UNITED STATES DEPARTMENT OF COMMERCE • MAURICE H. STANS, *Secretary*
NATIONAL BUREAU OF STANDARDS • Lewis M. Branscomb, *Director*

HANDBOOK H28 (1969)
SCREW-THREAD STANDARDS
FOR FEDERAL SERVICES

PART I

UNIFIED
UNJ
UNIFIED MINIATURE
SCREW THREADS

NBS Handbook H28 (1969)

Superseding H28 (1957) Part I and that applicable to Part I in the 1963 Supplement to H28

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Foreword

The Interdepartmental Screw Thread Committee (ISTC) was established to promote uniformity in screw-thread standards in the Department of Defense (including the Departments of the Army, Navy, and Air Force) and the Department of Commerce. The organization and functions of the ISTC are shown in its charter.

The ISTC shall be responsible for (1) recommending to appropriate activities research and development efforts relating to screw threads; (2) developing standards for screw threads; (3) participating in the development of standards for gages, dies, taps, and other items associated with the manufacture and use of interchangeable threaded parts employed by Government agencies; and (4) providing advisory services on science, technology, and standards of practice as these relate to screw threads.

The standards developed by the ISTC, on approval by the participating Departments and Agencies, are published in Handbook H28. The standards in Handbook H28 are revised as deemed necessary by the ISTC.

This 1969 issue of Part I is being published essentially to incorporate the changes in Part I made by the 1963 Supplement and to revise the sections on Nomenclature, and Gages and Gaging to be in general agreement with USA B1.7–1965 and USA B1.2–1966.

Handbook H28 is issued in 3 parts. This Part, Part I, contains information on Unified and Unified miniature screw threads. Part II contains information on pipe threads, including dryseal pipe threads; gas cylinder valve threads; hose coupling, including fire-hose coupling threads; and hose connections for welding and cutting equipment. Part III contains information on Acme, Stub-Acme, Buttress, and miscellaneous threads.

At this time, the latest issues of Parts II and III are those of 1957 identified by a block on the cover stating "Reprinted December 1966 with corrections". These two parts include the changes to the respective parts listed in the 1963 Supplement to H28.

In this 1969 issue of Part I, sections are being designated by arabic instead of roman numerals. Appendixes are designated by an arabic number preceded by A. To allow insertion of section 4 on UNJ threads, section I, Introduction, of the 1957 issue is included but without a section designation. Former sections II, III, and IV have been renumbered as sections 1, 2, and 3.

In this 1969 issue of Part I, when designating tables and figures, a number is only used once. For example, if a figure is designated figure 2.1, there will be no table 2.1.

In 1966, the American Standards Association (ASA) changed its name to the United States of America Standards Institute (USASI). In October 1969, USASI changed its name to the American National Standards Institute (ANSI).

All references to USASI herein will apply to the American National Standards Institute (ANSI). Preparation for printing of Handbook H28 has progressed too far to make the changes in name throughout the Handbook.

ARTHUR G. STRANG, *Chairman,*
Interdepartmental Screw Thread Committee

Metric Translation of Screw Thread Specifications

To facilitate and encourage the use of these unified screw thread standards in metric countries most of the specifications given in this document have been translated into metric language under the sponsorship of ASME and SAE. This translation appears as USA standard B1.1a–1968. The detailed specifications in metric language of the unified screw threads given in B1.1a–1968 is more extensive than is presently available for the ISO metric series of screw threads. Copies of USA standard B1.1a can be obtained for $3.00 from the American National Standards Institute, 1430 Broadway, New York, New York 10018.

Declaration of Accord

with respect to the

Unification of Screw Threads

It is hereby declared that the undersigned, representatives of their Government and Industry Bodies, charged with the development of standards for screw threads, Agree that the standards for the Unified Screw Threads given in the publications of the Committees of the British Standards Institution, Canadian Standards Association, American Standards Association and of the Interdepartmental Screw Thread Committee fulfill all of the basic requirements for general interchangeability of threaded products made in accordance with any of these standards.

The Bodies noted above will maintain continuous cooperation in the further development and extension of these standards.

Signed in Washington, D. C., this 18th day of November, 1948, at the National Bureau of Standards of the United States.

C. D. Howe	Ministry of Trade and Commerce, Dominion of Canada
J. G. Morrow	Canadian Standards Association
T. R. B. Sanders	Ministry of Supply, United Kingdom
Percy Good	British Standards Institution
Ewart Smith	Representative of British Industry
E. U. Condon	National Bureau of Standards U. S. Department of Commerce Interdepartmental Screw Thread Committee
Fred P. [illegible]	American Standards Association The American Society of Mechanical Engineers Society of Automotive Engineers
William L. Batt	Sponsors Council of United States and United Kingdom on the Unification of Screw Threads

APPROVAL BY

THE DEPARTMENTS OF DEFENSE AND COMMERCE

The accompanying Handbook H28 (1969), Part I, on Screw-Thread Standards for Federal Services, submitted by the Interdepartmental Screw Thread Committee, is hereby approved for use by the Departments of Defense and Commerce.

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Contents

Part I

INTRODUCTION

The purpose of Handbook H28 is to present complete dimensional data for the threads on the threaded products procured by the Federal Services. So far as practicable, these data are intended to conform to generally accepted commercial practice, although certain special requirements of the Federal Services necessitate the inclusion of some standards not generally applicable outside of the Government. References are cited throughout the text to the standards promulgated by the United States of America Standards Institute (USASI) and to such other published standards as are in agreement with the specifications herein.

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(The membership of the Industry Liaison Representatives on the USA Standards Committees closely allied with Screw Thread Standardization is shown following the representative's name and address. The titles of these USA Standards Committees are:

- B1 on the Standardization and Unification of Screw Threads
- B2 on the Standardization of Pipe and Hose Coupling Threads
- B18 on the Standardization of Bolts, Nuts, Rivets, Screws, and Similar Fasteners.
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UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

HANDBOOK H28

SCREW-THREAD STANDARDS

FOR FEDERAL SERVICES

SECTION 1

1969

NOMENCLATURE, DEFINITIONS, AND LETTER SYMBOLS FOR SCREW THREADS

CONTENTS

This section is in general agreement with United States of America Standards Institute Standard USA B1.7, Nomenclature, Definitions, and Letter Symbols for Screw Threads, published by The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017. The latest revision should be consulted when referring to this USA standard. As of date of issue of this section, USA B1.7–1965 is the latest revision. For further related definitions, see USA B18.12, Glossary of Terms for Mechanical Fasteners.

1. GENERAL

1.1. The purpose of this section is to establish uniform practices with regard to: (1) Screw-thread nomenclature, and (2) letter symbols for designating dimensions of screw threads for use on drawings, in tables of dimensions which set forth dimensional standards, and in other records, and for expressing mathematical relationships.

1.2. This section consists of a glossary of terms, tables of screw-thread dimensional symbols, illustrations showing the application of dimensional symbols, tables of thread series and dimensional designations, and an index.

1.3. Typography.—In accordance with the usual practice in published text, letter symbols and letter subscripts, whether upper or lower case, should be printed in italic type. An exception is Greek letters; Greek capital letters are always vertical, and lower case always resembles italics. In manuscripts this is indicated by underlining each symbol to be italicized. Coefficients, numeral subscripts, and exponents should be printed in vertical Arabic numerals. Standard mathematical notation should be followed.

2. DEFINITIONS OF TERMS

2.1. The terms commonly applied to screw threads may be classified in four general groups, namely, those relating to: (1) types of screw threads, (2) size and fit of mechanical parts in general, (3) geometrical elements of both straight and taper screw threads, and (4) dimensions of screw threads.

The definitions presented herein apply generally to theoretically correct leads and thread forms but also reflect practical considerations relative to production, gaging, and measurement of threads. With a few obvious exceptions the definitions apply generally to all forms of thread.

3. TERMS RELATING TO TYPES OF SCREW THREADS

3.1. Screw threads and the terms generally applied to designate the types of screw threads, are defined as follows:

3.2. SCREW THREAD.—A screw thread (hereinafter referred to as a thread), is a ridge, usually of uniform section and produced by forming a groove in the form of a helix on the external or internal surface of a cylinder, or in the form of a conical spiral on the external or internal surface of a cone or frustum of a cone. A screw thread formed on a cylinder is known as a *straight or parallel* thread, to distinguish it from a *taper* thread which is formed on a cone or frustum of a cone.

3.3. THREAD.—A thread is a portion of a screw thread encompassed by one pitch. On a single-start thread it is equal to one turn. (See par. 6.5 Threads per Inch and par. 6.6 Turns per Inch.)

3.4. SINGLE-START THREAD.—A single-start thread is one having the lead equal to the pitch. (See par. 6.2 Pitch and par. 6.3 Lead.)

3.5. MULTIPLE-START THREAD.—A multiple-start thread is one in which the lead is an integral multiple (other than one) of the pitch.

3.6. EXTERNAL THREAD.—An external thread is one on a cylindrical or conical external surface.

3.7. INTERNAL THREAD.—An internal thread is one on a cylindrical or conical internal surface.

3.8. RIGHT-HAND THREAD.—A thread is a right-hand thread if, when viewed axially, it winds in a clockwise and receding direction. A thread is considered to be right-hand unless specifically indicated otherwise.

3.9. LEFT-HAND THREAD.—A thread is a left-hand thread if, when viewed axially, it winds in a counterclockwise and receding direction. All left-hand threads are designated *LH*.

3.10. COMPLETE THREAD.—The complete or full form thread is that cross section of a threaded length having full form at crest and root. (See par. 3.14 Effective Thread, par. 6.26 Length of Complete Thread.)

NOTE: Formerly in pipe thread terminology this was referred to as "the perfect thread" but that is no longer considered desirable.

3.11. INCOMPLETE THREAD.—An incomplete thread is a threaded profile having either crests or roots, or both crests and roots, not fully formed, resulting from their intersection with the cylindrical or end surface of the work or the vanish cone. It may occur at either end of the thread.

NOTE: Formerly in pipe thread terminology this was referred to as "the imperfect thread" but that is no longer considered desirable.

3.12. LEAD-THREAD.—The lead-thread is that portion of the incomplete thread that is fully formed at root but not fully formed at crest which occurs at the entering end of either external or internal threads. (See note at par. 6.26.)

3.13. VANISH THREAD.—(Partial Thread, Washout Thread, or Thread Run-out.) A vanish thread is that portion of the incomplete thread which is not fully formed at root or at crest and root. It is produced by the chamfer at the starting end of the thread forming tool. (See par. 5.28 Vanish Cone.)

NOTE: Threads produced employing a cam actuated single tool process (frequently referred to as the Cridan process) or by a process employing similar type equipment, may have fully formed roots which run out on a vanish cone which is formed by the tool withdrawal pattern.

3.14. EFFECTIVE THREAD.—The effective (or useful) thread includes the complete thread, and those portions of the incomplete thread which are fully formed at the root but not at the crest (in taper pipe threads this includes the so-called black crest threads); thus excluding the vanish thread.

3.15. TOTAL THREAD.—The total thread includes the complete and all of the incomplete thread; thus including the vanish thread.

3.16. CLASSES OF THREADS.—Classes of threads are distinguished from each other by the amounts of tolerance or tolerance and allowance specified.

3.17. THREAD SERIES.—Thread series are groups of diameter/pitch combinations distinguished from each other by the number of threads per inch applied to specific diameters.

3.18. STRUCTURAL THREAD.—A structural thread is intended to develop a significant amount of the core strength of the externally threaded member before breaking the core of that member or stripping the external or internal threads of a threaded connection. A structural thread is not intended for, but may be used for attaching purposes. (UNC and UNF thread series are examples of Structural Threads with tolerance calculations based on a length of engagement equal to one diameter.)

3.19. ATTACHING-PURPOSE THREAD (also sometimes referred to as constructional or retaining threads).—An attaching-purpose thread is not intended to develop a significant amount of core strength of the externally or internally threaded member of a threaded connection. An attaching-purpose thread is not normally intended for structural purposes. (12 UN and 16 UN uniform pitch thread series are examples of Attaching-Purpose Threads with tolerance calculations based on a length of engagement equal to nine pitches.)

4. TERMS RELATING TO SIZE AND FIT

(These are definitions applying to mechanical parts, generally.)

4.1. Terms relating to the size and fit of parts, which are generally applicable to mechanical parts, including threads, are defined as follows:

4.2. DIMENSION.—A dimension is a geometrical characteristic such as diameter, length, angle, or center distance.

4.3. SIZE.—Size is a designation of magnitude. When a value is assigned to a dimension it is referred to hereinafter as the size of that dimension.

NOTE: It is recognized that the words "dimension" and "size" are both used at times to convey the meaning of magnitude.

4.4. NOMINAL SIZE.—The nominal size is the designation which is used for the purpose of general identification.

4.5. BASIC SIZE.—The basic size is that size from which the limits of size are derived by the application of allowances and tolerances.

4.6. REFERENCE SIZE.—A reference size is a size without tolerance used only for information purposes and does not govern manufacturing or inspection operations.

4.7. DESIGN SIZE.—The design size is the basic size with allowance applied, from which the limits of size are derived by the application of tolerances. If there is no allowance the design size is the same as the basic size.

4.8. ACTUAL SIZE.—An actual size is a measured size.

4.9. LIMITS OF SIZE.—The limits of size are the applicable maximum and minimum sizes. (See par. 4.14.)

4.10. MAXIMUM-MATERIAL-LIMIT.—A maximum-material-limit is that limit of size that provides the maximum amount of material for the part. Normally it is the maximum limit of size of an external dimension or the minimum limit of size of an internal dimension.

4.11. MINIMUM-MATERIAL-LIMIT.—A minimum-material-limit is that limit of size that provides the minimum amount of material for the part. Normally it is the minimum limit of size of an external dimension or the maximum limit of size of an internal dimension.

NOTE: Examples of exceptions are; an exterior corner radius where the maximum radius is the minimum-material-limit and the minimum radius is the maximum-material-limit.

4.12. ALLOWANCE.—An allowance is a prescribed difference between the maximum-material-limits of mating parts. It is the minimum clearance (positive allowance) or maximum interference (negative allowance) between such parts. (See par. 4.17 Fit.)

4.13. TOLERANCE.—A tolerance is the total permissible variation of a size. The tolerance is the difference between the limits of size.

4.14. TOLERANCE LIMIT.—A tolerance limit is the variation, positive or negative, by which a size is permitted to depart from the design size. (See par. 4.9.)

4.15. UNILATERAL TOLERANCE.—A unilateral tolerance is a tolerance in which variation is permitted only in one direction from the design size.

4.16. BILATERAL TOLERANCE.—A bilateral tolerance is a tolerance in which variation is permitted in both directions from the design size.

4.17. FIT.—Fit is the general term used to signify the range of tightness or looseness which may result from the application of a specific combination of allowances and tolerances in the design of mating parts.

4.18. ACTUAL FIT.—The actual fit between two mating parts is the relation existing between them with respect to the amount of clearance or interference that is present when they are assembled.

NOTE: Fits are of three general types: clearance, transition, and interference.

4.19. CLEARANCE FIT.—A clearance fit has limits of size so prescribed that a clearance always results when mating parts are assembled.

4.20. INTERFERENCE FIT.—An interference fit has limits of size so prescribed that an interference always results when mating parts are assembled.

4.21. TRANSITION FIT.—A transition fit has limits of size so prescribed that either a clearance or an interference may result when mating parts are assembled.

4.22. UNILATERAL TOLERANCE SYSTEM.—A design plan which uses only unilateral tolerances is known as a unilateral tolerance system.

4.23. BILATERAL TOLERANCE SYSTEM.—A design plan which uses only bilateral tolerances is known as a bilateral tolerance system.

4.24. BASIC HOLE SYSTEM.—A basic hole system is a system of fits in which the design size of the hole is the basic size and the allowance, if any, is applied to the shaft.

4.25. BASIC SHAFT SYSTEM.—A basic shaft system is a system of fits in which the design size of the shaft is the basic size and the allowance, if any, is applied to the hole.

5. TERMS RELATING TO GEOMETRICAL ELEMENTS OF SCREW THREADS

5.1. Terms relating to geometrical elements of both straight and taper threads are defined as follows:

5.2. THREAD AXIS.—The thread axis is the axis of its pitch cylinder or cone. (See par. 7.2.)

5.3. MAJOR CYLINDER.—The major cylinder bounds the crests of an external straight thread or the roots of an internal straight thread.

5.4. SHARP MAJOR CYLINDER.—The sharp major cylinder bounds the sharp crests of an external straight thread or the sharp roots of an internal straight thread.

5.5. MAJOR CONE.—The major cone bounds the crests of an external taper thread or the roots of an internal taper thread.

5.6. SHARP MAJOR CONE.—The sharp major cone has an apex angle equal to that of the pitch cone, the surface of which bounds the sharp crests of an external taper thread or the sharp roots of an internal taper thread.

5.7. PITCH CYLINDER.—The pitch cylinder is one of such diameter and location of its axis that its surface would pass through a straight thread in such a manner as to make the widths of the thread ridge and the thread groove equal and, therefore, is located equidistantly between the sharp major and minor cylinders of a given thread form. On a theoretically perfect thread these widths are equal to one-half of the basic pitch. (See par. 5.2 Axis of Thread, par. 6.21 Pitch Diameter.)

5.8. PITCH CONE.—The pitch cone is one of such apex angle and location of its vertex and axis that its surface would pass through a taper thread in such a manner as to make the widths of the thread ridge and the thread groove equal and, therefore, is located equidistantly between the sharp major and minor cones of a given thread form. On a theoretically perfect taper thread these widths are equal to one-half of the basic pitch. (See par. 5.2 Axis of Thread and par. 6.21 Pitch Diameter.)

5.9. MINOR CYLINDER.—The minor cylinder bounds the roots of an external straight thread or the crests of an internal straight thread.

5.10. SHARP MINOR CYLINDER.—The sharp minor cylinder bounds the sharp roots of an external straight thread or the sharp crests of an internal straight thread.

5.11. MINOR CONE.—The minor cone bounds the roots of an external taper thread or the crests of an internal taper thread.

5.12. SHARP MINOR CONE.—The sharp minor cone has an apex angle equal to that of the pitch cone, the surface of which bounds the sharp roots of an external taper thread or the sharp crests of an internal taper thread.

5.13. PITCH LINE.—The pitch line is a generator of the cylinder or cone specified in the definitions of par. 5.7 Pitch Cylinder and par. 5.8 Pitch Cone.

5.14. THREAD FORM.—The thread form is the thread profile in an axial plane for a length of one pitch of the complete thread.

5.15. BASIC THREAD FORM.—The basic thread form is the theoretical thread profile for a length of one pitch in an axial plane, from which the design thread forms for both the external and internal threads are developed.

5.16. DESIGN THREAD FORM.—The design thread form is the maximum material form permitted for the external or internal thread. In practice, however, the form of root is an indeterminate contour not encroaching on the maximum material form of the mating thread when assembled.

5.17. FUNDAMENTAL TRIANGLE.—The fundamental triangle is the triangle whose corners coincide with three consecutive intersections of the extended flanks of the basic thread form.

5.18. FLANK.—The flank (or side) of a thread is either surface connecting the crest with the root. The flank surface intersection with an axial plane is theoretically a straight line.

5.19. LEADING FLANK.—When a thread is about to be assembled with a mating thread, the leading flank of the thread faces the mating thread.

5.20. FOLLOWING FLANK.—The following flank of a thread faces the leading flank.

5.21. LOAD FLANK.—The load flank takes the externally applied axial load in an assembly. The term is used particularly in relation to buttress and other similar threads.

5.22. CLEARANCE FLANK.—The clearance flank faces the load flank.

5.23. CREST.—The crest is that surface of the thread which joins the flanks of the thread and is farthest from the cylinder or cone from which the thread projects.

5.24. ROOT.—The root is that surface of the thread which joins the flanks of adjacent thread forms and is identical with or immediately adjacent to the cylinder or cone from which the thread projects.

5.25. SHARP CREST (CREST APEX).—The sharp crest is the apex formed by the intersection of the flanks of a thread when extended, if necessary, beyond the crest.

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5.26. Sharp Root (Root Apex).—The sharp root is the apex formed by the intersection of the adjacent flanks of adjacent threads when extended, if necessary, beyond the root.

5.27. Base.—The base of a thread section coincides with the cylindrical or conical surface from which the thread projects.

5.28. Vanish Cone.—The surface of the vanish cone bounds the roots of the vanish thread formed by the lead or chamfer of the threading tool. (See fig. 1.2 and par. 3.13 Vanish Thread.)

5.29. Plane of Vanish Point.—The plane of vanish point of an external thread is the intersection of generators of the vanish cone with generators of the cylinder of the largest major diameter of the thread. (See fig. 1.5.)

5.30. Blunt Start or Blunt End Thread.—"Blunt start" or "blunt end" designates the removal of the incomplete thread at the end of the thread. This is a feature of threaded parts that are repeatedly assembled by hand, such as hose couplings and thread plug gages, to prevent cutting of hands and crossing of threads, and which was formerly known as a *Higbee cut*. (See fig. 1.1.)

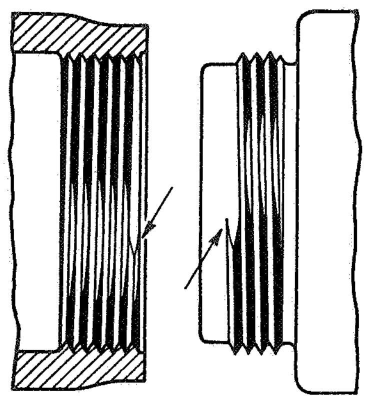

Figure 1.1. *Blunt start*

5.31. Gimlet Point.—A gimlet point is a threaded cone point at the entering end of an external thread.

5.32. Chamfer.—A chamfer is a conical surface at the end of a thread or shaft.

5.33. Countersink.—A countersink is a bevel or flare at the end of a hole.

5.34. Bottom of Chamfer.—On a chamfered internal taper thread, the bottom of the chamfer is defined as the intersection of the chamfer cone and the pitch cone of the thread.

6. TERMS RELATING TO DIMENSIONS OF SCREW THREADS

6.1. Terms relating to dimensions of both straight and taper threads are defined as follows:

6.2. Pitch.—The pitch of a thread having uniform spacing is the distance, measured parallel to its axis, between corresponding points on adjacent thread forms in the same axial plane and on the same side of the axis. The basic pitch is equal to the lead divided by the number of thread starts. (See par. 6.4 Helix Variation, par. 7.4.)

6.3. Lead.—When a threaded part is rotated about its axis with respect to a fixed mating thread, the lead is the axial distance moved by the part in relation to the amount of angular rotation. The basic lead is commonly specified as the distance to be moved in one complete rotation. It is necessary to distinguish measurement of lead from measurement of pitch, as uniformity of pitch measurements does not assure uniformity of lead. Variations in either lead or pitch cause the functional diameter of thread to differ from the pitch diameter. (See par. 7.5.)

6.4. Helix Variation.—Helix variation of a thread is a wavy deviation from true helical advancement. The "helical path" includes the helix with its superimposed variation and is measured either as the maximum deviation from the true helix or as the "cumulative pitch." The cumulative pitch is the distance measured parallel to the axis of the thread between corresponding points on any two thread forms whether or not they are in the same axial plane. (See par. 7.5.)

6.5. Threads per Inch.—The number of threads per inch is the reciprocal of the pitch in inches.

6.6. Turns per Inch.—The number of turns per inch is the reciprocal of the lead in inches.

6.7. Included Angle.—The included angle of a thread (or angle of thread) is the angle between the flanks of the thread measured in an axial plane.

6.8. Flank Angle.—The flank angle is the angle between the flank and the perpendicular to the axis of the thread, measured in an axial plane. A flank angle of a symmetrical thread is commonly termed the *half-angle of thread*. (See par. 7.3.)

6.9. Lead Angle.—On a straight thread, the lead angle is the angle made by the helix of the thread at the pitch line with a plane perpendicular to the axis. On a taper thread, the lead angle at a given axial position is the angle made by the conical spiral of the thread with the plane perpendicular to the axis, at the pitch line. (See fig. 1.2.)

6.10. Helix Angle.—On a straight thread, the helix angle is the angle made by the helix of the thread at the pitch line with the axis. On a taper thread, the helix angle at a given axial position is the angle made by the conical spiral of the thread with the axis at the pitch line. The helix angle is the complement of the lead angle. (See fig. 1.2.)

NOTE: The helix angle was formerly defined in accordance with the present definition of lead angle. (See par. 6.9.)

6.11. Thread Ridge Thickness.—The thread ridge thickness is the distance between the flanks of one thread ridge, normally measured parallel to the axis at the specified pitch radius. The thread ridge thickness may be specified and measured parallel to the axis at any other specified radius.

NOTE: The pitch radius is equal to one-half of the pitch diameter.

6.12. THREAD GROOVE WIDTH.—The thread groove width is the distance between the flanks of adjacent thread ridges normally measured parallel to the axis at the specified pitch radius. The thread groove width may be specified and measured parallel to the axis at any other specified radius.

6.13. FUNDAMENTAL TRIANGLE HEIGHT.—The fundamental triangle height of a thread, that is, the height of a sharp-V thread, is the distance, measured radially, between the sharp major and minor cylinders or cones.

6.14. THREAD HEIGHT.—The thread height (or depth) is the distance measured radially between the major and minor cylinders or cones.

NOTE: In American practice the thread height is often expressed as a percentage of three-fourths of the fundamental triangle height.

6.15. ADDENDUM.—The addendum of an external thread is the radial distance between the major and pitch cylinders or cones. The addendum of an internal thread is the radial distance between the minor and pitch cylinders or cones.

6.16. DEDENDUM.—The dedendum of an external thread is the radial distance between the pitch and minor cylinders or cones. The dedendum of an internal thread is the radial distance between the major and pitch cylinders or cones.

6.17. CREST TRUNCATION.—The crest truncation of a thread is the radial distance between the sharp crest (crest apex) and the cylinder or cone that would bound the crest.

6.18. ROOT TRUNCATION.—The root truncation of a thread is the radial distance between the sharp root (root apex) and the cylinder or cone that would bound the root.

6.19. MAJOR DIAMETER.—On a straight thread the major diameter is that of the major cylinder. On a taper thread the major diameter at a given position on the thread axis is that of the major cone at that position. (See par. 5.3 Major Cylinder and par. 5.5 Major Cone.)

6.20. MINOR DIAMETER.—On a straight thread the minor diameter is that of the minor cylinder. On a taper thread the minor diameter at a given position on the thread axis is that of the minor cone at that position. (See par. 5.9 Minor Cylinder and par. 5.11 Minor Cone.)

6.21. PITCH DIAMETER.—On a straight thread the pitch diameter is the diameter of the pitch cylinder. (See par. 5.7.) On a taper thread, the pitch diameter at a given position on the thread axis is the diameter of the pitch cone at that position. (See par. 5.8.) On a single-start thread of perfect form and lead, it is also the length between intercepts of a line which is perpendicular to the thread axis and intersects thread flanks on opposite sides of the thread axis. (See par. 7.6.)

NOTE: When the crest of a thread is truncated beyond the pitch line, the pitch diameter, pitch cylinder, or pitch cone would be based on a theoretical extension of the thread flanks.

NOTE: Pitch diameter on the buttress casing thread is defined by the American Petroleum Institute in API Standard 5B, as being midway between the major and minor diameters.

6.22. THREAD GROOVE DIAMETER (SIMPLE EFFECTIVE DIAMETER).—On a straight thread the thread groove diameter is the diameter of the coaxial cylinder, the surface of which would pass through the thread profiles at such points as to make the width of the thread groove equal to one-half of the basic pitch. It is the diameter yielded by measuring over or under cylinders (wires) or spheres (balls) inserted in the thread groove on opposite sides of the axis and computing the thread groove diameter as thus defined.

On a taper thread the thread groove diameter is the diameter at a given position on the thread axis of the coaxial cone, the surface of which would pass through the thread profiles at such points as to make the width of the thread groove (measured parallel to the axis) equal to one-half of the basic pitch. It is the diameter yielded by measuring over or under cylinders (wires) or spheres (balls) inserted in the thread groove on opposite sides of the axis and computing the thread groove diameter as thus defined. (See par. 7.6.)

6.23. THREAD RIDGE DIAMETER.—On a straight thread the thread ridge diameter is the diameter of the coaxial cylinder, the surface of which would pass through the thread profiles at such points as to make the thickness of the thread ridge equal to one-half of the basic pitch.

On a taper thread the thread ridge diameter is the diameter at a given position on the thread axis of the coaxial cone, the surface of which would pass through the thread profiles at such points as to make the thickness of the thread ridge (measured parallel to the axis) equal to one-half of the basic pitch. (See par. 7.6.)

6.24. FUNCTIONAL (VIRTUAL) DIAMETER.—The functional diameter of an external or internal thread is the pitch diameter of the enveloping thread of perfect pitch, lead, and flank angles, having full depth of engagement but clear at crests and roots, and of a specified length of engagement. It may be derived by adding to the pitch diameter in the case of an external thread, or subtracting from the pitch diameter in the case of an internal thread, the cumulative effects of deviations from specified profile, including variations in lead and flank angle over a specified length of engagement. The effects of taper, out-of-roundness, and surface defects may be positive or negative on either external or internal threads. (A perfect GO thread plug or ring gage, having a pitch diameter equal to that specified for the maximum-material-limit and having clearance at crest and root, is the enveloping thread corresponding to that limit.) (See par. 7.6.)

NOTE: Also called the Virtual Diameter, Effective Size, or Virtual Effective Diameter.

6.25. FORM DIAMETER.—The form diameter is the diameter at the point nearest the root from which the flank is required to be straight.

6.26. LENGTH OF COMPLETE THREAD.—The length of complete thread is the axial length of a part where the thread section has full form at both crest and root; that is, the vanish threads are not included. However, on commercial fasteners where there are unfilled crests at the start of rolled threads or a chamfer at the start of a thread, not exceeding two pitches in length, this is traditionally included in the specified thread length. (See par. 3.10 Complete Thread, par. 3.12 Lead Thread and par. 3.14 Effective Thread.)

NOTE: When designing threaded products, it is necessary to take cognizance of: (1) Such permissible length of chamfer and (2) the first threads which by virtue of gaging practice may exceed or be less than the product limits and which may be included within the length of complete thread. However, when the application is such as to require a minimum or maximum number, or length, of complete threads the specification shall so state. Similar specification is required for a definite length of engagement.

6.27. LENGTH OF THREAD ENGAGEMENT.—The length of thread engagement of two mating threads is the axial distance over which two mating threads are designed to contact. (See par. 6.26 Length of Complete Thread.)

6.28. DEPTH OF THREAD ENGAGEMENT.—The depth (or height) of thread engagement between two coaxially assembled mating threads is the radial distance by which their thread forms overlap each other.

6.29. MAJOR CLEARANCE.—The major clearance is the radial distance between the root of the internal thread and the crest of the external thread of the coaxially assembled design forms of mating threads.

6.30. MINOR CLEARANCE.—The minor clearance is the radial distance between the crest of the internal thread and the root of the external thread of the coaxially assembled design forms of mating threads.

6.31. TENSILE STRESS AREA.—The tensile stress area of an externally threaded part is the circular cross-sectional area, normal to the axis, of a theoretical circular cylinder which would fail under tension at the same load at which the threaded part fails, if the materials of both have the same mechanical properties.

6.32. THREAD SHEAR AREA.—The thread shear area of the external thread is the effective area in shear at a specified diameter of the mated internal thread. The thread shear area of the internal thread is the effective area in shear at a specified diameter of the mated external thread.

NOTE: The specified diameters are usually the maximum minor diameter of the mated internal thread and the minimum major diameter of the mated external thread.

6.33. STANDOFF.—The standoff is the axial distance between specified reference points on external and internal taper threaded members or gages, when assembled with a specified torque or under other specified conditions.

7. SCREW THREAD DEFINITIONS IN RELATION TO GAGING AND MEASUREMENT

7.1. The meanings of certain definitions, as given previously, require some explanation in regard to their practical application and the values or results obtained in gaging or measurement of threads. The terms involved are: thread axis, flank angle, pitch, lead, and pitch diameter.

7.2. THREAD AXIS.—The thread axis is the axis of the pitch cylinder or cone. The pitch cylinder is one of such diameter and location of its axis that its surface would pass through a straight thread in such a manner as to make the widths of the thread ridge and the thread groove equal. The pitch cone is one of such apex angle and locations of its vertex and axis that its surface would pass through a taper thread in such a manner as to make the widths of the thread ridge and the thread groove equal.

It is required that measurements of pitch, lead, and flank angle of a thread gage be made in an axial plane, making it necessary that the direction or location of the axis be accurately known. To locate this axis accurately is relatively difficult. Normally the major cylinder or cone of an external thread, or the minor cylinder or cone of an internal thread, may be used as the reference surface, provided that it is round and concentric with the pitch cylinder or cone. The amount of eccentricity of such a surface, if any, may be determined at various points along and around the thread, by measuring the distance from the crest to the top of a cylinder (wire) or sphere (ball) laid in the thread. Also, the axis may be established by conical centers in the ends of a thread plug gage, with respect to which the thread was originally generated.

7.3. FLANK ANGLE.—The flank angle is the angle between the flank and the perpendicular to the axis of the thread, measured in an axial plane. A flank angle of a symmetrical thread is commonly termed the *half-angle of thread.*

A flank angle is generally measured with respect to a reference surface, such surface being an end surface of a thread plug or ring gage or the major or minor cylinder or cone. Prior to using such a surface as a reference it is necessary to determine its actual relationship to the thread axis. The flank angle may also be measured with respect to an axis established by conical centers at the ends of a thread plug gage, with respect to which the thread was originally generated.

7.4. PITCH.—The pitch of a thread is the distance, measured parallel to its axis, between corresponding points on adjacent thread forms in the same axial plane and on the same side of the axis.

Measurements of pitch are commonly made from thread groove to thread groove in an axial plane using a ball contact piece to touch both flanks simultaneously. Such measurements establish the number of threads per unit of length (per inch) when the pitch is uniform, or the variations from the nominal pitch when the pitch is either uniform or periodic throughout the measured length of thread. (See par. 6.2.)

7.5. LEAD AND HELIX VARIATIONS.—When a threaded part is rotated about its axis with respect to a fixed contact piece inserted in a thread groove, the lead is the axial distance moved by the part in relation to the amount of angular rotation. Lead is commonly specified as the distance moved in one complete rotation. It is necessary to distinguish measurement of lead from measurement of pitch, as uniformity of pitch measurements does not assure uniformity of lead. Variations in either lead or pitch cause the functional diameter of a thread to differ from the pitch diameter.

Helix variation is a wavy deviation from true helical advancement.

Accordingly, it is necessary to measure lead or helix variation throughout one or more turns of a thread, in addition to measurements of pitch, in order to obtain full information regarding the dimensional deviations of the thread. (See pars. 6.3, 6.4.)

7.6. Pitch Diameter, Functional (Virtual) Diameter, Thread Ridge Diameter, and Thread Groove Diameter.—(As the definitions of these terms are rather lengthy they are not repeated here, but reference should be made to pars. 6.21 to 6.24, inclusive. For threads of perfect form and lead the numerical value of the diameter defined by any one of these terms is equal to the pitch diameter.)

7.6.1. Because of the nearly perfect flank angles and lead of a thread plug gage, the measurement yielded by employing the three-wire system is considered to be the pitch diameter.

7.6.2. On threads of imperfect form or lead it is generally impracticable to determine accurately the pitch diameter as defined; the result obtained in measuring or gaging the thread is an approximation of either the pitch diameter or the functional (virtual) diameter. This approximation may be regarded as a pitch diameter, functional diameter, thread groove diameter, or thread ridge diameter, as related to respective types of equipment and conditions of verifying or measuring a thread. When a thread size is verified by means of a GO thread plug or ring gage, which is within specified gage limits or tolerances and engages the thread throughout a specified length of engagement, a determination is made by the method of attributes that the functional (virtual) diameter does not exceed the maximum-material-limit. The size limit thus verified may be designated the "GO Functional Diameter." The GO thread plug or thread ring gage is the accepted criterion for verification of threaded product for GO functional diameter. However, various indicating type thread gages or thread snap gages having gaging elements which engage the thread over a length and flank engagement approximately equivalent to that of the GO thread plug or thread ring gage should give comparable results, and when properly correlated with the GO thread plug or thread ring gage may serve satisfactorily to give assurance that the functional diameter does not exceed the specified maximum-material-limit.

7.6.3. When a thread size is verified by means of a HI thread plug gage or LO thread ring gage, which is within specified gage limits or tolerances and enters or is entered with a drag over the length of thread specified, a determination is made that the functional diameter lies within the minimum-material-limit. The size limit thus verified may be designated the "HI Functional Diameter" or the "LO Functional Diameter." The HI thread plug or the LO thread ring gage is the accepted criterion for verification of the HI and LO functional diameters of classes 1A, 2A, 1B, 2B, and 3B threads. However, various types of thread snap gages or indicating type thread gages with thread gaging elements which engage the thread over a length and flank engagement approximately equivalent to that of a HI thread plug gage or a LO thread ring gage should give comparable results, and when properly correlated with the HI thread plug or LO thread ring gage may serve satisfactorily to give assurance that the functional diameter is within the minimum-material-limit.

7.6.4. Gaging practice approximating pitch diameter measurement has been termed "LO Minimum-Material-Limit Gaging" and is the accepted criterion for verifying the minimum-material-limit of class 3A external threads. Such verification is accomplished by means of a limit type thread snap or indicating type thread gage with gaging elements having a thread form equivalent to that of the LO thread ring gage. Many thread snap and indicating type thread gages having gaging elements which contact the thread over a length of approximately two pitches are currently in use for determining the minimum-material-limit of various classes of screw threads. However, optimum results for verification of conformance to specifications utilizing differential analysis require a determination of pitch diameter, and this is achieved by means of gaging elements which contact the thread over a maximum length of one pitch. The size limit thus verified may be designated the "Min Single Element PD."

7.6.5. Indicating type thread gages may serve as suitable alternates for gaging the minimum single element PD. A gage having two gaging elements is preferred for detecting an elliptical condition, while a gage having three gaging elements is preferred for detecting the multi-lobed condition.

7.6.6. Gaging practices employing indicating type thread gages with thread forms of gaging elements suitable for approximating pitch diameter measurement, should give comparable results and serve satisfactorily to give assurance that the pitch diameter lies within the minimum-material-limit. Thread forms of gaging elements such as the cone and vee with radius contacts for pitch diameter or radius rolls (simulating the best wire) for thread groove diameter are employed in these instances, and, dependent on design and length of engagement, approximate pitch diameter measurement. The choice as to a cone and vee arrangement compared to radius rolls is a matter of individual preference, in consideration of including or excluding either flank angle or pitch deviations in the measurement. In general, it may be stated that a minimum length of engagement coupled with minimum flank contact results in the closest approximation of pitch diameter.

Conversely it may be stated that by increasing the length of engagement and the flank contact, the gaging tends toward the LO functional diameter. In practice, the length of engagement varies from less than one to approximately three pitches for various designs of gaging elements.

7.6.7. In order to determine that the deviations in lead or flank angle do not exceed the equivalent of one-half of the pitch diameter tolerance, indicating type thread gages may be employed to indicate the differential between the GO functional diameter and the pitch diameter. When the differential exceeds the equivalent of one-half of the pitch diameter tolerance, it is necessary to make a further analysis to determine whether or not any individual thread element exceeds the equivalent of the allowable specified percentage of the pitch diameter tolerance. Deviations from specified size and profile include variations in lead, uniformity of helix, flank angle, and taper; also out-of-roundness, and surface defects. Indicating type thread gages for determining diameter equivalents of lead deviations have gaging elements of the specified form and length of the GO thread gage, by which a differential reading can be obtained between the measured functional diameter and the first-full-thread pitch diameter measured by a single ridge of the GO gaging element, excluding taper, if any. Indicating type thread gages for determining diameter equivalents of flank angle deviations are those by which a differential reading can be obtained between the first-full-thread pitch diameter determined by a single ridge of the GO gaging element and that determined by the indicating type thread gage for pitch diameter having radius-type gaging elements.

7.6.8. When a thread size of a taper thread is verified by means of a taper thread plug or ring gage, or equivalent, having a basic gaging notch or surface, or limit notches, and which is within specified gage limits or tolerances, a determination is made that the functional diameter throughout the specified length of hand engagement lies within specified size limits. The thread size thus verified may be designated the "Taper Thread Functional Diameter."

8. LETTER SYMBOLS AND DESIGNATIONS

8.1. Symbols associated with screw threads are of two kinds: (1) Letter symbols for designating dimensions of screw threads and threaded products; and (2) abbreviations used as designations for various standard thread forms and thread series.

8.2. Dimensional Symbols.

8.2.1. Standard letter symbols to designate the dimensions of screw threads in text and formulas are given in tables 1.4 and 1.6. General symbols are given in table 1.4 and pipe-thread symbols in table 1.6. The application of general symbols is illustrated in figures 1.2 and 1.3, and pipe-thread symbols in figure 1.5.

8.2.2. ISO symbols to designate screw thread dimensions are given in table 1.7. These symbols are commonly applied in Recommendations for Screw Threads of the International Standardization Organization (ISO).

8.3. Thread Designations.

8.3.1. Thread series designations are capital letter abbreviations of names used on drawings, in tables, and otherwise to designate various forms of thread and thread series, and commonly consist of combinations of such abbreviations. Assembled in tables 1.8 and 1.8a are the names and abbreviations which are now in use, together with references to standards in which they occur, for various standard threads.

8.3.2. Thread element designations are capital letter abbreviations based on names of various thread dimensions in thread designations. Such abbreviations are for use on drawings and are shown in table 1.9.

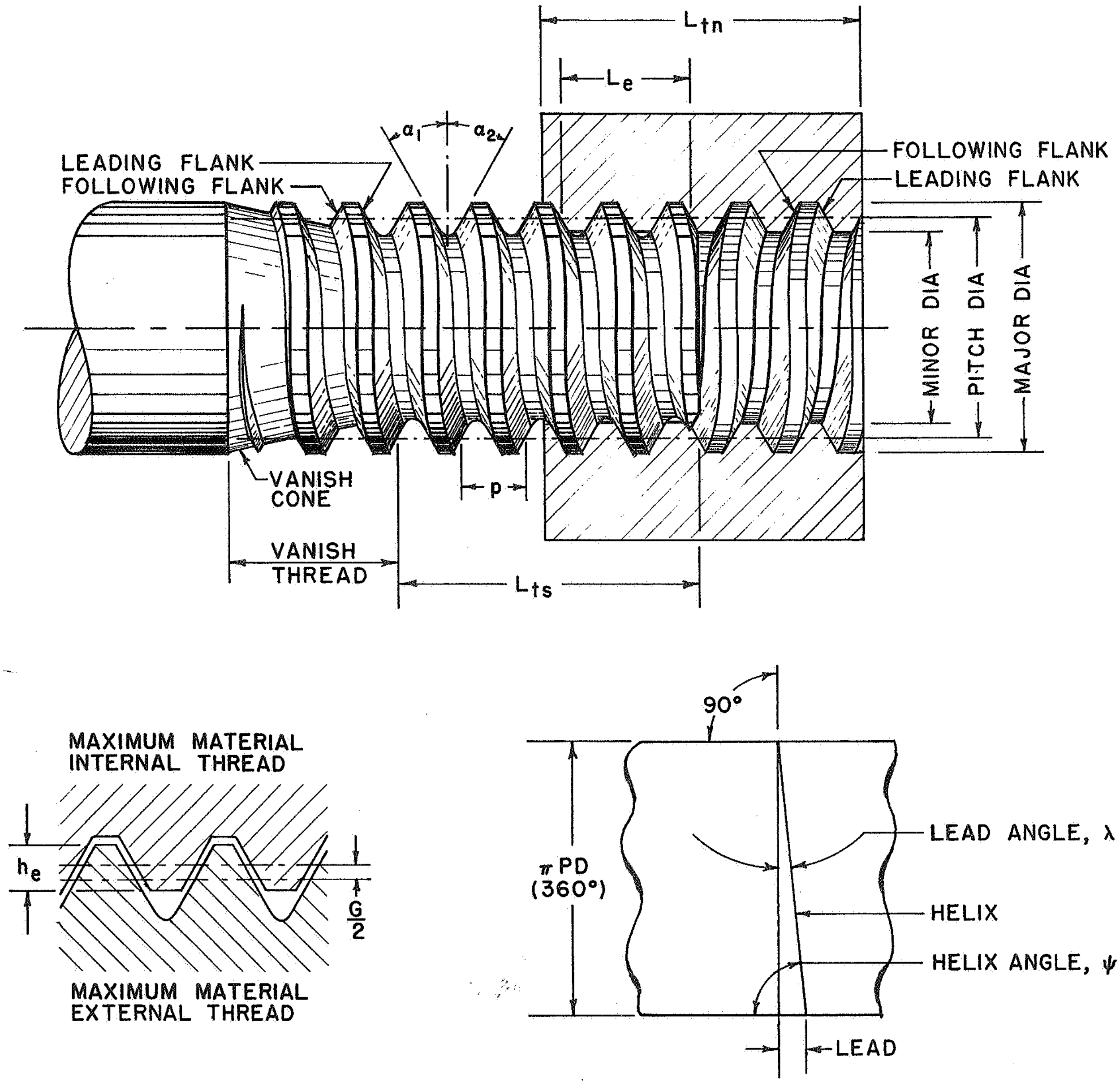

FIGURE 1.2. *General screw thread symbols (see table 1.4).*

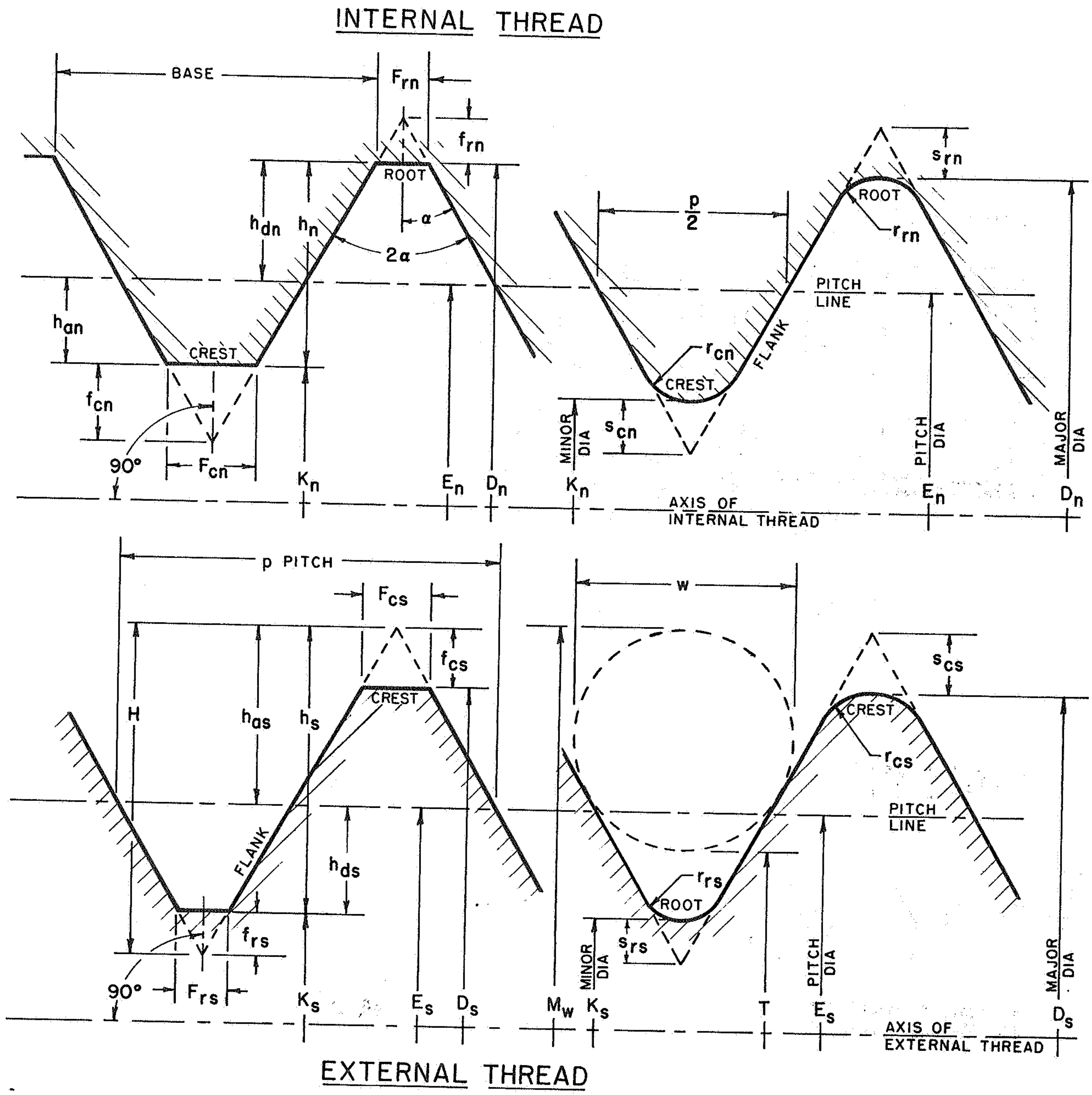

FIGURE 1.3. *General screw thread symbols (see table 1.4).*

NOTE: These diagrams are not intended to show standard forms but illustrate only the applications of symbols.

TABLE 1.4. *General Symbols (see figs. 1.2 and 1.3)*

Symbol	Dimension
D	Major diameter.[a,b]
E	Pitch diameter.[b]
K	Minor diameter.[b]
p	Pitch (Equals $1/n$).
L	Lead (Equals $1/N$).
n	Number of threads (pitches) per unit of length (per inch) (tpi) (Equals $1/p$).
N	Number of turns per unit of length (per inch) (Equals $1/L$).
H	Fundamental triangle height.
h	Thread height (or depth).[b]
h_a	Addendum.
h_d	Dedendum.
h_b	Symmetrical thread height.[c]
h_e	Depth of thread engagement.
α	Half-angle of symmetrical thread.
α_1	Angle between leading flank of thread and normal to thread axis.
α_2	Angle between following flank of thread and normal to thread axis.
λ	Lead angle ($\tan \lambda = L/\pi E$).
ψ	Helix angle ($\cot \psi = L/\pi E$).
	Radius of rounding at:
r_{cs}	Crest of external thread.
r_{rs}	Root of external thread.
r_{cn}	Crest of internal thread.
r_{rn}	Root of internal thread.
	Radial distance from apex of fundamental triangle to:
s_{cs}	Rounded crest of external thread.[d]
f_{cs}	Flat at crest of external thread.[d]
	Width of:
F	Flat (general).
F_{cs}	Flat at crest of external thread.[d]
G	Allowance at major, pitch, and minor diameters of external thread.
L_{ts}	Length of complete external thread.
L_{tn}	Length of complete internal thread including chamfer.
L_e	Length of thread engagement.
w	Diameter of measuring wires.
M_w	Measurement over wires.
T	Measurement under wires.
C	Correction to measurement over wires to give pitch diameter, $E = M_w - C - c$; $C = w(1 + \operatorname{cosec} \alpha) - (\cot \alpha)/2n$.
P	Correction to measurement under wires to give pitch diameter, $E = T + P - c$; $P = (p \cot \alpha)/2 - (\operatorname{cosec} \alpha - 1)w$.
λ'	Wire angle.
c	Wire angle correction.[e]
δ	Deviation in any dimension. Examples: Deviation in pitch, δp; deviation in flank half-angle, $\delta\alpha_1$ or $\delta\alpha_2$.
ΔE_α	Pitch-diameter equivalent of deviations in flank half-angle.
ΔE_p	Pitch-diameter equivalent of deviation in pitch.

[a] Exception: B is used for basic major diameter when this differs from the nominal major diameter.
[b] Subscripts s (for screw) or n (for nut) designating external and internal thread, respectively, may be used if necessary.
[c] For 60° Unified thread this equals 0.75H = 100 percent thread height.
[d] In addition to the symbol with subscript cs, symbols with subscripts rs, cn, and rn are also applicable as in the r_{cs}, etc., symbols above.
[e] See National Physical Laboratory "Gauging and Measuring Screw Threads," 1951, p. 23; Appendix A4 of H28.

GREEK ALPHABET

Α α Alpha	Δ δ Delta	Η η Eta	Κ κ Kappa	Ν ν Nu	Π π Pi	Τ τ Tau	Χ χ Chi
Β β Beta	Ε ϵ Epsilon	Θ θ Theta	Λ λ Lambda	Ξ ξ Xi	Ρ ρ Rho	Υ υ Upsilon	Ψ ψ Psi
Γ γ Gamma	Ζ ζ Zeta	Ι ι Iota	Μ μ Mu	Ο ο Omicron	Σ σ Sigma	Φ φ Phi	Ω ω Omega

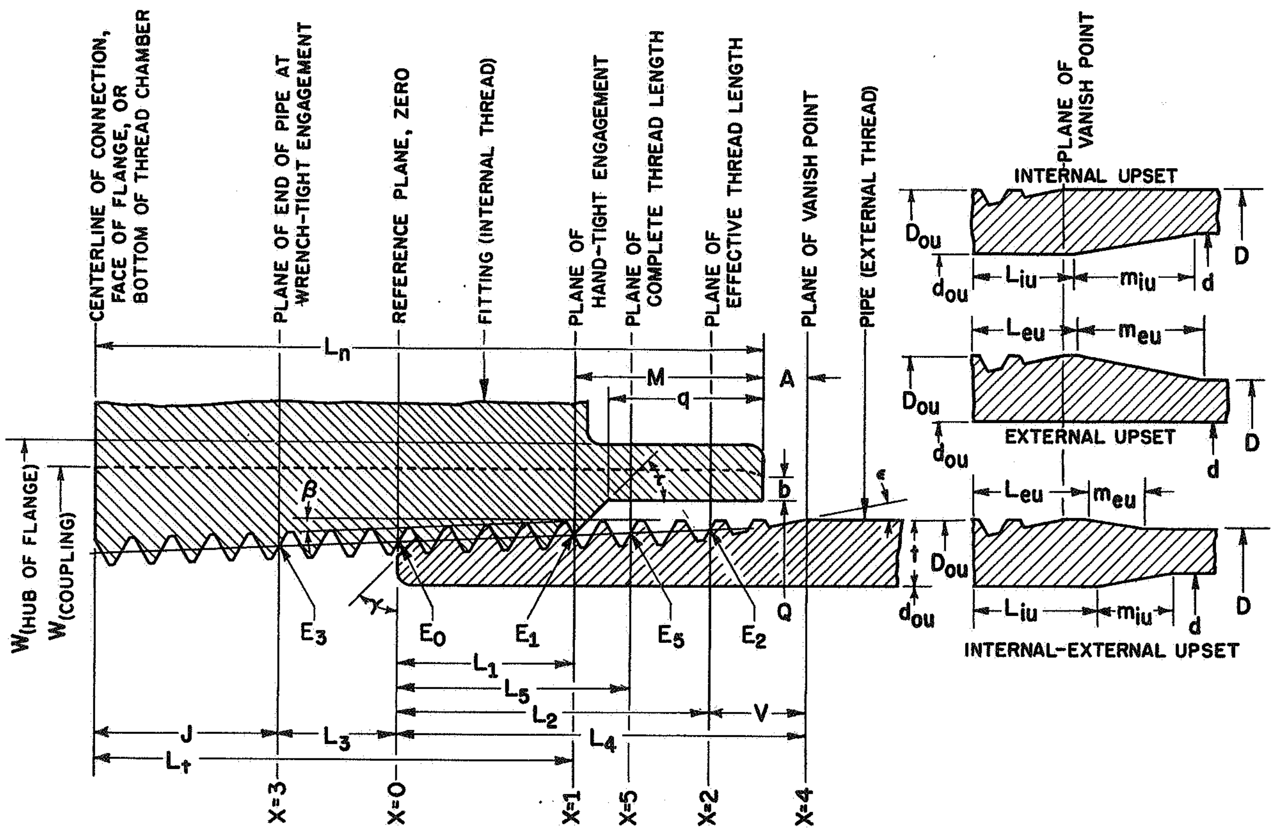

FIGURE 1.5. *Pipe and pipe thread symbols (see table 1.6).*

TABLE 1.6. *Pipe-thread symbols (see fig. 1.5)*

Symbol	Dimension	Symbol	Dimension
D	Outside diameter of pipe.	L_n	Length from center line of coupling, face of flange, or bottom of internal thread chamber to face of fitting.
d	Inside diameter of pipe.	b	Width of bearing face on coupling.
t	Wall thickness of pipe.	τ (tau)	Angle of chamfer at bottom of recess or counterbore measured from the axis.
D_x	Major diameter. (See footnotes a and b)	ϵ (epsilon)	Half apex angle of vanish cone.
E_x	Pitch diameter. (See footnotes a and b)	J	Length from center line of coupling, face of flange, or bottom of internal thread chamber to end of pipe, wrenched engagement.
K_x	Minor diameter. (See footnotes a and b)	L_t	(1) Length of straight full thread (see table 1.4). (2) Length from plane of handtight engagement to small end of full internal taper thread.
L_x	Length of thread from plane of pipe end to plane containing basic diameter D_x, E_x, or K_x.	Q	Diameter of recess or counterbore in fitting.
V	Length of vanish cone (washout) threads.	q	Depth of recess or counterbore in fitting.
β (beta)	Half apex angle of pitch cone of taper thread.	W	Outside diameter of coupling or hub of fitting.
γ (gamma)	Angle of chamfer at end of pipe measured from a plane normal to the axis.		
A	Handtight standoff of face of coupling from a plane containing vanish point on pipe.		
M	Length from plane of handtight engagement to the face of coupling on internally threaded member.		
S	Distance of gaging step of plug gage from face of ring gage for handtight engagement. Standoff.		

[a] Subscript x denotes plane containing the diameter. For axial *positions of planes* see below.
[b] Subscripts s (for screw) or n (for nut) designating external and internal threads, respectively, may also be used if necessary

DEFINITIONS OF PLANES DENOTED BY SUBSCRIPT x

$x = 0$	Plane of pipe end.
$x = 1$	Plane of handtight engagement or plane at mouth of coupling (excluding recess, if present). On British pipe threads this is designated the "gauge plane" and the major diameter in this plane is designated the "gauge diameter."
$x = 2$	Plane at which vanish threads on pipe commence.
$x = 3$	Plane in coupling reached by end of pipe in wrenched condition. (L_3 is measured from plane containing pipe end in position of handtight engagement.)
$x = 4$	Plane containing vanish point of thread on pipe.
$x = 5$	Plane at which major diameter cone of thread intersects outside diameter of pipe.

Additional special subscripts are as follows:

$x = 6$	Plane of the pipe end for railing joints.
$x = 7$	Plane of the API gage point at a specified length from the plane of vanish point.
$x = 8$	Plane of the large end of the "L_8 thread ring gage" for the National Gas Taper (compressed-gas cylinder valve inlet connection) thread.
$x = 9$	Plane of the small end of the "L_9 thread plug gage" for the National Gas Taper (compressed-gas cylinder inlet) thread.

TABLE 1.7 *ISO symbols*

Symbol	Dimension
d	Basic major diameter of bolt thread.
d_2	Basic pitch (effective) diameter of bolt thread.
d_1	Basic minor diameter of bolt thread.
D	Basic major diameter of nut thread.
D_1	Basic minor diameter of nut thread.
D_2	Basic pitch (effective) diameter of nut thread.
P	Pitch.
n	Number of threads per inch.
R	Radius of root of bolt thread.
H_1	Depth of thread engagement.
n_e	Number of threads in engagement.
S	Designation for thread engagement group Short.
N	Designation for thread engagement group Normal.
L	Designation for thread engagement group Long.
T	Tolerance.
T_d, T_{d2}, T_{d1}, T_{D1}, T_{D2}.	Tolerance for major diameter of bolt thread, for pitch (effective) diameter of bolt thread, etc.
ei, EI	Lower deviation.
es, ES	Upper deviation.
A	Allowance.

TABLE 1.8. *Thread series designations*[a,b]

Designation	Thread series	Reference: United States of America (USA) Standard	Reference: H28
ACME-C	Acme threads, centralizing	B1.5	Part III
ACME-G	Acme threads, general purpose (See also "Stub Acme")	B1.5	Part III
AMO	Microscope Objective threads	B1.11	Part III
ANPT	Aeronautical National form taper pipe threads	MIL-P-7105	
F-PTF	Dryseal (fine) taper pipe threads	B2.2	Part II
M	ISO metric threads		Part III
N BUTT	Buttress threads	B1.9	Part III
N, NC, NF, NEF	See table 1.8a		
	Gas Cylinder Valve Outlet and Inlet Threads:	B57.1	Part II
NGO (b)	Gas outlet threads		
NGS	Gas straight threads		
NGT	Gas taper threads		
SGT	Special gas taper threads		
NH, NPSH	Hose coupling threads	B2.4	Part II
NH	Fire-hose coupling threads		Part II
	Pipe Threads (except Dryseal):		
ANPT	Aeronautical National form taper pipe threads	MIL-P-7105	
NPSC	Straight pipe threads in pipe couplings	B2.1	Part II
NPSL	Straight pipe threads for loose-fitting mechanical joints with locknuts	B2.1	Part II
NPSM	Straight pipe threads for free-fitting mechanical joints for fixtures	B2.1	Part II
NPT	Taper pipe threads for general use	B2.1	Part II
NPTR	Taper pipe threads for railing joints	B2.1	Part II
	Dryseal Pipe Threads:		
F-PTF	Dryseal (fine) taper pipe threads	B2.2	Part II
NPSF	Dryseal fuel internal straight pipe threads	B2.2	Part II
NPSI	Dryseal intermediate internal straight pipe threads	B2.2	Part II
NPTF	Dryseal taper pipe threads	B2.2	Part II
PTF-SAE, SHORT	Dryseal SAE short taper pipe threads	B2.2	Part II
PTF-SPL, SHORT	Dryseal special short taper pipe threads	B2.2	Part II
PTF-SPL, EXTRA SHORT	Dryseal special extra short taper pipe threads	B2.2	Part II
SPL-PTF	Dryseal special taper pipe threads	B2.2	Part II
NR, NS	See table 1.8a		
SGT	Special gas taper threads	B57.1	Part II
SPL-PTF	See under "Dryseal pipe threads"		
STUB ACME	Stub Acme threads	B1.8	Part III
	Surveying instrument mounting threads		Part III
UN series	See table 1.8a (0.06 in. (1.5 mm) and larger)		
UNJ series	See table 1.8a (0.06 in. (1.5 mm) and larger)		
UNM	Unified Miniature thread series (0.055 in. (1.4 mm) and smaller)	B1.10	Section 5

[a] Methods of designating multiple threads are shown in USA B1.5, Acme screw threads, and Part III of Handbook H28.
[b] All threads, except NGO, are right hand unless otherwise designated. For NGO threads, designations "RH" or "LH" are required.

TABLE 1.8a. *Designations for UN, UNJ, N, NR thread series*

Basic thread series	External thread root	Constant pitch	Coarse	Fine	Extra fine	Special diameters, pitches, or lengths of engagement	Reference: United States of America (USA) Standard	Reference: H28
UN	With optional radius root on external thread.	UN	UNC	UNF	UNEF	UNS	B1.1 B1.1	Section 2 Section 3
UNJ	With 0.15011p to 0.18042p mandatory radius root on external thread.	UNJ	UNJC	UNJF	UNJEF	UNJS		Section 4
N[a]		N	NC	NF	NEF	NS		Appendix A1
NR		NR					MIL-B-7838	

[a] This series superseded by UN series.

TABLE 1.9 *Dimensional designations for use on drawings*

Designation	Dimension	Designation	Dimension
CR	Crest radius.	RR	Root radius.
DR	Differential reading.	T	Tolerance.
FD	Functional diameter.	TGD	Thread groove diameter.
G	Allowance.	TGW	Thread groove width.
L	Lead.	TPI	Threads per inch.
LE	Length of thread engagement.	TRD	Thread ridge diameter.
P	Pitch.	TRT	Thread ridge thickness.
PD	Pitch diameter.		

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UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

HANDBOOK H28

SCREW-THREAD STANDARDS

FOR FEDERAL SERVICES

SECTION 2

1969

UNIFIED THREAD FORM AND THREAD SERIES FOR BOLTS, SCREWS, NUTS, TAPPED HOLES, AND GENERAL APPLICATIONS

CONTENTS

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1. INTRODUCTION

The Unified thread standards shown in this section are in agreement with International Standardization Organization (ISO) Recommendations:

R68 Screw Threads (That part dealing with the ISO Basic Thread Profile), and

R263 ISO Inch Screw Threads, General Plan and Selection for Screws, Bolts, and Nuts (diameter range 0.06 to 6 inch).

This section is in general agreement with United States of America Standard USA B1.1, Unified Screw Threads, published by The American Society of Mechanical Engineers, 345 East 47th Street, New York, N.Y. 10017; also with CSA B1.1, Standard for Unified and American Screw Threads, published by the Canadian Standards Association, Ottawa, Canada; and with British Standard 1580, Unified Screw Threads, published by the British Standards Institution, 2 Park Street, London, W.1. The latest revision should be consulted when referring to such standards. As of date of issue of this section of H28, USA B1.1-1960 is the latest revision of B1.1.

The Unified screw thread standards shown in this section constitute the basic thread standards used in the United States for the screw threads used on threaded fasteners. Unified screw threads are a complete and integrated system of threads for fastening purposes in mechanisms and structures. Their outstanding characteristic is general interchangeability of threads achieved through the standardization of thread form, diameter-pitch combinations, and limits of size.

The standards have as their original basis the work done about a century ago by William Sellers in the United States and Sir Joseph Whitworth in Great Britain. Throughout the intervening years there have been many further developments and revisions, culminating in the system of Unified Threads approved and adopted for use by all inch-using countries.

Unification of screw thread standards received its impetus from the need for interchangeability among the billions of fasteners used in the complex equipment of modern warfare which equipment was, and continues to be, made in different countries. Equally important, however, are international trade in mechanisms of all kinds and the servicing of transportation equipment which moves from country to country. These have made unification not only highly advantageous but practically essential.

Unified screw threads had their origin in an Accord signed at Washington, D.C., on November 18, 1948, by representatives of Standardizing Bodies of Canada, the United Kingdom, and the United States. The Unified standard threads generally supersede the American standard threads. Threads are classed as Unified if they have the basic Unified thread form and have limits of size and tolerances based on the Unified formulations. Such threads are identified by the letter combination "UN" in the thread symbol.

In relation to previous American practice, Unified threads have substantially the same thread form and are mechanically interchangeable with American National threads of the same diameter and pitch.

The principal differences between the two systems relate to the application of allowances, the variation of tolerances with size, difference in amount of pitch diameter tolerance on external and internal threads, and differences in thread designations. Under the Unified system, an allowance is provided on both the classes 1A and 2A external threads, whereas under the American National system only the class 1 external thread has an allowance. Under the Unified system, the pitch diameter tolerance of an internal thread is 30 percent greater than that of the external thread, but such tolerances are equal under the American National system. Since the tolerances differ, the letter "A" is used in the thread symbol to denote an external thread and the letter "B" is used to denote an internal thread. Unified tolerances and allowances for both standard and special diameter-pitch combinations are derived from the same formula, but American National tolerances for special threads have a different basis from that for some standard threads.

2. UNIFIED THREAD FORM

2.1. BASIC THREAD FORM.—The Unified thread form is the basis of all thread dimensions given in this section. The formulas for its proportions are given in table 2.1, together with figure 2.2, showing the basic profile from which the design forms are derived. Both the ISO basic profile and the American (U.S.) concept of the basic Unified thread form are shown. These are essentially alike except that in the second illustration the position of the basic minor diameter provides for the long established practice in the U. S. of considering 100 percent thread height as being equal to $0.75H$ measured from the basic major diameter.

2.1(a) *Angle of thread.*—The basic angle of thread between the flanks of the thread, measured in an axial plane, is 60°. The line bisecting this 60° angle is perpendicular to the axis of the screw thread.

2.1(b) *Form of crest.*—The form of the crest of external threads is flat. The crest of the basic thread form of the external thread shall be truncated from the sharp crest an amount equal to $0.125\,H$, where H is the depth of the fundamental triangle. The form of the crest of internal threads is flat and the crest shall be truncated from the sharp crest an amount equal to $0.25\,H$.

2.1(c) *Rounded root forms.*—The crest clearances allowed are such as to permit rounded root forms in both the external and internal threads. Rounded roots are required in some applications and are made by tools that are purposely rounded. Otherwise, rounded roots may be the result of tool wear.

2.1(d) *Clearance at minor diameter.*—A clearance is provided at the minor diameter of the internal thread by truncating from the sharp crest an amount equal to $0.25\,H$.

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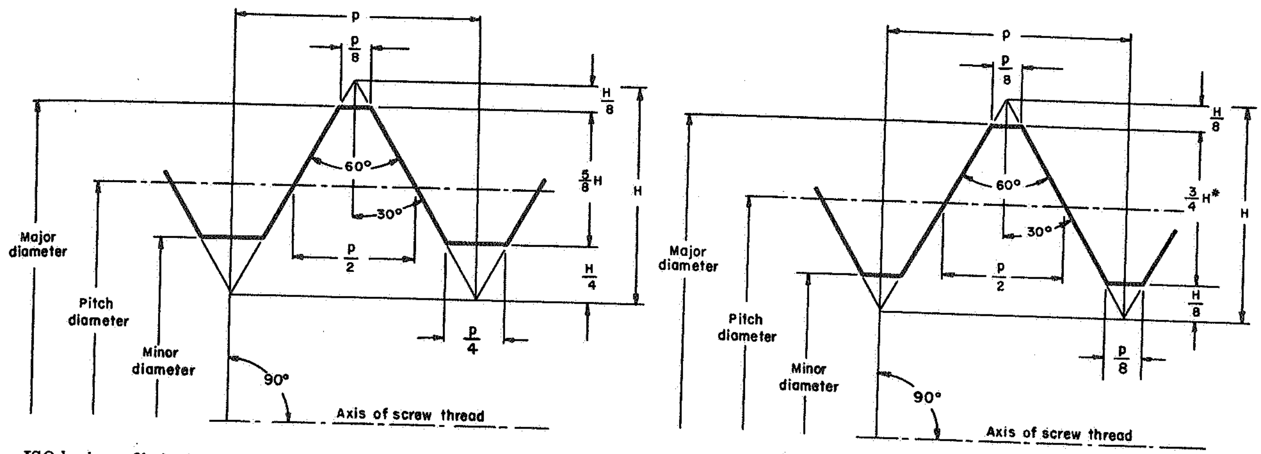
TABLE 2.1. *Thread data, Unified thread form (see fig. 2.4.)*

Threads per inch, n	Pitch, $p = 1/n$	Flat at internal thread crest, $F_{cn} = p/4 = 0.25/n$	Flat at internal thread root and external thread crest, $F_{rn} = F_{cs} = p/8 = 0.125/n$	Height of sharp v-thread, $H = .8660254/n$	Twice min truncation of internal thread root, $2f_{rn} = H/12 = 0.0721688/n$	Max truncation of internal thread root and external thread crest, $f_{rn} = f_{cs} = H/8 = 0.108253/n$	Truncation of external thread rounded root, $s_{rs} = H/6 = 0.144338/n$	Half addendum of external thread, $3H/16 = 0.162380/n$	Addendum of internal thread and truncation of internal thread crest, $h_{an} = f_{cn} = H/4 = 0.216506/n$	Dedendum of internal thread and addendum of external thread, $h_{dn} = h_{as} = 3H/8 = 0.324759/n$	Height of internal thread and depth of thread engagement, $h_n = h_e = 5H/8 = 0.541266/n$	Height of external thread and max height of internal thread, $h_s = 17H/24 = 0.613435/n$	([a]) Twice the external thread addendum, $h_b = 2h_{as} = 3H/4 = 0.649519/n$	Thread height from basic flat crest to sharp root, $7H/8 = 0.757772/n$	Difference between max major and pitch diameters of internal thread, $11H/12 = 0.793857/n$	Double height of internal thread, $2h_n = 5H/4 = 1.082532/n$	Double height of external thread, $17H/12 = 1.226868/n$
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in
80	0.012500	0.00312	0.00156	0.010825+	0.00090	0.00135+	0.00180	0.00203	0.00271	0.00406	0.00677	0.00767	0.008119	0.00947	0.00992	0.01353	0.01534
72	.013889	.00347	.00174	.012028	.00100	.00150	.00200	.00226	.00301	.00451	.00752	.00852	.009021	.01052	.01103	.01504	.01704
64	.0156250	.00391	.00195+	.013532	.00113	.00169	.00226	.00254	.00338	.00507	.00846	.00958	.010149	.01184	.01240	.01691	.01917
56	.017857	.00446	.00223	.015465−	.00129	.00193	.00258	.00290	.00387	.00580	.00967	.01095+	.011599	.01353	.01418	.01933	.02191
48	.020833	.00521	.00260	.018042	.00150	.00226	.00301	.00338	.00451	.00677	.01128	.01278	.013532	.01579	.01654	.02255+	.02556
44	.022727	.00568	.00284	.019682	.00164	.00246	.00328	.00369	.00492	.00738	.01230	.01394	.014762	.01722	.01804	.02460	.02788
40	.025000	.006250	.00312	.021651	.00180	.00271	.00361	.00406	.00541	.00812	.01353	.01534	.016238	.01894	.01985−	.02706	.03067
36	.027778	.00694	.00347	.024056	.00200	.00301	.00401	.00451	.00601	.00902	.01504	.01704	.018042	.02105−	.02205+	.03007	.03408
32	.031250	.00781	.00391	.027063	.00226	.00338	.00451	.00507	.00677	.01015−	.01691	.01917	.020297	.02368	.02481	.03383	.03834
28	.035714	.00893	.00446	.030929	.00258	.00387	.00515+	.00580	.00773	.01160	.01933	.02191	.023197	.02706	.02835+	.03866	.04382
27	.037037	.00926	.00463	.032075+	.00267	.00401	.00535−	.00601	.00802	.01203	.02005−	.02272	.024056	.02807	.02940	.04009	.04544
24	.041667	.01042	.00521	.036084	.00301	.00451	.00601	.00677	.00902	.01353	.02255+	.02556	.027063	.03157	.03308	.04511	.05112
20	.050000	.01250	.006250	.043301	.00361	.00541	.00722	.00812	.01083	.01624	.02706	.03067	.032476	.03789	.03969	.05413	.06134
18	.055556	.01389	.00694	.048113	.00401	.00601	.00802	.00902	.01203	.01804	.03007	.03408	.036084	.04210	.04410	.06014	.06816
16	.062500	.01562	.00781	.054127	.00451	.00677	.00902	.01015−	.01353	.02030	.03383	.03834	.040595−	.04736	.04962	.06766	.07668
14	.071429	.01786	.00893	.061859	.00515+	.00773	.01031	.01160	.01546	.02320	.03866	.04382	.046394	.05413	.05670	.07732	.08763
13	.076923	.01923	.00962	.066617	.00555+	.00833	.01110	.01249	.01665+	.02498	.04164	.04719	.049963	.05829	.06107	.08327	.09437
12	.083333	.02083	.01042	.072169	.00601	.00902	.01203	.01353	.01804	.02706	.04511	.05112	.054127	.06315−	.06615+	.09021	.10224
11.5	.086957	.02174	.01087	.075307	.00628	.00941	.01255+	.01412	.01883	.02824	.04707	.05334	.056480	.06589	.06903	.09413	.10668
11	.090909	.02273	.01136	.078730	.00656	.00984	.01312	.01476	.01968	.02952	.04921	.05577	.059047	.06889	.07217	.09841	.11153
10	.100000	.02500	.01250	.086603	.00722	.01083	.01443	.01624	.02165+	.03248	.05413	.06134	.064952	.07578	.07939	.10825+	.12269
9	.111111	.02778	.01389	.096225+	.00802	.01203	.01604	.01804	.02406	.03608	.06014	.06816	.072169	.08420	.08821	.12028	.13632
8	.125000	.031250	.01562	.108253	.00902	.01353	.01804	.02030	.02706	.04059	.06766	.07668	.081190	.09472	.09923	.13532	.15336
7	.142857	.03571	.01786	.123718	.01031	.01546	.02062	.02320	.03093	.04639	.07732	.08763	.092788	.10825+	.11341	.15465−	.17527
6	.166667	.04167	.02083	.144338	.01203	.01804	.02406	.02706	.03608	.05413	.09021	.10224	.108253	.12630	.13231	.18042	.20448
5	.200000	.05000	.02500	.173205+	.01443	.02165+	.02887	.03248	.04330	.06495+	.10825+	.12269	.129904	.15155+	.15877	.21651	.24537
4.5	.222222	.05556	.02778	.192450	.01604	.02406	.03208	.03608	.04811	.07217	.12028	.13632	.144338	.16839	.17641	.24056	.27264
4	.250000	.06250	.031250	.216506	.01804	.02706	.03608	.04059	.05413	.08119	.13532	.15336	.162380	.18944	.19846	.27063	.30672

[a] This is taken as 100 percent thread height and is now known as a symmetrical thread form. It is equivalent to the "basic height" h of the original American National form.



ISO basic profile for inch and metric threads.

* 3H/4=100 percent thread height

American (U.S.) symmetrical thread form from which percentages of thread height are calculated.

FIGURE 2.2. *Basic unified thread form; ISO basic profile and American (U.S.) symmetrical thread form.*

2.1(e) *Clearance at major diameter.*—A clearance is provided at the major diameter of the internal thread by making the thread form at the root such that its width is less than 0.125 *p*.

2.2. DESIGN FORM OF EXTERNAL THREAD.—The design form for an external Unified thread, i.e., the form of an external thread in its maximum material condition, shown in figure 2.3, is derived from the fundamental triangle. It is truncated at the major diameter to 0.125 *H*. In practice, due to providing for tool crest wear at the thread roots, i.e., the minor diameter, the roots are shown as a rounded contour and cleared beyond the flat width of 0.25 *p* for the minimum minor diameter of the internal thread. Also, in practice, the crests of the external threads may be rounded within the confines established by the major diameter tolerance.

2.3. DESIGN FORM OF INTERNAL THREAD.—The design form for an internal Unified thread, i.e., the form of an internal thread in its maximum material condition, shown in figure 2.3, is derived from the fundamental triangle. It is similar to the basic form except that the truncation at the minor diameter is an amount equal to one-quarter of the fundamental triangle height (0.25*H*). In practice, due to providing for tool crest wear at the thread roots, i.e., the major diameter, the roots are shown as a rounded contour and cleared beyond the flat width of 0.125 *p* for the maximum major diameter of the internal thread.

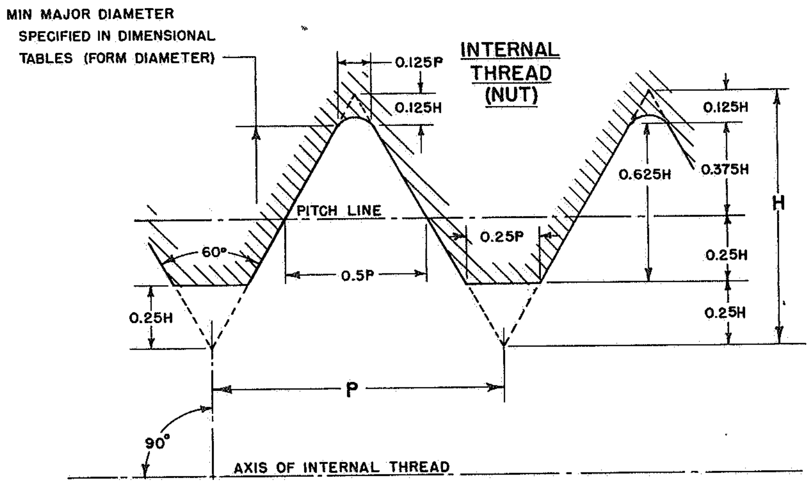
2.4. BASIC THREAD DATA.—The basic thread data for all standard pitches of the Unified form of thread are given in table 2.1.

3. THREAD SERIES, ORDER OF SELECTION, AND SUGGESTED APPLICATIONS

3.1. THREAD SERIES DEFINITION.—Thread series are groups of diameter-pitch combinations distinguished from each other by the number of threads per inch applied to series of specific diameters. The various diameter-pitch combinations of three series with graded pitches and 8 series with constant pitches are given in table 2.7, p. 2.08. The symbols for designating the various thread series are shown in table 2.7. In table 2.21, p. 2.26, the limits of size of the series in table 2.7 are given but the full range is not covered in the case of the 4UN, 6UN, and 8UN series. (See par. 11 Limits of Size, p. 2.25.)

3.2. ORDER OF SELECTION.—Whenever possible, selection should be made from table 2.21, p. 2.26, Standard series limits of size—Unified screw threads, preference being given to the coarse-thread and fine-thread series. If threads in the standard series do not meet the requirements of design, reference should be made to the selected combinations in table 3.1. The third expedient is to compute the limits of size for a special diameter-pitch combination in accordance with table 3.11. The fourth and last resort is calculation by the formulas in section 3.

3.3. UNC, COARSE-THREAD SERIES.—This series is generally utilized for the bulk production of bolts, screws, nuts, and other general engineering applications. It is used in general applications for threading into lower tensile strength materials such as cast iron, mild steel, and softer materials to obtain the optimum resistance to stripping of the internal



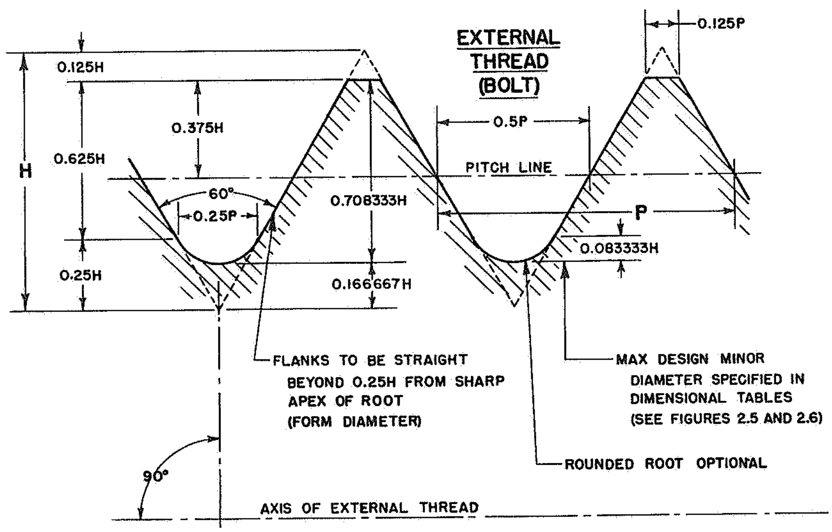


FIGURE 2.3. *Unified internal and external screw thread design forms (maximum material condition).*

NOTE: See table 2.1 for numerical values. In practice the crests of external threads may be rounded.

thread. It is applicable for rapid assembly or disassembly, or if corrosion or slight damage is possible. The basic dimensions and limits of size for this series are shown in tables 2.8 and 2.21.

3.4. UNF, FINE-THREAD SERIES.—This series is suitable for the production of bolts, screws, nuts, and other applications where the coarse series is not applicable. External threads of this series have greater tensile stress area than comparable sizes of the coarse series. The fine series is suitable when the resistance to stripping of both external and mating internal threads equals or exceeds the tensile load carrying capacity of the externally threaded member. It is also used where the length of engagement is short, where a smaller lead angle is desired, or where the wall thickness demands a fine pitch. It may also be used for threading into lower strength materials where maximum strength of the external thread is not required, otherwise, the length of engagement must be selected to meet the above required strength conditions.

Fine threads up to and including 1 in size are suitable for screw, bolt, and nut, and other threaded fastener applications. Sizes over 1 in may not be suitable unless the mating materials are compatible as outlined above. The basic dimensions and limits of

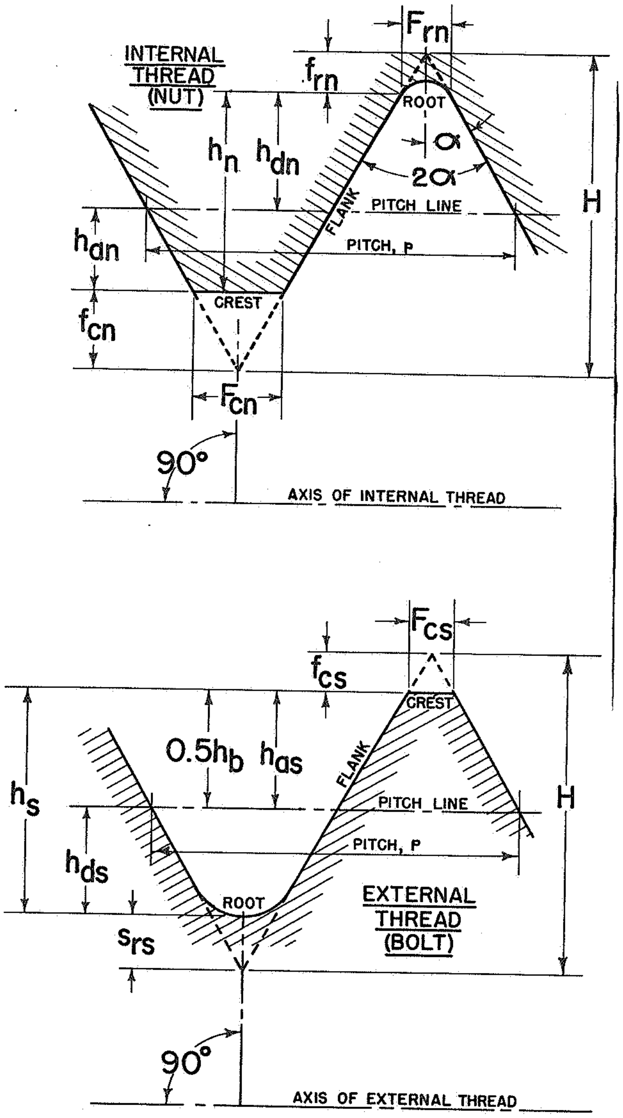


FIGURE 2.4. *Symbols for thread data in table 2.1.*

size for this series are shown in tables 2.9 and 2.21.

3.5. UNEF, EXTRA-FINE THREAD SERIES.—This series is applicable where even finer pitches of threads are desirable for short lengths of engagement and for thin-walled tubes, nuts, ferrules, or couplings. It is also generally applicable under the conditions stated above for the fine threads. The basic dimensions and limits of size for this series are shown in tables 2.10 and 2.21.

3.6. UN, CONSTANT PITCH SERIES.—The various constant-pitch series with 4, 6, 8, 12, 16, 20, 28, and 32 threads per inch, given in table 2.7, offer a comprehensive range of diameter-pitch combinations for those purposes where the threads in the UNC, UNF, and UNEF series do not meet the particular requirements of the design. The constant pitch series have application on parts that are repeatedly assembled and disassembled or where it might be advantageous to rethread oversize to recondition the threaded portions of the parts. Whenever a thread in a constant-pitch series also appears in the UNC, UNF, or UNEF series, the symbols, tolerances, and limits of size of those standard series are applicable. When selecting threads from these constant-pitch series, preference should be given whenever possible to those tabulated in the 8-, 12-, or 16-thread series. The basic dimensions for the 4-, 6-, 20-, 28-, and 32-thread series are shown in tables 2.11, 2.12, 2.16, 2.17, and 2.18.

3.6(a) *8UN, 8-thread series.*—The 8UN series is a uniform-pitch series for large diameters or for use as a compromise between the coarse- and fine-thread series. Although originally intended for high-pressure-joint bolts and nuts, it is now widely used as a substitute for the coarse-thread series for diameters larger than 1 in. The basic dimensions for this series are shown in table 2.13.

3.6(b) *12UN, 12-thread series.*—The 12UN series is a uniform-pitch series for large diameters requiring threads of medium-fine pitch. Although originally intended for boiler practice, it is now used as a continuation of the fine-thread series for diameters larger than 1.5 in. The basic dimensions for this series are shown in table 2.14.

3.6(c) *16UN, 16-thread series.*—The 16UN series is a uniform-pitch series for large diameters requiring fine-pitch threads. It is suitable for adjusting collars and retaining nuts, and also serves as a continutation of the extra-fine-thread series for diameters larger than 1.6875 in. The basic dimensions for this series are shown in table 2.15.

3.7. HIGH-TEMPERATURE, HIGH-STRENGTH APPLICATIONS.—For these applications the coarse-thread series is recommended in sizes from 0.25 to 1 in and the 8-thread series in sizes over 1 in. Limits of size are given in table 2.21. Some high-temperature applications involving special physical characteristics or conditions may require modification of thread dimensions. See italicized part in par. 4.2, p. 2.19, and par. 10.5, p. 2.24.

3.8. SELECTED COMBINATIONS OF UNS THREADS.—These data are tabulated in table 3.1 for some selected combinations of diameter and pitch of Unified special screw threads, designated UNS, with pitch diameter tolerances based on a length of thread engagement of 9 times the pitch. The pitch diameter limits are applicable to a length of engagement of from 5 to 15 times the pitch. (This should not be confused with the length of thread on mating parts, as it may exceed the length of engagement by a considerable amount.)

3.9. FINE THREADS FOR THIN-WALL TUBING.—The limits of size for a 27-thread series, ranging from 0.25 to 1 in nominal size, are included in table 3.1. These threads are recommended for general use on thin-wall tubing. For more detailed information see part II of Handbook H28.

3.10. THREADS OF SPECIAL DIAMETERS, PITCHES, AND LENGTHS OF ENGAGEMENT.—For information on special threads, see section 3.

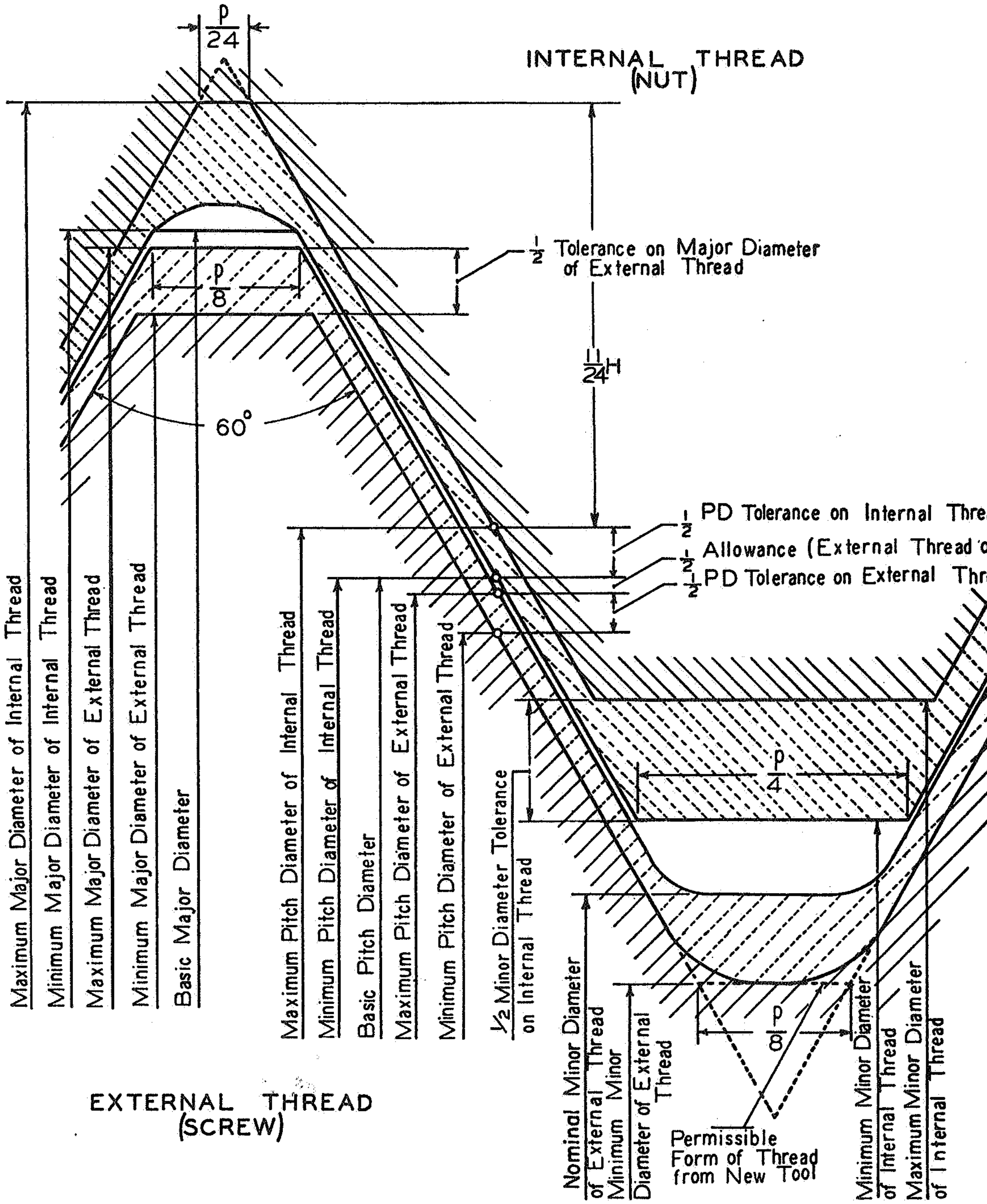


FIGURE 2.5. *Disposition of tolerances, allowances, and crests clearances for classes 1A, 2A, 1B, and 2B.*

NOTE: "Nominal minor diameter of external thread" is that specified in tables.

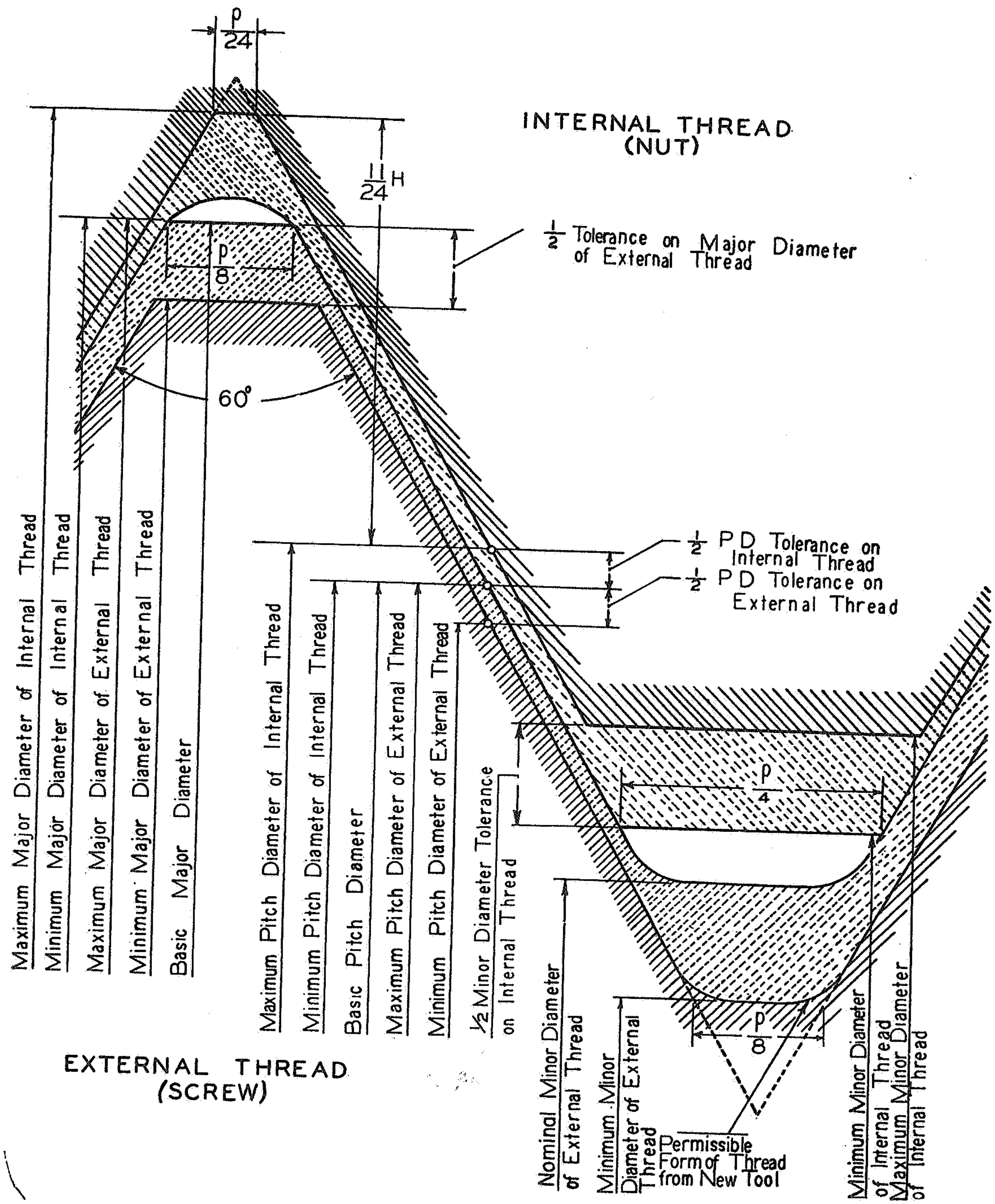


FIGURE 2.6. *Disposition of tolerances and crest clearances for classes 3A and 3B.*

NOTE: "Nominal minor diameter of external thread" is that specified in tables.

TABLE 2.7. *Unified standard screw thread series*

Nominal size and basic major diameter		Threads per inch											Nominal size and basic major diameter
		Series with graded pitches			Series with constant pitches								
Primary	Secondary	Coarse UNC	Fine UNF	Extra fine UNEF	4UN	6UN	8UN	12UN	16UN	20UN	28UN	32UN	
in	*in*												*in*
.060			80										.060
	.073	64	72										.073
.086		56	64										.086
	.099	48	56										.099
.112		40	48										.112
.125		40	44										.125
.138		32	40									UNC	.138
.164		32	36									UNC	.164
.190		24	32									UNF	.190
	.216	24	28	32							UNF	UNEF	.216
.250		20	28	32						UNC	UNF	UNEF	.250
.3125		18	24	32						20	28	UNEF	.3125
.375		16	24	32					UNC	20	28	UNEF	.375
.4375		14	20	28					16	UNF	UNEF	32	.4375
.500		13	20	28					16	UNF	UNEF	32	.500
.5625		12	18	24				UNC	16	20	28	32	.5625
.625		11	18	24				12	16	20	28	32	.625
	.6875			24				12	16	20	28	32	.6875
.750		10	16	20				12	UNF	UNEF	28	32	.750
	.8125			20				12	16	UNEF	28	32	.8125
.875		9	14	20				12	16	UNEF	28	32	.875
	.9375			20				12	16	UNEF	28	32	.9375
1.000		8	12	20			UNC	UNF	16	UNEF	28	32	1.000
	1.0625			18			8	12	16	20	28		1.0625
1.125		7	12	18			8	UNF	16	20	28		1.125
	1.1875			18			8	12	16	20	28		1.1875
1.250		7	12	18			8	UNF	16	20	28		1.250
	1.3125			18			8	12	16	20	28		1.3125
1.375		6	12	18		UNC	8	UNF	16	20	28		1.375
	1.4375			18		6	8	12	16	20	28		1.4375
1.500		6	12	18		UNC	8	UNF	16	20	28		1.500
	1.5625			18		6	8	12	16	20			1.5625
1.625				18		6	8	12	16	20			1.625
	1.6875			18		6	8	12	16	20			1.6875
1.750		5				6	8	12	16	20			1.750
	1.8125					6	8	12	16	20			1.8125
1.875						6	8	12	16	20			1.875
	1.9375					6	8	12	16	20			1.9375
2.000		4.5				6	8	12	16	20			2.000
	2.125					6	8	12	16	20			2.125
2.250		4.5				6	8	12	16	20			2.250
	2.375					6	8	12	16	20			2.375
2.500		4			UNC	6	8	12	16	20			2.500
	2.625				4	6	8	12	16	20			2.625
2.750		4			UNC	6	8	12	16	20			2.750
	2.875				4	6	8	12	16	20			2.875
3.000		4			UNC	6	8	12	16	20			3.000
	3.125				4	6	8	12	16				3.125
3.250		4			UNC	6	8	12	16				3.250
	3.375				4	6	8	12	16				3.375
3.500		4			UNC	6	8	12	16				3.500
	3.625				4	6	8	12	16				3.625
3.750		4			UNC	6	8	12	16				3.750
	3.875				4	6	8	12	16				3.875
4.000		4			UNC	6	8	12	16				4.000
	4.125				4	6	8	12	16				4.125
4.250					4	6	8	12	16				4.250
	4.375				4	6	8	12	16				4.375
4.500					4	6	8	12	16				4.500
	4.625				4	6	8	12	16				4.625
4.750					4	6	8	12	16				4.750
	4.875				4	6	8	12	16				4.875
5.000					4	6	8	12	16				5.000
	5.125				4	6	8	12	16				5.125
5.250					4	6	8	12	16				5.250
	5.375				4	6	8	12	16				5.375
5.500					4	6	8	12	16				5.500
	5.625				4	6	8	12	16				5.625
5.750					4	6	8	12	16				5.750
	5.875				4	6	8	12	16				5.875
6.000					4	6	8	12	16				6.000

TABLE 2.8. *Coarse thread series, basic dimensions, UNC*

Nominal size and basic major diameter, D: Primary	Nominal size and basic major diameter, D: Secondary	Threads per inch, n	Basic pitch diameter, E	Minor[a] diameter, external threads, K_s	Minor[a] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[b] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
in	*in*		*in*	*in*	*in*	*deg*	*min*	*in*^{2}	*in*^{2}
	.073	64	0.0629	0.0538	0.0561	4	31	0.00218	0.00263
.086		56	.0744	.0641	.0667	4	22	.00310	.00370
	.099	48	.0855	.0734	.0764	4	26	.00406	.00487
.112		40	.0958	.0813	.0849	4	45	.00496	.00604
.125		40	.1088	.0943	.0979	4	11	.00672	.00796
.138		32	.1177	.0997	.1042	4	50	.00745	.00909
.164		32	.1437	.1257	.1302	3	58	.01196	.0140
.190		24	.1629	.1389	.1449	4	39	.01450	.0175
	.216	24	.1889	.1649	.1709	4	1	.0206	.0242
.250		20	.2175	.1887	.1959	4	11	.0269	.0318
.3125		18	.2764	.2443	.2524	3	40	.0454	.0524
.375		16	.3344	.2983	.3073	3	24	.0678	.0775
.4375		14	.3911	.3499	.3602	3	20	.0933	.1063
.500		13	.4500	.4056	.4167	3	7	.1257	.1419
.5625		12	.5084	.4603	.4723	2	59	.162	.182
.625		11	.5660	.5135	.5266	2	56	.202	.226
.750		10	.6850	.6273	.6417	2	40	.302	.334
.875		9	.8028	.7387	.7547	2	31	.419	.462
1.000		8	.9188	.8466	.8647	2	29	.551	.606
1.125		7	1.0322	.9497	.9704	2	31	.693	.763
1.250		7	1.1572	1.0747	1.0954	2	15	.890	.969
1.375		6	1.2667	1.1705	1.1946	2	24	1.054	1.155
1.500		6	1.3917	1.2955	1.3196	2	11	1.294	1.405
1.750		5	1.6201	1.5046	1.5335	2	15	1.74	1.90
2.000		4.5	1.8557	1.7274	1.7594	2	11	2.30	2.50
2.250		4.5	2.1057	1.9774	2.0094	1	55	3.02	3.25
2.500		4	2.3376	2.1933	2.2294	1	57	3.72	4.00
2.750		4	2.5876	2.4433	2.4794	1	46	4.62	4.93
3.000		4	2.8376	2.6933	2.7294	1	36	5.62	5.97
3.250		4	3.0876	2.9433	2.9794	1	29	6.72	7.10
3.500		4	3.3376	3.1933	3.2294	1	22	7.92	8.33
3.750		4	3.5876	3.4433	3.4794	1	16	9.21	9.66
4.000		4	3.8376	3.6933	3.7294	1	11	10.61	11.08

[a] Design form. See fig. 2.3.
[b] See formula under definition of tensile stress area in appendix A5.

TABLE 2.9. *Fine thread series, basic dimensions, UNF*

Nominal size[a] and basic major diameter, D: Primary	Nominal size[a] and basic major diameter, D: Secondary	Threads per inch, n	Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
in	*in*		*in*	*in*	*in*	*deg*	*min*	*in*^{2}	*in*^{2}
.060		80	0.0519	0.0447	0.0465	4	23	0.00151	0.00180
	.073	72	.0640	.0560	.0580	3	57	.00237	.00278
.086		64	.0759	.0668	.0691	3	45	.00339	.00394
	.099	56	.0874	.0771	.0797	3	43	.00451	.00523
.112		48	.0985	.0864	.0894	3	51	.00566	.00661
.125		44	.1102	.0971	.1004	3	45	.00716	.00830
.138		40	.1218	.1073	.1109	3	44	.00874	.01015
.164		36	.1460	.1299	.1339	3	28	.01285	.01474
.190		32	.1697	.1517	.1562	3	21	.0175	.0200
	.216	28	.1928	.1722	.1773	3	22	.0226	.0258
.250		28	.2268	.2062	.2113	2	52	.0326	.0364
.3125		24	.2854	.2614	.2674	2	40	.0524	.0580
.375		24	.3479	.3239	.3299	2	11	.0809	.0878
.4375		20	.4050	.3762	.3834	2	15	.1090	.1187
.500		20	.4675	.4387	.4459	1	57	.1486	.1599
.5625		18	.5264	.4943	.5024	1	55	.189	.203
.625		18	.5889	.5568	.5649	1	43	.240	.256
.750		16	.7094	.6733	.6823	1	36	.351	.373
.875		14	.8286	.7874	.7977	1	34	.480	.509
1.000		12	.9459	.8978	.9098	1	36	.625	.663
1.125		12	1.0709	1.0228	1.0348	1	25	.812	.856
1.250		12	1.1959	1.1478	1.1598	1	16	1.024	1.073
1.375		12	1.3209	1.2728	1.2848	1	9	1.260	1.315
1.500		12	1.4459	1.3978	1.4098	1	3	1.521	1.581

[a] For sizes larger than 1.5 inch, use the 12-thread series. See table 2.14.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

Table 2.10. *Extra-fine thread series, basic dimensions, UNEF*

Nominal size[a] and basic major diameter, D		Threads per inch, n	Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
Primary	Secondary								
in	*in*		*in*	*in*	*in*	*deg*	*min*	*in*²	*in*²
	.216	32	0.1957	0.1777	0.1822	2	55	0.0242	0.0270
.250		32	.2297	.2117	.2162	2	29	.0344	.0379
.3125		32	.2922	.2742	.2787	1	57	.0581	.0625
.375		32	.3547	.3367	.3412	1	36	.0878	.0932
.4375		28	.4143	.3937	.3988	1	34	.1201	.1274
.500		28	.4768	.4562	.4613	1	22	.162	.170
.5625		24	.5354	.5114	.5174	1	25	.203	.214
.625		24	.5979	.5739	.5799	1	16	.256	.268
	.6875	24	.6604	.6364	.6424	1	9	.315	.329
.750		20	.7175	.6887	.6959	1	16	.369	.386
	.8125	20	.7800	.7512	.7584	1	10	.439	.458
.875		20	.8425	.8137	.8209	1	5	.515	.536
	.9375	20	.9050	.8762	.8834	1	0	.598	.620
1.000		20	.9675	.9387	.9459	0	57	.687	.711
	1.0625	18	1.0264	.9943	1.0024	0	59	.770	.799
1.125		18	1.0889	1.0568	1.0649	0	56	.871	.901
	1.1875	18	1.1514	1.1193	1.1274	0	53	.977	1.009
1.250		18	1.2139	1.1818	1.1899	0	50	1.090	1.123
	1.3125	18	1.2764	1.2443	1.2524	0	48	1.208	1.244
1.375		18	1.3389	1.3068	1.3149	0	48	1.333	1.370
	1.4375	18	1.4014	1.3693	1.3774	0	43	1.464	1.503
1.500		18	1.4639	1.4318	1.4399	0	42	1.60	1.64
	1.5625	18	1.5264	1.4943	1.5024	0	40	1.74	1.79
1.625		18	1.5889	1.5568	1.5649	0	38	1.89	1.94
	1.6875	18	1.6514	1.6193	1.6274	0	37	2.05	2.10

[a] For sizes larger than 1.6875 in, use 16-thread series. See table 2.15.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

Table 2.11. *4-thread series, basic dimensions, 4UN*

Nominal size and basic major diameter, D		Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
Primary	Secondary							
in	*in*	*in*	*in*	*in*	*deg*	*min*	*in*²	*in*²
2.500[a]		2.3376	2.1933	2.2294	1	57	3.72	4.00
	2.625	2.4626	2.3183	2.3544	1	51	4.16	4.45
2.750[a]		2.5876	2.4433	2.4794	1	46	4.62	4.93
	2.875	2.7126	2.5683	2.6044	1	41	5.11	5.44
3.000[a]		2.8376	2.6933	2.7294	1	36	5.62	5.97
	3.125	2.9626	2.8183	2.8544	1	32	6.16	6.52
3.250[a]		3.0876	2.9433	2.9794	1	29	6.72	7.10
	3.375	3.2126	3.0683	3.1044	1	25	7.31	7.70
3.500[a]		3.3376	3.1933	3.2294	1	22	7.92	8.33
	3.625	3.4626	3.3183	3.3544	1	19	8.55	9.00
3.750[a]		3.5876	3.4433	3.4794	1	16	9.21	9.66
	3.875	3.7126	3.5683	3.6044	1	14	9.90	10.36
4.000[a]		3.8376	3.6933	3.7294	1	11	10.61	11.08
	4.125	3.9626	3.8183	3.8544	1	9	11.34	11.83
4.250		4.0876	3.9433	3.9794	1	7	12.10	12.61
	4.375	4.2126	4.0683	4.1044	1	5	12.88	13.41
4.500		4.3376	4.1933	4.2294	1	3	13.69	14.23
	4.625	4.4626	4.3183	4.3544	1	1	14.52	15.1
4.750		4.5876	4.4433	4.4794	1	0	15.4	15.9
	4.875	4.7126	4.5683	4.6044	0	58	16.3	16.8
5.000		4.8376	4.6933	4.7294	0	57	17.2	17.8
	5.125	4.9626	4.8183	4.8544	0	55	18.1	18.7
5.250		5.0876	4.9423	4.9794	0	54	19.1	19.7
	5.375	5.2126	5.0683	5.1044	0	52	20.0	20.7
5.500		5.3376	5.1933	5.2294	0	51	21.0	21.7
	5.625	5.4626	5.3183	5.3544	0	50	22.1	22.7
5.750		5.5876	5.4433	5.4794	0	49	23.1	23.8
	5.875	5.7126	5.5683	5.6044	0	48	24.2	24.9
6.000		5.8376	5.6933	5.7294	0	47	25.3	26.0

[a] These are standard sizes of the UNC series.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

TABLE 2.12. *6-thread series, basic dimensions, 6UN*

Nominal size and basic major diameter, D: Primary	Nominal size and basic major diameter, D: Secondary	Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
in	*in*	*in*	*in*	*in*	*deg*	*min*	*in²*	*in²*
1.375[a]		1.2667	1.1705	1.1946	2	24	1.054	1.155
	1.4375	1.3292	1.2330	1.2571	2	17	1.171	1.277
1.500[a]		1.3917	1.2955	1.3196	2	11	1.294	1.405
	1.5625	1.4542	1.3580	1.3821	2	5	1.423	1.54
1.625		1.5167	1.4205	1.4446	2	0	1.56	1.68
	1.6875	1.5792	1.4830	1.5071	1	55	1.70	1.83
1.750		1.6417	1.5455	1.5696	1	51	1.85	1.98
	1.8125	1.7042	1.6080	1.6321	1	47	2.00	2.14
1.875		1.7667	1.6705	1.6946	1	43	2.16	2.30
	1.9375	1.8292	1.7330	1.7571	1	40	2.33	2.47
2.000		1.8917	1.7955	1.8196	1	36	2.50	2.65
	2.125	2.0167	1.9205	1.9446	1	30	2.86	3.05
2.250		2.1417	2 0455	2.0696	1	25	3.25	3.42
	2.375	2.2667	2.1705	2.1946	1	20	3.66	3.85
2.500		2.3917	2.2955	2.3196	1	16	4.10	4.29
	2.625	2.5167	2.4205	2.4446	1	12	4.56	4.76
2.750		2.6417	2.5455	2.5696	1	9	5.04	5.26
	2.875	2.7667	2.6705	2.6946	1	6	5.55	5.78
3.000		2.8917	2.7955	2.8196	1	3	6.09	6.33
	3.125	3.0167	2.9205	2.9446	1	0	6.64	6.89
3.250		3.1417	3.0455	3.0696	0	58	7.23	7.49
	3.375	3.2667	3.1705	3.1946	0	56	7.84	8.11
3.500		3.3917	3.2955	3.3196	0	54	8.47	8.75
	3.625	3.5167	3.4205	3.4446	0	52	9.12	9.42
3.750		3.6417	3.5455	3.5696	0	50	9.81	10.11
	3.875	3.7667	3.6705	3.6946	0	48	10.51	10.83
4.000		3.8917	3.7955	3.8196	0	47	11.24	11.57
	4.125	4.0167	3.9205	3.9446	0	45	12.00	12.33
4.250		4.1417	4.0455	4.0696	0	44	12.78	13.12
	4.375	4.2667	4.1705	4.1946	0	43	13.58	13.94
4.500		4.3917	4.2955	4.3196	0	42	14.41	14.78
	4.625	4.5167	4.4205	4.4446	0	40	15.3	15.6
4.750		4.6417	4.5455	4.5696	0	39	16.1	16.5
	4.875	4.7667	4.6705	4.6946	0	38	17.0	17.5
5.000		4.8917	4.7955	4.8196	0	37	18.0	18.4
	5.125	5.0167	4.9205	4.9446	0	36	18.9	19.3
5.250		5.1417	5.0455	5.0696	0	35	19.9	20.3
	5.375	5.2667	5.1705	5.1946	0	35	20.9	21.3
5.500		5.3917	5.2955	5.3196	0	34	21.9	22.4
	5.625	5.5167	5.4205	5.4446	0	33	23.0	23.4
5.750		5.6417	5.5455	5.5696	0	32	24.0	24.5
	5.875	5.7667	5.6705	5.6946	0	32	25.1	25.6
6.000		5.8917	5.7955	5.8196	0	31	26.3	26.8

[a] These are standard sizes of the UNC series.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

TABLE 2.13. *8-thread series, basic dimensions, 8UN*

Nominal size and basic major diameter, D — Primary	Nominal size and basic major diameter, D — Secondary	Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
in	*in*	*in*	*in*	*in*	*deg*	*min*	*in*²	*in*²
1.000[a]		0.9188	0.8466	0.8647	2	29	0.551	0.606
	1.0625	.9813	.9091	.9272	2	19	.636	.695
1.125		1.0438	.9716	.9897	2	11	.728	.790
	1.1875	1.1063	1.0341	1.0522	2	4	.825	.892
1.250		1.1688	1.0966	1.1147	1	57	.929	1.000
	1.3125	1.2313	1.1591	1.1772	1	51	1.039	1.114
1.375		1.2938	1.2216	1.2397	1	46	1.155	1.233
	1.4375	1.3563	1.2841	1.3022	1	41	1.277	1.360
1.500		1.4188	1.3466	1.3647	1	36	1.405	1.492
	1.5625	1.4813	1.4091	1.4272	1	32	1.54	1.63
1.625		1.5438	1.4716	1.4897	1	29	1.68	1.78
	1.6875	1.6063	1.5341	1.5522	1	25	1.83	1.93
1.750		1.6688	1.5966	1.6147	1	22	1.98	2.08
	1.8125	1.7313	1.6591	1.6772	1	19	2.14	2.25
1.875		1.7938	1.7216	1.7397	1	16	2.30	2.41
	1.9375	1.8563	1.7841	1.8022	1	14	2.47	2.59
2.000		1.9188	1.8466	1.8647	1	11	2.65	2.77
	2.125	2.0438	1.9716	1.9897	1	7	3.03	3.15
2.250		2.1688	2.0966	2.1147	1	3	3.42	3.56
	2.375	2.2938	2.2216	2.2397	1	0	3.85	3.99
2.500		2.4188	2.3466	2.3647	0	57	4.29	4.44
	2.625	2.5438	2.4716	2.4897	0	54	4.76	4.92
2.750		2.6688	2.5966	2.6147	0	51	5.26	5.43
	2.875	2.7938	2.7216	2.7397	0	49	5.78	5.95
3.000		2.9188	2.8466	2.8647	0	47	6.32	6.51
	3.125	3.0438	2.9716	2.9897	0	45	6.89	7.08
3.250		3.1688	3.0966	3.1147	0	43	7.49	7.69
	3.375	3.2938	3.2216	3.2397	0	42	8.11	8.31
3.500		3.4188	3.3466	3.3647	0	40	8.75	8.96
	3.625	3.5438	3.4716	3.4897	0	39	9.42	9.64
3.750		3.6688	3.5966	3.6147	0	37	10.11	10.34
	3.875	3.7938	3.7216	3.7397	0	36	10.83	11.06
4.000		3.9188	3.8466	3.8647	0	35	11.57	11.81
	4.125	4.0438	3.9716	3.9897	0	34	12.34	12.59
4.250		4.1688	4.0966	4.1147	0	33	13.12	13.38
	4.375	4.2938	4.2216	4.2397	0	32	13.94	14.21
4.500		4.4188	4.3466	4.3647	0	31	14.78	15.1
	4.625	4.5438	4.4716	4.4897	0	30	15.6	15.9
4.750		4.6688	4.5966	4.6147	0	29	16.5	16.8
	4.875	4.7938	4.7216	4.7397	0	29	17.4	17.7
5.000		4.9188	4.8466	4.8647	0	28	18.4	18.7
	5.125	5.0438	4.9716	4.9897	0	27	19.3	19.7
5.250		5.1688	5.0966	5.1147	0	26	20.3	20.7
	5.375	5.2938	5.2216	5.2397	0	26	21.3	21.7
5.500		5.4188	5.3466	5.3647	0	25	22.4	22.7
	5.625	5.5438	5.4716	5.4897	0	25	23.4	23.8
5.750		5.6688	5.5966	5.6147	0	24	24.5	24.9
	5.875	5.7938	5.7216	5.7397	0	24	25.6	26.0
6.000		5.9188	5.8466	5.8647	0	23	26.8	27.1

[a] This is a standard size of the UNC series.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

Table 2.14. *12-thread series, basic dimensions, 12UN*

Nominal size and basic major diameter, D: Primary	Nominal size and basic major diameter, D: Secondary	Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ: deg	Lead angle at basic pitch diameter, λ: min	Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
in	*in*	*in*	*in*	*in*	*deg*	*min*	*in²*	*in²*
.5625[a]		0.5084	0.4603	0.4723	2	59	0.162	0.182
.625		.5709	.5228	.5348	2	40	.210	.232
	.6875	.6334	.5853	.5973	2	24	.264	.289
.750		.6959	.6478	.6598	2	11	.323	.351
	.8125	.7584	.7103	.7223	2	0	.390	.420
.875		.8209	.7728	.7848	1	51	.462	.495
	.9375	.8834	.8353	.8473	1	43	.540	.576
1.000[a]		.9459	.8978	.9098	1	36	.625	.663
	1.0625	1.0084	.9603	.9723	1	30	.715	.756
1.125[a]		1.0709	1.0228	1.0348	1	25	.812	.856
	1.1875	1.1334	1.0853	1.0973	1	20	.915	.961
1.250[a]		1.1959	1.1478	1.1598	1	16	1.024	1.073
	1.3125	1.2584	1.2103	1.2223	1	12	1.139	1.191
1.375[a]		1.3209	1.2728	1.2848	1	9	1.260	1.315
	1.4375	1.3834	1.3353	1.3473	1	6	1.388	1.445
1.500[a]		1.4459	1.3978	1.4098	1	3	1.52	1.58
	1.5625	1.5084	1.4603	1.4723	1	0	1.66	1.72
1.625		1.5709	1.5228	1.5348	0	58	1.81	1.87
	1.6875	1.6334	1.5853	1.5973	0	56	1.96	2.03
1.750		1.6959	1.6478	1.6598	0	54	2.12	2.19
	1.8125	1.7584	1.7103	1.7223	0	52	2.28	2.35
1.875		1.8209	1.7728	1.7848	0	50	2.45	2.53
	1.9375	1.8834	1.8353	1.8473	0	48	2.63	2.71
2.000		1.9459	1.8978	1.9098	0	47	2.81	2.89
	2.125	2.0709	2.0228	2.0348	0	44	3.19	3.28
2.250		2.1959	2.1478	2.1598	0	42	3.60	3.69
	2.375	2.3209	2.2728	2.2848	0	39	4.04	4.13
2.500		2.4459	2.3978	2.4098	0	37	4.49	4.60
	2.625	2.5709	2.5228	2.5348	0	35	4.97	5.08
2.750		2.6959	2.6478	2.6598	0	34	5.48	5.59
	2.875	2.8209	2.7728	2.7848	0	32	6.01	6.13
3.000		2.9459	2.8978	2.9098	0	31	6.57	6.69
	3.125	3.0709	3.0228	3.0348	0	30	7.15	7.28
3.250		3.1959	3.1478	3.1598	0	29	7.75	7.89
	3.375	3.3209	3.2728	3.2848	0	27	8.38	8.52
3.500		3.4459	3.3978	3.4098	0	26	9.03	9.18
	3.625	3.5709	3.5228	3.5348	0	26	9.71	9.86
3.750		3.6959	3.6478	3.6598	0	25	10.42	10.57
	3.875	3.8209	3.7728	3.7848	0	24	11.14	11.30
4.000		3.9459	3.8978	3.9098	0	23	11.90	12.06
	4.125	4.0709	4.0228	4.0348	0	22	12.67	12.84
4.250		4.1959	4.1478	4.1598	0	22	13.47	13.65
	4.375	4.3209	4.2728	4.2848	0	21	14.30	14.48
4.500		4.4459	4.3978	4.4098	0	21	15.1	15.3
	4.625	4.5709	4.5228	4.5348	0	20	16.0	16.2
4.750		4.6959	4.6478	4.6598	0	19	16.9	17.1
	4.875	4.8209	4.7728	4.7848	0	19	17.8	18.0
5.000		4.9459	4.8978	4.9098	0	18	18.8	19.0
	5.125	5.0709	5.0228	5.0348	0	18	19.8	20.0
5.250		5.1959	5.1478	5.1598	0	18	20.8	21.0
	5.375	5.3209	5.2728	5.2848	0	17	21.8	22.0
5.500		5.4459	5.3978	5.4098	0	17	22.8	23.1
	5.625	5.5709	5.5228	5.5348	0	16	23.9	24.1
5.750		5.6959	5.6478	5.6598	0	16	25.0	25.2
	5.875	5.8209	5.7728	5.7848	0	16	26.1	26.4
6.000		5.9459	5.8978	5.9098	0	15	27.3	27.5

[a] These are standard sizes of the UNC or UNF series.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

TABLE 2.15. *16-thread series, basic dimensions, 16UN*

Nominal size and basic major diameter, D		Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi \left(\frac{E}{2} - \frac{3H}{16}\right)^2$
Primary	Secondary							
in	*in*	*in*	*in*	*in*	*deg*	*min*	*in*²	*in*²
.375[a]		0.3344	0.2983	0.3073	3	24	0.0678	0.0775
.4375		.3969	.3608	.3698	2	52	.0997	.1114
.500		.4594	.4233	.4323	2	29	.1378	.151
.5625		.5219	.4858	.4948	2	11	.182	.198
.625		.5844	.5483	.5573	1	57	.232	.250
	.6875	.6469	.6108	.6198	1	46	.289	.308
.750[a]		.7094	.6733	.6823	1	36	.351	.373
	.8125	.7719	.7358	.7448	1	29	.420	.444
.875		.8344	.7983	.8073	1	22	.495	.521
	.9375	.8969	.8608	.8698	1	16	.576	.604
1.000		.9594	.9233	.9323	1	11	.663	.693
	1.0625	1.0219	.9858	.9948	1	7	.756	.788
1.125		1.0844	1.0483	1.0573	1	3	.856	.889
	1.1875	1.1469	1.1108	1.1198	1	0	.961	.997
1.250		1.2094	1.1733	1.1823	0	57	1.073	1.111
	1.3125	1.2719	1.2358	1.2448	0	54	1.191	1.230
1.375		1.3344	1.2983	1.3073	0	51	1.315	1.356
	1.4375	1.3969	1.3608	1.3698	0	49	1.445	1.488
1.500		1.4594	1.4233	1.4323	0	47	1.58	1.63
	1.5625	1.5219	1.4858	1.4948	0	45	1.72	1.77
1.625		1.5844	1.5483	1.5573	0	43	1.87	1.92
	1.6875	1.6469	1.6108	1.6198	0	42	2.03	2.08
1.750		1.7094	1.6733	1.6823	0	40	2.19	2.24
	1.8125	1.7719	1.7358	1.7448	0	39	2.35	2.41
1.875		1.8344	1.7983	1.8073	0	37	2.53	2.58
	1.9375	1.8969	1.8608	1.8698	0	36	2.71	2.77
2.000		1.9594	1.9233	1.9323	0	35	2.89	2.95
	2.125	2.0844	2.0483	2.0573	0	33	3.28	3.35
2.250		2.2094	2.1733	2.1823	0	31	3.69	3.76
	2.375	2.3344	2.2983	2.3073	0	29	4.13	4.21
2.500		2.4594	2.4233	2.4323	0	28	4.60	4.67
	2.625	2.5844	2.5483	2.5573	0	26	5.08	5.16
2.750		2.7094	2.6733	2.6823	0	25	5.59	5.68
	2.875	2.8344	2.7983	2.8073	0	24	6.13	6.22
3.000		2.9594	2.9233	2.9323	0	23	6.69	6.78
	3.125	3.0844	3.0483	3.0573	0	22	7.28	7.37
3.250		3.2094	3.1733	3.1823	0	21	7.89	7.99
	3.375	3.3344	3.2983	3.3073	0	21	8.52	8.63
3.500		3.4594	3.4233	3.4323	0	20	9.18	9.29
	3.625	3.5844	3.5483	3.5573	0	19	9.86	9.98
3.750		3.7094	3.6733	3.6823	0	18	10.57	10.69
	3.875	3.8344	3.7983	3.8073	0	18	11.30	11.43
4.000		3.9594	3.9233	3.9323	0	17	12.06	12.19
	4.125	4.0844	4.0483	4.0573	0	17	12.84	12.97
4.250		4.2094	4.1733	4.1823	0	16	13.65	13.78
	4.375	4.3344	4.2983	4.3073	0	16	14.48	14.62
4.500		4.4594	4.4233	4.4323	0	15	15.34	15.5
	4.625	4.5844	4.5483	4.5573	0	15	16.2	16.4
4.750		4.7094	4.6733	4.6823	0	15	17.1	17.3
	4.875	4.8344	4.7983	4.8073	0	14	18.0	18.2
5.000		4.9594	4.9233	4.9323	0	14	19.0	19.2
	5.125	5.0844	5.0483	5.0573	0	13	20.0	20.1
5.250		5.2094	5.1733	5.1823	0	13	21.0	21.1
	5.375	5.3344	5.2983	5.3073	0	13	22.0	22.2
5.500		5.4594	5.4233	5.4323	0	13	23.1	23.2
	5.625	5.5844	5.5483	5.5573	0	12	24.1	24.3
5.750		5.7094	5.6733	5.6823	0	12	25.2	25.4
	5.875	5.8344	5.7983	5.8073	0	12	26.4	26.5
6.000		5.9594	5.9233	5.9323	0	11	27.5	27.7

[a] These are standard sizes of the UNC or UNF Series.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

TABLE 2.16. *20-thread series, basic dimensions, 20UN*

Nominal size and basic major diameter, D		Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D-2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2}-\frac{3H}{16}\right)^2$
Primary	Secondary							
in	*in*	*in*	*in*	*in*	*deg*	*min*	*in²*	*in²*
.250[a]		0.2175	0.1887	0.1959	4	11	0.0269	0.0318
.3125		.2800	.2512	.2584	3	15	.0481	.0547
.375		.3425	.3137	.3209	2	40	.0755	.0836
.4375[a]		.4050	.3762	.3834	2	15	.1090	.1187
.500[a]		.4675	.4387	.4459	1	57	.1486	.160
.5625		.5300	.5012	.5084	1	43	.194	.207
.625		.5925	.5637	.5709	1	32	.246	.261
	.6875	.6550	.6262	.6334	1	24	.304	.320
.750[a]		.7175	.6887	.6959	1	16	.369	.386
	.8125[a]	.7800	.7512	.7584	1	10	.439	.458
.875[a]		.8425	.8137	.8209	1	5	.515	.536
	.9375[a]	.9050	.8762	.8834	1	0	.598	.620
1.000[a]		.9675	.9387	.9459	0	57	.687	.711
	1.0625	1.0300	1.0012	1.0084	0	53	.782	.807
1.125		1.0925	1.0637	1.0709	0	50	.882	.910
	1.1875	1.1550	1.1262	1.1334	0	47	.990	1.018
1.250		1.2175	1.1887	1.1959	0	45	1.103	1.133
	1.3125	1.2800	1.2512	1.2584	0	43	1.222	1.254
1.375		1.3425	1.3137	1.3209	0	41	1.348	1.382
	1.4375	1.4050	1.3762	1.3834	0	39	1.479	1.51
1.500		1.4675	1.4387	1.4459	0	37	1.62	1.65
	1.5625	1.5300	1.5012	1.5084	0	36	1.76	1.80
1.625		1.5925	1.5637	1.5709	0	34	1.91	1.95
	1.6875	1.6550	1.6262	1.6334	0	33	2.07	2.11
1.750		1.7175	1.6887	1.6959	0	32	2.23	2.27
	1.8125	1.7800	1.7512	1.7584	0	31	2.40	2.44
1.875		1.8425	1.8137	1.8209	0	30	2.57	2.62
	1.9375	1.9050	1.8762	1.8834	0	29	2.75	2.80
2.000		1.9675	1.9387	1.9459	0	28	2.94	2.99
	2.125	2.0925	2.0637	2.0709	0	26	3.33	3.39
2.250		2.2175	2.1887	2.1959	0	25	3.75	3.81
	2.375	2.3425	2.3137	2.3209	0	23	4.19	4.25
2.500		2.4675	2.4387	2.4459	0	22	4.66	4.72
	2.625	2.5925	2.5637	2.5709	0	21	5.15	5.21
2.750		2.7175	2.6887	2.6959	0	20	5.66	5.73
	2.875	2.8425	2.8137	2.8209	0	19	6.20	6.27
3.000		2.9675	2.9387	2.9459	0	18	6.77	6.84

[a] These are standard sizes of the UNC, UNF, or UNEF series.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

TABLE 2.17. *28-thread series, basic dimensions, 28UN*

Nominal size and basic major diameter, D		Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
Primary	Secondary							
in	*in*	*in*	*in*	*in*	*deg*	*min*	*in*^{2}	*in*^{2}
	.216[a]	0.1928	0.1722	0.1773	3	22	0.0226	0.0258
.250[a]		.2268	.2062	.2113	2	52	.0326	.0364
.3125		.2893	.2687	.2738	2	15	.0556	.0606
.375		.3518	.3312	.3363	1	51	.0848	.0909
.4375[a]		.4143	.3937	.3988	1	34	.1201	.1274
.500[a]		.4768	.4562	.4613	1	22	.162	.170
.5625		.5393	.5187	.5238	1	12	.209	.219
.625		.6018	.5812	.5863	1	5	.263	.274
	.6875	.6643	.6437	.6488	0	59	.323	.335
.750		.7268	.7062	.7113	0	54	.389	.402
	.8125	.7893	.7687	.7738	0	50	.461	.475
.875		.8518	.8312	.8363	0	46	.539	.554
	.9375	.9143	.8937	.8988	0	43	.624	.640
1.000		.9768	.9562	.9613	0	40	.714	.732
	1.0625	1.0393	1.0187	1.0238	0	38	.811	.830
1.125		1.1018	1.0812	1.0863	0	35	.914	.933
	1.1875	1.1643	1.1437	1.1488	0	34	1.023	1.044
1.250		1.2268	1.2062	1.2113	0	32	1.138	1.160
	1.3125	1.2893	1.2687	1.2738	0	30	1.259	1.282
1.375		1.3518	1.3312	1.3363	0	29	1.386	1.411
	1.4375	1.4143	1.3937	1.3988	0	28	1.52	1.55
1.500		1.4768	1.4562	1.4613	0	26	1.66	1.69

[a] These are standard sizes of the UNF or UNEF series.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

TABLE 2.18. *32-thread series, basic dimensions, 32UN*

Nominal size and basic major diameter, D		Basic pitch diameter, E	Minor[b] diameter, external threads, K_s	Minor[b] diameter, internal threads, K_n	Lead angle at basic pitch diameter, λ		Sectional area at minor diameter at $D - 2h_b$	Tensile stress[c] area, $\pi\left(\frac{E}{2} - \frac{3H}{16}\right)^2$
Primary	Secondary							
in	*in*	*in*	*in*	*in*	*deg*	*min*	*in*^{2}	*in*^{2}
.138[a]		0.1177	0.0997	0.1042	4	50	0.00745	0.00909
.164[a]		.1437	.1257	.1302	3	58	.01196	.0140
.190[a]		.1697	.1517	.1562	3	21	.01750	.0200
	.216[a]	.1957	.1777	.1822	2	55	.242	.0270
.250[a]		.2297	.2117	.2162	2	29	.0344	.0379
.3125[a]		.2922	.2742	.2787	1	57	.0581	.0625
.375[a]		.3547	.3367	.3412	1	36	.0878	.0932
.4375		.4172	.3992	.4037	1	22	.1237	.1301
.500		.4797	.4617	.4662	1	11	.166	.173
.5625		.5422	.5242	.5287	1	3	.214	.222
.625		.6047	.5867	.5912	0	57	.268	.278
	.6875	.6672	.6492	.6537	0	51	.329	.339
.750		.7297	.7117	.7162	0	47	.395	.407
	.8125	.7922	.7742	.7787	0	43	.468	.480
.875		.8547	.8367	.8412	0	40	.547	.560
	.9375	.9172	.8992	.9037	0	37	.632	.646
1.000		.9797	.9617	.9662	0	35	.723	.738

[a] These are standard sizes of the UNC, UNF, or UNEF series.
[b] Design form. See fig. 2.3.
[c] See formula under definition of tensile stress area in appendix A5.

4. THREAD CLASSES

Thread classes are distinguished from each other by the amounts of tolerance and allowance. The function of these classes is to assure the interchangeability of threaded parts. Six distinct classes of screw threads have been established for general use. These classes are: 1A, 2A, and 3A (for external threads only) and 1B, 2B, and 3B (for internal threads only). The disposition of the tolerances, allowances, and crest clearances for the various classes is illustrated in figures 2.5 and 2.6, p. 2.06.

The requirements for a screw-thread fit for a specific application can be met by specifying the proper combination of classes for the components. For example, an external thread made to class 2A limits can be used with an internal thread made to classes 1B, 2B, or 3B limits for specific applications. It is not the purpose of this standard to limit applications of the various standard classes.

4.1. Classes 1A and 1B Threads.—Classes 1A and 1B threads replace class 1 for new designs. These classes are intended for ordnance and other special uses. They are used on threaded components where quick and easy assembly is necessary and where a liberal allowance is required to permit ready assembly, even with slightly bruised or dirty threads.

Maximum diameters of class 1A (external) threads are less than basic by the amount of the same allowance as applied to class 2A. For the intended applications in American practice the allowance is not available for plating or coating. Where the thread is plated or coated, special provisions are necessary. The minimum diameters of class 1B (internal) threads, whether or not plated or coated, are basic, affording no allowance or clearance for assembly with maximum material external thread components having maximum diameters which are basic.

Allowances and tolerances for the respective thread series are specified in tables and their application is shown in figure 2.5.

4.2. Classes 2A and 2B Threads.—Class 2A for external threads and 2B for internal threads are the most commonly used thread standards for general applications, including production of bolts, screws, nuts, and similar threaded fasteners.

The maximum diameters of class 2A (external) uncoated threads are less than basic by the amount of the allowance. The allowance minimizes galling and seizing in high-cycle wrench assembly, or it can be used to accommodate plated finishes or other coating. However, for threads with additive finish, the maximum diameters of class 2A may be exceeded by the amount of the allowance; i.e., the 2A maximum diameters apply to an unplated part or to a part before plating whereas the basic diameters (the 2A maximum diameter plus allowance) apply to a part after plating. The minimum diameters of class 2B (internal) threads, whether or not plated or coated, are basic, affording no allowance or clearance in assembly at maximum material limits. See par. 3.7, p. 2.05.

Certain applications require an allowance to permit application of the proper lubricant when making up the assembly, particularly with pressure vessels and steel pipe flanges, fittings, and valves for high-temperature, high-pressure service. For such applications class 2A, which has an allowance, and class 2B are recommended, replacing class 7 which was previously established for such applications but which has been discontinued as a standard. See par. 3.7. In this application, when the thread is coated, the 2A allowance may not be consumed by such coating.

Allowances and tolerances for the respective thread series are specified in the tables and their application is shown in figure 2.5.

4.3. Classes 3A and 3B Threads.—Class 3A for external threads and class 3B for internal threads provide for applications where closeness of fit and accuracy of lead and angle of thread are important. They are obtainable consistently only by the use of high quality production equipment supported by a very efficient system of gaging and inspection. The maximum diameters of class 3A (external) threads and the minimum diameters of class 3B (internal) threads, whether or not plated or coated, are basic, affording no allowance or clearance for assembly of maximum-material components.

No allowance is provided, but since the tolerances on GO gages are within the limits of size of the product, the gages will assure a slight clearance between product made to the maximum material limits. Tolerances for the respective thread series are specified in tables and their application is shown in figure 2.6.

5. ALLOWANCES

The allowance is minus and is applied from the basic size to below basic size. Allowance is applied only to the classes 1A and 2A external threads. Values of the allowance for these two classes are obtained by use of a C factor of 0.3 in the formula shown in par. 6.1.

6. TOLERANCES

The internal thread tolerance is plus and is applied from the basic size to above the basic size for all three thread classes.

The external thread tolerance is minus and is applied:

1. from the basic size to below the basic size for class 3A (see fig. 2.6),

2. from the design size (basic size minus allowance) to below design size for classes 1A and 2A (see fig. 2.5).

The tolerances specified represent the extreme variations permitted on the product.

6.1. Pitch Diameter Tolerances.—The basic formula for pitch diameter tolerance is composed of the following increments:

P.D. Tolerance

$$= C(0.0015\sqrt[3]{D} + 0.0015\sqrt[3]{L_e} + 0.015\sqrt[3]{p^2}),$$

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TABLE 2.19. *Increments in pitch diameter tolerance formula*[a]

[PD tolerance = $C(0.0015\sqrt[3]{D} + 0.0015\sqrt{L_e} + 0.015\sqrt[3]{p^2})$]

Diameter increments

D	$0.0015\sqrt[3]{D}$	D	$0.0015\sqrt[3]{D}$
in	in	in	in
0.0600	0.000587	1.9375	0.001870
.0625	.000595	2.0000	.001890
.0730	.000627	2.1250	.001928
.0860	.000662	2.2500	.001966
.0938	.000682	2.3750	.002001
.0990	.000694	2.5000	.002036
.1120	.000723	2.6250	.002069
.1250	.000750	2.7500	.002102
.1380	.000775	2.8750	.002133
.1640	.000821	3.0000	.002163
.1875	.000859	3.1250	.002193
.1900	.000862	3.2500	.002222
.2160	.000900	3.3750	.002250
.2500	.000945	3.5000	.002277
.3125	.001018	3.6250	.002304
.3750	.001082	3.7500	.002330
.4375	.001139	3.8750	.002356
.5000	.001191	4.0000	.002381
.5625	.001238	4.1250	.002406
.6250	.001282	4.2500	.002430
.6875	.001324	4.3750	.002453
.7500	.001363	4.5000	.002476
.8125	.001400	4.6250	.002499
.8750	.001435	4.7500	.002521
.9375	.001468	4.8750	.002543
1.0000	.001500	5.0000	.002565
1.0625	.001531	5.1250	.002586
1.1250	.001560	5.2500	.002607
1.1875	.001588	5.3750	.002628
1.2500	.001616	5.5000	.002648
1.3125	.001642	5.6250	.002668
1.3750	.001668	5.7500	.002687
1.4375	.001693	5.8750	.002707
1.5000	.001717	6.0000	.002726
1.5625	.001741	7.0000	.002869
1.6250	.001764	8.0000	.003000
1.6875	.001786	9.0000	.003120
1.7500	.001808	10.0000	.003232
1.8125	.001829	12.0000	.003434
1.8750	.001850	14.0000	.003615
		16.0000	.003780
		18.0000	.003931
		20.0000	.004072
		24.0000	.004327

Length of engagement increments

Based on[b] 1D for sizes	9p for tpi	20p for tpi	L_e	$0.0015 \times \sqrt{L_e}$
in			in	in
.060			0.0600	0.000367
.0625			.0625	.000375
.073			.0730	.000405
.0781			.0781	.000419
.086			.0860	.000440
.0938			.0938	.000459
.099			.0990	.000472
.1094			.1094	.000496
.112			.1120	.000502
.1125	80		.1125	.000503
.125	72		.1250	.000530
.138			.1380	.000557
.1406	64		.1406	.000562
.1562			.1562	.000593
.1607	56		.1607	.000601
.164			.1640	.000607
.1719			.1719	.000622
.1875	48		.1875	.000650
.190			.1900	.000654
.2031			.2031	.000676
.2045	44		.2045	.000678
.216			.2160	.000697
.2188	40		.2188	.000702
.225			.2250	.000712
.2344			.2344	.000726
.250	36	80	.2500	.000750
.2656			.2656	.000773
.2778		72	.2778	.000791
.2812	32		.2812	.000795
.2969			.2969	.000817
.3125		64	.3125	.000839
.3214	28		.3214	.000850
.3281			.3281	.000859
.3333	27	60	.3333	.000866
.3438			.3438	.000880
.3571		56	.3571	.000896
.3594			.3594	.000899
.375	24		.3750	.000919
.3906			.3906	.000937
.4062			.4062	.000956
.4167		48	.4167	.000968
.4219			.4219	.000974
.4375			.4375	.000992
.450	20		.4500	.001006
.4545		44	.4545	.001011

Based on[b] 1D for sizes	9p for tpi	20p for tpi	L_e	$0.0015 \times \sqrt{L_e}$
in			in	in
.500	18	40	0.5000	0.001061
.5556		36	.5556	.001118
.5625	16		.5625	.001125
.625		32	.6250	.001186
.6429	14		.6429	.001203
.6875			.6875	.001244
.6923	13		.6923	.001248
.7143		28	.7143	.001268
.7407		27	.7407	.001291
.750	12		.7500	.001299
.7826	11.5		.7826	.001327
.8125			.8125	.001352
.8182	11		.8182	.001357
.8333		24	.8333	.001369
.875			.8750	.001403
.900	10		.9000	.001423
.9375			.9375	.001452
1.000	9	20	1.0000	.001500
1.0625		18	1.0625	.001546
1.1111			1.1111	.001581
1.125	8		1.1250	.001591
1.1875			1.1875	.001635
1.250		16	1.2500	.001677
1.2857	7		1.2857	.001701
1.3125			1.3125	.001718
1.375			1.3750	.001759
1.4286		14	1.4286	.001793
1.4375			1.4375	.001798
1.500	6		1.5000	.001837
1.5385		13	1.5385	.001861
1.5625			1.5625	.001875
1.625			1.6250	.001912
1.6667		12	1.6667	.001936
1.6875			1.6875	.001949
1.7391		11.5	1.7391	.001978
1.750			1.7500	.001984
1.800	5		1.8000	.002012
1.8125			1.8125	.002019
1.8182		11	1.8182	.002023
1.875			1.8750	.002054
1.9375			1.9375	.002088
2.000	4.5	10	2.0000	.002121
2.125			2.1250	.002187
2.2222		9	2.2222	.002236
2.250	4		2.2500	.002250

Based on[b] 1D for sizes	20p for tpi	L_e	$0.0015 \times \sqrt{L_e}$
in		in	in
2.375		2.3750	0.002312
2.500	8	2.5000	.002372
2.625		2.6250	.002430
2.750		2.7500	.002487
2.8571	7	2.8571	.002535
2.875		2.8750	.002543
3.000		3.0000	.002598
3.125		3.1250	.002652
3.250		3.2500	.002704
3.3333	6	3.3333	.002739
3.375		3.3750	.002756
3.500		3.5000	.002806
3.625		3.6250	.002856
3.750		3.7500	.002905
3.875		3.8750	.002953
4.000	5	4.0000	.003000
4.125		4.1250	.003047
4.250		4.2500	.003092
4.375		4.3750	.003137
4.4444	4.5	4.4444	.003162
4.500		4.5000	.003182
4.625		4.6250	.003226
4.750		4.7500	.003269
4.875		4.8750	.003312
5.000	4	5.0000	.003354
5.125		5.1250	.003396
5.250		5.2500	.003437
5.375		5.3750	.003478
5.500		5.5000	.003518
5.625		5.6250	.003558
5.750		5.7500	.003597
5.875		5.8750	.003636
6.000		6.0000	.003674
6.500		6.5000	.003824
7.000		7.0000	.003969
7.500		7.5000	.004108
8.000		8.0000	.004243
8.500		8.5000	.004373
9.000		9.0000	.004500
9.500		9.5000	.004623
10.000		10.0000	.004743
10.500		10.5000	.004861
11.000		11.0000	.004975
11.500		11.5000	.005087
12.000		12.0000	.005196