ASME B18.2.1-1996

[Revision of ANSI B18.2.1-1981 (R1992)]

# SQUARE AND HEX BOLTS AND SCREWS (INCH SERIES)

AN AMERICAN NATIONAL STANDARD



The American Society of Mechanical Engineers

# Erratum
# to
# ASME B18.2.1-1996
# Square and Hex Bolts and Screws (Inch Series)

On page 13, Table 4, the fourteenth entry under "Basic" in Column *H* is revised. Revision appears on the overleaf.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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July 2003

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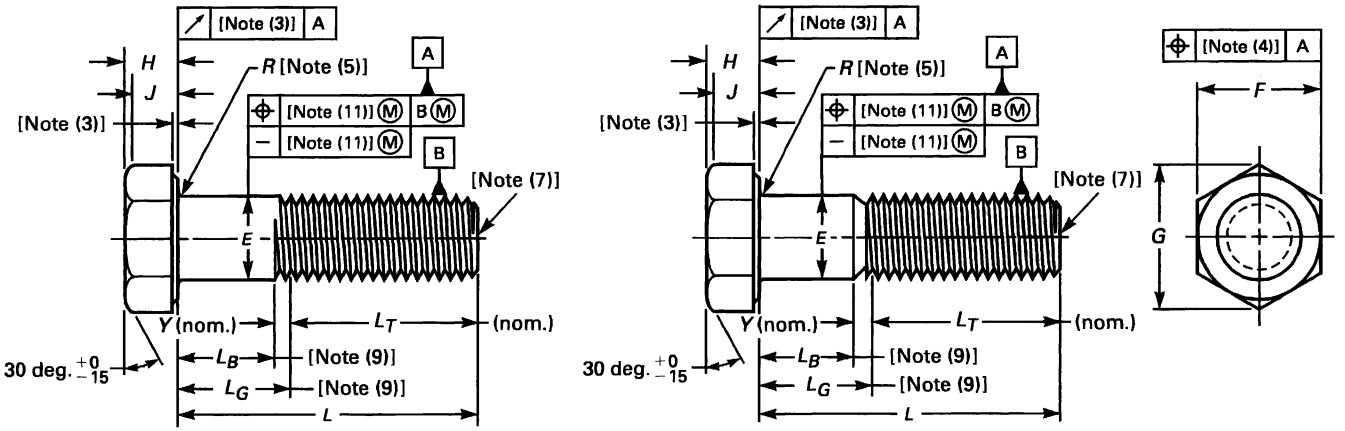


Cut Thread

Rolled Thread

## TABLE 4 DIMENSIONS OF HEX CAP SCREWS

| Nominal Size or Basic Product Diameter [Note (15)] | | E | | F | | | G | | H | | | J | $L_T$ | | Y | Circular Runout of Bearing Surface FIM [Note (3)] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Body Diameter [Note (6)] | | Width Across Flats | | | Width Across Corners [Note (2)] | | Head Height | | | Wrenching Height [Note (2)] | Thread Length for Screw Lengths [Note (9)] | | Transition Thread Length [Notes (9), (10)] | |
| | | | | | | | | | | | | | 6 in. and Shorter | Over 6 in. | | |
| | | Max. | Min. | Basic | Max. | Min. | Max. | Min. | Basic | Max. | Min. | Min. | Nom. | Nom. | Max. | Max. |
| 1/4 | 0.2500 | 0.2500 | 0.2450 | 7/16 | 0.438 | 0.428 | 0.505 | 0.488 | 5/32 | 0.163 | 0.150 | 0.106 | 0.750 | 1.000 | 0.250 | 0.010 |
| 5/16 | 0.3125 | 0.3125 | 0.3065 | 1/2 | 0.500 | 0.489 | 0.577 | 0.557 | 13/64 | 0.211 | 0.195 | 0.140 | 0.875 | 1.125 | 0.278 | 0.011 |
| 3/8 | 0.3750 | 0.3750 | 0.3690 | 9/16 | 0.562 | 0.551 | 0.650 | 0.628 | 15/64 | 0.243 | 0.226 | 0.160 | 1.000 | 1.250 | 0.312 | 0.012 |
| 7/16 | 0.4375 | 0.4375 | 0.4305 | 5/8 | 0.625 | 0.612 | 0.722 | 0.698 | 9/32 | 0.291 | 0.272 | 0.195 | 1.125 | 1.375 | 0.357 | 0.013 |
| 1/2 | 0.5000 | 0.5000 | 0.4930 | 3/4 | 0.750 | 0.736 | 0.866 | 0.840 | 5/16 | 0.323 | 0.302 | 0.215 | 1.250 | 1.500 | 0.385 | 0.014 |
| 9/16 | 0.5625 | 0.5625 | 0.5545 | 13/16 | 0.812 | 0.798 | 0.938 | 0.910 | 23/64 | 0.371 | 0.348 | 0.250 | 1.375 | 1.625 | 0.417 | 0.015 |
| 5/8 | 0.6250 | 0.6250 | 0.6170 | 15/16 | 0.938 | 0.922 | 1.083 | 1.051 | 25/64 | 0.403 | 0.378 | 0.269 | 1.500 | 1.750 | 0.455 | 0.017 |
| 3/4 | 0.7500 | 0.7500 | 0.7410 | 1 1/8 | 1.125 | 1.100 | 1.299 | 1.254 | 15/32 | 0.483 | 0.455 | 0.324 | 1.750 | 2.000 | 0.500 | 0.020 |
| 7/8 | 0.8750 | 0.8750 | 0.8660 | 1 5/16 | 1.312 | 1.285 | 1.516 | 1.465 | 35/64 | 0.563 | 0.531 | 0.378 | 2.000 | 2.250 | 0.556 | 0.023 |
| 1 | 1.0000 | 1.0000 | 0.9900 | 1 1/2 | 1.500 | 1.469 | 1.732 | 1.675 | 39/64 | 0.627 | 0.591 | 0.416 | 2.250 | 2.500 | 0.625 | 0.026 |
| 1 1/8 | 1.1250 | 1.1250 | 1.1140 | 1 11/16 | 1.688 | 1.631 | 1.949 | 1.859 | 11/16 | 0.718 | 0.658 | 0.461 | 2.500 | 2.750 | 0.714 | 0.029 |
| 1 1/4 | 1.2500 | 1.2500 | 1.2390 | 1 7/8 | 1.875 | 1.812 | 2.165 | 2.066 | 25/32 | 0.813 | 0.749 | 0.530 | 2.750 | 3.000 | 0.714 | 0.033 |
| 1 3/8 | 1.3750 | 1.3750 | 1.3630 | 2 1/16 | 2.062 | 1.994 | 2.382 | 2.273 | 27/32 | 0.878 | 0.810 | 0.569 | 3.000 | 3.250 | 0.833 | 0.036 |
| 1 1/2 | 1.5000 | 1.5000 | 1.4880 | 2 1/4 | 2.250 | 2.175 | 2.598 | 2.480 | 15/16 | 0.974 | 0.902 | 0.640 | 3.250 | 3.500 | 0.833 | 0.039 |
| 1 3/4 | 1.7500 | 1.7500 | 1.7380 | 2 5/8 | 2.625 | 2.538 | 3.031 | 2.893 | 1 3/32 | 1.134 | 1.054 | 0.748 | 3.750 | 4.000 | 1.000 | 0.046 |
| 2 | 2.0000 | 2.0000 | 1.9880 | 3 | 3.000 | 2.900 | 3.464 | 3.306 | 1 7/32 | 1.263 | 1.175 | 0.825 | 4.250 | 4.500 | 1.111 | 0.052 |
| 2 1/4 | 2.2500 | 2.2500 | 2.2380 | 3 3/8 | 3.375 | 3.262 | 3.897 | 3.719 | 1 3/8 | 1.423 | 1.327 | 0.933 | ... | 5.000 | 1.111 | 0.059 |
| 2 1/2 | 2.5000 | 2.5000 | 2.4880 | 3 3/4 | 3.750 | 3.625 | 4.330 | 4.133 | 1 17/32 | 1.583 | 1.479 | 1.042 | ... | 5.500 | 1.250 | 0.065 |
| 2 3/4 | 2.7500 | 2.7500 | 2.7380 | 4 1/8 | 4.125 | 3.988 | 4.763 | 4.546 | 1 11/16 | 1.744 | 1.632 | 1.151 | ... | 6.000 | 1.250 | 0.072 |
| 3 | 3.0000 | 3.0000 | 2.9880 | 4 1/2 | 4.500 | 4.350 | 5.196 | 4.959 | 1 7/8 | 1.935 | 1.815 | 1.290 | ... | 6.500 | 1.250 | 0.079 |

AN AMERICAN NATIONAL STANDARD

# ASME B18.2.1a-1999

# ADDENDA

to

## ASME B18.2.1-1996
## SQUARE AND HEX BOLTS AND SCREWS (INCH SERIES)

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Three Park Avenue • New York, NY 10016

Date of Issuance: October 8, 1999



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.

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

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Mechanical Engineers

AN AMERICAN NATIONAL STANDARD

# SQUARE AND HEX BOLTS AND SCREWS (INCH SERIES)

ASME B18.2.1-1996
[Revision of ANSI B18.2.1-1981 (R1992)]

Date of Issuance: July 29, 1997

The 1996 edition of this Standard is being issued with an automatic addenda subscription service. The use of an addenda allows revisions made in response to public review comments or committee actions to be published as necessary. The next edition of this Standard is scheduled for publication in 1999.



The American Society of Mechanical Engineers
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# ASME B18.2.1a-1999

Following approval by the ASME B18 Committee and ASME, and after public review, ASME B18.2.1a-1999 was approved by the American National Standards Institute on April 9, 1999.

Addenda to the 1996 edition of ASME B18.2.1 are issued in the form of replacement pages. Revisions, additions, and deletions are incorporated directly into the affected pages. It is advisable, however, that this page, the Addenda title and copyright pages, and all replaced pages be retained for reference.

## SUMMARY OF CHANGES

This is the first Addenda to be published to ASME B18.2.1-1996.

Replace or insert the pages listed. Changes given below are identified on the pages by a margin note, **(a)**, placed next to the affected area. The pages not listed are the reverse sides of the listed pages and contain no changes.

| *Page* | *Location* | *Change* |
|---|---|---|
| vi.1 | Correspondence With B18 Committee | Added |
| ix | Contents | Updated to reflect Addenda |
| 10 | Table 3 | In fifth column, second entry corrected by errata to read $1\frac{1}{16}$ |
| 16–18 | Table 4, Note (5) | Four equations deleted by errata |
| | Fig. 2 | Four equations added by errata |
| | Table 4, Note (11) | Revised |
| 23, 24 | Fig. 5 | Four equations added by errata |
| | Table 6, Note (7) | Four equations deleted by errata |
| | Table 6, Note (11) | Revised |
| 33 | Appendix I | Deleted |
| 35 | Appendix II | Revised in its entirety |

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# FOREWORD

(This Foreword is not part of ASME B18.2.1-1996.)

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

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

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

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

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

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

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

At a meeting on June 8, 1951, Subcommittee 2 reaffirmed its acceptance of the unified dimensions, which corresponded with those in the March 1951 draft, but attempted to select bet-

ter nomenclature for the unified products. A final draft incorporating the nomenclature *Finished Hexagon Bolts and Nuts* and containing numerous editorial changes was submitted for letter ballot in September 1951. Following approval by the B18 Committee and the sponsors, the proposal was presented to the American Standards Association for approval and designation as an American Standard. This was granted on March 24, 1952.

Recognizing the standard was in need of additional refinements, Subcommittee 2 began immediately to revise it, removing inconsistencies with respect to fillets, improving the length tolerances on heavy hexagon bolts, and incorporating numerous other corrections and clarifications. The most noteworthy editorial change was a decision to combine the coverage for hexagon cap screws and square head set screws from the B18.2 standard with the coverage for slotted head cap screws and slotted headless set screws from the B18.6 standard and publish them in a separate document. The requirements for the unified hexagon cap screws and finished hexagon bolts being identical in the overlapping sizes, this data would now be available in two publications. Following approvals by the B18 Committee and sponsor organizations, the proposal was submitted to the American Standards Association and declared an American Standard on February 2, 1955.

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

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

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

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

Subcommittee 2 continued to further develop refinements initiated by the simplification subgroup and revisions reflecting changes in manufacturing practices and consumer requirements. This work culminated in Subcommittee acceptance of a 1970 proposal incorporating, in addition to numerous editorial changes, revisions in the following significant areas: addition of coverage for askew head bolts and hex head lag screws; addition of straightness requirements to applicable products; addition of minimum fillet to square and hex bolts and lag screws; appli-

cation of UNR threads and new concepts for controlling thread length on products having Unified threads; and clarification of grade markings, thread runout gages and formulas for dimensions. Also included were refinements to hex cap screw and heavy hex screw requirements consisting of addition of wrenching height and revision of underhead fillets, washer face thicknesses and controls on angularity of bearing face. The proposed revision, after approval by letter ballot of the B18 Committee in March, 1970 was subsequently approved by the sponsors and submitted to the American National Standards Institute for designation as an American National Standard. This was granted on January 18, 1972.

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

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 which should be certified to assure 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.

Additionally, 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 is included for the first time to assist users and is similar to the pattern used for metric bolts and screws.

ASME B18.2.1-1996 was approved by the American National Standards Institute (ANSI) on December 4, 1996.

# CORRESPONDENCE WITH B18 COMMITTEE (a)

*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 Main Committee
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*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.

*Interpretations.* Upon request, the B18 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 Main 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 which are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format will be rewritten in this 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 Main Committee regularly holds meetings, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the B18 Main Committee.

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

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

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# CONTENTS

(a)

# SQUARE AND HEX BOLTS AND SCREWS (INCH SERIES)

## 1 INTRODUCTORY NOTES

### 1.1 Scope

**1.1.1** This Standard covers the complete general and dimensional data for eight product types of inch series square and hex bolts and screws recognized as American National Standard. Also included are appendixes covering thread runout sleeve gages, gaging procedure for checking bolt and screw straightness, grade markings for steel bolts and screws, formulas on which dimensional data are based, and a specification to assist in identifying a product as being a screw or a bolt. It should be understood, however, that where questions arise concerning acceptance of product, the dimensions in the tables shall govern over recalculation by formula. Heavy hex structural bolts, formerly covered in ANSI 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 manufacturers concerning lists of stock production sizes.

**1.1.3** Square and Hex Bolts and Screws purchased for Government use shall conform to this Standard and to any additional requirements specified in the purchase order or contract. See Appendix E for the Government Part Identifying Numbering System (PIN code) and other requirements for hexagon head cap screws.

### 1.2 Dimensions

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

Symbols specifying geometric characteristics are in accord with ASME Y14.5M, Dimensioning and Tolerancing.

### 1.3 Options

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

### 1.4 Terminology

As used in this Standard, the term "long bolt" or "long screw" means a bolt or screw of a diameter-length combination which is not threaded for full length, and the term "short bolt" or "short screw" means a bolt or screw of a diameter-length combination which is required to be 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 (ref. Gage 3.1, 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 which includes the length of incomplete threads, the extrusion angle on rolled threads, and tolerances on grip length. Where specified, maximum transition thread length ($Y$, max.) is a reference dimension intended for calculation purposes only.