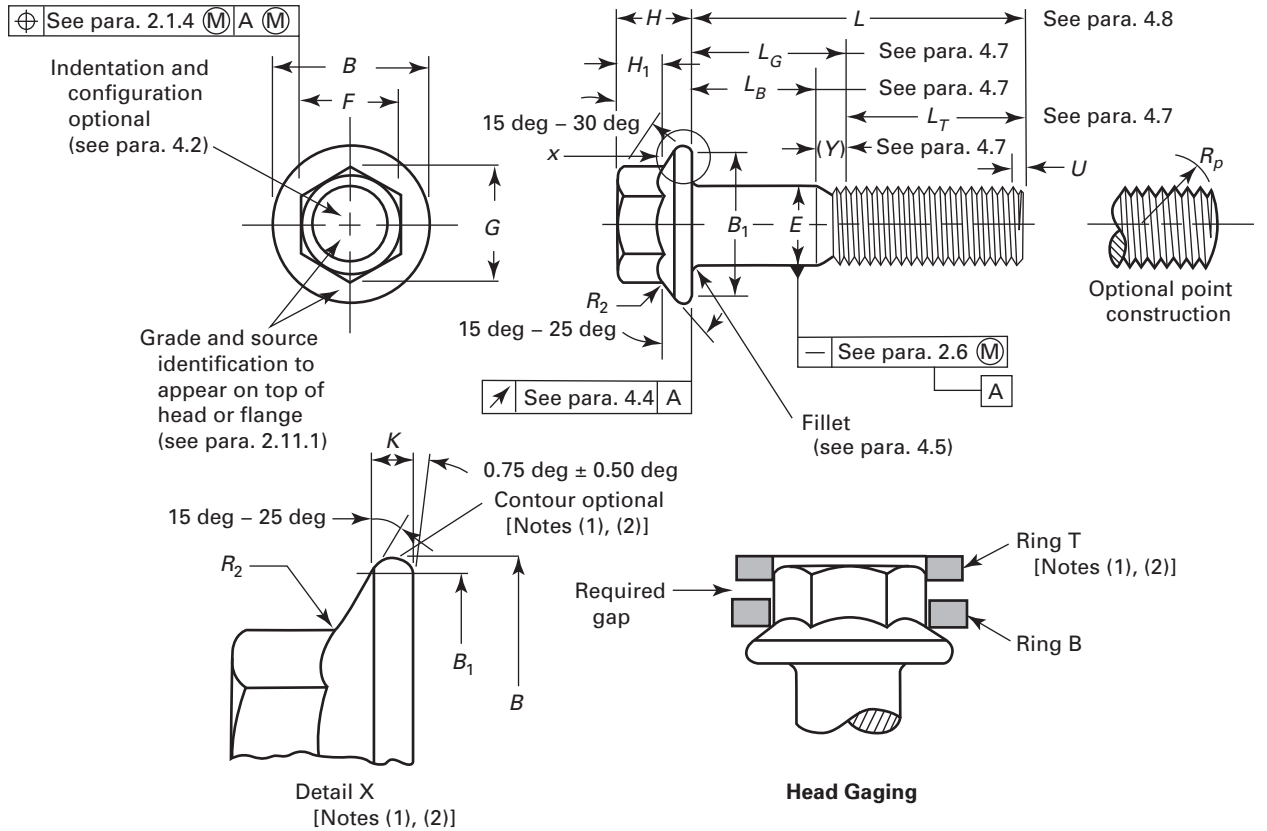
Table 7 Dimensions of Heavy Hex Screws

Nominal Size or Basic Product Diameter	Body Diameter, <i>E</i> (See Para. 4.6)		Width Across Flats, <i>F</i> (See Para. 2.1.2)		Width Across Corners, <i>G</i>		Head Height, <i>H</i>		Minimum Wrenching Height, <i>J</i>	Thread Length for Screw Lengths, <i>L_T</i> (See Para. 4.7)		Transition Thread Length, <i>Y</i> (See Para. 4.7) Reference	Maximum Total Runout of Bearing Surface FIM (See Para. 4.4)
	Max.	Min.	Basic	Max.	Min.	Max.	Min.	6 in. and Shorter		Over 6 in.			
						Basic	Max.	Nom.		Nom.			
3/8	0.3750	0.360	1 1/16	0.688	0.669	0.794	0.763	15/64	0.243	0.226	1.000	1.250	0.014
1/2	0.5000	0.482	7/8	0.875	0.850	1.010	0.969	5/16	0.323	0.302	1.250	1.500	0.016
5/8	0.6250	0.605	1 1/16	1.062	1.031	1.227	1.175	25/64	0.403	0.378	1.500	1.750	0.019
3/4	0.7500	0.729	1 1/4	1.250	1.212	1.443	1.383	15/32	0.483	0.455	1.750	2.000	0.022
7/8	0.8750	0.852	1 1/2	1.438	1.394	1.660	1.589	35/64	0.563	0.531	2.000	2.250	0.025
1	1.0000	0.976	1 5/8	1.625	1.575	1.876	1.796	39/64	0.627	0.591	2.250	2.500	0.028
1 1/8	1.1250	1.098	1 15/16	1.812	1.756	2.093	2.002	1 1/16	0.718	0.658	2.500	2.750	0.032
1 1/4	1.2500	1.223	2	2.000	1.938	2.309	2.209	25/32	0.813	0.749	2.750	3.000	0.035
1 3/8	1.3750	1.345	2 3/16	2.188	2.119	2.526	2.416	27/32	0.878	0.810	3.000	3.250	0.038
1 1/2	1.5000	1.470	2 3/8	2.375	2.300	2.742	2.622	1 1/8	0.974	0.902	3.250	3.500	0.041
1 5/8	1.6250	1.591	2 9/16	2.562	2.481	2.959	2.829	1	1.038	0.962	3.500	3.750	0.044
1 3/4	1.7500	1.716	2 3/4	2.750	2.662	3.175	3.035	1 3/32	1.134	1.054	3.750	4.000	0.048
1 7/8	1.8750	1.839	2 15/16	2.938	2.844	3.392	3.242	1 7/32	1.198	1.114	4.000	4.250	0.052
2	2.0000	1.964	3 1/8	3.125	3.025	3.608	3.449	1 1/2	1.263	1.175	4.250	4.500	0.055
2 1/4	2.2500	2.214	3 1/2	3.500	3.388	4.041	3.862	1 3/8	1.423	1.327	...	5.000	0.061
2 1/2	2.5000	2.4610	3 7/8	3.8750	3.750	4.474	4.275	1 3/2	1.583	1.479	...	5.500	0.068
2 3/4	2.7500	2.7110	4 1/4	4.2500	4.112	4.907	4.688	1 7/16	1.744	1.632	...	6.000	0.074
3	3.0000	2.9610	4 5/8	4.6250	4.475	5.340	5.102	1 7/8	1.935	1.815	...	6.500	0.081
3 1/4	3.2500	3.2100	5	5.0000	4.838	5.774	5.515	2	2.126	1.998	...	7.000	0.091
3 1/2	3.5000	3.4610	5 3/8	5.3750	5.200	6.207	5.928	2 1/4	2.256	2.120	...	7.500	0.098
3 3/4	3.7500	3.7109	5 3/4	5.7500	5.562	6.640	6.341	2 3/8	2.447	2.303	...	8.000	0.105
4	4.0000	3.9609	6 1/8	6.1250	5.925	7.073	6.755	2 1/2	2.576	2.424	...	8.500	0.112
4 1/4	4.2500	4.2228	6 1/2	6.5000	6.288	7.506	7.168	2 3/4	2.768	2.608	...	9.000	0.119
4 1/2	4.5000	4.4727	6 5/8	6.8750	6.650	7.939	7.581	2 7/8	2.896	2.728	...	9.500	0.126
4 3/4	4.7500	4.7227	7 1/4	7.2500	7.012	8.372	7.994	3	3.088	2.912	...	10.00	0.133
5	5.0000	4.9726	7 5/8	7.6250	7.375	8.805	8.408	3 1/8	3.217	3.033	...	10.500	0.14
5 1/4	5.2500	5.2226	8	8.0000	7.738	9.238	8.821	3 3/8	3.408	3.216	...	11.000	0.147
5 1/2	5.5000	5.4726	8 3/8	8.3750	8.100	9.671	9.234	3 1/2	3.538	3.338	...	11.500	0.154
5 3/4	5.7500	5.7225	8 3/4	8.7500	8.462	10.104	9.647	3 5/8	3.729	3.521	...	12.000	0.161
6	6.0000	5.9725	9 1/8	9.1250	8.825	10.537	10.060	3 3/4	3.858	3.642	...	12.500	0.168

GENERAL NOTES:

- (a) *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.
- (b) Refer to section 4 for further information.

Table 8 Dimensions of Hex Flange Screws



Nominal Size or Basic Major Diam. of Thread	Body Diam., <i>E</i>		Width Across Flats, <i>F</i> (See Para. 2.1.2)			Width Across Corners, <i>G</i>		Maximum Flange Diam., <i>B</i>	Minimum Flange Thickness, <i>K</i>	Maximum Head Height, <i>H</i>	Minimum Hex Height, <i>H</i> ₁	Maximum Flange Top Radius, <i>R</i> ₂	
	Max.	Min.	Basic	Max.	Min.	Max.	Min.						
1/4	0.2500	0.2500	0.2450	3/8	0.3750	0.367	0.433	0.409	0.56	0.04	0.28	0.17	0.015
5/16	0.3125	0.3125	0.3065	1/2	0.5000	0.489	0.577	0.548	0.68	0.05	0.32	0.21	0.019
3/8	0.3750	0.3750	0.3690	9/16	0.5625	0.551	0.650	0.618	0.81	0.06	0.39	0.25	0.022
7/16	0.4375	0.4375	0.4305	5/8	0.6250	0.612	0.722	0.685	0.93	0.07	0.46	0.30	0.026
1/2	0.5000	0.5000	0.4930	3/4	0.7500	0.736	0.866	0.825	1.07	0.08	0.51	0.34	0.030
9/16	0.5625	0.5625	0.5545	13/16	0.8125	0.798	0.938	0.895	1.19	0.09	0.57	0.38	0.034
5/8	0.6250	0.6250	0.6170	15/16	0.9375	0.922	1.083	1.034	1.33	0.10	0.62	0.42	0.038
3/4	0.7500	0.7500	0.7410	1 1/8	1.1250	1.100	1.299	1.234	1.59	0.11	0.73	0.51	0.045

Table 8 Dimensions of Hex Flange Screws (Cont'd)

Nominal Size or Basic Major Diam. of Thread	Minimum Bearing Diam., B_1	Maximum Runout of Bearing Surface FIM	Thread Length, L_T		Maximum Transition Thread Length, Y		Ring T		Ring B		
			For Screws With $L \leq$ 6 in.	For Screws With $L >$ 6 in.	For Screws With $L \leq$ 6 in.	For Screws With $L >$ 6 in.	Inside Diameter +0.0000 -0.0003	Minimum Thickness	Inside Diameter +0.0000 -0.0003	Thickness +0.0000 -0.0003	
			Basic	Basic							
$\frac{1}{4}$	0.2500	0.480	0.010	0.750	1.000	0.400	0.650	0.4380	0.500	0.4093	0.0514
$\frac{5}{16}$	0.3125	0.600	0.011	0.875	1.125	0.417	0.667	0.5820	0.500	0.5483	0.0643
$\frac{3}{8}$	0.3750	0.730	0.012	1.000	1.250	0.438	0.688	0.6550	0.500	0.6183	0.0771
$\frac{7}{16}$	0.4375	0.850	0.013	1.125	1.375	0.464	0.714	0.7300	0.500	0.6853	0.0900
$\frac{1}{2}$	0.5000	0.980	0.014	1.250	1.500	0.481	0.731	0.8750	0.500	0.8253	0.1029
$\frac{9}{16}$	0.5625	1.100	0.015	1.375	1.625	0.750	0.750	0.9500	0.500	0.8953	0.1157
$\frac{5}{8}$	0.6250	1.230	0.017	1.500	1.750	0.773	0.773	1.0750	0.500	1.0343	0.1286
$\frac{3}{4}$	0.7500	1.470	0.020	1.750	2.000	0.800	0.800	1.3120	0.500	1.2343	0.1543

GENERAL NOTE: Refer to section 4 for further information.

NOTES:

- (1) Head acceptability shall be determined using the two rings described in Table 10. Ring B shall be placed on the screw head followed by Ring T. The head is acceptable if ring T does not contact ring B after both rings are in place on the head.
- (2) The top surface of the flange shall be conical or slightly rounded (convex). Radius, R_2 , applies both at the corners and at the flats of the hexagon. The contour of edge at flange periphery, between the maximum flange diameter, B , max., and the minimum bearing circle diameter, B_1 , min., shall be optional provided that the minimum flange edge thickness, K , min., is maintained at the minimum bearing circle diameter, B_1 , min.

gripping device at a distance of one screw diameter from the underside of the head.

4.5 Fillet

Two styles of head-to-shank fillets are provided for long screws in lengths longer than the maximum lengths specified in Table 10. Style 1 will be supplied unless Style 2 is specified by the purchaser.

Style 1 is a continuous radius in accordance with the maximum-minimum limits for R shown in Table 10.

Style 2 has an elliptical shape defined as a smooth, multiradius, concave curve tangent to the underhead bearing surface at a point no greater than one-half of E_{ar} max. or less than one-half of E_{ar} 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_f . No radius in the fillet shall be less than R , min. (see Fig. 1 and Table 10).

For short screws threaded full length (Table 10), the fillet shall be a smooth, concave curve lying within the envelope established by either

(a) a continuous radius tangent to the underhead bearing surface and min./max. shank diameter E_1 , min. (minimum pitch diameter) to E , max., whose value shall be no less than R , min. as specified in Table 10 or

(b) a continuous or multiradius curve tangent to the underhead bearing surface at a point no greater than one-half E_{ar} max. from the axis of screw and tangent to the maximum shank diameter, E , max., at a distance not exceeding L_f max. from the bearing surface

No radius in the multiradius curve shall be less than R , min. specified in Table 10 (see Fig. 2), where

$$L_f, \text{ max.} = \frac{E_{ar} \text{ max.} - E_1, \text{ min.}}{2}$$

E_1 , min. = minimum specified pitch diameter of coarse thread: UNC-2A

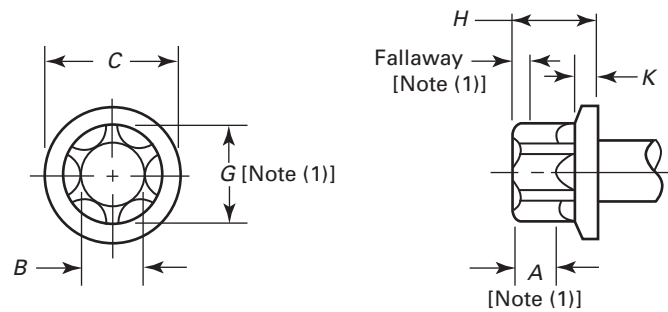
E_{ar} max. = maximum fillet transition diameter (see Table 10)

$$E_{1ar} \text{ min.} = E_{ar} \text{ max.} - 0.5 (E_{ar} \text{ max.} - E_1, \text{ min.})$$

4.6 Body Diameter

The diameter of body, except for a length equal to L_{ar} max. under the head, shall conform to the limits for E given in Tables 6 through 9. The diameter of the unthreaded length on short screws that are threaded for full length shall not be less than the minimum pitch diameter of the thread nor greater than the nominal diameter specified in Tables 6 through 9.

A die seam and swell or fin is permissible along the body diameter respectively for screws over 1 in. Any die seam, swell, or fin shall not exceed the basic screw diameter by more than shown below. When specified by the purchaser, the die seam and swell on the body shall be removed. Upon completion of the machining, all dimensions and geometric requirements specified for the bearing surface and body diameter shall be met.

Table 9 Dimensions of Lobed Head Screws

Nominal Size or Basic Major Diam. of Thread		Width Across Corners, <i>G</i>		Head Height, <i>H</i>		Flange Thickness, <i>K</i>		Flange Diam., <i>C</i>		Maximum Minor Diam., <i>B</i>	Drive Size
		Reference	Max.	Min.	Max.	Min.	Max.	Min.			
$\frac{1}{4}$	0.2500	0.2870	0.255	0.245	0.070	0.060	0.375	0.365	0.2073	E8	
$\frac{5}{16}$	0.3125	0.3620	0.323	0.313	0.100	0.090	0.469	0.457	0.2663	E10	
$\frac{3}{8}$	0.3750	0.4310	0.394	0.384	0.125	0.115	0.562	0.550	0.3103	E12	
$\frac{7}{16}$	0.4375	0.4990	0.472	0.462	0.155	0.145	0.656	0.642	0.3613	E14	
$\frac{1}{2}$	0.5000	0.5710	0.515	0.505	0.160	0.150	0.750	0.735	0.4113	E16	
$\frac{9}{16}$	0.5625	0.6450	0.551	0.541	0.165	0.153	0.844	0.828	0.4663	E18	
$\frac{5}{8}$	0.6250	0.7150	0.630	0.620	0.200	0.188	0.938	0.921	0.5183	E20	
$\frac{3}{4}$	0.7500	0.8600	0.787	0.777	0.255	0.243	1.125	1.107	0.6183	E24	
$\frac{7}{8}$	0.8750	1.0000	0.866	0.856	0.270	0.260	1.312	1.293	0.7193	E28	
1	1.0000	1.1380	1.063	1.053	0.355	0.343	1.500	1.479	0.8393	E32	
$1\frac{1}{8}$	1.1250	1.2800	1.181	1.171	0.382	0.370	1.688	1.665	0.9433	E36	
$1\frac{1}{4}$	1.2500	1.4200	1.299	1.289	0.422	0.410	1.875	1.852	1.0463	E40	
$1\frac{3}{8}$	1.3750	1.5620	1.417	1.407	0.453	0.441	2.062	2.038	1.1513	E44	

GENERAL NOTE: Refer to section 4 for further information.

NOTE:

- (1) Fallaway, *G*, *A*, *B*, and other configuration characteristic acceptance shall be determined based on the gage and gaging practice in Mandatory Appendix I.

Table 10 Dimensions of Underhead Fillets

Nominal Size or Basic Product Diameter	Long Screws (See Fig. 1)					Long and Short Screws		Short Screws (See Fig. 2)	
	Fillet Transition Diameter, E_a		Fillet Length, L_a		Radius of Fillet, R		Maximum Fillet Transition Diameter, E_a	Maximum Fillet Length, L_f	
	Max.	Min.	Max.	Min.	Max.	Min.			
1/4	0.2500	0.300	0.280	0.087	0.043	0.025	0.015	0.300	0.043
5/16	0.3125	0.362	0.342	0.087	0.043	0.025	0.015	0.362	0.045
3/8	0.3750	0.425	0.405	0.087	0.043	0.025	0.015	0.425	0.048
7/16	0.4375	0.488	0.468	0.087	0.043	0.025	0.015	0.488	0.052
1/2	0.5000	0.550	0.530	0.087	0.043	0.025	0.015	0.550	0.053
9/16	0.5625	0.652	0.602	0.157	0.078	0.045	0.020	0.652	0.075
5/8	0.6250	0.715	0.665	0.157	0.078	0.045	0.020	0.715	0.078
3/4	0.7500	0.840	0.790	0.157	0.078	0.045	0.020	0.840	0.081
7/8	0.8750	1.005	0.955	0.227	0.113	0.065	0.040	1.005	0.105
1	1.0000	1.190	1.120	0.332	0.166	0.095	0.060	1.190	0.140
1 1/8	1.1250	1.315	1.245	0.332	0.166	0.095	0.060	1.315	0.146
1 1/4	1.2500	1.440	1.370	0.332	0.166	0.095	0.060	1.440	0.146
1 3/8	1.3750	1.565	1.495	0.332	0.166	0.095	0.060	1.565	0.154
1 1/2	1.5000	1.690	1.620	0.332	0.166	0.095	0.060	1.690	0.154
1 3/4	1.7500	1.940	1.870	0.332	0.166	0.095	0.060	1.940	0.166
2	2.0000	2.190	2.120	0.332	0.166	0.095	0.060	2.190	0.173
2 1/4	2.2500	2.440	2.370	0.332	0.166	0.095	0.060	2.440	0.173
2 1/2	2.5000	2.690	2.620	0.332	0.166	0.095	0.060	2.690	0.183
2 3/4	2.7500	2.940	2.870	0.332	0.166	0.095	0.060	2.940	0.183
3	3.0000	3.190	3.120	0.332	0.166	0.095	0.060	3.190	0.183

Fig. 1 Underhead Fillet for Long Screws

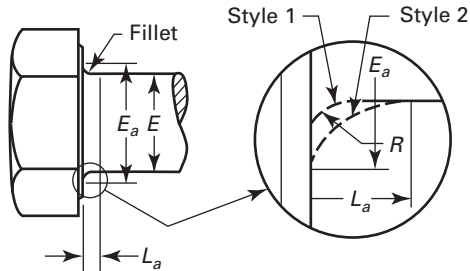


Fig. 3 L_G , Maximum and L_B , Minimum for Short Screws Threaded Full Length

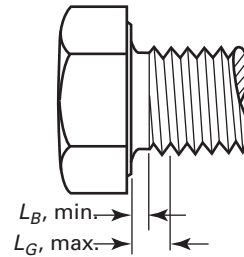


Fig. 2 Underhead Fillet for Short Screws Threaded Full Length

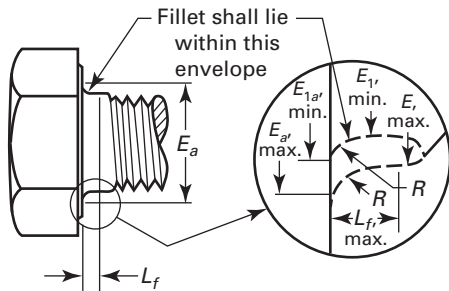


Table 11 L_G , Maximum and L_B , Minimum Limitations for Short Screws Threaded Full Length

Nominal Size of Basic Product Diameter	For Nominal Product Lengths [Note (1)]		L_G , Max. [Note (2)]		L_G , Max. [Note (3)]			L_B , Min. [Note (4)]
	Less Than or Equal to	All Thread Series	For Nominal Product Lengths		Coarse (UNC) Thread	Fine (UNF) Thread	8 (UN) Thread	All Thread Series
			Greater Than	Less Than or Equal to [Note (5)]				
1/4	0.500	0.075	0.500	1.125	0.125	0.089	...	0.043
5/16	0.625	0.083	0.625	1.250	0.139	0.104	...	0.045
3/8	0.750	0.094	0.750	1.375	0.156	0.104	...	0.048
7/16	0.875	0.107	0.875	1.625	0.179	0.125	...	0.052
1/2	1.000	0.115	1.000	1.750	0.192	0.125	...	0.053
9/16	1.125	0.125	1.125	2.000	0.208	0.139	...	0.075
5/8	1.250	0.136	1.250	2.125	0.227	0.139	...	0.078
3/4	1.500	0.150	1.500	2.500	0.250	0.156	...	0.081
7/8	...	...	...	2.750	0.278	0.179	...	0.105
1	...	...	...	3.000	0.312	0.208	...	0.140
1 1/8	...	...	...	3.500	0.357	0.208	0.312	0.146
1 1/4	...	...	...	3.750	0.357	0.208	0.312	0.146
1 3/8	...	...	...	4.250	0.417	0.208	0.312	0.154
1 1/2	...	...	...	4.500	0.417	0.208	0.312	0.154
1 3/4	...	...	...	5.125	0.500	...	0.312	0.166
2	...	...	...	5.750	0.556	...	0.312	0.173
2 1/4	...	...	...	6.500	0.556	...	0.312	0.173
2 1/2	...	...	...	7.125	0.625	...	0.312	0.183
2 3/4	...	...	...	7.625	0.625	...	0.312	0.183
3	...	...	...	8.125	0.625	...	0.312	0.183

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.
- (4) L_B , min. equals fillet length, L_f , max., as given in Table 10.
- (5) Longest screw threaded full length.

4.7 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.

For short screws threaded full length, L_G , max. and L_B , min. are given in Table 11 (see Fig. 3). Long screws not threaded full length of diameters through 1 1/2 in. and lengths through 12 in. L_G , max. and L_B , min. are specified in Table 12.

For diameter-length combinations not included in Table 11 or 12, the maximum grip gaging length, L_G , max., for long screws that are not threaded full length, as calculated and rounded to two decimal places, shall be equal to the nominal screw length minus the nominal thread length (L_G , max. = L , nom. - L_T). It shall be used as the criterion for inspection.

Nominal 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. Nominal thread length equals twice the basic thread diameter plus 0.25 in. for nominal screw length 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. For diameter length combinations not included in Table 11 or 12, the minimum body length, L_B , min., 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). It shall be a criterion for inspection.

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

4.8 Length Tolerances

Screw length tolerances are given in Table 13.

4.9 Material

Unless otherwise specified, chemical and mechanical properties of steel screws shall conform to ASTM A 449, ASTM A 354, or SAE J429. Stainless steel screws shall conform to the requirements of ASTM F 593. Nonferrous screws shall conform to the requirements of ASTM F 468.

Table 12 Maximum Grip Gaging Lengths, L_G , and Minimum Body Lengths, L_B , for Screws

Nom. Size	Nominal Length														
	1¼	1⅜	1½	1⅞	2	2¼	2½	2⅞	3	3¼	3½	3⅞			
¼	0.50/0.25	0.63/0.38	0.75/0.50	0.88/0.62	1.00/0.75	1.12/0.88	1.25/1.00	1.38/1.12	1.50/1.25	1.62/1.38	1.75/1.50	1.88/1.62	2.00/1.75	2.12/1.88	2.52/2.00
5/16	Full thread	0.50/0.22	0.62/0.35	0.75/0.47	0.88/0.60	1.00/0.72	1.12/0.85	1.25/0.97	1.38/1.10	1.50/1.22	1.62/1.35	1.75/1.47	1.88/1.60	2.00/1.72	2.12/1.85
3/8	Full thread	Full thread	0.50/0.19	0.62/0.31	0.75/0.44	0.88/0.56	1.00/0.69	1.12/0.81	1.25/0.94	1.38/1.06	1.50/1.19	1.62/1.31	1.75/1.44	1.88/1.56	2.00/1.69
7/16	Full thread	Full thread	Full thread	Full thread	0.63/0.27	0.75/0.39	0.88/0.52	1.00/0.64	1.12/0.77	1.25/0.89	1.38/1.02	1.50/1.14	1.62/1.27	1.75/1.39	1.88/1.52
1/2	Full thread	Full thread	Full thread	Full thread	Full thread	0.63/0.24	0.75/0.38	0.88/0.49	1.00/0.62	1.12/0.74	1.25/0.86	1.38/0.99	1.50/1.12	1.62/1.24	1.75/1.36
9/16	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	0.75/0.33	0.88/0.45	1.00/0.58	1.12/0.75	1.25/0.83	1.38/0.96	1.50/1.08	1.62/1.21
5/8	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	0.75/0.30	0.88/0.42	1.00/0.55	1.12/0.67	1.25/0.80	1.38/0.92	1.50/1.05
3/4	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	0.88/0.38	1.00/0.50	1.12/0.62	1.25/0.75
7/8	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	0.88/0.32	1.00/0.44
1	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread
1⅛	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread
1¼	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread
1⅝	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread
1¾	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread
1½	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread

Table 12 Maximum Grip Gaging Lengths, L_G , and Minimum Body Lengths, L_B , for Screws (Cont'd)

Nom. Size	Nominal Length														
	3 ¹ / ₄	3 ¹ / ₂	3 ³ / ₄	4	4 ¹ / ₄	4 ¹ / ₂	4 ³ / ₄	5	5 ¹ / ₄	5 ¹ / ₂	5 ³ / ₄	6	6 ¹ / ₄	6 ¹ / ₂	6 ³ / ₄
1/4	$L_G, \max/L_B, \min$	2.50/2.25	2.75/2.50	3.00/2.75	3.25/3.00	3.50/3.25	3.75/3.50	4.00/3.75	4.25/4.00	4.50/4.25	4.75/4.50	5.00/4.75	5.25/5.00	5.50/5.25	5.75/5.50
5/16	$L_G, \max/L_B, \min$	2.38/2.10	2.62/2.35	2.88/2.60	3.12/2.85	3.38/3.10	3.62/3.35	3.88/3.60	4.12/3.85	4.38/4.10	4.62/4.35	4.88/4.60	5.12/4.85	5.38/5.10	5.62/5.35
3/8	$L_G, \max/L_B, \min$	2.25/1.94	2.50/2.19	2.75/2.44	3.00/2.69	3.25/2.94	3.50/3.19	3.75/3.44	4.00/3.69	4.25/3.94	4.50/4.19	4.75/4.44	5.00/4.69	5.25/4.94	5.50/5.19
7/16	$L_G, \max/L_B, \min$	2.12/1.77	2.38/2.02	2.62/2.27	2.88/2.52	3.12/2.77	3.38/3.02	3.62/3.27	3.88/3.52	4.12/3.77	4.38/4.02	4.63/4.27	4.88/4.52	5.12/4.77	5.38/5.02
1/2	$L_G, \max/L_B, \min$	2.00/1.62	2.25/1.86	2.50/2.12	2.75/2.36	3.00/2.62	3.25/2.86	3.50/3.12	3.75/3.36	4.00/3.62	4.25/3.87	4.50/4.12	4.75/4.36	5.00/4.62	5.25/4.86
9/16	$L_G, \max/L_B, \min$	1.88/1.46	2.12/1.71	2.38/1.96	2.62/2.21	2.88/2.46	3.12/2.71	3.38/2.96	3.62/3.21	3.88/3.46	4.12/3.71	4.38/3.96	4.62/4.21	4.88/4.45	5.12/4.71
5/8	$L_G, \max/L_B, \min$	1.75/1.30	2.00/1.55	2.25/1.80	2.50/2.05	2.75/2.30	3.00/2.55	3.25/2.80	3.50/3.05	3.75/3.30	4.00/3.55	4.25/3.80	4.50/4.05	4.75/4.30	5.00/4.55
3/4	$L_G, \max/L_B, \min$	1.50/1.00	1.75/1.25	2.00/1.50	2.25/1.75	2.50/2.00	2.75/2.25	3.00/2.50	3.25/2.75	3.50/3.00	3.75/3.25	4.00/3.50	4.25/3.75	4.50/4.00	4.75/4.25
7/8	$L_G, \max/L_B, \min$	1.25/0.69	1.50/0.94	1.75/1.19	2.00/1.44	2.25/1.69	2.50/1.94	2.75/2.19	3.00/2.44	3.25/2.69	3.50/2.94	3.75/3.19	4.00/3.44	4.25/3.69	4.50/3.94
1	$L_G, \max/L_B, \min$	1.00/0.38	1.25/0.62	1.50/0.88	1.75/1.12	2.00/1.38	2.25/1.62	2.50/1.88	2.75/2.12	3.00/2.38	3.25/2.62	3.50/2.88	3.75/3.12	4.00/3.38	4.25/3.63
1 1/8	$L_G, \max/L_B, \min$	Full thread	Full thread	1.25/0.54	1.50/0.79	1.75/1.04	2.00/1.29	2.25/1.54	2.50/1.79	2.75/2.04	3.00/2.29	3.25/2.54	3.50/2.79	3.75/3.04	4.00/3.29
1 1/4	$L_G, \max/L_B, \min$	Full thread	Full thread	Full thread	1.25/0.54	1.50/0.79	1.75/1.04	2.00/1.29	2.25/1.54	2.50/1.79	2.75/2.04	3.00/2.29	3.25/2.54	3.50/2.79	3.75/3.04
1 3/8	$L_G, \max/L_B, \min$	Full thread	Full thread	Full thread	Full thread	Full thread	1.50/0.79	1.75/1.04	2.00/1.29	2.25/1.54	2.50/1.79	2.75/2.04	3.00/2.29	3.25/2.54	3.50/2.79
1 1/2	$L_G, \max/L_B, \min$	Full thread	Full thread	Full thread	Full thread	Full thread	Full thread	1.50/0.67	1.75/0.92	2.00/1.17	2.25/1.42	2.50/1.67	2.75/1.92	3.00/2.17	3.25/2.42

Table 12 Maximum Grip Gaging Lengths, L_G , and Minimum Body Lengths, L_B , for Screws (Cont'd)

Nom. Size	Nominal Length														
	7	7 ¹ / ₄	7 ¹ / ₂	7 ³ / ₄	8	8 ¹ / ₄	8 ¹ / ₂	8 ³ / ₄	9	9 ¹ / ₄	9 ¹ / ₂	9 ³ / ₄	10	11	12
¹ / ₄	6.00/5.75	6.25/6.00	6.50/6.25	6.75/6.50	7.00/6.75	7.25/7.00	7.50/7.25	7.75/7.50	8.00/7.75	8.25/8.00	8.50/8.25	8.75/8.50	9.00/8.75	10.00/9.75	11.00/10.75
⁵ / ₁₆	5.88/5.60	6.12/5.85	6.38/6.10	6.62/6.35	6.88/6.60	7.12/6.85	7.38/7.10	7.62/7.35	7.88/7.60	8.12/7.85	8.38/8.10	8.62/8.35	8.88/8.60	9.88/9.60	10.88/9.60
³ / ₈	5.75/5.44	6.00/5.69	6.25/5.94	6.50/6.19	6.75/6.44	7.00/6.69	7.25/6.94	7.50/7.19	7.75/7.44	8.00/7.69	8.25/7.94	8.50/8.19	8.75/8.44	9.75/9.44	10.75/10.44
⁷ / ₁₆	5.62/5.27	5.88/5.52	6.12/5.77	6.38/6.02	6.62/6.27	6.88/6.52	7.12/6.77	7.38/7.02	7.62/7.27	7.88/7.52	8.12/7.77	8.38/8.02	8.62/8.27	9.62/9.27	10.62/10.27
¹ / ₂	5.50/5.12	5.75/5.36	6.00/5.62	6.25/5.87	6.50/6.12	6.75/6.36	7.00/6.62	7.25/6.86	7.50/7.12	7.75/7.36	8.00/7.62	8.25/7.86	8.50/8.12	9.50/8.12	10.50/9.12
⁹ / ₁₆	5.38/4.96	5.62/5.20	5.88/5.46	6.12/5.71	6.38/5.96	6.62/6.21	6.88/6.46	7.12/6.71	7.38/6.96	7.62/7.21	7.88/7.46	8.12/7.71	8.38/7.96	9.38/8.96	10.38/9.96
⁵ / ₈	5.25/4.80	5.50/5.05	5.75/5.30	6.00/5.55	6.25/5.80	6.50/6.05	6.75/6.30	7.00/6.55	7.25/6.80	7.50/7.05	7.75/7.30	8.00/7.55	8.25/7.80	9.25/8.80	10.25/9.80
³ / ₄	5.00/4.50	5.25/4.75	5.50/5.00	5.75/5.25	6.00/5.50	6.25/5.75	6.50/6.00	6.75/6.25	7.00/6.50	7.25/6.75	7.50/7.00	7.75/7.25	8.00/7.50	9.00/8.50	10.00/9.50
⁷ / ₈	4.75/4.19	5.00/4.44	5.25/4.69	5.50/4.94	5.75/5.19	6.00/5.44	6.25/5.69	6.50/5.94	6.75/6.19	7.00/6.44	7.25/6.89	7.50/6.94	7.75/7.19	8.75/8.19	9.75/9.19
1	4.50/3.88	4.75/4.12	5.00/4.38	5.25/4.52	5.50/4.88	5.75/5.12	6.00/5.38	6.25/5.62	6.50/5.88	6.75/6.12	7.00/6.38	7.25/6.62	7.50/6.88	8.50/7.88	9.50/8.88
¹ / ₂	4.25/3.54	4.50/3.79	4.75/4.04	5.00/4.29	5.25/4.54	5.50/4.79	5.75/5.04	6.00/5.29	6.25/5.54	6.50/5.79	6.75/6.04	7.00/6.29	7.25/6.54	8.25/7.54	9.25/8.54
¹ / ₄	4.00/3.29	4.25/3.54	4.50/3.79	4.75/4.04	5.00/4.29	5.25/4.54	5.50/4.79	5.75/5.04	6.00/5.29	6.25/5.54	6.50/5.79	6.75/6.04	7.00/6.29	8.00/6.29	9.00/7.29
¹ / ₈	3.75/3.04	4.00/3.29	4.25/3.54	4.50/3.79	4.75/4.04	5.00/4.29	5.25/4.54	5.50/4.79	5.75/5.04	6.00/5.29	6.25/5.54	6.50/5.79	6.75/6.04	7.75/7.04	8.75/8.04
¹ / ₂	3.50/2.67	3.75/2.92	4.00/3.17	4.25/3.42	4.50/3.67	4.75/3.92	5.00/4.17	5.25/4.42	5.50/4.67	5.75/4.92	6.00/5.17	6.25/5.42	6.50/5.67	7.50/6.67	8.50/7.67

Table 13 Length Tolerances for Screws

Nominal Length	Nominal Size					
	$\frac{1}{4}$ to $\frac{3}{8}$	$\frac{7}{16}$ and $\frac{1}{2}$	$\frac{9}{16}$ to $\frac{3}{4}$	$\frac{7}{8}$ and 1	$1\frac{1}{8}$ to $1\frac{1}{2}$	Over $1\frac{1}{2}$
Up to 1 in., incl.	+0.00	+0.00	+0.00	...	...	...
	-0.03	-0.03	-0.03	...	...	...
Over 1 in. to $2\frac{1}{2}$ in., incl.	+0.00	+0.00	+0.00	+0.00	+0.00	+0.00
	-0.04	-0.06	-0.08	-0.10	-0.12	-0.18
Over $2\frac{1}{2}$ in. to 4 in., incl.	+0.00	+0.00	+0.00	+0.00	+0.00	+0.00
	-0.06	-0.08	-0.10	-0.14	-0.16	-0.20
Over 4 in. to 6 in., incl.	+0.00	+0.00	+0.00	+0.00	+0.00	+0.00
	-0.10	-0.10	-0.10	-0.16	-0.18	-0.22
Longer than 6 in.	+0.00	+0.00	+0.00	+0.00	+0.00	+0.00
	-0.18	-0.18	-0.18	-0.20	-0.22	-0.24

4.10 Additional Requirements

For additional requirements, see sections 1 and 2.

5 LAG SCREWS

5.1 General

Square lag and hex lag screws are presented in Tables 14 and 15.

5.2 Head Taper

Maximum width across flats and corners 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 and corners. (This is not applicable to askew head bolts.)

5.3 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. When specified by the purchaser, the die seam shall be removed. Upon completion of the machining, all dimensions and geometric requirements specified for the bearing surface and head shall be met.

5.4 Body Diameter

Any swell or fin under the head or any die seam on the body shall not exceed the basic bolt diameter by more than the following:

(a) 0.030 in. for sizes up through $\frac{1}{2}$ in.

(b) 0.050 in. for sizes over $\frac{1}{2}$ in. through $\frac{3}{4}$ in.

(c) 0.060 in. for sizes over $\frac{3}{4}$ in. through $1\frac{1}{4}$ in.

5.5 Reduced Diameter Body

Screws may be obtained in reduced diameter body. Where reduced diameter body is specified, the body diameter shall be reduced to the blank diameter before threading, and a shoulder of full body diameter under the head shall be provided.

5.6 Thread

Dimensions for lag screw threads are contained in Table 16.

5.7 Thread Length

The minimum thread length shall be equal to one-half of the nominal screw length +0.50 in., or 6 in., whichever is shorter. Screws too short for the formula thread length shall be threaded as close to the head or shoulder as practicable.

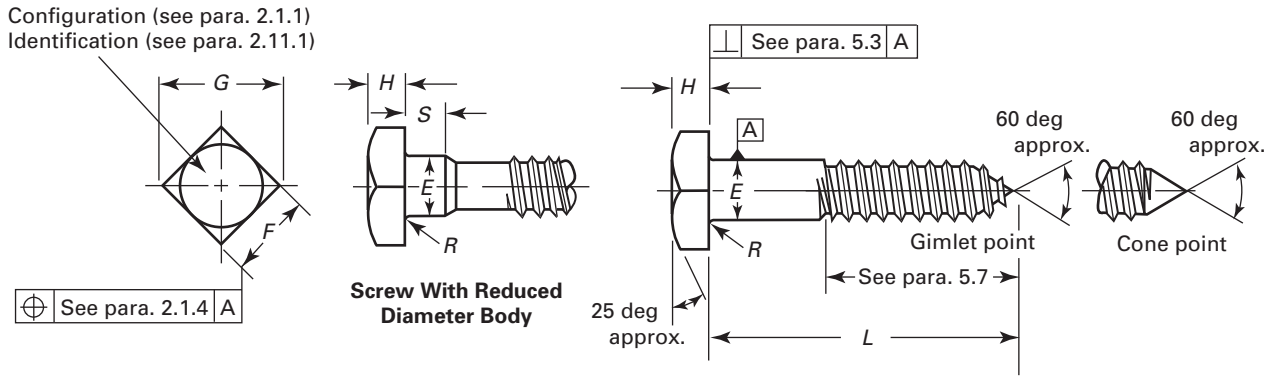
5.8 Material

Unless otherwise specified, steel screws shall conform to the low carbon steel chemical requirements only in ASTM A 307, Grade A. When stainless steel is specified, screws shall conform to the chemical requirements only of Group ASTM F 593, Group 1, Condition CW (304). When a nonferrous material is specified, screws shall conform to the chemical requirements only of ASTM F 468.

5.9 Additional Requirements

For additional requirements, see sections 1 and 2.

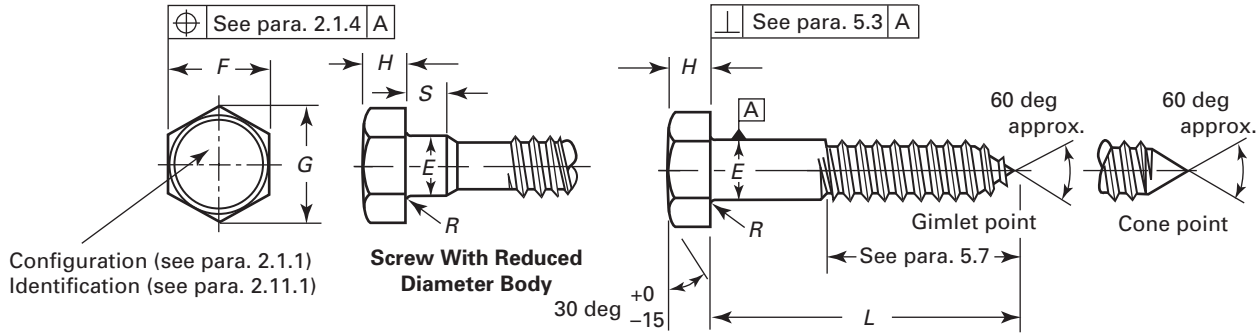
Table 14 Dimensions of Square Lag Screws



Nominal Size or Basic Product Diameter	Body or Shoulder Diameter, <i>E</i> (See Paras. 5.4 and 5.5)		Width Across Flats, <i>F</i> (See Para. 2.1.2)			Width Across Corners, <i>G</i>		Head Height, <i>H</i>			Minimum Shoulder Length, <i>S</i> (See Para. 5.5)	Radius of Fillet, <i>R</i>		
	Max.	Min.	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.		Max.	Min.	
No. 10	0.1900	0.199	0.178	$\frac{9}{32}$	0.281	0.271	0.398	0.372	$\frac{1}{8}$	0.140	0.110	0.094	0.03	0.01
$\frac{1}{4}$	0.2500	0.260	0.237	$\frac{3}{8}$	0.375	0.362	0.530	0.498	$\frac{11}{64}$	0.188	0.156	0.094	0.03	0.01
$\frac{5}{16}$	0.3125	0.324	0.298	$\frac{1}{2}$	0.500	0.484	0.707	0.665	$\frac{13}{64}$	0.220	0.186	0.125	0.03	0.01
$\frac{3}{8}$	0.3750	0.388	0.360	$\frac{9}{16}$	0.562	0.544	0.795	0.747	$\frac{1}{4}$	0.268	0.232	0.125	0.03	0.01
$\frac{7}{16}$	0.4375	0.452	0.421	$\frac{5}{8}$	0.625	0.603	0.884	0.828	$\frac{19}{64}$	0.316	0.278	0.156	0.03	0.01
$\frac{1}{2}$	0.5000	0.515	0.482	$\frac{3}{4}$	0.750	0.725	1.061	0.995	$\frac{21}{64}$	0.348	0.308	0.156	0.03	0.01
$\frac{5}{8}$	0.6250	0.642	0.605	$\frac{15}{16}$	0.938	0.906	1.326	1.244	$\frac{27}{64}$	0.444	0.400	0.312	0.06	0.02
$\frac{3}{4}$	0.7500	0.768	0.729	$1\frac{1}{8}$	1.125	1.088	1.591	1.494	$\frac{1}{2}$	0.524	0.476	0.375	0.06	0.02
$\frac{7}{8}$	0.8750	0.895	0.852	$1\frac{5}{16}$	1.312	1.269	1.856	1.742	$\frac{19}{32}$	0.620	0.568	0.375	0.06	0.02
1	1.0000	1.022	0.976	$1\frac{1}{2}$	1.500	1.450	2.121	1.991	$\frac{21}{32}$	0.684	0.628	0.625	0.09	0.03
$1\frac{1}{8}$	1.1250	1.149	1.098	$1\frac{11}{16}$	1.688	1.631	2.386	2.239	$\frac{3}{4}$	0.780	0.720	0.625	0.09	0.03
$1\frac{1}{4}$	1.2500	1.277	1.223	$1\frac{7}{8}$	1.875	1.812	2.652	2.489	$\frac{27}{32}$	0.876	0.812	0.625	0.09	0.03

GENERAL NOTE: Refer to section 5 for further information on lag screws.

Table 15 Dimensions of Hex Lag Screws



Nominal Size or Basic Product Diameter	Body or Shoulder Diameter, E (See Paras. 5.4 and 5.5)		Width Across Flats, F (See Para. 2.1.2)			Width Across Corners, G		Head Height, H			Minimum Shoulder Length, S (See Para. 5.5)	Radius of Fillet, R		
	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	15/16	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

GENERAL NOTE: Refer to section 5 for further information on lag screws.

Table 16 Dimensions of Lag Screw Threads

Nominal Size or Basic Product Diameter	Threads per Inch	Major Diameter		Root Diameter		Length Tolerance		
		Max.	Min.	Max.	Min.	≤ 6 in.	> 6 in.	
No. 10	0.190	11	0.199	0.178	0.122	0.107	±0.12	±0.25
1/4	0.250	10	0.260	0.237	0.177	0.160	±0.12	±0.25
5/16	0.312	9	0.324	0.298	0.228	0.210	±0.12	±0.25
3/8	0.375	7	0.388	0.360	0.268	0.250	±0.12	±0.25
1/2	0.500	6	0.515	0.482	0.374	0.354	±0.12	±0.25
5/8	0.625	5	0.642	0.605	0.473	0.453	±0.25	±0.25
3/4	0.750	4 1/2	0.768	0.729	0.582	0.562	±0.25	±0.25
7/8	0.875	4	0.895	0.852	0.686	0.665	±0.25	±0.25
1	1.000	3 1/2	1.022	0.976	0.784	0.760	±0.25	±0.25
1 1/8	1.125	3 1/4	1.149	1.100	0.892	0.867	±0.25	±0.25
1 1/4	1.250	3 1/4	1.277	1.223	1.017	0.987	±0.25	±0.25

GENERAL NOTE: Pilot hole sizes can be established by starting with a fractional drill size closest to the root diameter. Hard woods require a larger pilot hole size than softer woods.

MANDATORY APPENDIX I

GAGE AND GAGING PRACTICES FOR EXTERNAL LOBED HEAD DRIVE SYSTEM

I-1 SCOPE

This Standard outlines the inspection method and acceptance criteria for external fastener drive configurations having six lobes.

I-2 DEFINITIONS

drive system configuration: a gear-like shape comprising six equally spaced external radii connected by six equally spaced internal radii.

external drive: has the configuration formed on the extreme end of the product's head or shank. The configuration has an engagement length, Y , and a maximum fallaway height. The top outer edge of the configuration may be chamfered or rounded (see Fig. I-1). The gage defined in this Standard inspects those characteristics.

I-3 GAGE TYPE

Gages shall be manufactured of tool steel hardened and tempered to a minimum of Rockwell HRC 61.

I-3.1 GO Gages

The external GO gages inspect the acceptability of the configuration and its height of the external drive.

I-3.2 NO-GO Gages

The external NO-GO gages determine the amount of nonconforming configuration (fallaway) present on the external drive.

I-4 INSPECTING EXTERNAL CONFIGURATION

The gaging for the external drive is a single gage consisting of a GO on one end and a NO-GO on the other. These fixed limit gages shall conform to the specifications in Table I-1 (see Fig. I-2).

I-5 ACCEPTANCE CRITERIA

The external drive is acceptable only if it conforms to all three of the following inspections (see Fig. I-3):

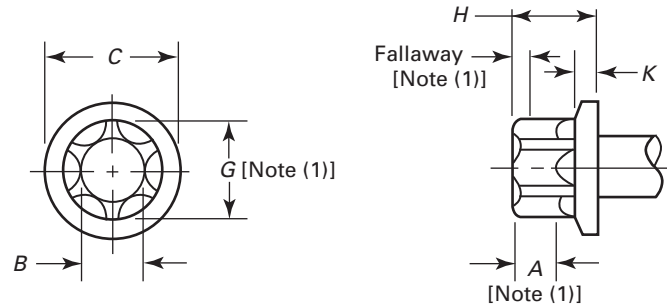
(a) *Configuration — Outside Diameter*. The product must freely enter the gage GO hole.

(b) *Fallaway*. Insert the product into the NO-GO (Fallaway) hole from the bottom of the gage. The product may enter the NO-GO hole but must not protrude above the top surface of the gage.

(c) *Engagement Length*. Insert the product into the lobed portion of the gage from the bottom. The product must enter the lobed portion of the gage and protrude above the step in the gage. Insert each product three times rotating the product each time to inspect all three pairs of interior lobes on the product. All three positions must conform.

Screws with heavy coatings that fail to meet the gaging requirements shall be stripped of the coating and inspected for acceptance in the plain (uncoated) condition.

Fig. I-1 External Lobe Head Configuration



NOTE:

(1) Fallaway, G, A, B, and other configuration characteristic acceptance shall be determined based on the gage and gaging practice in Mandatory Appendix I.

Table I-1 External Lobed Head Gage

Drive Size	A	B	R	H	L	AA	W	J	K	T
	0.0003 -0.0001	0.0003 -0.0003	0.0000 -0.0002	Ref.	Ref.	0.0003 -0.0001	Ref.	Ref.	0.0050 -0.0000	0.0000 -0.0010
E8	0.2900	0.2070	0.0635	0.2500	3.0000	0.2710	0.7500	0.4571	0.0570	0.0630
E10	0.3650	0.2660	0.0922	0.2500	3.0000	0.3480	1.0000	0.6189	0.0720	0.0790
E12	0.4340	0.3100	0.0945	0.2500	3.0000	0.4060	1.0000	0.6799	0.0900	0.1000
E14	0.5020	0.3610	0.1035	0.3750	3.0000	0.4670	1.0000	0.7598	0.1190	0.1060
E16	0.5740	0.4110	0.1185	0.3750	4.0000	0.5340	1.0000	0.8531	0.1280	0.1170
E18	0.6490	0.4660	0.1325	0.3750	4.0000	0.6020	1.5000	0.9469	0.1470	0.1440
E20	0.7190	0.5180	0.1430	0.3750	4.0000	0.6650	1.5000	1.0630	0.1610	0.1620
E24	0.8640	0.6180	0.1860	0.3750	4.0000	0.8030	1.5000	1.3382	0.2220	0.2110
E28	1.0040	0.7190	0.2150	0.3750	6.0000	0.9340	2.0000	1.5230	0.2730	0.2490
E32	1.1420	0.8390	0.2250	0.3750	6.0000	1.0500	2.0000	1.6110	0.3160	0.2710
E36	1.2840	0.9430	0.2540	0.5000	8.0000	1.1800	4.0000	1.8550	0.3620	0.3120
E40	1.4240	1.0460	0.2820	0.5000	8.0000	1.3090	4.0000	2.0990	0.4130	0.3500
E44	1.5660	1.1510	0.3100	0.5000	8.0000	1.4410	4.0000	2.2250	0.4550	0.3910

GENERAL NOTE: Material: tool steel HRC 58-62.

Fig. I-2 External Lobed Head Gauge

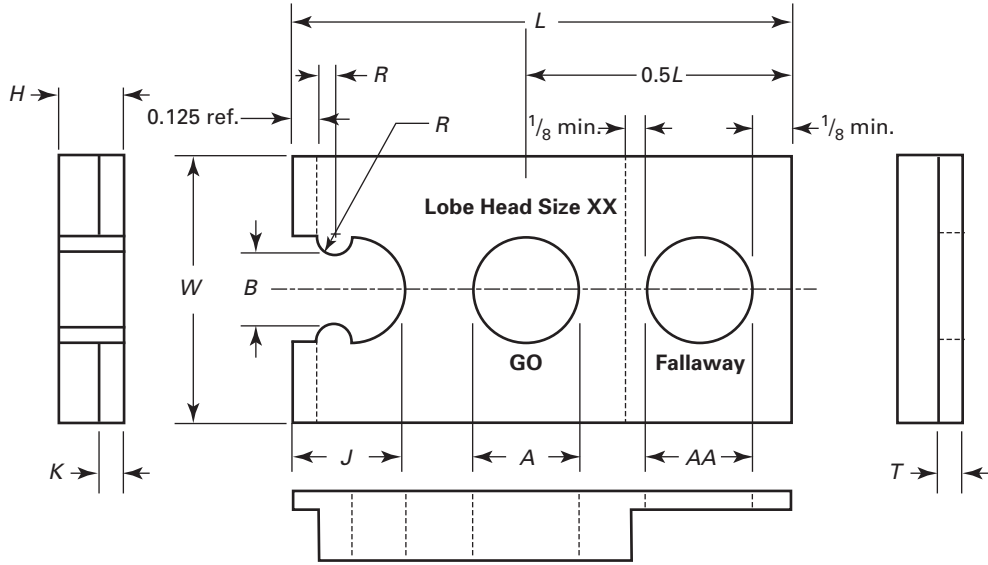
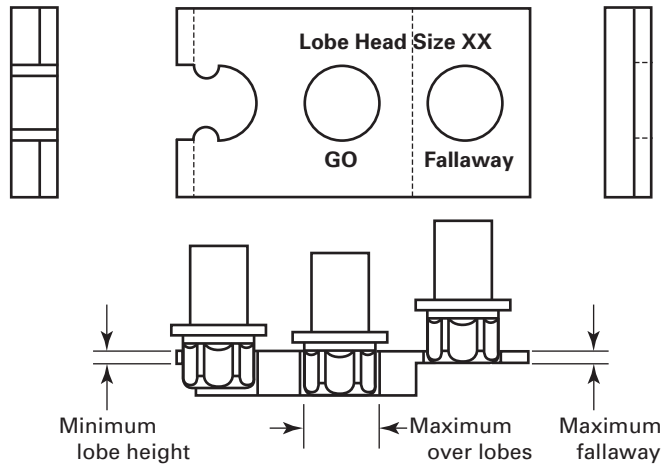


Fig. I-3 External Lobed Head Inspection



NONMANDATORY APPENDIX A FORMULAS FOR BOLT AND SCREW HEAD DIMENSIONS

See Table A-1 for formulas for bolt and screw head dimensions.

Table A-1 Head Formula

Product	Size	Width Across Flats		Head Height		Width Across Corners Limits
		Basic [Note (1)]	Tolerance (Minus)	Basic [Note (2)]	Tolerance (Plus or Minus)	
Square bolt and square lag screw	No. 10	$F = 1.5000D - 0.004$	0.050D	$H = 0.667D$	$0.016D + 0.012$	Max. $G = 1.4142$ (Max. F)
	$\frac{1}{4}$ – $1\frac{1}{2}$	$F = 1.5000D$	0.050D	$H = 0.667D$	$0.016D + 0.012$	Min. $G = 1.373$ (Min. F)
Hex bolt and hex lag screw	$\frac{1}{4}$	$F = 1.500D + 0.062$	0.050D	$H = 0.625D + 0.016$	$0.016D + 0.012$ [Note (3)]	Max. $G = 1.1547$ (Max. F) Min. $G = 1.14$ (Min. F)
	$\frac{5}{16}$ – $\frac{7}{16}$	$F = 1.500D$	0.050D	$H = 0.625D + 0.016$	$0.016D + 0.012$ [Note (3)]	
	$\frac{1}{2}$ – $\frac{7}{8}$	$F = 1.500D$	0.050D	$H = 0.625D + 0.031$	$0.016D + 0.012$ [Note (3)]	
	1 – $1\frac{7}{8}$	$F = 1.500D$	0.050D	$H = 0.625D + 0.062$	$0.016D + 0.012$ [Note (3)]	
	2 – $3\frac{3}{4}$	$F = 1.500D$	0.050D	$H = 0.625D + 0.125$	$0.016D + 0.012$ [Note (3)]	
	4	$F = 1.500D$	0.050D	$H = 0.625D + 0.188$	$0.016D + 0.012$ [Note (3)]	
Hex cap screw	$\frac{1}{4}$	$F = 1.500D + 0.062$	$0.015D + 0.006$	$H = 0.625D$	$0.015D + 0.003$	Max. $G = 1.1547$ (Max. F) Min. $G = 1.14$ (Min. F)
	$\frac{5}{16}$ – $\frac{5}{8}$	$F = 1.500D$	$0.015D + 0.006$	$H = 0.625D$	$0.015D + 0.003$	
	$\frac{3}{4}$ – $\frac{7}{8}$	$F = 1.500D$	$0.025D + 0.006$	$H = 0.625D$	$0.015D + 0.003$	
	1	$F = 1.500D$	$0.025D + 0.006$	$H = 0.625D - 0.016$	$0.015D + 0.003$	
	$1\frac{1}{8}$ – $1\frac{7}{8}$	$F = 1.500D$	0.050D	$H = 0.625D - 0.016$	$0.016D + 0.012$	
	2 – $2\frac{3}{4}$ 3–6	$F = 1.500D$ $F = 1.500D$	0.050D 0.050D	$H = 0.625D - 0.031$ $H = 0.625D$	$0.016D + 0.012$ $0.016D + 0.012$	
Heavy hex bolt	$\frac{3}{8}$ –3	$F = 1.500D + 0.125$	0.050D	Same as for hex bolt [Note (4)]	Same as for hex bolt [Note (4)]	Max. $G = 1.1547$ (Max. F) Min. $G = 1.14$ (Min. F)
Heavy hex screw	$\frac{3}{8}$ –6	$F = 1.500D + 0.125$	0.050D	Same as for hex cap screw [Note (5)]	Same as for hex cap screw [Note (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, $1\frac{1}{8}$ in. through $2\frac{1}{2}$ in. sizes adjusted upward to thirty-seconds, and $2\frac{3}{4}$ in. through 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. For sizes $3\frac{1}{4}$ in. through 4 in., minimum head height is equal to $0.625D - (0.016D + 0.012)$.
- (4) In 1960, head heights for heavy hex bolts were reduced. Prior to 1960, head heights were $0.750D + 0.062$ in. Plus tolerance was $0.016D + 0.012$ in. Minus tolerance was adjusted so that minimum head height was the 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 $0.750D + 0.31$ in. for sizes $\frac{1}{2}$ in. through $\frac{7}{8}$ in., $0.750D$ for sizes 1 in. through $1\frac{7}{8}$ in., and $0.750D - 0.062$ in. for sizes 2 in. through 3 in. Tolerance on head height for all sizes was $\pm 0.016D + 0.012$ in., where
 - D = basic (nominal) bolt or screw diameter
 - F = width across flats
 - G = width across corner

NONMANDATORY APPENDIX B

WEIGHT IN POUNDS OF 100 STEEL HEX CAP SCREWS FOR GIVEN DIAMETER/LENGTH COMBINATION

See Table B-1.

Table B-1 Weights

Lengths, Multiple of Diameter	Diameter			
	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1
3D	1.44	11.59	38.23	90.96
4D	1.74	14.35	47.56	113.04
5D	2.08	17.11	56.89	135.12
6D	2.43	19.87	66.22	157.20
7D	2.77	22.63	75.55	179.30
8D	3.12	25.39	84.88	201.30

NONMANDATORY APPENDIX C COUNTERSUNK CENTER HOLES

Plain or bell-type, 60-deg combined drills and countersinks may be used to produce countersunk center holes in the points for support of long parts under the provisions of para. 2.7 (see Tables C-1 and C-2 and ASME B94.11M-1993).

Table C-1 Maximum Allowable Countersunk Center Hole Size by Drill Designation Number for Various Basic Bolt or Screw Diameters

Bolt or Screw Diam.	Plain-Type Number								Bell-Type Number							
	1	2	3	4	5	6	7	8	11	12	13	14	15	16	17	18
$\frac{3}{16}$ through $\frac{3}{8}$	X	...	...	...	...	...	...	...	X	...	...	...	...	...	...	...
Over $\frac{3}{8}$ through $\frac{5}{8}$...	X	...	...	...	...	...	...	...	X	...	...	...	...	...	...
Over $\frac{5}{8}$ through $\frac{7}{8}$	X	...	...	...	...	...	...	...	X	...	...	...	...	...
Over $\frac{7}{8}$ through $1\frac{3}{8}$	X	...	...	...	...	...	...	...	X	...	...	...	...
Over $1\frac{3}{8}$ through 2	X	...	...	...	...	...	...	...	X	...	...	...
Over 2 through 3	X	...	...	...	...	...	...	...	X	...	...
Over 3 through 5	X	...	...	...	...	...	...	...	X	...
Over 5 through 8	X	...	...	...	...	...	...	...	X

Table C-2 Maximum Allowable Center Hole Depth

Drill Size	Depth, Max.
1	0.101
2	0.149
3	0.250
4	0.297
5	0.422
6	0.485
7	0.594
8	0.704
[Notes (1), (2)]	...

NOTES:

- (1) Based on included angle of 60 deg. Larger angles are not recommended.
- (2) Drill length tolerances of +0.008 in. through size 2 and +0.016 in. for sizes 3 through 8.

INTENTIONALLY LEFT BLANK

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, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)	B18.2.1-2010
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-2010
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 (R2010)
Straightness Gage and Gaging for Bolts and Screws	B18.2.9-2010
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 (R2010)
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
Metric Thread-Forming and Thread-Cutting Tapping Screws	B18.6.5M-2000 (R2005)
Metric Machine Screws	B18.6.7M-1999 (R2010)
Wing Nuts (Inch Series)	B18.6.9-2010
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)
Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)	B18.21.1-2009
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 (R2010)
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).....	B18.29.1-2010
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
Threaded Rods (Inch Series).....	B18.31.3-2009
Threaded Rod (Metric Series).....	B18.31.4M-2009

The ASME Publications Catalog shows a complete list of all the Standards published by the Society. For a complimentary catalog, or the latest information about our publications, call 1-800-THE-ASME (1-800-843-2763).

INTENTIONALLY LEFT BLANK

ASME B18.2.1-2010

ISBN 978-0-7918-3310-0



9 780791 833100



M04410