U.S. DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS

REPORT OF THE NATIONAL SCREW THREAD COMMISSION

(REVISED 1933)

MISCELLANEOUS PUBLICATION NO. 141

May 28, 1934

ERRATA

NATIONAL BUREAU OF STANDARDS MISCELLANEOUS PUBLICATION NO. 141
1933 REPORT OF THE NATIONAL SCREW THREAD COMMISSION

Page 68, last line (above footnote) change "thread" to "threaded".

Page 75, Table 32, in column headed "3/4", change ".6993" to ".6903"

Page 87, running head, change "ECIAL" to "SPECIAL".

Page 97, Table 44, add to title, "and American National fire-hose coupling threads".
Add "(max.)" to heading "Inside diameter of nipple, C".
Add the following to the table:

2 1/2	Fire hose	7 1/2	1	15/16	11/16	1/4	2 17/32	5 1/4
3	Fire hose	6	1 1/8	1 1/16	13/16	5/16	3 1/32	5
3 1/2	Fire hose	6	1 1/8	1 1/16	13/16	5/16	3 17/32	5
4 1/2	Fire hose	4	1 1/4	1 3/16	15/16	7/16	4 17/32	3 3/4

Page 98, Table 45, footnote 2, last line, change "nipplee" to "nipple".

Page 144, first line, change "15" to "150".

Page 151, line 35, change "know" to "known".

Page 162, line 2, change "0.010" to "0.020".
line 3, change "0.005" to "0.010".
lines 5-8, change to read as follows:

"5. CLEARANCE AT MAJOR DIAMETER.- A clearance shall be provided at the major diameter by making the major diameter of the nut or threaded hole 0.020 inch larger than basic for 10 or less threads per inch, and 0.010 inch larger than basic for more than 10 threads per inch."

Fig. 53, change "ALLOWANCE ON MAJOR DIAMETER = 0.01 INCH" to "ALLOWANCE ON MAJOR DIAMETER".

Page 166, column 8, change ".2816" to ".2716".
column 9, change ".2774" to ".2674".
column 12, change ".2847" to ".2843".

NATIONAL BUREAU OF STANDARDS

U.S. DEPARTMENT OF COMMERCE

DANIEL C. ROPER, Secretary

BUREAU OF STANDARDS

LYMAN J. BRIGGS, Director

REPORT OF THE NATIONAL SCREW THREAD COMMISSION

(FOURTH EDITION, REVISED 1933)

AS APPROVED APRIL 10, 1933

Miscellaneous Publication No. 141

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PREFACE

Progress in commercial screw thread practice, which is based very extensively on the standards established by the National Screw Thread Commission, has been such as to require several revisions and some additions to the standards promulgated in the Commission's 1928 report. This report, the fourth to be published, embodies necessary changes. The experience of the Commission demonstrates that technical standards, to be useful, cannot be static, but must be revised and adapted to meet changing requirements.

Major revisions of the previously published standards consist in: The addition of the 1⅜-, 3¼-, 3½-, 3¾-, and 4-inch sizes to the coarse-thread series; the addition of the 1⅜-inch size to the fine-thread series; the elimination of all sizes above 1½ inches from the fine-thread series; the elimination of the small machine screw sizes from class 4, close fit; the addition of four sizes and pitches to the hose-coupling threads; the revision of tolerances for pipe thread gages; and the revision of the specifications for Acme threads, including a new recommended series of diameters and pitches. The volume of the report has been reduced by the elimination of standards for body dimensions of bolts, nuts, and screws, and standards for the design of gage blanks, except by reference to the latest revisions of other published standards for these products.

New material added to the body of the report includes specifications for an 8-pitch and a 16-pitch thread series for special applications, which, together with the previously published 12-pitch series, are presented as a separate section. These series, demanded by industry, constitute in effect an amplification of the fine-thread series, and are a substitute for the sizes above 1½ inches in that series which have been deleted. A new table of tolerances for gages used in the inspection of class 4, close fit product is also included.

In the appendixes the recommended practice for threading tools has been deleted. The Commission's purpose to stimulate much-needed activity in the standardization of taps, die-head chasers, and other threading tools has been fulfilled. Published standards for such tools, which have received general recognition, are referred to in the report.

The assistance and cooperation of many individuals, manufacturers, and users of screw-thread products, tools, and gages, and of the American Society of Mechanical Engineers, the Society of Automotive Engineers, the American Standards Association, and several of the sectional committees organized under its procedure, the Federal Specifications Board, the United States Army, the United States Navy, the Bureau of Standards, the National Board of Fire Underwriters, the American Petroleum Institute, the International Acetylene Association, the Gas Products Association, and the American Gage Design Committee, are gratefully acknowledged by the Commission.

CONTENTS

[1] Partially new material not included in report revised June 22, 1928.

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APPROVAL BY THE COMMISSION AND TRANSMITTAL TO THE SECRETARIES OF WAR, NAVY, AND COMMERCE

Hon. George H. Dern
Secretary of War
Hon. Claude A. Swanson
Secretary of the Navy
Hon. Daniel C. Roper
Secretary of Commerce

April 10, 1933.

To the honorables the Secretary of War, the Secretary of the Navy, the Secretary of Commerce:

The National Screw Thread Commission, having revised its Progress Report, approved June 22, 1928, herewith submits its report revised to 1933, for your acceptance and approval, in accordance with Public Act No. 201, approved July 18, 1918 (c. 156, sec. 2, 40 Stat. 913); as amended by Public Act No. 324, approved March 3, 1919 (c. 96, 40 Stat. 1291); Public Resolution No. 34 (H.J.Res. 299, 66th Cong.), approved March 23, 1920; Public Resolution No. 43 (H.J.Res. 227, 67th Cong.), approved March 21, 1922; and Public Act No. 125, approved April 16, 1926 (c. 148, sec. 1, 44 Stat. 297).

Lyman J. Briggs,
Chairman.
J. O. Johnson, *Colonel, U.S.A.*,
E. C. Peck, *Lieut. Colonel, U.S.A.*,
Appointed by the Secretary of War.
C. S. Gillette, *Commander, U.S.N.*,
J. H. Buchanan, *Lieut. Commander, U.S.N.*,
Appointed by the Secretary of the Navy.
F. O. Wells,
Appointed by the Secretary of Commerce from nominations by the American Society of Mechanical Engineers.
Geo. S. Case,
Earle Buckingham,
Appointed by the Secretary of Commerce from nominations by the Society of Automotive Engineers.

APPROVAL BY THE SECRETARIES OF WAR, NAVY, AND COMMERCE

The attached report prepared by the National Screw Thread Commission, in accordance with the law establishing the Commission, Public Act No. 201 (H.R. 10852, 65th Cong.), amended by Public Act No. 324 (H.R. 15495, 65th Cong.), Public Resolution No. 34 (H.J.Res. 299, 66th Cong.), Public Resolution No. 43 (H.J.Res. 227, 67th Cong.), and Public Act No. 125 (H.R. 264, 69th Cong.), is hereby accepted and approved.

(Signed June 1, 1933) George H. Dern,
Secretary of War.

(Signed June 5, 1933) Claude A. Swanson,
Secretary of the Navy.

(Signed June 3, 1933) Daniel C. Roper,
Secretary of Commerce.

1933 REPORT OF THE NATIONAL SCREW THREAD COMMISSION

AS APPROVED APRIL 10, 1933

SECTION I. INTRODUCTION

1. HISTORICAL

The initial accomplishment in the standardization of screw threads in the United States was the report under date of December 15, 1864, of the special committee appointed by the Franklin Institute on April 21, 1861, for the investigation of a proper system of screw threads, bolt heads, and nuts to be recommended by the institute for adoption and general use by American engineers.

In its report this committee recommended a thread system designed by William Sellers. This thread system specified a single series of pitches for certain diameters from one-fourth inch to 6 inches, inclusive. The threads had an included angle of 60° and a flat at the crest and root equal to one eighth of the pitch. This system came into general use and was known as the Franklin Institute thread, the Sellers thread, and commonly as the United States thread.

The accomplishments realized in the adoption of the Franklin Institute, or United States Standard thread, in 1864 were brought about largely by the great need of standard threads by American railroads for the development of their lines and equipment. In May 1868, this thread was adopted by the United States Navy. In recent years numerous organizations have carried forward the standardization of screw threads. The American Society of Mechanical Engineers, the Society of Automotive Engineers, the Bureau of Standards, and prominent manufacturers of specialized threaded products have been the chief influences in standardization of screw threads in this country.

While the United States standard thread system fulfilled a great need in the period of the development of our great railway systems, it did not fully meet the requirements of modern manufacture because of the need for additional standard sizes and pitches developed in other industries, and especially because of the need for definitely specified limiting sizes of threaded parts. To fulfill the first of these needs a thread system having finer pitches than the United States standard system was recommended by the Society of Automotive Engineers, and a machine-screw thread series which provided smaller sizes of screws than the United States standard threads was recommended by the American Society of Mechanical Engineers. The progress of machine design and manufacture has established an extensive use of these fine thread series.

2. NEED FOR DEFINITE SPECIFICATIONS

The difficulties encountered in obtaining enormous quantities of war material needed by the United States Government during the World War pointed out to Government establishments as well as manufacturers the need for definite and complete specifications for material required. Such specifications should be so written that the qualities desired in the product are stated in definite terms of known measurable standards, and correctly defined by the largest tolerance limits compatible with the satisfactory use or performance of the articles or material for the purpose intended. A prerequisite of the quantity production of machine parts is standardization of form and dimensions of parts, which involves also the specification of limiting dimensions of the manufactured product in order that interchangeability may be established. The economic advantages of producing interchangeable machined parts, particularly when made in different manufacturing plants located at a distance from each other, which will assemble without difficulty and in a dependable manner, are generally recognized.

The standardization of screw threads, involving as it does the specification of sizes which are necessary to industry, the elimination of unnecessary sizes, and the securing of interchangeability, is especially important because of their use in enormous quantities in all varieties of mechanisms. Such standardization is important to the user of a machine, as well as to the manufacturer, as the user should be able to buy locally a screw or nut for replacement in case of breakage or wear.

A screw-thread fit cannot be accurately made with the same facility as the fit of a plain hole and shaft. In the fit of a plain hole and shaft only three elements are taken into account in securing a given class of fit, namely, roundness, diameter, and length; whereas in a screw-thread fit it is necessary to consider roundness, length, major diameter, pitch diameter, minor diameter, angle of thread, and pitch or lead. A variation in any one of these elements of a screw thread will prevent a good fit, so that it is much more difficult to make a good screw-thread fit than it is to make a plain bearing fit.

3. AUTHORIZATION OF COMMISSION BY CONGRESS

Through the efforts of several of the engineering societies, the Bureau of Standards, and prominent manufacturers of screw-thread products, a petition was presented to Congress requesting the appointment of a Commission to investigate and promulgate standards of screw threads to be adopted by manufacturing plants under the control of the Army and Navy and for adoption and use by the public. As a result of this action the National Screw Thread Commission was authorized for a period of six months by act of Congress, approved July 18, 1918 (Public Act No. 201, H.R. 10852, 65th Cong.). Prior to the expiration of the original term of six months for which the Commission was appointed, it became apparent that it would be impossible to complete in a satisfactory manner the work outlined by the Commission. Extensions of time were therefore asked by the Commission and granted by Congress in accordance with the following acts: Public Act No. 324 (H.R. 15495, 65th Cong.); Public Resolution No. 34 (H.J.Res. 299, 66th Cong.); and Public Joint Resolution No. 43 (H.J.Res. 227, 67th Cong.) The limit on the term of the Commission was then removed by the following act of Congress (Public Act No. 125, H.R. 264, 69th Cong.):

AN ACT To amend an act to provide for the appointment of a commission to standardize screw threads

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an act entitled "An act to provide for the appointment of a commission to standardize screw threads," approved July 18, 1918, as amended by an act approved March 3, 1919, and extended by public resolutions approved March 23, 1920, and March 21, 1922, be, and the same is hereby, amended so that it will read:

That a Commission is hereby created, to be known as the Commission for the Standardization of Screw Threads, hereinafter referred to as the Commission, which shall be composed of nine commissioners, one of whom shall be the Director of the Bureau of Standards, who shall be chairman of the Commission; two representatives of the Army, to be appointed by the Secretary of War; two representatives of the Navy, to be appointed by the Secretary of the Navy, and four to be appointed by the Secretary of Commerce, two of whom shall be chosen from nominations made by the American Society of Mechanical Engineers and two from nominations made by the Society of Automotive Engineers.

Sec. 2. That it shall be the duty of said Commission to ascertain and establish standards for screw threads, which shall be submitted to the Secretary of War, the Secretary of the Navy, and the Secretary of Commerce for their acceptance and approval. Such standards, when thus accepted and approved, shall be adopted and used in the several manufacturing plants under the control of the War and Navy Departments, and, so far as practicable, in all specifications for screw threads in proposals for manufactured articles, parts, or materials to be used under the direction of these departments.

Sec. 3. That the Secretary of Commerce shall promulgate such standards for use by the public and cause the same to be published as a public document.

Sec. 4. That the Commission shall serve without compensation, but nothing herein shall be held to affect the pay of the commissioners appointed from the Army and Navy or of the Director of the Bureau of Standards.

Sec. 5. That the Commission may adopt rules and regulations in regard to its procedure and the conduct of its business.

Approved April 16, 1926.

4. ORGANIZATION OF THE COMMISSION

(*a*) Preliminary Meeting.—As soon as nominees were selected by the various organizations to be represented in the Commission a preliminary meeting was called at Washington, D.C., on September 12, 1918, by Dr. S. W. Stratton, Director of the Bureau of Standards and chairman of the Commission. At this meeting the organization of the Commission was planned in order that work could be started as soon as formal appointments of the various members of the Commission were made. The various commissioners were formally appointed under date of September 21, 1918.

(*b*) Members.—In accordance with the act, the following members have been appointed:

Appointed by the Secretary of Commerce:

	Date appointed
Chairman:	
Dr. S. W. Stratton, Director of Bureau of Standards, Washington, D.C.	September 21, 1918.
Dr. G. K. Burgess, Director of Bureau of Standards, Washington, D.C., succeeding Dr. S. W. Stratton	April 23, 1923.
Dr. Lyman J. Briggs, Acting Director of Bureau of Standards, Washington, D.C., succeeding Dr. G. K. Burgess	July 2, 1932.
On nomination by the American Society of Mechanical Engineers:	
James Hartness	September 21, 1918.
F. O. Wells	September 21, 1918.
Ralph E. Flanders, succeeding James Hartness	December 15, 1920.
Luther D. Burlingame, succeeding Ralph E. Flanders	December 10, 1924.

	Date appointed
Appointed by the Secretary of Commerce—Continued.	
On nomination by the Society of Automotive Engineers:	
H. T. Herr	September 21, 1918.
E. H. Ehrman	September 21, 1918.
Earle Buckingham, succeeding H. T. Herr	April 8, 1921.
George S. Case, succeeding E. H. Ehrman	October 3, 1922.
Appointed by the Secretary of War:	
E. C. Peck, lieutenant colonel, Ordnance, U.S. Army	September 21, 1918.
O. B. Zimmerman, major of Engineers, U.S. Army	September 21, 1918.
John O. Johnson, major of Ordnance, succeeding Maj. O. B. Zimmerman	May 23, 1919.
Appointed by the Secretary of the Navy:	
E. J. Marquart, commander, U.S. Navy Bureau of Ordnance	September 21, 1918.
S. M. Robinson, commander, U.S. Navy, Bureau of Steam Engineering	September 21, 1918.
N. H. Wright, commander, U.S. Navy, Bureau of Steam Engineering, succeeding Commander S. M. Robinson	July 14, 1919.
L. N. McNair, commander, U.S. Navy, Bureau of Ordnance, succeeding Commander E. J. Marquart	October 7, 1919.
Joseph S. Evans, commander, U.S. Navy, Bureau of Steam Engineering, succeeding Commander N. H. Wright	May 10, 1920.
S. M. Robinson, commander, U.S. Navy, Bureau of Steam Engineering, succeeding Commander J. S. Evans	November 8,1921.
J. N. Ferguson, commander, U.S. Navy, Bureau of Ordnance, succeeding Commander L. N. McNair	January 9, 1922.
C. A. Jones, lieutenant commander, U.S. Navy, Bureau of Engineering, succeeding Commander S. M. Robinson	March 21, 1922.
M. A. Libbey, commander, U.S. Navy, Bureau of Engineering, succeeding Commander C. A. Jones	July 19, 1922.
John B. Rhodes, commander, U.S. Navy, Bureau of Ordnance, succeeding Commander J. N. Ferguson	February 20, 1924.
T. C. Kinkaid, commander, U.S. Navy, Bureau of Ordnance, succeeding Commander John B. Rhodes	July 3, 1926.
Harry B. Hird, commander, U.S. Navy, Bureau of Engineering, succeeding Commander M. A. Libbey	February 18, 1927.
D. P. Moon, lieutenant commander, U.S. Navy, Bureau of Ordnance, succeeding Commander T. C. Kinkaid	October 29, 1927.
Roger W. Paine, lieutenant commander, U.S. Navy, Bureau of Engineering, succeeding Comdr. Harry B. Hird	August 20, 1928.
Herman A. Spanagel, lieutenant commander, U.S. Navy, Bureau of Ordnance, succeeding Lt. Comdr. D. P. Moon	June 22, 1929.
John H. Buchanan, lieutenant commander, U.S. Navy, Bureau of Ordnance, succeeding Lt. Comdr. Herman A. Spanagel	June 22, 1932.
C. S. Gillette, commander, U.S. Navy, Bureau of Engineering, succeeding Lt. Comdr. Roger W. Paine	July 7, 1932.

(*c*) Officers.—The following officers were elected by the Commission at the first meeting:

Lieut. Col. E. C. Peck, vice chairman for meetings held in Washington.
James Hartness, vice chairman for meetings held outside of Washington.
H. L. Van Keuren, executive secretary.
H. W. Bearce, general secretary.
Robert Lacy, first lieutenant of Engineers, U.S. Army, assistant secretary.
A. W. Coombs, stenographic reporter.

(*d*) Personnel on European Trip.—In July 1919, the Commission conferred with British and French engineers and manufacturers of screw-thread products, for the purpose of discussing the tentative report prepared by the Commission with reference to its suitability to serve as a basis for international standardization of screw threads.

The Commission was represented by the following persons:

E. C. Peck (chairman), representative U.S. Army, lieutenant colonel, Ordnance, U.S. Army.
F. O. Wells (vice chairman), representative A.S.M.E.
L. D. Burlingame, representative A.S.M.E., alternate for James Hartness.
E. Buckingham, representative S.A.E., alternate for H. T. Herr.
H. L. Horning, representative S.A.E., alternate for E. H. Ehrman.
J. O. Johnson, representative U.S. Army, major, Ordnance, U.S. Army.
L. B. McBride, representative U.S. Navy, commander, U.S. Navy.
H. C. Dickinson, representative Department of Commerce, U.S. Government, advisory member.
H. W. Bearce, representative Bureau of Standards, U.S.A. (general secretary).
Robert Lacy, representative U.S. Army, first lieutenant Engineers, U.S. Army (technical secretary).

(*e*) Present Organization.—At the time of publication of this 1933 revised report the Commission comprises the following:

Members:
Dr. Lyman J. Briggs, chairman.
Lieut. Col. E. C. Peck, vice chairman.
F. O. Wells.
Col. John O. Johnson.
Prof. Earle Buckingham.
George S. Case.
Lt. Comdr. John H. Buchanan.
Comdr. C. S. Gillette.
H. W. Bearce, secretary.

Staff (Bureau of Standards):
D. R. Miller, technical investigator.
I. H. Fullmer, editor.
E. G. Hubbell, stenographic reporter.

(*f*) General Procedure.—In its work of establishing standards for screw threads, the Commission has made particular efforts to secure actual facts concerning the need of standardization and the economic conditions to be provided for in the production and use of screw threads.

Steps were taken to secure from various screw-thread authorities and representative manufacturers and users, testimony as to the nature of the standards to be adopted for the use of the Government and for American manufacturers. To secure this information public hearings were conducted in various industrial centers throughout the country; and Government officials, authorities on screw threads, manufacturers, and users of screw-thread products, as well as manufacturers of taps, dies, gages, and other tools required for producing screw-thread products, were invited to attend these hearings and present their views on various phases of the subject. In addition, announcements of the meetings, extending invitations to all interested to be present, were published in the technical magazines. Topic sheets were distributed in advance of the hearings in order that witnesses could prepare their views on the subjects of the meeting in a definite, concise, and authentic form.

A large amount of evidence was collected in this way and the opportunity was available for the various members of the Commission to bring out by cross-examination information which could have been secured in no other way. This evidence was tabulated for the consideration of the Commission in formulating its report.

A large number of experiments and tests were made by the Bureau of Standards to verify the results obtained at the various hearings and also in connection with the development of tolerances and of other technical subjects considered by the Commission. In addition to the experiments conducted by the Bureau of Standards, the members of the Commission individually conducted experiments and research work at their own expense.

In view of the fact that international standardization of screw threads is very desirable, the Commission visited Europe in July 1919, to confer with British and French engineering standards organizations, and while no definite agreements were reached in regard to international standardization of screw threads, it was apparent in both France and England that the engineers and manufacturers in these countries were anxious to cooperate with the United States in this work. Such an international standard should be established by giving consideration to the predominating sizes and standards used in manufactured products.

The advances made by the Commission up to date will facilitate manufacture in case of war, make the best use of labor in our industries in time of peace, increase the safety of travel by rail, steamship, automobile, and airplane, and, in general, will increase the dependability of all mechanisms. The general adoption of a national thread system establishes a definite procedure to be followed explicitly for producing interchangeable threaded products.

The Commission, in formulating this report, has acted largely in a judicial capacity, basing its decisions upon evidence received from authorities on screw-thread subjects and upon the conclusions drawn by other organizations having to do with standardization of screw threads. In addition, the various subjects dealt with have been considered with a knowledge of present manufacturing conditions and with anticipation of further development in the production of screw-thread products. Above all, it is the intention of the Commission to facilitate and promote progress in manufacture.

5. ARRANGEMENT OF REPORT

There are included in the body of the report specifications for threaded products and gages, embodying sufficient information to permit the writing of definite and complete specifications for the purchase of screw-thread products. In the appendixes there is arranged supplementary information of both a general and a technical nature, including such specifications as are not intended to be mandatory.

The specifications in the report have been arranged, as far as possible, by products. For example, one section deals with threads for bolts and nuts, etc., another with hose-coupling threads, another with pipe threads, etc. As far as practicable, each section is arranged in the following order:

1. Form of thread.
2. Thread series.
3. Classification and tolerances.
4. Tables of dimensions.
5. Gages.

SECTION II. TERMINOLOGY

In this report there are utilized, as far as possible, nontechnical words and terms which best convey alike to the producer and user of screw threads the information presented.

1. DEFINITIONS

The following definitions are given of the more important terms used in the report. Definitions of terms which are obviously elementary in character are intentionally omitted.

(*a*) TERMS RELATING TO SCREW THREADS.—1. *Screw thread.*—A ridge of uniform section in the form of a helix on the surface of a cylinder or cone.

2. *External and internal threads.*[2]—An external thread is a thread on the outside of a member. Example: A threaded plug.

An internal thread is a thread on the inside of a member. Example: A threaded hole.

3. *Major diameter (formerly known as "outside diameter").*—The largest diameter of the thread of the screw or nut. The term "major diameter" replaces the term "outside diameter" as applied to the thread of a screw and also the term "full diameter" as applied to the thread of a nut.

4. *Minor diameter (formerly known as "core diameter").*—The smallest diameter of the thread of the screw or nut. The term "minor diameter" replaces the term "core diameter" as applied to the thread of a screw and also the term "inside diameter" as applied to the thread of a nut.

5. *Pitch diameter.*—On a straight screw thread, the diameter of an imaginary cylinder, the surface of which would pass through the threads at such points as to make equal the width of the threads and the width of the spaces cut by the surface of the cylinder. On a taper screw thread, the diameter, at a given distance from a reference plane perpendicular to the axis of an imaginary cone, the surface of which would pass through the threads at such points as to make equal the width of the threads and the width of the spaces cut by the surface of the cone.

6. *Pitch.*—The distance from a point on a screw thread to a corresponding point on the next thread measured parallel to the axis.

$$\text{The pitch in inches} = \frac{1}{\text{Number of threads per inch}}$$

7. *Lead.*—The distance a screw thread advances axially in one turn. On a single-thread screw the lead and pitch are identical; on a double-thread screw the lead is twice the pitch; on a triple-thread screw the lead is three times the pitch, etc.

8. *Angle of thread.*—The angle included between the sides of the thread measured in an axial plane.

9. *Helix angle.*—The angle made by the helix of the thread at the pitch diameter with a plane perpendicular to the axis.

10. *Crest.*—The top surface joining the two sides of a thread.

11. *Root.*—The bottom surface joining the sides of two adjacent threads.

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[2] These terms are here defined because of possible confusion arising from the fact that an "internal member" has an "external thread," and vice versa. For the sake of brevity an external thread is hereinafter referred to as a "screw," and an internal thread as a "nut."

12. *Side.*—The surface of the thread which connects the crest with the root.

13. *Axis of a screw.*—The longitudinal central line through the screw.

14. *Base of thread.*—The bottom section of the thread; the greatest section between the two adjacent roots.

15. *Depth of thread.*—The distance between the crest and the base of thread measured normal to the axis.

16. *Number of threads.*—Number of threads in 1 inch of length.

17. *Length of engagement.*—The length of contact between two mating parts, measured axially.

18. *Depth of engagement.*—The depth of thread contact of two mating parts, measured radially.

19. *Pitch line.*—An element of the imaginary cylinder or cone specified in definition 5.

20. *Thickness of thread.*—The distance between the adjacent sides of the thread measured along or parallel to the pitch line.

(*b*) TERMS RELATING TO CLASSIFICATION AND TOLERANCES.—1. *Allowance.*—An intentional difference in the dimensions of mating parts. It is the minimum clearance or the maximum interference which is intended between mating parts. It represents the condition of the tightest permissible fit, or the largest internal member mated with the smallest external member. Examples:

One-half inch, class 1, loose fit, American National coarse thread series:	
Minimum pitch diameter of nut	0. 4500
Maximum pitch diameter of screw	. 4478
Allowance (positive)	. 0022
One-half inch, class 4, close fit, American National coarse thread series:	
Minimum pitch diameter of nut	. 4500
Maximum pitch diameter of screw	. 4504
Allowance (negative)	. 0004

2. *Tolerance.*—The amount of variation permitted in the size of a part. Example:

One-half-inch screw, class 1, loose fit, American National coarse thread series:	
Maximum pitch diameter	0. 4478
Minimum pitch diameter	. 4404
Tolerance	. 0074

3. *Basic size.*—The theoretical or nominal standard size from which all variations are made.

4. *Crest clearance.*—Defined on a screw form as the space between the crest of a thread and the root of its mating thread.

5. *Finish.*—The character of the surface on a screw thread or other product.

6. *Fit.*—The relation between two mating parts with reference to the conditions of assembly; for example: Wrench fit; close fit; medium fit; free fit; loose fit. The quality of fit is dependent upon both the relative size and finish of the mating parts.

7. *Neutral zone.*—A positive allowance. (See "Allowance".)

8. *Limits.*—The extreme permissible dimensions of a part. Example:

One-half-inch screw, class 1, loose fit, American National coarse thread series:		
Maximum pitch diameter	0. 4478	These are the limits.
Minimum pitch diameter	. 4404	

2. ILLUSTRATIONS SHOWING TERMINOLOGY

Figures 1 and 2 illustrate the use of the terms and symbols used in the report as herein defined.

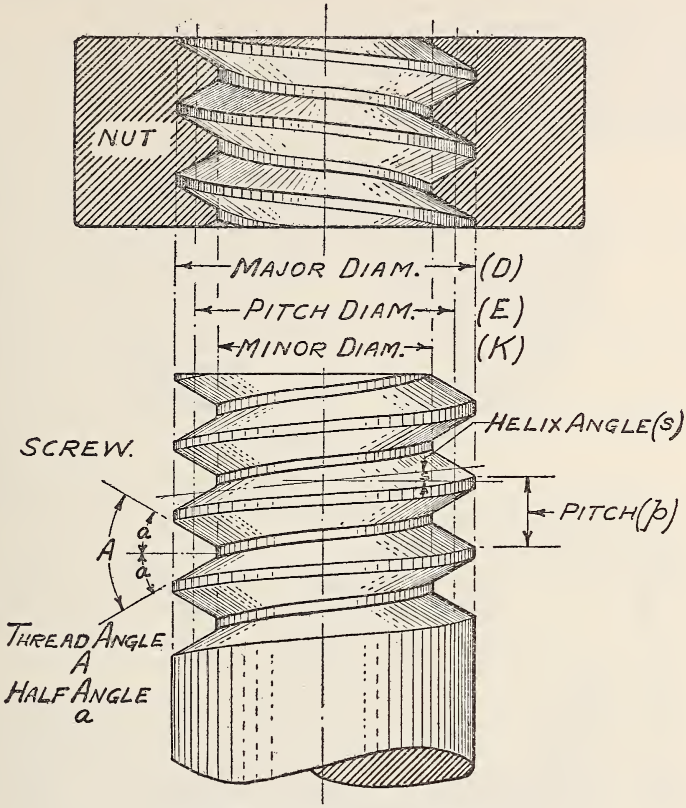

FIGURE 1.—*Screw-thread notation:*

3. SYMBOLS

For use in formulas for expressing relations of screw threads, and for use on drawings and for similar purposes, the following symbols should be used:

Major diameter	D
Corresponding radius	d
Pitch diameter	E
Corresponding radius	e
Minor diameter	K
Corresponding radius	k
Angle of thread	A
One half angle of thread	a
Number of turns per inch	N
Number of threads per inch	n
Lead	$L=\frac{1}{N}$

Pitch or thread interval	$p=\frac{1}{n}$
Helix angle	s
Tangent of helix angle	$S=\frac{L}{3.14159 \times E}$
Width of basic flat at top, crest, or root	F
Depth of basic truncation	f
Depth of sharp V thread	H
Depth of American National form of thread	h
Length of engagement	Q
Included angle of taper	Y
One half included angle of taper	y

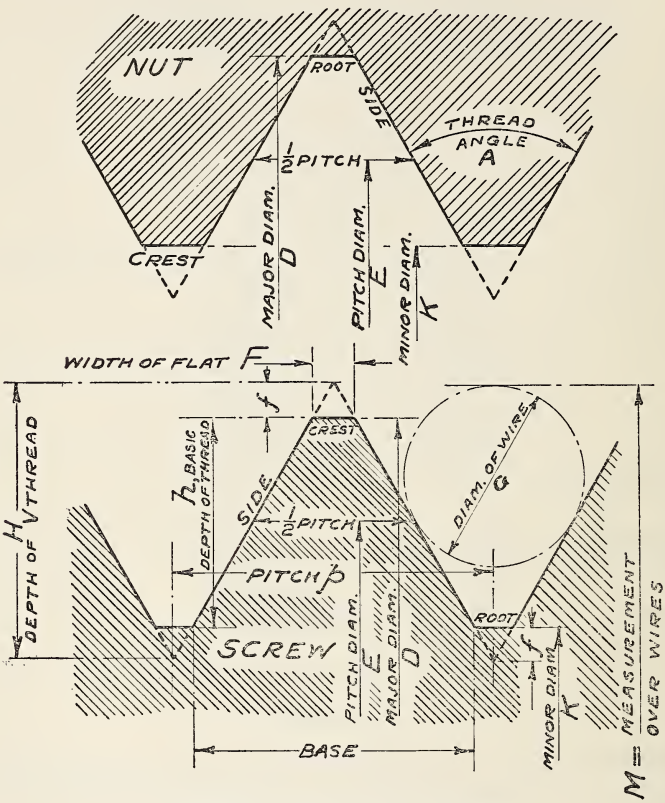

FIGURE 2.—*Screw-thread notation.*

Additional symbols for American National Pipe Threads are given in section VII.

Symbols are for use on correspondence, drawings, shop and storeroom cards, specifications for parts, taps, dies, gages, etc., and on tools and gages.

The method of designating a screw thread by means of symbols is by the use of the initial letters of the thread series, preceded by the diameter in inches (or the screw number) and number of threads per inch, all in Arabic characters, and followed by the classification of fit in Arabic numerals. If the thread is left hand, the symbol "LH" shall follow the class of fit. No symbol is used to distinguish right-hand threads. For screw threads of American National form but of special diameters, pitches, and lengths of engagement, the symbol "NS" is used. Examples:

	Mark
American National coarse thread series:	
To specify a threaded part 1 inch diameter, 8 threads per inch, class 1 fit	*1″—8NC—1*
Threaded part 1 inch diameter, 8 threads per inch, class 2 fit, left hand	*1″—8NC—2LH*
American National fine thread series:	
Threaded part 1 inch diameter, 14 threads per inch, class 4 fit	1″ *—14NF—4*
American National 8-, 12-, or 16-pitch thread series:	
Threaded part 1 inch diameter, 12 threads per inch, class 3 fit	*1″—12N—3*
Threaded part 1½ inches diameter, 8 threads per inch, class 2 fit, left hand	*1½″—8N—2LH*
American National form, special pitch:	
Threaded part 1 inch diameter, 18 threads per inch, class 2 fit	*1″—18—NS—2*
Threaded part 1¼ inches diameter, 20 threads per inch, class 3 fit, left hand	*1¼″—20NS—3LH*
American National pipe threads:	
American National taper pipe thread. Threaded part 1 inch diameter, 11½ threads per inch	*1″—11½NPT*
American National straight pipe thread	*1″—11½NPS*
American National fire-hose coupling threads and American National hose-coupling threads:	
Threaded part 3 inches diameter, 6 threads per inch	*3″—6NH*
Threaded part 1 inch diameter, 11½ threads per inch	*1″—11½NH*

The number of threads per inch shall be indicated in all cases, irrespective of whether it is the standard number of threads for that particular size of threaded part, or special.

Symbols for Wire Measurements

Measurement over wires	M
Diameter of wire	G
Corresponding radius	g

SECTION III. SCREW THREADS FOR BOLTS, MACHINE SCREWS, NUTS, TAPPED HOLES, ETC.

1. AMERICAN NATIONAL FORM OF THREAD

The form of thread profile specified herein, known previously as the "United States standard or Sellers' profile", is adopted by the Commission and shall hereafter be known as the "American National form of thread."

The American National form of thread shall be used for all screw-thread work except when otherwise specified for special purposes.

(a) SPECIFICATIONS

1. Angle of Thread.—The basic angle of thread (A) between the sides 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. Flat at Crest and Root.—The flat at the root and crest of the basic thread form is $\frac{1}{8} \times p$, or $0.125 \times p$.

3. Depth of Thread.—The depth of the basic thread form is

$$h = 0.649519 \times p, \text{ or } h = \frac{0.649519}{n}$$

where

p = pitch in inches
n = number of threads per inch
h = basic depth of thread

4. Clearance at Minor Diameter.—A clearance shall be provided at the minor diameter of the nut by removing from the crest of the basic thread form an amount such as to provide a depth of thread not less than 62 to 75 percent (depending on the size), and not more than 83⅓ percent of the basic thread depth. (See fig. 17, p. 31.)

5. Clearance at Major Diameter.—A clearance shall be provided at the major diameter of the nut by removing from above the basic thread form an amount such that the width of flat shall be less than $\frac{1}{8} \times p$, but not less than $\frac{1}{24} \times p$.

(b) ILLUSTRATION

There are indicated in figure 3 the relations as specified herein for the American National form of thread for the minimum nut and maximum screw, free or medium fits. These relations are further shown in figures 7 and 9.

2. THREAD SERIES

It is the aim of the Commission, in establishing thread systems for general use, to eliminate all unnecessary sizes and, in addition, to utilize as far as possible present predominating sizes. While from certain standpoints it would have been desirable to make simplifications in the thread systems and to establish more thoroughly consistent standards, it is believed that any radical change at the present time would be out of place and interfere with manufacturing conditions, and would involve great economic loss.

The testimony given at the various hearings held by the Commission is very consistent in favoring the maintenance of the present coarse-thread and fine-thread series, the coarse-thread series being the "United States standard" threads, supplemented in the sizes below one fourth inch by sizes taken from the standard established by the American Society of Mechanical Engineers (A.S.M.E.). The fine-thread series is composed of standards that have been found necessary, and consists of sizes taken from the standards of the Society of Automotive Engineers (S.A.E.) and the fine-thread series of the American Society of Mechanical Engineers (A.S.M.E.).

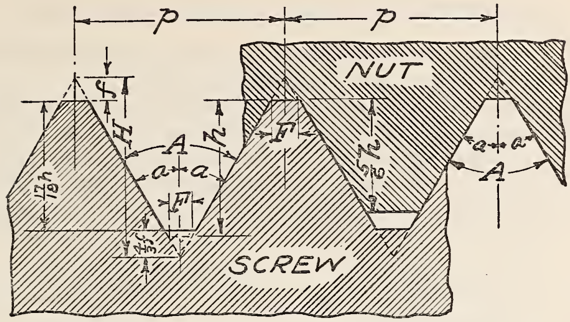

FIGURE 3.—*American National form of thread.*

NOTE.—No allowance is shown. This condition exists in class 2, free fit, and class 3, medium fit, where both the minimum nut and the maximum screw are basic.

NOTATION

n=number of threads per inch
H=0.866025 p depth of 60° sharp V thread
h=0.649519 p depth of American National form of thread
$\frac{5}{6}h$=0.541266 p maximum depth of engagement
$\frac{17}{18}h$=0.613435 p
F=0.125000 p width of flat at crest and root of American National form
f=0.108253 p } depth of truncation
$=\frac{1}{8}H$
$=\frac{1}{6}h$

(a) AMERICAN NATIONAL COARSE-THREAD SERIES

In table 1 are specified the nominal sizes and basic dimensions of the "American National coarse-thread series."

The American National coarse-thread series is recommended for general use in engineering work, in machine construction where conditions are favorable to the use of bolts, screws, and other threaded components where quick and easy assembly of the parts is desired, and for all work where conditions do not require the use of fine-pitch threads.

TABLE 1.—*American National coarse-thread series*

Identification		Basic diameters			Thread data						
Sizes	Threads per inch, *n*	Major diameter, *D*	Pitch diameter, *E*	Minor diameter, *K*	Metric equivalent of major diameter	Pitch, *p*	Depth of thread, *h*	Basic width of flat, *p*/8	Minimum width of flat at major diameter of nut, *p*/24	Helix angle at basic pitch diameter, *s*	Basic area of section at root of thread, $\frac{\pi K^2}{4}$
1	2	3	4	5	6	7	8	9	10	11	12
		Inches	*Inches*	*Inches*	*mm*	*Inch*	*Inch*	*Inch*	*Inch*	*Deg. Min.*	*Square inches*
1	64	0. 073	0. 0629	0. 0527	1. 854	0. 01562	0. 01015	0. 00195	0. 00065	4 31	0. 0022
2	56	. 086	. 0744	. 0628	2. 184	. 01786	. 01160	. 00223	. 00074	4 22	. 0031
3	48	. 099	. 0855	. 0719	2. 515	. 02083	. 01353	. 00260	. 00087	4 26	. 0041
4	40	. 112	. 0958	. 0795	2. 845	. 02500	. 01624	. 00312	. 00104	4 45	. 0050
5	40	. 125	. 1088	. 0925	3. 175	. 02500	. 01624	. 00312	. 00104	4 11	. 0067
6	32	. 138	. 1177	. 0974	3. 505	. 03125	. 02030	. 00391	. 00130	4 50	. 0075
8	32	. 164	. 1437	. 1234	4. 166	. 03125	. 02030	. 00391	. 00130	3 58	. 0120
10	24	. 190	. 1629	. 1359	4. 826	. 04167	. 02706	. 00521	. 00174	4 39	. 0145
12	24	. 216	. 1889	. 1619	5. 486	. 04167	. 02706	. 00521	. 00174	4 1	. 0206
¼	20	. 2500	. 2175	. 1850	6. 350	. 05000	. 03248	. 00625	. 00208	4 11	. 0269
5/16	18	. 3125	. 2764	. 2403	7. 938	. 05556	. 03608	. 00694	. 00231	3 40	. 0454
⅜	16	. 3750	. 3344	. 2938	9. 525	. 06250	. 04059	. 00781	. 00260	3 24	. 0678
7/16	14	. 4375	. 3911	. 3447	11. 113	. 07143	. 04639	. 00893	. 00298	3 20	. 0933
½	13	. 5000	. 4500	. 4001	12. 700	. 07692	. 04996	. 00962	. 00321	3 7	. 1257
9/16	12	. 5625	. 5084	. 4542	14. 288	. 08333	. 05413	. 01042	. 00347	2 59	. 1620
⅝	11	. 6250	. 5660	. 5069	15. 875	. 09091	. 05905	. 01136	. 00379	2 56	. 2018
¾	10	. 7500	. 6850	. 6201	19. 050	. 10000	. 06495	. 01250	. 00417	2 40	. 3020
⅞	9	. 8750	. 8028	. 7307	22. 225	. 11111	. 07217	. 01389	. 00463	2 31	. 4193
1	8	1. 0000	. 9188	. 8376	25. 400	. 12500	. 08119	. 01562	. 00521	2 29	. 5510
1⅛	7	1. 1250	1. 0322	. 9394	28. 575	. 14286	. 09279	. 01786	. 00595	2 31	. 6931
1¼	7	1. 2500	1. 1572	1. 0644	31. 750	. 14286	. 09279	. 01786	. 00595	2 15	. 8898
1⅜	6	1. 3750	1. 2667	1. 1585	34. 925	. 16667	. 10825	. 02083	. 00694	2 24	1. 0541
1½	6	1. 5000	1. 3917	1. 2835	38. 100	. 16667	. 10825	. 02083	. 00694	2 11	1. 2938
1¾	5	1. 7500	1. 6201	1. 4902	44. 450	. 20000	. 12990	. 02500	. 00833	2 15	1. 7441
2	4½	2. 0000	1. 8557	1. 7113	50. 800	. 22222	. 14434	. 02778	. 00926	2 11	2. 3001
2¼	4½	2. 2500	2. 1057	1. 9613	57. 150	. 22222	. 14434	. 02778	. 00926	1 55	3. 0212
2½	4	2. 5000	2. 3376	2. 1752	63. 500	. 25000	. 16238	. 03125	. 01042	1 57	3. 7161
2¾	4	2. 7500	2. 5876	2. 4252	69. 850	. 25000	. 16238	. 03125	. 01042	1 46	4. 6194
3	4	3. 0000	2. 8376	2. 6752	76. 200	. 25000	. 16238	. 03125	. 01042	1 36	5. 6209
3¼	4	3. 2500	3. 0876	2. 9252	82. 550	. 25000	. 16238	. 03125	. 01042	1 29	6. 7205
3½	4	3. 5000	3. 3376	3. 1752	88. 900	. 25000	. 16238	. 03125	. 01042	1 22	7. 9183
3¾	4	3. 7500	3. 5876	3. 4252	95. 250	. 25000	. 16238	. 03125	. 01042	1 16	9. 2143
4	4	4. 0000	3. 8376	3. 6752	101. 600	. 25000	. 16238	. 03125	. 01042	1 11	10. 6084

(b) AMERICAN NATIONAL FINE-THREAD SERIES

In table 2 are specified the nominal sizes and basic dimensions of the "American National fine-thread series".

The American National fine-thread series is recommended for general use in automotive and aircraft work, for use where the design requires both strength and reduction in weight, and where special conditions require a fine thread.

Table 2.—*American National fine-thread series*

Identification		Basic diameters			Thread data						
Sizes	Threads per inch, n	Major diameter, D	Pitch diameter, E	Minor diameter, K	Metric equivalent of major diameter	Pitch, p	Depth of thread, h	Basic width of flat, $p/8$	Minimum width of flat at major diameter of nut, $p/24$	Helix angle at basic pitch diameter, s	Basic area of section at root of thread, $\frac{\pi K^2}{4}$
1	2	3	4	5	6	7	8	9	10	11	12
		Inches	*Inches*	*Inches*	*mm*	*Inch*	*Inch*	*Inch*	*Inch*	*Deg. Min.*	*Square inches*
0	80	0.060	0.0519	0.0438	1.524	0.01250	0.00812	0.00156	0.00052	4 23	0.0015
1	72	.073	.0640	.0550	1.854	.01389	.00902	.00174	.00058	3 57	.0024
2	64	.086	.0759	.0657	2.184	.01562	.01015	.00195	.00065	3 45	.0034
3	56	.099	.0874	.0758	2.515	.01786	.01160	.00223	.00074	3 43	.0045
4	48	.112	.0985	.0849	2.845	.02083	.01353	.00260	.00087	3 51	.0057
5	44	.125	.1102	.0955	3.175	.02273	.01476	.00284	.00095	3 45	.0072
6	40	.138	.1218	.1055	3.505	.02500	.01624	.00312	.00104	3 44	.0087
8	36	.164	.1460	.1279	4.166	.02778	.01804	.00347	.00116	3 28	.0128
10	32	.190	.1697	.1494	4.826	.03125	.02030	.00391	.00130	3 21	.0175
12	28	.216	.1928	.1696	5.486	.03571	.02320	.00446	.00149	3 22	.0226
¼	28	.2500	.2268	.2036	6.350	.03571	.02320	.00446	.00149	2 52	.0326
5/16	24	.3125	.2854	.2584	7.938	.04167	.02706	.00521	.00174	2 40	.0524
⅜	24	.3750	.3479	.3209	9.525	.04167	.02706	.00521	.00174	2 11	.0809
7/16	20	.4375	.4050	.3725	11.113	.05000	.03248	.00625	.00208	2 15	.1090
½	20	.5000	.4675	.4350	12.700	.05000	.03248	.00625	.00208	1 57	.1486
9/16	18	.5625	.5264	.4903	14.288	.05556	.03608	.00694	.00231	1 55	.1888
⅝	18	.6250	.5889	.5528	15.875	.05556	.03608	.00694	.00231	1 43	.2400
¾	16	.7500	.7094	.6688	19.050	.06250	.04059	.00781	.00260	1 36	.3513
⅞	14	.8750	.8286	.7822	22.225	.07143	.04639	.00893	.00298	1 34	.4805
1	14	1.0000	.9536	.9072	25.400	.07143	.04639	.00893	.00298	1 22	.6464
1⅛	12	1.1250	1.0709	1.0167	28.575	.08333	.05413	.01042	.00347	1 25	.8118
1¼	12	1.2500	1.1959	1.1417	31.750	.08333	.05413	.01042	.00347	1 16	1.0238
1⅜	12	1.3750	1.3209	1.2667	34.925	.08333	.05413	.01042	.00347	1 9	1.2602
1½	12	1.5000	1.4459	1.3917	38.100	.08333	.05413	.01042	.00347	1 3	1.5212

3. CLASSIFICATION AND TOLERANCES

There are established herein for general use four distinct classes of screw-thread fits as specified in the following brief outline. These four classes of fits, together with the accompanying specifications, are for the purpose of insuring the interchangeable manufacture of screw-thread parts throughout the country.

It is not the intention of the Commission arbitrarily to place a general class or grade of work in a specific class of fit. Each manufacturer and user of screw threads is free to select the class of fit best adapted to his particular needs. The tolerances and dimensions for four classes of fit are given in tables 3 to 14, inclusive, and summarized in tables 15 and 16.

Class 1, loose fit	Includes screw-thread work of rough commercial quality, where the threads must assemble readily, and a certain amount of shake or play is not objectionable.
Class 2, free fit	Includes the great bulk of screw-thread work of ordinary quality, of finished and semifinished bolts and nuts, machine screws, etc.
Class 3, medium fit	Includes the better grade of interchangeable screw-thread work.
Class 4, close fit	Includes screw-thread work requiring a fine snug fit, much closer than the medium fit. In this class of fit selective assembly of parts may be necessary.

An examination of the dimensional specifications for the various classes of fit shows that a screw made to one class of fit may be used with a nut or tapped hole made to some other class of fit. The resulting quality of fit may represent an intermediate class or may approximate one of the classes of fit adopted as standard. The use of different classes of fit on the screw and threaded hole may be justified when equipment available is such that one member can be economically produced to a higher accuracy than the other. For instance, common commercial machine screws are made to class 2, free fit, while machine-screw nuts are commonly supplied in class 1, loose fit; or, ground-thread taps may make it practicable to produce class 3 nuts for use with class 1 or class 2 screws.

(a) GENERAL SPECIFICATIONS

The following general specifications apply to all classes of fit specified for the American National coarse-thread series and the American National fine-thread series.

1. Uniform Minimum Nut.—The pitch diameter of the minimum threaded hole or nut corresponds to the basic size.

2. Uniform Minor Diameter of Nut.—The minor diameter of the threaded hole or nut, of any given size and pitch, is the same for fits of classes 1 to 4, inclusive.

3. Length of Engagement.—A length of engagement equal to the basic major diameter is the basis of the tolerances specified herein for screw-thread products.

4. Tolerances.[3]—(*a*) The tolerances specified represent the extreme variations permitted on the product.

[3] Recommendations and explanations regarding the application of tolerances are given in appendix 1.

(*b*) The tolerance on the nut is plus, and is applied from the basic size to above basic size.

(*c*) The tolerance on the screw is minus, and is applied from the maximum screw size to below the maximum screw size.

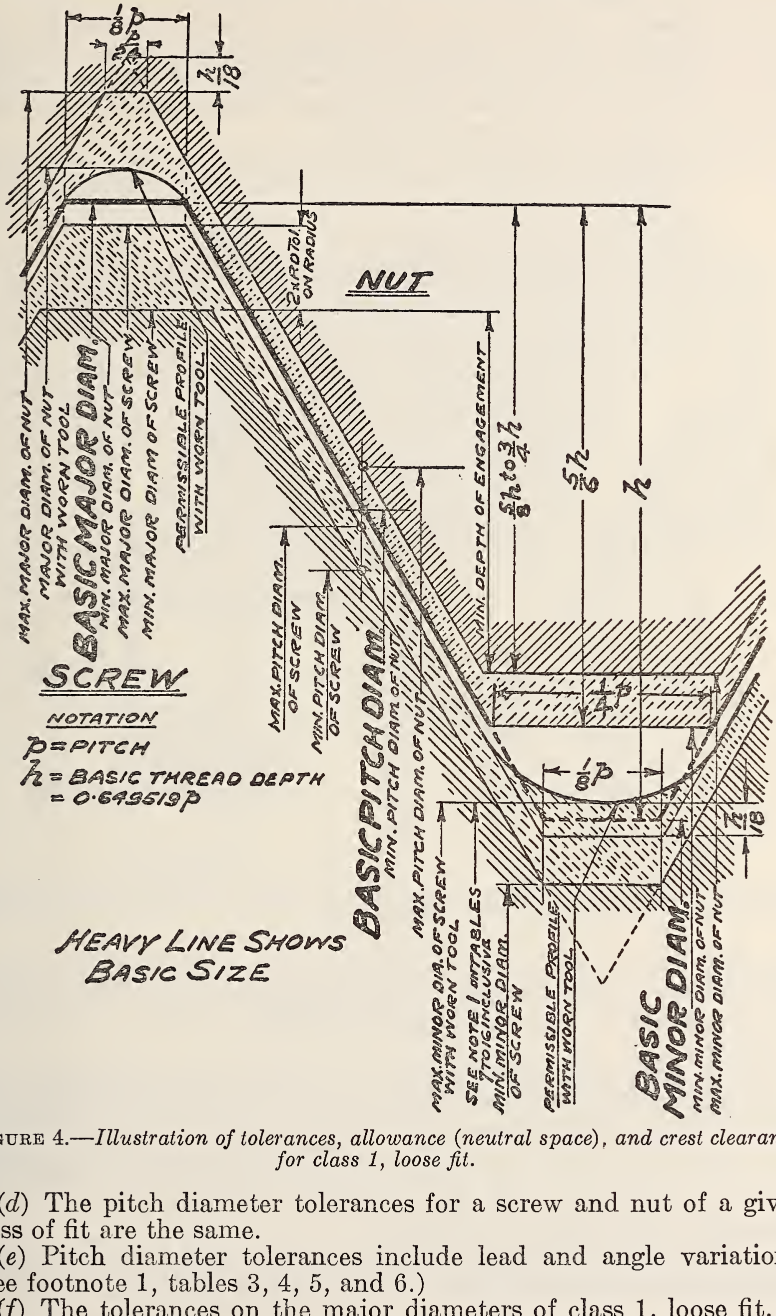

FIGURE 4.—*Illustration of tolerances, allowance (neutral space), and crest clearances for class 1, loose fit.*

(*d*) The pitch diameter tolerances for a screw and nut of a given class of fit are the same.

(*e*) Pitch diameter tolerances include lead and angle variations. (See footnote 1, tables 3, 4, 5, and 6.)

(*f*) The tolerances on the major diameters of class 1, loose fit, or class 2, free fit screws are twice the tolerance values allowed on the pitch diameters of the same respective classes and pitches with the following exception: On class 2, free fit, American National coarse-thread series, externally threaded parts of unfinished, hot-rolled material, the same tolerances on major diameter are applied as on class 1, loose fit screws.

The tolerances on the major diameters of class 3, medium fit, and class 4, close fit screws, American National coarse-thread series, are the same as those on class 2, free fit finished screws of the same thread series; and for the American National fine-thread series are the same as those on class 2, free fit of that series.

(*g*) The minimum minor diameter of a screw of a given pitch is such as to result in a basic flat ($\frac{1}{8} \times p$) at the root when the pitch

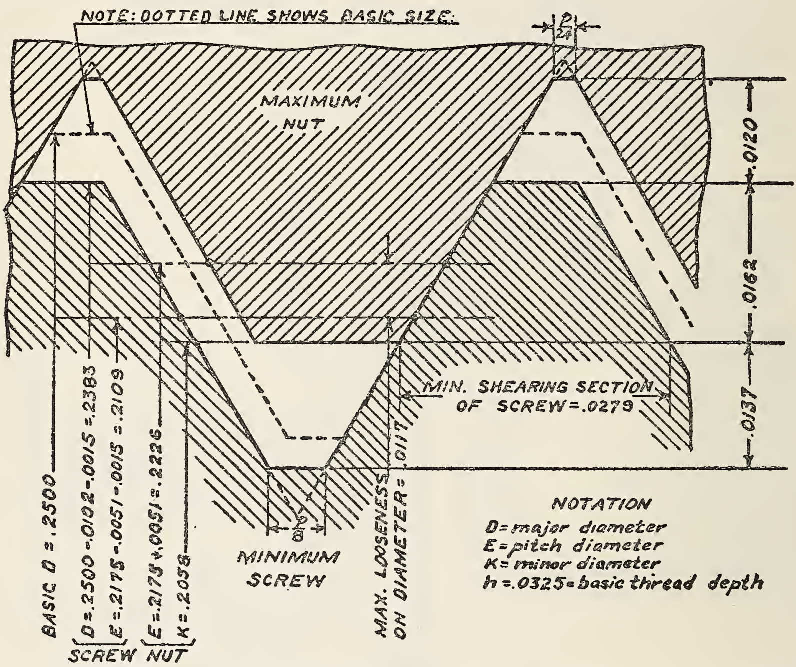

Figure 5.—*Illustration of loosest condition for class 1, loose fit, one-fourth inch, 20 threads.*

diameter of the screw is at its minimum value. When the maximum screw is basic, the minimum minor diameter of the screw will be below the basic minor diameter by the amount of the specified pitch diameter tolerance.

(*h*) The maximum minor diameter of a screw of a given pitch may be such as results from the use of a worn or rounded threading tool, when the pitch diameter is at its maximum value. In no case, however, should the form of a thread, as results from tool wear, be such as to cause the screw to be rejected on the maximum minor diameter by a "go" ring gage, the minor diameter of which is equal to the minimum minor diameter of the nut.

(*i*) The maximum major diameter of the nut of a given pitch is such as to result in a flat equal to one third of the basic flat ($\frac{1}{24} \times p$)

when the pitch diameter of the nut is at its maximum value. When the minimum nut is basic, its maximum major diameter will be above the basic major diameter by the amount of the specified pitch diameter tolerance plus two ninths of the basic thread depth.

(*j*) The nominal minimum major diameter of a nut is the basic major diameter. In no case, however, should the minimum major diameter of the nut, as results from a worn tap or cutting tool, be such as to cause the nut to be rejected on the minimum major diameter by a "go" plug gage made to the standard form at the crest.

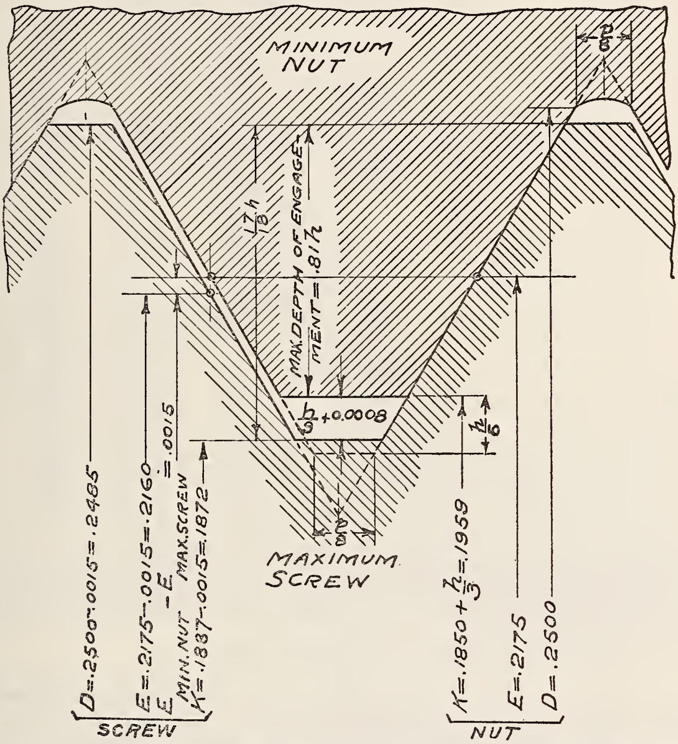

FIGURE 6.—*Illustration of tightest condition for class 1, loose fit, one-fourth inch, 20 threads.*

NOTATION

D=major diameter
E=pitch diameter
K=minor diameter
h=0.0325=basic thread depth

(*k*) Tolerances are based on the pitch of the thread and a length of engagement equal to the basic major diameter, but may be used for lengths of engagement up to 1½ diameters. (For longer lengths of engagement see section V, p. 76.)

(b) CLASSIFICATION OF FITS

1. CLASS 1, LOOSE FIT.—(*a*) *Definition.*—The loose-fit class is intended to cover the manufacture of threaded parts where quick and easy assembly is necessary and a considerable amount of shake or play is not objectionable.

TABLE 3.—*Class 1, loose fit, allowances and tolerances for screws and nuts*

Threads per inch	Allowances	Pitch-diameter tolerances [1]	Lead errors consuming one half of pitch-diameter tolerances [2]	Errors in half-angle consuming one half of pitch-diameter tolerances	
1	2	3	4	5	
	Inch	*Inch*	*Inch*	*Deg.*	*Min.*
80	0.0007	0.0024	0.0007	3	40
72	.0007	.0025	.0007	3	26
64	.0007	.0026	.0008	3	10
56	.0008	.0028	.0008	3	0
48	.0009	.0031	.0009	2	50
44	.0009	.0032	.0009	2	41
40	.0010	.0034	.0010	2	36
36	.0011	.0036	.0010	2	28
32	.0011	.0038	.0011	2	19
28	.0012	.0043	.0012	2	18
24	.0013	.0046	.0013	2	6
20	.0015	.0051	.0015	1	57
18	.0016	.0057	.0016	1	58
16	.0018	.0063	.0018	1	55
14	.0021	.0070	.0020	1	52
13	.0022	.0074	.0021	1	50
12	.0024	.0079	.0023	1	49
11	.0026	.0085	.0025	1	47
10	.0028	.0092	.0027	1	45
9	.0031	.0100	.0029	1	43
8	.0034	.0111	.0032	1	42
7	.0039	.0124	.0036	1	39
6	.0044	.0145	.0042	1	40
5	.0052	.0169	.0049	1	37
4½	.0057	.0184	.0053	1	35
4	.0064	.0204	.0059	1	33

[1] *The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance cannot, therefore, be used on pitch diameter unless the lead and angle of the thread are perfect. Columns 4 and 5 give, for information, the errors in lead (per length of thread engaged) and in angle, each of which can be compensated for by half the tolerance on the pitch diameter given in column 3. If lead and angle errors both exist to the amount tabulated, the pitch diameter of a bolt, for example, must be reduced by the full tolerance or it will not enter the "go" gage.*

[2] Between any 2 threads not farther apart than the length of engagement.

This class has an allowance on the screw to permit ready assembly even when the threads are slightly bruised or dirty.

(*b*) *Minimum nut basic.*—The pitch diameter of the minimum nut of a given diameter and pitch corresponds to the basic pitch diameter, as specified in the tables of thread series given herein, which is computed from the basic major diameter of the thread. The pitch diameter of the minimum nut is the theoretical pitch diameter for that size.

(*c*) *Maximum screw below basic.*[4]—The dimensions of the maximum screw of a given pitch and diameter are below the basic dimensions as specified in the tables of thread series given herein, which are computed from the basic major diameter of the threads, by the amount of the allowance given in table 3.

(*d*) *Allowance and tolerance values.*—Allowances and tolerances are specified in table 3.

2. CLASS 2, FREE FIT.—(*a*) *Definition.*—The free-fit class is intended to apply to interchangeable manufacture where the threaded members

[4] The maximum minor diameter of the screw is above the basic minor diameter as shown in fig. 4.

are to assemble nearly or entirely with the fingers, where a moderate amount of shake or play between the assembled threaded members is not objectionable, and where no allowance is required. This class includes the great bulk of fastening screws.

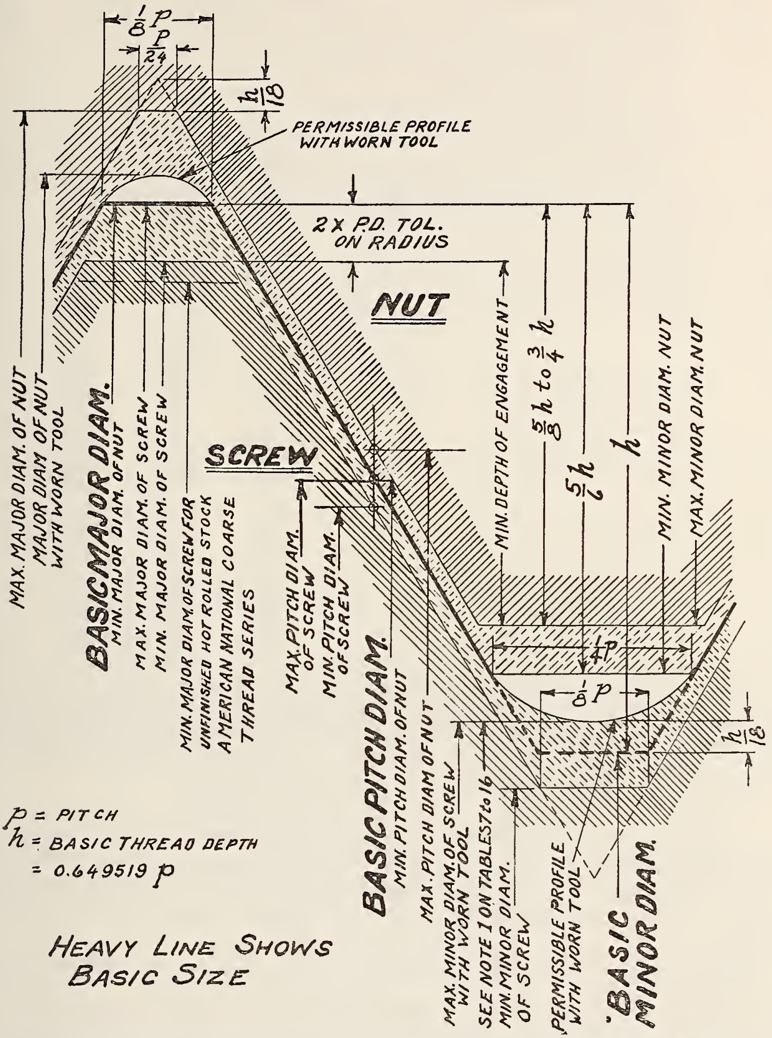

FIGURE 7.—*Illustration of tolerances and crest clearances for class 2, free fit;*

(*b*) *Minimum nut basic.*—The pitch diameter of the minimum nut of a given diameter and pitch corresponds to the basic pitch diameter, as specified in tables of thread series given herein, which is computed from the basic major diameter of the thread.

TABLE 4.—*Class 2, free fit, tolerances for screws and nuts (no allowances)*

Threads per inch	Allowances	Pitch-diameter tolerances [1]	Lead errors consuming one half of pitch-diameter tolerances [2]	Errors in half-angle consuming one half of pitch-diameter tolerances	
1	2	3	4	5	
	Inch	*Inch*	*Inch*	*Deg.*	*Min.*
80	0.0000	0.0017	0.0005	2	36
72	.0000	.0018	.0005	2	28
64	.0000	.0019	.0005	2	19
56	.0000	.0020	.0006	2	8
48	.0000	.0022	.0006	2	1
44	.0000	.0023	.0007	1	56
40	.0000	.0024	.0007	1	50
36	.0000	.0025	.0007	1	43
32	.0000	.0027	.0008	1	39
28	.0000	.0031	.0009	1	39
24	.0000	.0033	.0010	1	31
20	.0000	.0036	.0010	1	22
18	.0000	.0041	.0012	1	25
16	.0000	.0045	.0013	1	22
14	.0000	.0049	.0014	1	19
13	.0000	.0052	.0015	1	17
12	.0000	.0056	.0016	1	17
11	.0000	.0059	.0017	1	14
10	.0000	.0064	.0018	1	13
9	.0000	.0070	.0020	1	12
8	.0000	.0076	.0022	1	10
7	.0000	.0085	.0025	1	8
6	.0000	.0101	.0029	1	9
5	.0000	.0116	.0033	1	6
4½	.0000	.0127	.0037	1	5
4	.0000	.0140	.0040	1	4

[1] *The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance cannot, therefore, be used on pitch diameter unless the lead and angle of the thread are perfect. Columns 4 and 5 give, for information, the errors in lead (per length of thread engaged) and in angle, each of which can be compensated for by half the tolerance on the pitch diameter given in column 3. If lead and angle errors both exist to the amount tabulated, the pitch diameter of a bolt, for example, must be reduced by the full tolerance or it will not enter a basic nut or gage.*

[2] Between any two threads not farther apart than the length of engagement.

(*c*) *Maximum screw basic.*[5]—The major diameter and pitch diameter of the maximum screw of a given pitch and diameter correspond to the basic dimensions, as specified in tables of thread series given herein, which are computed from the basic major diameter of the thread.

(*d*) *Allowance and tolerance values.*—Allowances and tolerances are specified in table 4.

3. CLASS 3, MEDIUM FIT.—(*a*) *Definition.*—The medium-fit class is intended to apply to the manufacture of the higher grade of threaded parts which are to assemble nearly or entirely with the fingers and must have the minimum amount of shake or play between the threaded members. It is the same in every particular as class 2, free fit, except that the tolerances are smaller.

[5] The maximum minor diameter of the screw is above the basic minor diameter, as shown in fig. 7.

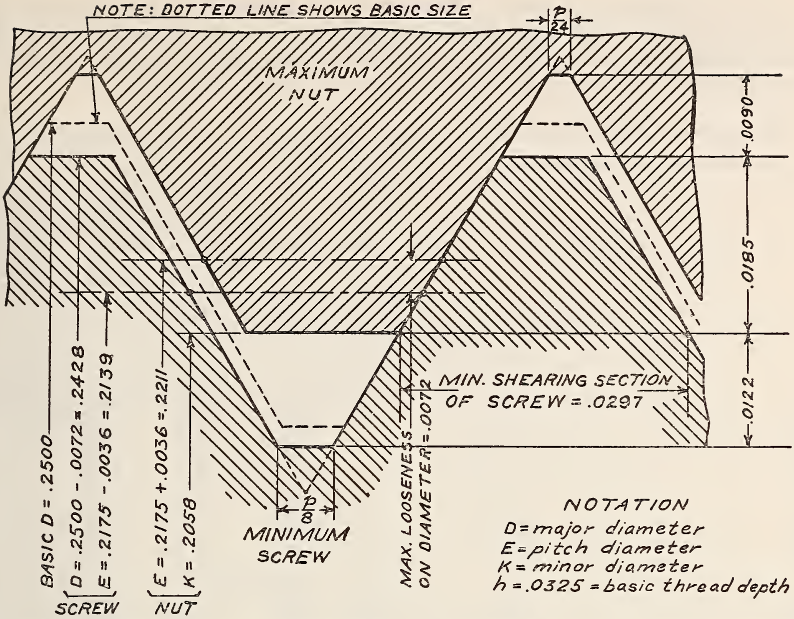

FIGURE 8.—*Illustration of loosest condition for class 2, free fit, one-fourth inch, 20 threads.*

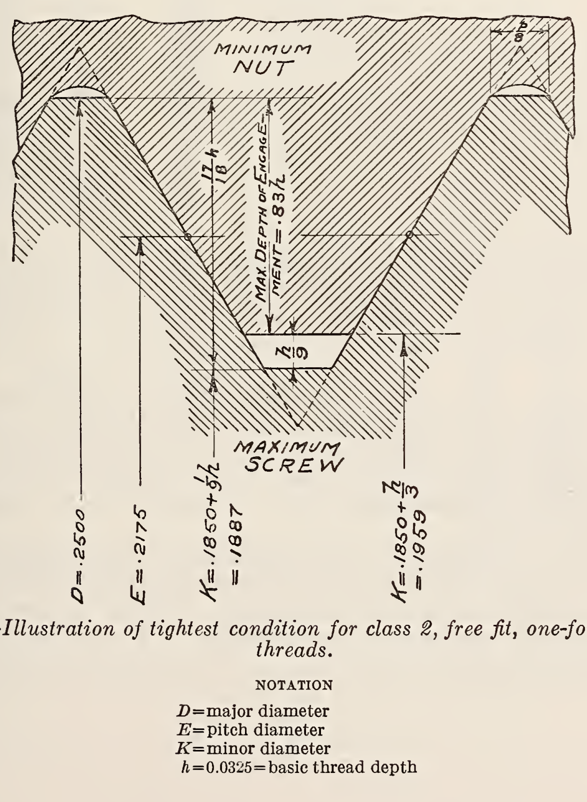

FIGURE 9.—*Illustration of tightest condition for class 2, free fit, one-fourth inch, 20 threads.*

NOTATION

D=major diameter
E=pitch diameter
K=minor diameter
h=0.0325=basic thread depth

(*b*) *Minimum nut basic.*—The pitch diameter of the minimum nut of a given diameter and pitch corresponds to the basic pitch diameter, as specified in tables of thread series given herein, which is computed from the basic major diameter of the thread.

TABLE 5.—*Class 3, medium fit, tolerances for screws and nuts* (*no allowances*)

Threads per inch	Allowances	Pitch-diameter tolerances [1]	Lead errors consuming one half of pitch-diameter tolerances [2]	Errors in half-angle consuming one half of pitch-diameter tolerances
1	2	3	4	5
	Inch	*Inch*	*Inch*	*Deg. Min.*
80	0.0000	0.0013	0.0004	1 59
72	.0000	.0013	.0004	1 47
64	.0000	.0014	.0004	1 43
56	.0000	.0015	.0004	1 36
48	.0000	.0016	.0005	1 28
44	.0000	.0016	.0005	1 21
40	.0000	.0017	.0005	1 18
36	.0000	.0018	.0005	1 14
32	.0000	.0019	.0005	1 10
28	.0000	.0022	.0006	1 11
24	.0000	.0024	.0007	1 6
20	.0000	.0026	.0008	1 0
18	.0000	.0030	.0009	1 2
16	.0000	.0032	.0009	0 59
14	.0000	.0036	.0010	0 58
13	.0000	.0037	.0011	0 55
12	.0000	.0040	.0012	0 55
11	.0000	.0042	.0012	0 53
10	.0000	.0045	.0013	0 52
9	.0000	.0049	.0014	0 51
8	.0000	.0054	.0016	0 50
7	.0000	.0059	.0017	0 47
6	.0000	.0071	.0020	0 49
5	.0000	.0082	.0024	0 47
4½	.0000	.0089	.0026	0 46
4	.0000	.0097	.0028	0 44

[1] *The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance cannot, therefore, be used on pitch diameter unless the lead and angle of the thread are perfect. Columns 4 and 5 give, for information, the errors in lead (per length of thread engaged) and in angle, each of which can be compensated for by half the tolerance on the pitch diameter given in column 3. If lead and angle errors both exist to the amount tabulated, the pitch diameter of a bolt, for example, must be reduced by the full tolerance or it will not enter a basic nut or gage.*

[2] Between any 2 threads not farther apart than the length of engagement.

(*c*) *Maximum screw basic.*[6]—The major diameter and pitch diameter of the maximum screw of a given pitch and diameter correspond to the basic dimensions, as specified in tables of thread series given herein, which are computed from the basic major diameter of the thread.

(*d*) *Allowance and tolerance values.*—Allowances and tolerances are specified in table 5.

4. CLASS 4, CLOSE FIT.—(*a*) *Definition.*—The close-fit class is intended for threaded work of the finest commercial quality where very little shake or play is desirable, and where a screw driver or wrench may be necessary for assembly. In the manufacture of

[6] The maximum minor diameter of the screw is above the basic minor diameter, as shown in fig. 10.

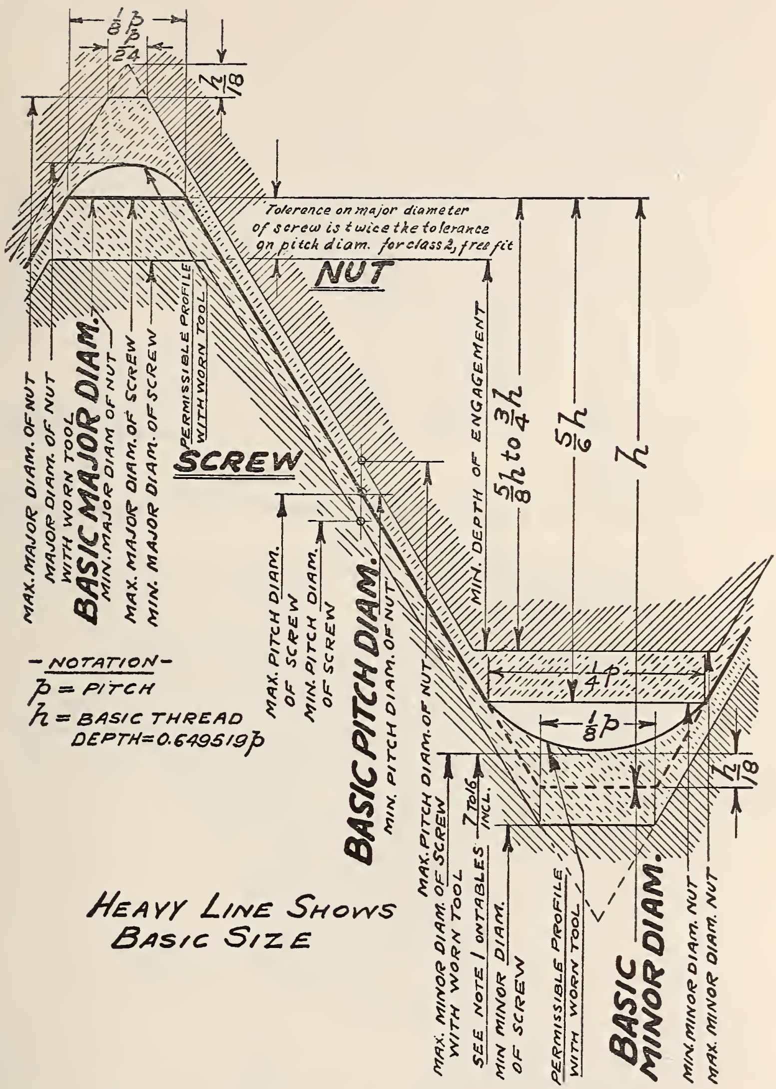

FIGURE 10.—*Illustration of tolerances and crest clearances for class 3, medium fit.*

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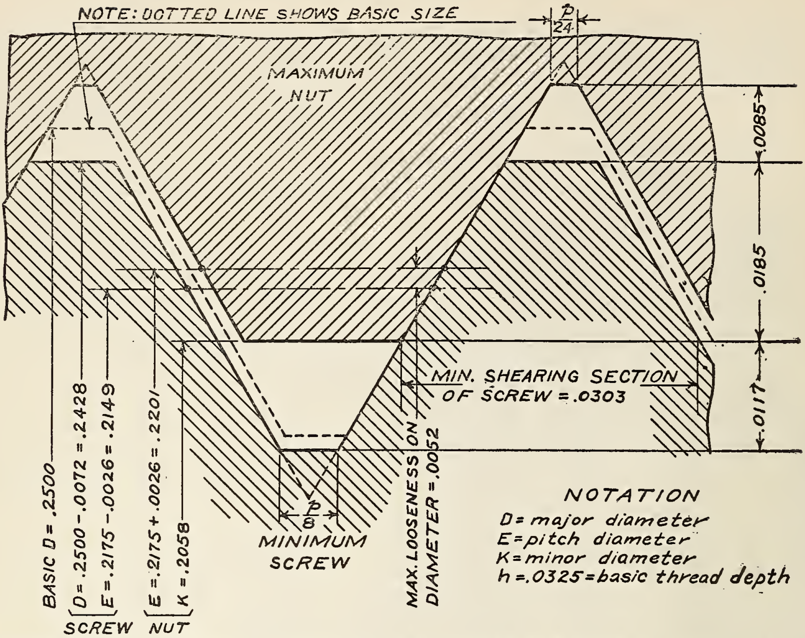

Figure 11.—*Illustration of loosest condition for class 3, medium fit, one-fourth inch, 20 threads.*

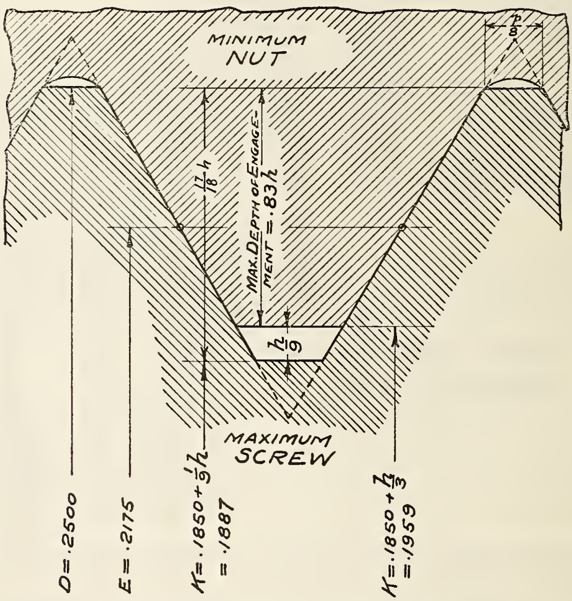

Figure 12.—*Illustration of tightest condition for class 3, medium fit, one-fourth inch, 20 threads.*

NOTATION

D=major diameter
E=pitch diameter
K=minor diameter
h=0.0325=basic thread depth

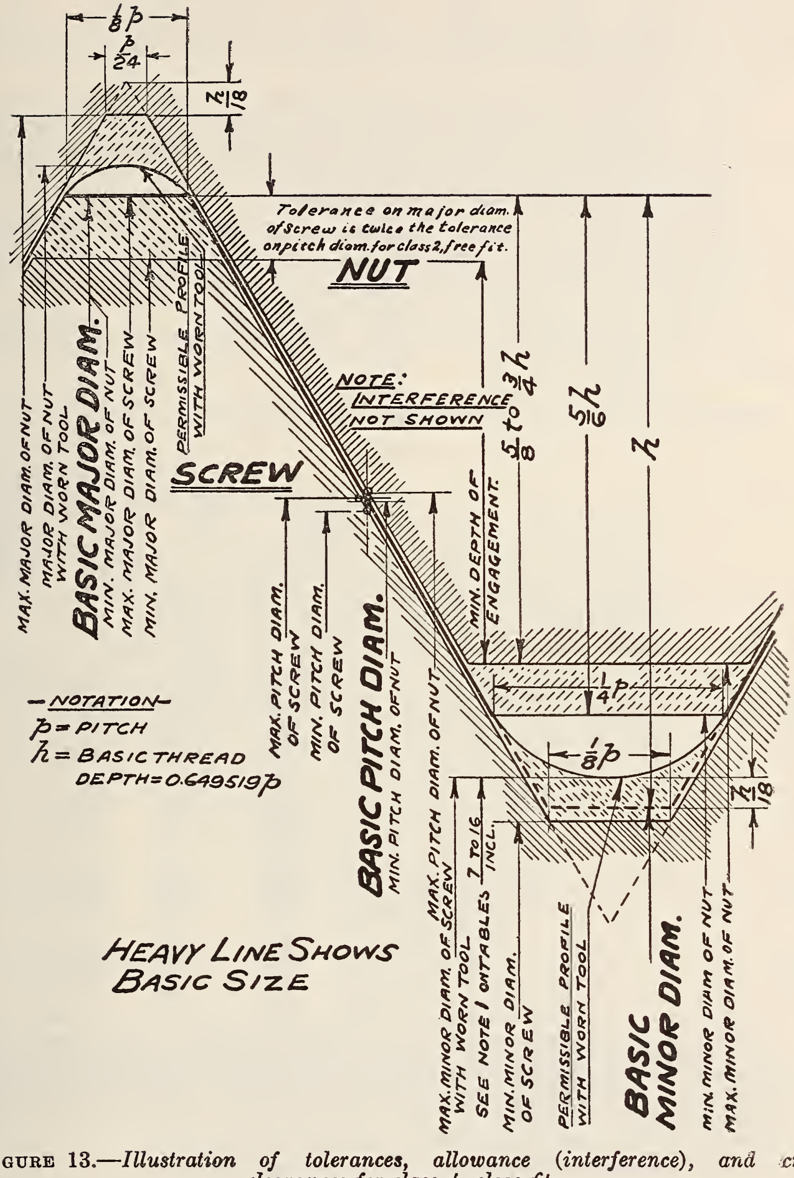

FIGURE 13.—*Illustration of tolerances, allowance (interference), and crest clearances for class 4, close fit.*

screw-thread products belonging in this class it will be necessary to use precision tools,[7] gages made to special tolerances for this class (see table 21, p. 58), and other refinements. This quality of work should, therefore, be used only in cases where requirements of the mechanism being produced are exacting, or where special conditions require screws having a precision fit. In order to secure the fit desired it may be necessary in some cases to select the parts when the product is being assembled.

(b) *Minimum nut basic.*—The pitch diameter of the minimum nut of a given diameter and pitch corresponds to the basic pitch diameter, as specified in tables of thread series given herein, which is computed from the basic major diameter of the thread.

(c) *Maximum screw above basic.*—The pitch diameter of the maximum screw of a given diameter and pitch is above the basic dimensions as specified in tables of thread series given herein, which are computed from the basic major diameter of the thread, by the amount of the allowance (interference) specified in table 6.

(d) *Allowance and tolerance values.*—Allowances and tolerances are specified in table 6.

TABLE 6.—*Class 4, close fit, allowances and tolerances for screws and nuts*

Threads per inch	Interferences or negative allowances	Pitch-diameter tolerances [1]	Lead errors consuming one half of pitch-diameter tolerances [2]	Errors in half angle consuming one half of pitch-diameter tolerances	
1	2	3	4	5	
	Inch	*Inch*	*Inch*	*Deg.*	*Min.*
28	0.0002	0.0011	0.0003	0	35
24	.0003	.0012	.0003	0	33
20	.0003	.0013	.0004	0	30
18	.0003	.0015	.0004	0	31
16	.0004	.0016	.0005	0	29
14	.0004	.0018	.0005	0	29
13	.0004	.0019	.0005	0	28
12	.0005	.0020	.0006	0	28
11	.0005	.0021	.0006	0	26
10	.0006	.0023	.0007	0	26
9	.0006	.0024	.0007	0	25
8	.0007	.0027	.0008	0	25
7	.0008	.0030	.0009	0	24
6	.0009	.0036	.0010	0	25
5	.0010	.0041	.0012	0	23
4½	.0011	.0044	.0013	0	23
4	.0013	.0048	.0014	0	22

[1] *The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance cannot, therefore, be used on pitch diameter unless the lead and angle of the thread are perfect. Columns 4 and 5 give, for information, the errors in lead (per length of thread engaged) and in angle, each of which can be compensated for by half the tolerance on the pitch diameter given in column 3. If lead and angle errors both exist to the amount tabulated, the pitch diameter of a bolt, for example, must be reduced by the full tolerance or it will not enter the "go" gage.*

[2] Between any 2 threads not farther apart than the length of engagement.

[7] Including positive control of taps and dies by means of a lead screw. See p. 145.

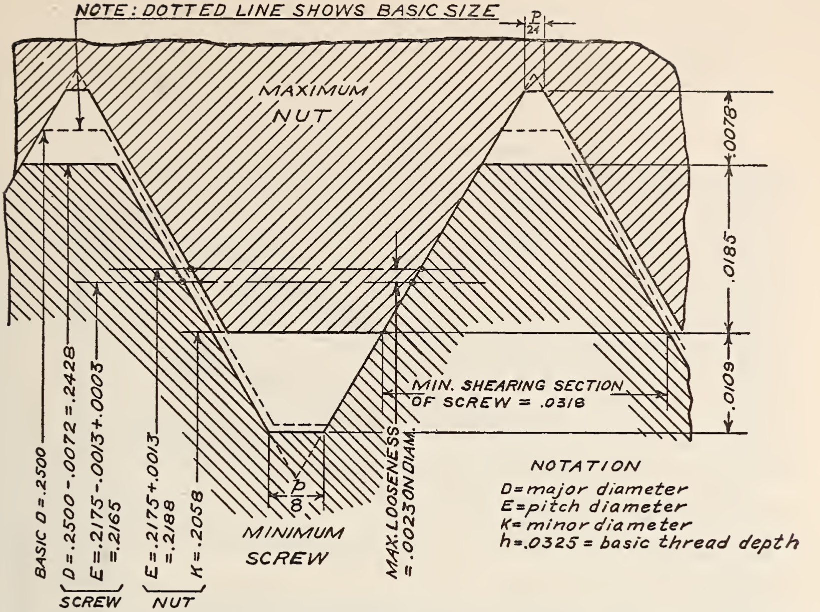

FIGURE 14.—*Illustration of loosest condition for class 4, close fit, one-fourth inch, 20 threads.*

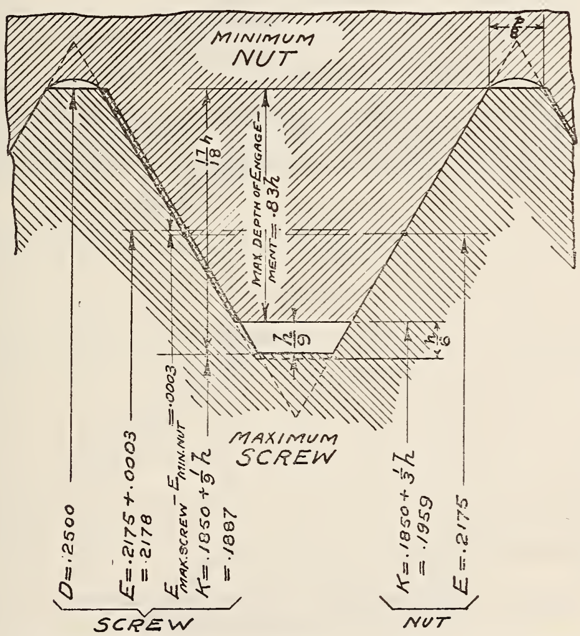

FIGURE 15.—*Illustration of tightest condition for class 4, close fit, one-fourth inch, 20 threads.*

NOTATION

D=major diameter
E=pitch diameter
K=minor diameter
h=0.0325=basic thread depth

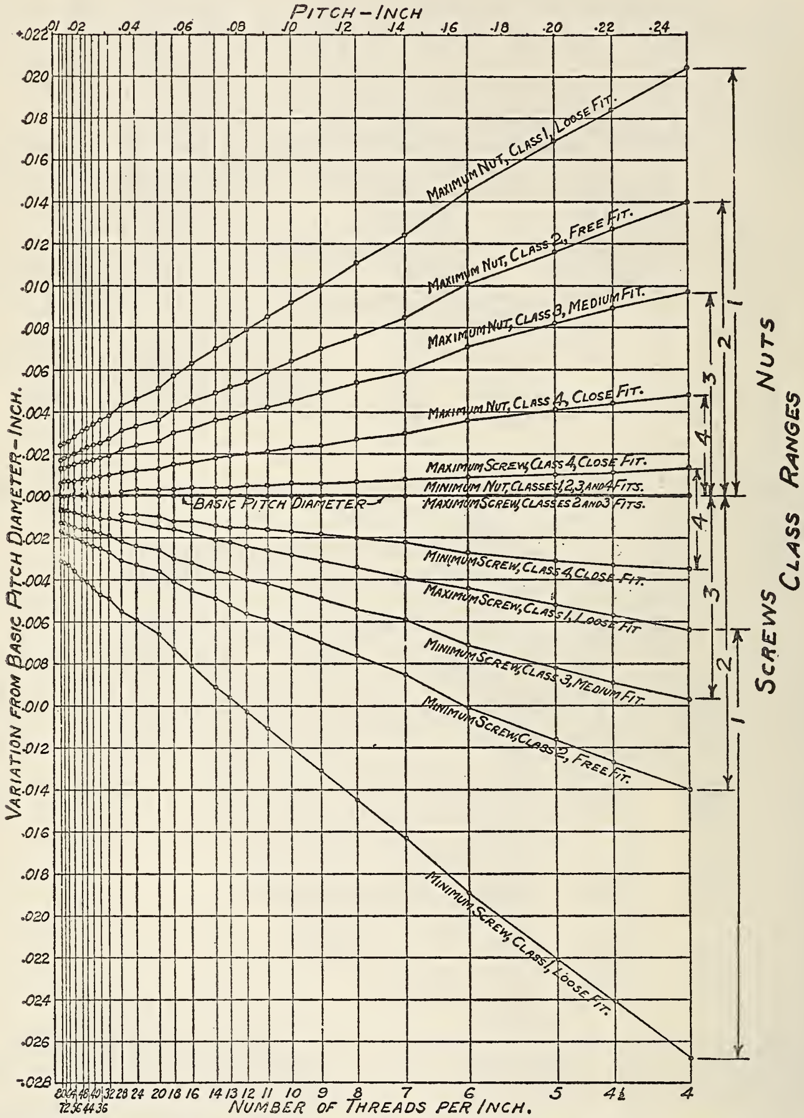

Figure 16.—*Relation of maximum and minimum pitch diameters of classes 1, 2, 3, and 4 fits to basic pitch diameters.*

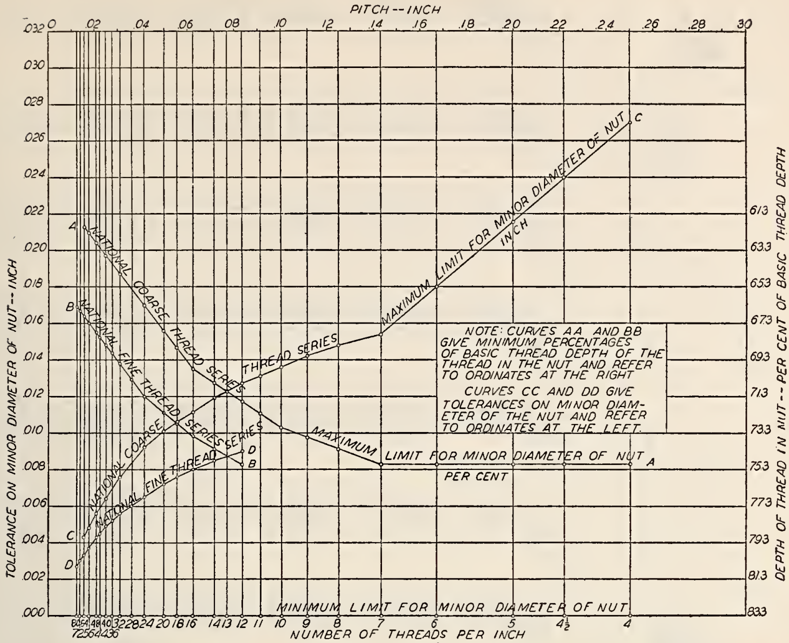

Figure 17.—*Limits for minor diameter of nut, American National coarse and fine thread series.*

4. TABLES OF LIMITING DIMENSIONS

The limiting dimensions of American National coarse and American National fine threads, to be made to the tolerances and allowances determining the various classes of fit, as herein established, are here tabulated.

TABLE 7.—*Class 1, loose fit, American National coarse-thread series*

Sizes	Threads per inch	Screw sizes					Nut sizes					Basic major diamete
		Major diameter		Pitch diameter		Minor diameter, maximum [1]	Minor diameter		Pitch diameter		Major diameter, minimum [2]	
		Max.	Min.	Max.	Min.		Min.	Max.	Min.	Max.		
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1	64	0.0723	0.0671	0.0622	0.0596	0.0531	0.0561	0.0604	0.0629	0.0655	0.0730	0.0730
2	56	.0852	.0796	.0736	.0708	.0633	.0667	.0715	.0744	.0772	.0860	.0860
3	48	.0981	.0919	.0846	.0815	.0725	.0764	.0820	.0855	.0886	.0990	.0990
4	40	.1110	.1042	.0948	.0914	.0803	.0849	.0913	.0958	.0992	.1120	.1120
5	40	.1240	.1172	.1078	.1044	.0933	.0979	.1043	.1088	.1122	.1250	.1250
6	32	.1369	.1293	.1166	.1128	.0986	.1042	.1118	.1177	.1215	.1380	.1380
8	32	.1629	.1553	.1426	.1388	.1246	.1302	.1378	.1437	.1475	.1640	.1640
10	24	.1887	.1795	.1616	.1570	.1376	.1449	.1541	.1629	.1675	.1900	.1900
12	24	.2147	.2055	.1876	.1830	.1636	.1709	.1801	.1889	.1935	.2160	.2160
¼	20	.2485	.2383	.2160	.2109	.1872	.1959	.2060	.2175	.2226	.2500	.2500
5/16	18	.3109	.2995	.2748	.2691	.2427	.2524	.2630	.2764	.2821	.3125	.3125
⅜	16	.3732	.3606	.3326	.3263	.2965	.3073	.3184	.3344	.3407	.3750	.3750
7/16	14	.4354	.4214	.3890	.3820	.3478	.3602	.3721	.3911	.3981	.4375	.4375
½	13	.4978	.4830	.4478	.4404	.4034	.4167	.4290	.4500	.4574	.5000	.5000
9/16	12	.5601	.5443	.5060	.4981	.4579	.4723	.4850	.5084	.5163	.5625	.5625
⅝	11	.6224	.6054	.5634	.5549	.5109	.5266	.5397	.5660	.5745	.6250	.6250
¾	10	.7472	.7288	.6822	.6730	.6245	.6417	.6553	.6850	.6942	.7500	.7500
⅞	9	.8719	.8519	.7997	.7897	.7356	.7547	.7689	.8028	.8128	.8750	.8750
1	8	.9966	.9744	.9154	.9043	.8432	.8647	.8795	.9188	.9299	1.0000	1.0000
1⅛	7	1.1211	1.0963	1.0283	1.0159	.9458	.9704	.9858	1.0322	1.0446	1.1250	1.1250
1¼	7	1.2461	1.2213	1.1533	1.1409	1.0708	1.0954	1.1108	1.1572	1.1696	1.2500	1.2500
1⅜	6	1.3706	1.3416	1.2623	1.2478	1.1661	1.1946	1.2126	1.2667	1.2812	1.3750	1.3750
1½	6	1.4956	1.4666	1.3873	1.3728	1.2911	1.3196	1.3376	1.3917	1.4062	1.5000	1.5000
1¾	5	1.7448	1.7110	1.6149	1.5980	1.4994	1.5335	1.5551	1.6201	1.6370	1.7500	1.7500
2	4½	1.9943	1.9575	1.8500	1.8316	1.7217	1.7594	1.7835	1.8557	1.8741	2.0000	2.0000

2¼	4½	2.2443	2.2075	2.1000	2.0816	1.9717	2.0094	2.0335	2.1057	2.1241	2.2500	2.2500
2½	4	2.4936	2.4528	2.3312	2.3108	2.1869	2.2294	2.2564	2.3376	2.3580	2.5000	2.5000
2¾	4	2.7436	2.7028	2.5812	2.5608	2.4369	2.4794	2.5064	2.5876	2.6080	2.7500	2.7500
3	4	2.9936	2.9528	2.8312	2.8108	2.6869	2.7294	2.7564	2.8376	2.8580	3.0000	3.0000
3¼	4	3.2436	3.2028	3.0812	3.0608	2.9369	2.9794	3.0064	3.0876	3.1080	3.2500	3.2500
3½	4	3.4936	3.4528	3.3312	3.3108	3.1869	3.2294	3.2564	3.3376	3.3580	3.5000	3.5000
3¾	4	3.7436	3.7028	3.5812	3.5608	3.4369	3.4794	3.5064	3.5876	3.6080	3.7500	3.7500
4	4	3.9936	3.9528	3.8312	3.8108	3.6869	3.7294	3.7564	3.8376	3.8580	4.0000	4.0000

[1] [2] See footnotes on p. 41.

TABLE 8.—*Class 2, free fit, American National coarse-thread series*

Sizes	Threads per inch	Screw sizes: Major diameter: Maximum	Screw sizes: Major diameter: Semifinished and finished bolts and screws, Min.	Screw sizes: Major diameter: Threaded parts of unfinished, hot-rolled material, Min.	Screw sizes: Pitch diameter, Max.	Screw sizes: Pitch diameter, Min.	Screw sizes: Minor diameter, maximum [1]	Nut sizes: Minor diameter, Min.	Nut sizes: Minor diameter, Max.	Nut sizes: Pitch diameter, Min.	Nut sizes: Pitch diameter, Max.	Nut sizes: Major diameter, minimum [2]	Basic major diameter
1	2	3	4	4a	5	6	7	8	9	10	11	12	13
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1	64	0.0730	0.0692	0.0678	0.0629	0.0610	0.0538	0.0561	0.0604	0.0629	0.0648	0.0730	0.0730
2	56	.0860	.0820	.0804	.0744	.0724	.0641	.0667	.0715	.0744	.0764	.0860	.0860
3	48	.0990	.0946	.0928	.0855	.0833	.0734	.0764	.0820	.0855	.0877	.0990	.0990
4	40	.1120	.1072	.1052	.0958	.0934	.0813	.0849	.0913	.0958	.0982	.1120	.1120
5	40	.1250	.1202	.1182	.1088	.1064	.0943	.0979	.1043	.1088	.1112	.1250	.1250
6	32	.1380	.1326	.1304	.1177	.1150	.0997	.1042	.1118	.1177	.1204	.1380	.1380
8	32	.1640	.1586	.1564	.1437	.1410	.1257	.1302	.1378	.1437	.1464	.1640	.1640
10	24	.1900	.1834	.1808	.1629	.1596	.1389	.1449	.1541	.1629	.1662	.1900	.1900
12	24	.2160	.2094	.2068	.1889	.1856	.1649	.1709	.1801	.1889	.1922	.2160	.2160
1/4	20	.2500	.2428	.2398	.2175	.2139	.1887	.1959	.2060	.2175	.2211	.2500	.2500
5/16	18	.3125	.3043	.3011	.2764	.2723	.2443	.2524	.2630	.2764	.2805	.3125	.3125
3/8	16	.3750	.3660	.3624	.3344	.3299	.2983	.3073	.3184	.3344	.3389	.3750	.3750
7/16	14	.4375	.4277	.4235	.3911	.3862	.3499	.3602	.3721	.3911	.3960	.4375	.4375
1/2	13	.5000	.4896	.4852	.4500	.4448	.4056	.4167	.4290	.4500	.4552	.5000	.5000
9/16	12	.5625	.5513	.5467	.5084	.5028	.4603	.4723	.4850	.5084	.5140	.5625	.5625
5/8	11	.6250	.6132	.6080	.5660	.5601	.5135	.5266	.5397	.5660	.5719	.6250	.6250
3/4	10	.7500	.7372	.7316	.6850	.6786	.6273	.6417	.6553	.6850	.6914	.7500	.7500
7/8	9	.8750	.8610	.8550	.8028	.7958	.7387	.7547	.7689	.8028	.8098	.8750	.8750
1	8	1.0000	.9848	.9778	.9188	.9112	.8466	.8647	.8795	.9188	.9264	1.0000	1.0000
1 1/8	7	1.1250	1.1080	1.1002	1.0322	1.0237	.9497	.9704	.9858	1.0322	1.0407	1.1250	1.1250

1¼	7	1. 2500	1. 2330	1. 2252	1. 1572	1. 1487	1. 0747	1. 0954	1. 1108	1. 1572	1. 1657	1. 2500	1. 2500
1⅜	6	1. 3750	1. 3548	1. 3460	1. 2667	1. 2566	1. 1705	1. 1946	1. 2126	1. 2667	1. 2768	1. 3750	1. 3750
1½	6	1. 5000	1. 4798	1. 4710	1. 3917	1. 3816	1. 2955	1. 3196	1. 3376	1. 3917	1. 4018	1. 5000	1. 5000
1¾	5	1. 7500	1. 7268	1. 7162	1. 6201	1. 6085	1. 5046	1. 5335	1. 5551	1. 6201	1. 6317	1. 7500	1. 7500
2	4½	2. 0000	1. 9746	1. 9632	1. 8557	1. 8430	1. 7274	1. 7594	1. 7835	1. 8557	1. 8684	2. 0000	2. 0000
2¼	4½	2. 2500	2. 2246	2. 2132	2. 1057	2. 0930	1. 9774	2. 0094	2. 0335	2. 1057	2. 1184	2. 2500	2. 2500
2½	4	2. 5000	2. 4720	2. 4592	2. 3376	2. 3236	2. 1933	2. 2294	2. 2564	2. 3376	2. 3516	2. 5000	2. 5000
2¾	4	2. 7500	2. 7220	2. 7092	2. 5876	2. 5736	2. 4433	2. 4794	2. 5064	2. 5876	2. 6016	2. 7500	2. 7500
3	4	3. 0000	2. 9720	2. 9592	2. 8376	2. 8236	2. 6933	2. 7294	2. 7564	2. 8376	2. 8516	3. 0000	3. 0000
3¼	4	3. 2500	3. 2220	3. 2092	3. 0876	3. 0736	2. 9433	2. 9794	3. 0064	3. 0876	3. 1016	3. 2500	3. 2500
3½	4	3. 5000	3. 4720	3. 4592	3. 3376	3. 3236	3. 1933	3. 2294	3. 2564	3. 3376	3. 3516	3. 5000	3. 5000
3¾	4	3. 7500	3. 7220	3. 7092	3. 5876	3. 5736	3. 4433	3. 4794	3. 5064	3. 5876	3. 6016	3. 7500	3. 7500
4	4	4. 0000	3. 9720	3. 9592	3. 8376	3. 8236	3. 6933	3. 7294	3. 7564	3. 8376	3. 8516	4. 0000	4. 0000

[1] [2] See footnotes on p. 41.

TABLE 9.—*Class 3, medium fit, American National coarse-thread series*

Sizes	Threads per inch	Screw sizes: Major diameter, Max.	Screw sizes: Major diameter, Min.	Screw sizes: Pitch diameter, Max.	Screw sizes: Pitch diameter, Min.	Screw sizes: Minor diameter, maximum [1]	Nut sizes: Minor diameter, Min.	Nut sizes: Minor diameter, Max.	Nut sizes: Pitch diameter, Min.	Nut sizes: Pitch diameter, Max.	Nut sizes: Major diameter, minimum [2]	Basic major diameter
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1	64	0.0730	0.0692	0.0629	0.0615	0.0538	0.0561	0.0604	0.0629	0.0643	0.0730	0.0730
2	56	.0860	.0820	.0744	.0729	.0641	.0667	.0715	.0744	.0759	.0860	.0860
3	48	.0990	.0946	.0855	.0839	.0734	.0764	.0820	.0855	.0871	.0990	.0990
4	40	.1120	.1072	.0958	.0941	.0813	.0849	.0913	.0958	.0975	.1120	.1120
5	40	.1250	.1202	.1088	.1071	.0943	.0979	.1043	.1088	.1105	.1250	.1250
6	32	.1380	.1326	.1177	.1158	.0997	.1042	.1118	.1177	.1196	.1380	.1380
8	32	.1640	.1586	.1437	.1418	.1257	.1302	.1378	.1437	.1456	.1640	.1640
10	24	.1900	.1834	.1629	.1605	.1389	.1449	.1541	.1629	.1653	.1900	.1900
12	24	.2160	.2094	.1889	.1865	.1649	.1709	.1801	.1889	.1913	.2160	.2160
1/4	20	.2500	.2428	.2175	.2149	.1887	.1959	.2060	.2175	.2201	.2500	.2500
5/16	18	.3125	.3043	.2764	.2734	.2443	.2524	.2630	.2764	.2794	.3125	.3125
3/8	16	.3750	.3660	.3344	.3312	.2983	.3073	.3184	.3344	.3376	.3750	.3750
7/16	14	.4375	.4277	.3911	.3875	.3499	.3602	.3721	.3911	.3947	.4375	.4375
1/2	13	.5000	.4896	.4500	.4463	.4056	.4167	.4290	.4500	.4537	.5000	.5000
9/16	12	.5625	.5513	.5084	.5044	.4603	.4723	.4850	.5084	.5124	.5625	.5625
5/8	11	.6250	.6132	.5660	.5618	.5135	.5266	.5397	.5660	.5702	.6250	.6250
3/4	10	.7500	.7372	.6850	.6805	.6273	.6417	.6553	.6850	.6895	.7500	.7500
7/8	9	.8750	.8610	.8028	.7979	.7387	.7547	.7689	.8028	.8077	.8750	.8750
1	8	1.0000	9848	.9188	.9134	.8466	.8647	.8795	.9188	.9242	1.0000	1.0000
1 1/8	7	1.1250	1.1080	1.0322	1.0263	.9497	.9704	.9858	1.0322	1.0381	1.1250	1.1250
1 1/4	7	1.2500	1.2330	1.1572	1.1513	1.0747	1.0954	1.1108	1.1572	1.1631	1.2500	1.2500
1 3/8	6	1.3750	1.3548	1.2667	1.2596	1.1705	1.1946	1.2126	1.2667	1.2738	1.3750	1.3750
1 1/2	6	1.5000	1.4798	1.3917	1.3846	1.2955	1.3196	1.3376	1.3917	1.3988	1.5000	1.5000
1 3/4	5	1.7500	1.7268	1.6201	1.6119	1.5046	1.5335	1.5551	1.6201	1.6283	1.7500	1.7500
2	4 1/2	2.0000	1.9746	1.8557	1.8468	1.7274	1.7594	1.7835	1.8557	1.8646	2.0000	2.0000
2 1/4	4 1/2	2.2500	2.2246	2.1057	2.0968	1.9774	2.0094	2.0335	2.1057	2.1146	2.2500	2.2500
2 1/2	4	2.5000	2.4720	2.3376	2.3279	2.1933	2.2294	2.2564	2.3376	2.3473	2.5000	2.5000
2 3/4	4	2.7500	2.7220	2.5876	2.5779	2.4433	2.4794	2.5064	2.5876	2.5973	2.7500	2.7500
3	4	3.0000	2.9720	2.8376	2.8279	2.6933	2.7294	2.7564	2.8376	2.8473	3.0000	3.0000
3 1/4	4	3.2500	3.2220	3.0876	3.0779	2.9433	2.9794	3.0064	3.0876	3.0973	3.2500	3.2500
3 1/2	4	3.5000	3.4720	3.3376	3.3279	3.1933	3.2294	3.2564	3.3376	3.3473	3.5000	3.5000
3 3/4	4	3.7500	3.7220	3.5876	3.5779	3.4433	3.4794	3.5064	3.5876	3.5973	3.7500	3.7500
4	4	4.0000	3.9720	3.8376	3.8279	3.6933	3.7294	3.7564	3.8376	3.8473	4.0000	4.0000

[1] [2] See footnotes on p. 41.

TABLE 10.—*Class 4, close fit, American National coarse-thread series*

Sizes	Threads per inch	Screw sizes: Major diameter, Max.	Screw sizes: Major diameter, Min.	Screw sizes: Pitch diameter, Max.	Screw sizes: Pitch diameter, Min.	Screw sizes: Minor diameter, maximum [1]	Nut sizes: Minor diameter, Min.	Nut sizes: Minor diameter, Max.	Nut sizes: Pitch diameter, Min.	Nut sizes: Pitch diameter, Max.	Nut sizes: Major diameter, minimum [2]	Basic major diameter
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
¼	20	0. 2500	0. 2428	0. 2178	0. 2165	0. 1887	0. 1959	0. 2060	0. 2175	0. 2188	0. 2500	0. 2500
5/16	18	. 3125	. 3043	. 2767	. 2752	. 2443	. 2524	. 2630	. 2764	. 2779	. 3125	. 3125
⅜	16	. 3750	. 3660	. 3348	. 3332	. 2983	. 3073	. 3184	. 3344	. 3360	. 3750	. 3750
7/16	14	. 4375	. 4277	. 3915	. 3897	. 3499	. 3602	. 3721	. 3911	. 3929	. 4375	. 4375
½	13	. 5000	. 4896	. 4504	. 4485	. 4056	. 4167	. 4290	. 4500	. 4519	. 5000	. 5000
9/16	12	. 5625	. 5513	. 5089	. 5069	. 4603	. 4723	. 4850	. 5084	. 5104	. 5625	. 5625
⅝	11	. 6250	. 6132	. 5665	. 5644	. 5135	. 5266	. 5397	. 5660	. 5681	. 6250	. 6250
¾	10	. 7500	. 7372	. 6856	. 6833	. 6273	. 6417	. 6553	. 6850	. 6873	. 7500	. 7500
⅞	9	. 8750	. 8610	. 8034	. 8010	. 7387	. 7547	. 7689	. 8028	. 8052	. 8750	. 8750
1	8	1. 0000	. 9848	. 9195	. 9168	. 8466	. 8647	. 8795	. 9188	. 9215	1. 0000	1. 0000
1⅛	7	1. 1250	1. 1080	1. 0330	1. 0300	. 9497	. 9704	. 9858	1. 0322	1. 0352	1. 1250	1. 1250
1¼	7	1. 2500	1. 2330	1. 1580	1. 1550	1. 0747	1. 0954	1. 1108	1. 1572	1. 1602	1. 2500	1. 2500
1⅜	6	1. 3750	1. 3548	1. 2676	1. 2640	1. 1705	1. 1946	1. 2126	1. 2667	1. 2703	1. 3750	1. 3750
1½	6	1. 5000	1. 4798	1. 3926	1. 3890	1. 2955	1. 3196	1. 3376	1. 3917	1. 3953	1. 5000	1. 5000
1¾	5	1. 7500	1. 7268	1. 6211	1. 6170	1. 5046	1. 5335	1. 5551	1. 6201	1. 6242	1. 7500	1. 7500
2	4½	2. 0000	1. 9746	1. 8568	1. 8524	1. 7274	1. 7594	1. 7835	1. 8557	1. 8601	2. 0000	2. 0000
2¼	4½	2. 2500	2. 2246	2. 1068	2. 1024	1. 9774	2. 0094	2. 0335	2. 1057	2. 1101	2. 2500	2. 2500
2½	4	2. 5000	2. 4720	2. 3389	2. 3341	2. 1933	2. 2294	2. 2564	2. 3376	2. 3424	2. 5000	2. 5000
2¾	4	2. 7500	2. 7220	2. 5889	2. 5841	2. 4433	2. 4794	2. 5064	2. 5876	2. 5924	2. 7500	2. 7500
3	4	3. 0000	2. 9720	2. 8389	2. 8341	2. 6933	2. 7294	2. 7564	2. 8376	2. 8424	3. 0000	3. 0000
3¼	4	3. 2500	3. 2220	3. 0889	3. 0841	2. 9433	2. 9794	3. 0064	3. 0876	3. 0924	3. 2500	3. 2500
3½	4	3. 5000	3. 4720	3. 3389	3. 3341	3. 1933	3. 2294	3. 2564	3. 3376	3. 3424	3. 5000	3. 5000
3¾	4	3. 7500	3. 7220	3. 5889	3. 5841	3. 4433	3. 4794	3. 5064	3. 5876	3. 5924	3. 7500	3. 7500
4	4	4. 0000	3. 9720	3. 8389	3. 8341	3. 6933	3. 7294	3. 7564	3. 8376	3. 8424	4. 0000	4. 0000

[1] [2] See footnotes on p. 41.

Table 11.—*Class 1, loose fit, American National fine-thread series*

Sizes	Threads per inch	Screw sizes					Nut sizes					Basic major diameter
		Major diameter		Pitch diameter		Minor diameter, maximum [1]	Minor diameter		Pitch diameter		Major diameter, minimum [2]	
		Max.	Min.	Max.	Min.		Min.	Max.	Min.	Max.		
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
0	80	0.0593	0.0545	0.0512	0.0488	0.0440	0.0465	0.0492	0.0519	0.0543	0.0600	0.0600
1	72	.0723	.0673	.0633	.0608	.0553	.0580	.0610	.0640	.0665	.0730	.0730
2	64	.0853	.0801	.0752	.0726	.0661	.0691	.0724	.0759	.0785	.0860	.0860
3	56	.0982	.0926	.0866	.0838	.0763	.0797	.0834	.0874	.0902	.0990	.0990
4	48	.1111	.1049	.0976	.0945	.0855	.0894	.0937	.0985	.1016	.1120	.1120
5	44	.1241	.1177	.1093	.1061	.0962	.1004	.1049	.1102	.1134	.1250	.1250
6	40	.1370	.1302	.1208	.1174	.1063	.1109	.1158	.1218	.1252	.1380	.1380
8	36	.1629	.1557	.1449	.1413	.1288	.1339	.1391	.1460	.1496	.1640	.1640
10	32	.1889	.1813	.1686	.1648	.1506	.1562	.1618	.1697	.1735	.1900	.1900
12	28	.2148	.2062	.1916	.1873	.1710	.1773	.1833	.1928	.1971	.2160	.2160
1/4	28	.2488	.2402	.2256	.2213	.2050	.2113	.2173	.2268	.2311	.2500	.2500
5/16	24	.3112	.3020	.2841	.2795	.2601	.2674	.2739	.2854	.2900	.3125	.3125
3/8	24	.3737	.3645	.3466	.3420	.3226	.3299	.3364	.3479	.3525	.3750	.3750
7/16	20	.4360	.4258	.4035	.3984	.3747	.3834	.3906	.4050	.4101	.4375	.4375
1/2	20	.4985	.4883	.4660	.4609	.4372	.4459	.4531	.4675	.4726	.5000	.5000
9/16	18	.5609	.5495	.5248	.5191	.4927	.5024	.5100	.5264	.5321	.5625	.5625
5/8	18	.6234	.6120	.5873	.5816	.5552	.5649	.5725	.5889	.5946	.6250	.6250
3/4	16	.7482	.7356	.7076	.7013	.6715	.6823	.6903	.7094	.7157	.7500	.7500
7/8	14	.8729	.8589	.8265	.8195	.7853	.7977	.8062	.8286	.8356	.8750	.8750
1	14	.9979	.9839	.9515	.9445	.9103	.9227	.9312	.9536	.9606	1.0000	1.0000
1 1/8	12	1.1226	1.1068	1.0685	1.0606	1.0204	1.0348	1.0438	1.0709	1.0788	1.1250	1.1250
1 1/4	12	1.2476	1.2318	1.1935	1.1856	1.1454	1.1598	1.1688	1.1959	1.2038	1.2500	1.2500
1 3/8	12	1.3726	1.3568	1.3185	1.3106	1.2704	1.2848	1.2938	1.3209	1.3288	1.3750	1.3750
1 1/2	12	1.4976	1.4818	1.4435	1.4356	1.3954	1.4098	1.4188	1.4459	1.4538	1.5000	1.5000

[1] [2] See footnotes on p. 41.

TABLE 12.—*Class 2, free fit, American National fine-thread series*

Sizes	Threads per inch	Screw sizes: Major diameter, Max.	Screw sizes: Major diameter, Min.	Screw sizes: Pitch diameter, Max.	Screw sizes: Pitch diameter, Min.	Screw sizes: Minor diameter, maximum [1]	Nut sizes: Minor diameter, Min.	Nut sizes: Minor diameter, Max.	Nut sizes: Pitch diameter, Min.	Nut sizes: Pitch diameter, Max.	Nut sizes: Major diameter, minimum [2]	Basic major diameter
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
0	80	0.0600	0.0566	0.0519	0.0502	0.0447	0.0465	0.0492	0.0519	0.0536	0.0600	0.0600
1	72	.0730	.0694	.0640	.0622	.0560	.0580	.0610	.0640	.0658	.0730	.0730
2	64	.0860	.0822	.0759	.0740	.0668	.0691	.0724	.0759	.0778	.0860	.0860
3	56	.0990	.0950	.0874	.0854	.0771	.0797	.0834	.0874	.0894	.0990	.0990
4	48	.1120	.1076	.0985	.0963	.0864	.0894	.0937	.0985	.1007	.1120	.1120
5	44	.1250	.1204	.1102	.1079	.0971	.1004	.1049	.1102	.1125	.1250	.1250
6	40	.1380	.1332	.1218	.1194	.1073	.1109	.1158	.1218	.1242	.1380	.1380
8	36	.1640	.1590	.1460	.1435	.1299	.1339	.1391	.1460	.1485	.1640	.1640
10	32	.1900	.1846	.1697	.1670	.1517	.1562	.1618	.1697	.1724	.1900	.1900
12	28	.2160	.2098	.1928	.1897	.1722	.1773	.1833	.1928	.1959	.2160	.2160
1/4	28	.2500	.2438	.2268	.2237	.2062	.2113	.2173	.2268	.2299	.2500	.2500
5/16	24	.3125	.3059	.2854	.2821	.2614	.2674	.2739	.2854	.2887	.3125	.3125
3/8	24	.3750	.3684	.3479	.3446	.3239	.3299	.3364	.3479	.3512	.3750	.3750
7/16	20	.4375	.4303	.4050	.4014	.3762	.3834	.3906	.4050	.4086	.4375	.4375
1/2	20	.5000	.4928	.4675	.4639	.4387	.4459	.4531	.4675	.4711	.5000	.5000
9/16	18	.5625	.5543	.5264	.5223	.4943	.5024	.5100	.5264	.5305	.5625	.5625
5/8	18	.6250	.6168	.5889	.5848	.5568	.5649	.5725	.5889	.5930	.6250	.6250
3/4	16	.7500	.7410	.7094	.7049	.6733	.6823	.6903	.7094	.7139	.7500	.7500
7/8	14	.8750	.8652	.8286	.8237	.7874	.7977	.8062	.8286	.8335	.8750	.8750
1	14	1.0000	.9902	.9536	.9487	.9124	.9227	.9312	.9536	.9585	1.0000	1.0000
1 1/8	12	1.1250	1.1138	1.0709	1.0653	1.0228	1.0348	1.0438	1.0709	1.0765	1.1250	1.1250
1 1/4	12	1.2500	1.2388	1.1959	1.1903	1.1478	1.1598	1.1688	1.1959	1.2015	1.2500	1.2500
1 3/8	12	1.3750	1.3638	1.3209	1.3153	1.2728	1.2848	1.2938	1.3209	1.3265	1.3750	1.3750
1 1/2	12	1.5000	1.4888	1.4459	1.4403	1.3978	1.4098	1.4188	1.4459	1.4515	1.5000	1.5000

[1] [2] See footnotes on p. 41.

TABLE 13.—*Class 3, medium fit, American National fine-thread series*

Sizes	Threads per inch	Screw sizes					Nut sizes					Basic major diameter
		Major diameter		Pitch diameter		Minor diameter, maximum [1]	Minor diameter		Pitch diameter		Major diameter, minimum [2]	
		Max.	Min.	Max.	Min.		Min.	Max.	Min.	Max.		
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
0	80	0.0600	0.0566	0.0519	0.0506	0.0447	0.0465	0.0492	0.0519	0.0532	0.0600	0.0600
1	72	.0730	.0694	.0640	.0627	.0560	.0580	.0610	.0640	.0653	.0730	.0730
2	64	.0860	.0822	.0759	.0745	.0668	.0691	.0724	.0759	.0773	.0860	.0860
3	56	.0990	.0950	.0874	.0859	.0771	.0797	.0834	.0874	.0889	.0990	.0990
4	48	.1120	.1076	.0985	.0969	.0864	.0894	.0937	.0985	.1001	.1120	.1120
5	44	.1250	.1204	.1102	.1086	.0971	.1004	.1049	.1102	.1118	.1250	.1250
6	40	.1380	.1332	.1218	.1201	.1073	.1109	.1158	.1218	.1235	.1380	.1380
8	36	.1640	.1590	.1460	.1442	.1299	.1339	.1391	.1460	.1478	.1640	.1640
10	32	.1900	.1846	.1697	.1678	.1517	.1562	.1618	.1697	.1716	.1900	.1900
12	28	.2160	.2098	.1928	.1906	.1722	.1773	.1833	.1928	.1950	.2160	.2160
1/4	28	.2500	.2438	.2268	.2246	.2062	.2113	.2173	.2268	.2290	.2500	.2500
5/16	24	.3125	.3059	.2854	.2830	.2614	.2674	.2739	.2854	.2878	.3125	.3125
3/8	24	.3750	.3684	.3479	.3455	.3239	.3299	.3364	.3479	.3503	.3750	.3750
7/16	20	.4375	.4303	.4050	.4024	.3762	.3834	.3906	.4050	.4076	.4375	.4375
1/2	20	.5000	.4928	.4675	.4649	.4387	.4459	.4531	.4675	.4701	.5000	.5000
9/16	18	.5625	.5543	.5264	.5234	.4943	.5024	.5100	.5264	.5294	.5625	.5625
5/8	18	.6250	.6168	.5889	.5859	.5568	.5649	.5725	.5889	.5919	.6250	.6250
3/4	16	.7500	.7410	.7094	.7062	.6733	.6823	.6903	.7094	.7126	.7500	.7500
7/8	14	.8750	.8652	.8286	.8250	.7874	.7977	.8062	.8286	.8322	.8750	.8750
1	14	1.0000	.9902	.9536	.9500	.9124	.9227	.9312	.9536	.9572	1.0000	1.0000
1 1/8	12	1.1250	1.1138	1.0709	1.0669	1.0228	1.0348	1.0438	1.0709	1.0749	1.1250	1.1250
1 1/4	12	1.2500	1.2388	1.1959	1.1919	1.1478	1.1598	1.1688	1.1959	1.1999	1.2500	1.2500
1 3/8	12	1.3750	1.3638	1.3209	1.3169	1.2728	1.2848	1.2938	1.3209	1.3249	1.3750	1.3750
1 1/2	12	1.5000	1.4888	1.4459	1.4419	1.3978	1.4098	1.4188	1.4459	1.4499	1.5000	1.5000

[1] [2] See footnotes on p. 41.

TABLE 14.—*Class 4, close fit, American National fine-thread series*

Sizes	Threads per inch	Screw sizes: Major diameter, Max.	Screw sizes: Major diameter, Min.	Screw sizes: Pitch diameter, Max.	Screw sizes: Pitch diameter, Min.	Screw sizes: Minor diameter, maximum [1]	Nut sizes: Minor diameter, Min.	Nut sizes: Minor diameter, Max.	Nut sizes: Pitch diameter, Min.	Nut sizes: Pitch diameter, Max.	Nut sizes: Major diameter, minimum [2]	Basic major diameter
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1/4	28	0.2500	0.2438	0.2270	0.2259	0.2062	0.2113	0.2173	0.2268	0.2279	0.2500	0.2500
5/16	24	.3125	.3059	.2857	.2845	.2614	.2674	.2739	.2854	.2866	.3125	.3125
3/8	24	.3750	.3684	.3482	.3470	.3239	.3299	.3364	.3479	.3491	.3750	.3750
7/16	20	.4375	.4303	.4053	.4040	.3762	.3834	.3906	.4050	.4063	.4375	.4375
1/2	20	.5000	.4928	.4678	.4665	.4387	.4459	.4531	.4675	.4688	.5000	.5000
9/16	18	.5625	.5543	.5267	.5252	.4943	.5024	.5100	.5264	.5279	.5625	.5625
5/8	18	.6250	.6168	.5892	.5877	.5568	.5649	.5725	.5889	.5904	.6250	.6250
3/4	16	.7500	.7410	.7098	.7082	.6733	.6823	.6903	.7094	.7110	.7500	.7500
7/8	14	.8750	.8652	.8290	.8272	.7874	.7977	.8062	.8286	.8304	.8750	.8750
1	14	1.0000	.9902	.9540	.9522	.9124	.9227	.9312	.9536	.9554	1.0000	1.0000
1 1/8	12	1.1250	1.1138	1.0714	1.0694	1.0228	1.0348	1.0438	1.0709	1.0729	1.1250	1.1250
1 1/4	12	1.2500	1.2388	1.1964	1.1944	1.1478	1.1598	1.1688	1.1959	1.1979	1.2500	1.2500
1 3/8	12	1.3750	1.3638	1.3214	1.3194	1.2728	1.2848	1.2938	1.3209	1.3229	1.3750	1.3750
1 1/2	12	1.5000	1.4888	1.4464	1.4444	1.3978	1.4098	1.4188	1.4459	1.4479	1.5000	1.5000

[1] Dimensions given for the maximum minor diameter of the screw are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the screw shall be that corresponding to a flat at the minor diameter of the minimum screw equal to $\frac{1}{8} \times p$, and may be determined by subtracting the basic thread depth, h (or $0.6495p$), from the minimum pitch diameter of the screw.

[2] Dimensions for the minimum major diameter of the nut correspond to the basic flat ($\frac{1}{8} \times p$), and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the nut shall be that corresponding to a flat at the major diameter of the maximum nut equal to $\frac{1}{24} \times p$, and may be determined by adding $1\frac{2}{9} \times h$ (or $0.7939p$) to the maximum pitch diameter of the nut.

TABLE 15.—*Limiting dimensions and tolerances, classes 1, 2, 3, and 4 fits, American National coarse-thread series*

		Machine screw number or nominal size															
		1	2	3	4	5	6	8	10	12	¼	5/16	⅜	7/16	½	9/16	⅝
		Threads per inch															
		64	56	48	40	40	32	32	24	24	20	18	16	14	13	12	11
BOLTS AND SCREWS		*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Class 1, major diameter	Max.	0.0723	0.0852	0.0981	0.1110	0.1240	0.1369	0.1629	0.1887	0.2147	0.2485	0.3109	0.3732	0.4354	0.4978	0.5601	0.6224
	Min.	.0671	.0796	.0919	.1042	.1172	.1293	.1553	.1795	.2055	.2383	.2995	.3606	.4214	.4830	.5443	.6054
	Tol.	.0052	.0056	.0062	.0068	.0068	.0076	.0076	.0092	.0092	.0102	.0114	.0126	.0140	.0148	.0158	.0170
Classes 2, 3, and 4, major diameter	Max.	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375	.5000	.5625	.6250
	Min.	.0692	.0820	.0946	.1072	.1202	.1326	.1586	.1834	.2094	.2428	.3043	.3660	.4277	.4896	.5513	.6132
	Tol.	.0038	.0040	.0044	.0048	.0048	.0054	.0054	.0066	.0066	.0072	.0082	.0090	.0098	.0104	.0112	.0118
Class 2, major diameter (threaded parts of unfinished, hot-rolled material)	Max.	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375	.5000	.5625	.6250
	Min.	.0678	.0804	.0928	.1052	.1182	.1304	.1564	.1808	.2068	.2398	.3011	.3624	.4235	.4852	.5467	.6080
	Tol.	.0052	.0056	.0062	.0068	.0068	.0076	.0076	.0092	.0092	.0102	.0114	.0126	.0140	.0148	.0158	.0170
Class 1, minor diameter	Max.[1]	.0531	.0633	.0725	.0803	.0933	.0986	.1246	.1376	.1636	.1872	.2427	.2965	.3478	.4034	.4579	.5109
Classes 2, 3, and 4, minor diameter	Max.[1]	.0538	.0641	.0734	.0813	.0943	.0997	.1257	.1389	.1649	.1887	.2443	.2983	.3499	.4056	.4603	.5135
Class 1, loose fit, pitch diameter	Max.	.0622	.0736	.0846	.0948	.1078	.1166	.1426	.1616	.1876	.2160	.2748	.3326	.3890	.4478	.5060	.5634
	Min.	.0596	.0708	.0815	.0914	.1044	.1128	.1388	.1570	.1830	.2109	.2691	.3263	.3820	.4404	.4981	.5549
	Tol.	.0026	.0028	.0031	.0034	.0034	.0038	.0038	.0046	.0046	.0051	.0057	.0063	.0070	.0074	.0079	.0085
Class 2, free fit, pitch diameter	Max.	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500	.5084	.5660
	Min.	.0610	.0724	.0833	.0934	.1064	.1150	.1410	.1596	.1856	.2139	.2723	.3299	.3862	.4448	.5028	.5601
	Tol.	.0019	.0020	.0022	.0024	.0024	.0027	.0027	.0033	.0033	.0036	.0041	.0045	.0049	.0052	.0056	.0059
Class 3, medium fit, pitch diameter	Max.	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500	.5084	.5660
	Min.	.0615	.0729	.0839	.0941	.1071	.1158	.1418	.1605	.1865	.2149	.2734	.3312	.3875	.4463	.5044	.5618
	Tol.	.0014	.0015	.0016	.0017	.0017	.0019	.0019	.0024	.0024	.0026	.0030	.0032	.0036	.0037	.0040	.0042
Class 4, close fit, pitch diameter	Max.	-------	-------	-------	-------	-------	-------	-------	-------	-------	.2178	.2767	.3348	.3915	.4504	.5089	.5665
	Min.	-------	-------	-------	-------	-------	-------	-------	-------	-------	.2165	.2752	.3332	.3897	.4485	.5069	.5644
	Tol.	-------	-------	-------	-------	-------	-------	-------	-------	-------	.0013	.0015	.0016	.0018	.0019	.0020	.0021

Nuts and Tapped Holes																	
Classes 1, 2, 3, and 4, major diameter	Min.[2]	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375	.5000	.5625	.6250
Classes 1, 2, 3, and 4, minor diameter	Max	.0604	.0715	.0820	.0913	.1043	.1118	.1378	.1541	.1801	.2060	.2630	.3184	.3721	.4290	.4850	.5397
	Min	.0561	.0667	.0764	.0849	.0979	.1042	.1302	.1449	.1709	.1959	.2524	.3073	.3602	.4167	.4723	.5266
	Tol	.0043	.0048	.0056	.0064	.0064	.0076	.0076	.0092	.0092	.0101	.0106	.0111	.0119	.0123	.0127	.0131
Classes 1, 2, 3, and 4, pitch diameter	Min	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500	.5084	.5660
Class 1, loose fit, pitch diameter	Max.[3]	.0655	.0772	.0886	.0992	.1122	1215	.1475	.1675	.1935	.2226	.2821	.3407	.3981	.4574	.5163	.5745
	Tol	.0026	.0028	.0031	.0034	.0034	.0038	.0038	.0046	.0046	.0051	.0057	.0063	.0070	.0074	.0079	.0085
Class 2, free fit, pitch diameter	Max.[3]	.0648	.0764	.0877	.0982	.1112	.1204	.1464	.1662	.1922	.2211	.2805	.3389	.3960	.4552	.5140	.5719
	Tol	.0019	.0020	.0022	.0024	.0024	.0027	.0027	.0033	.0033	.0036	.0041	.0045	.0049	.0052	.0056	.0059
Class 3, medium fit, pitch diameter	Max.[3]	.0643	.0759	.0871	.0975	.1105	.1196	.1456	.1653	.1913	.2201	.2794	.3376	.3947	.4537	.5124	.5702
	Tol	.0014	.0015	.0016	.0017	.0017	.0019	.0019	.0024	.0024	.0026	.0030	.0032	.0036	.0037	.0040	.0042
Class 4, close fit, pitch diameter	Max.[3]	--------	--------	--------	--------	--------	--------	--------	--------	--------	.2188	.2779	.3360	.3929	.4519	.5104	.5681
	Tol	--------	--------	--------	--------	--------	--------	--------	--------	--------	.0013	.0015	.0016	.0018	.0019	.0020	.0021

[1] See footnote 1 on p. 49. [2] See footnote 2 on p. 49. [3] See footnote 3 on p. 49.

TABLE 15.—*Limiting dimensions and tolerances, classes 1, 2, 3, and 4 fits, American National coarse-thread series*—Continued

Bolts and Screws		Sizes: 3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4
	Threads per inch	10	9	8	7	7	6	6	5	4 1/2	4 1/2	4	4	4	4	4	4	4
		Inch	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Class 1, major diameter	Max	0. 7472	0. 8719	0. 9966	1. 1211	1. 2461	1. 3706	1. 4956	1. 7448	1. 9943	2. 2443	2. 4936	2. 7436	2. 9936	3. 2436	3. 4936	3. 7436	3. 9936
	Min	. 7288	. 8519	. 9744	1. 0963	1. 2213	1. 3416	1. 4666	1. 7110	1. 9575	2. 2075	2. 4528	2. 7028	2. 9528	3. 2028	3. 4528	3. 7028	3. 9528
	Tol	. 0184	. 0200	. 0222	. 0248	. 0248	. 0290	. 0290	. 0338	. 0368	. 0368	. 0408	. 0408	. 0408	. 0408	. 0408	. 0408	. 0408
Classes 2, 3, and 4, major diameter	Max	. 7500	. 8750	1. 0000	1. 1250	1. 2500	1. 3750	1. 5000	1. 7500	2. 0000	2. 2500	2. 5000	2. 7500	3. 0000	3. 2500	3. 5000	3. 7500	4. 0000
	Min	. 7372	. 8610	. 9848	1. 1080	1. 2330	1. 3548	1. 4798	1. 7268	1. 9746	2. 2246	2. 4720	2. 7220	2. 9720	3. 2220	3. 4720	3. 7220	3. 9720
	Tol	. 0128	. 0140	. 0152	. 0170	. 0170	. 0202	. 0202	. 0232	. 0254	. 0254	. 0280	. 0280	. 0280	. 0280	. 0280	. 0280	. 0280
Class 2, major diameter (threaded parts of unfinished, hot-rolled material)	Max	. 7500	. 8750	1. 0000	1. 2500	1. 2500	1. 3750	1. 5000	1. 7500	2. 0000	2. 2500	2. 5000	2. 7500	3. 0000	3. 2500	3. 5000	3. 7500	4. 0000
	Min	. 7316	. 8550	. 9778	1. 1002	1. 2252	1. 3460	1. 4710	1. 7162	1. 9632	2. 2132	2. 4592	2. 7092	2. 9592	3. 2092	3. 4592	3. 7092	3. 9592
	Tol	. 0184	. 0200	. 0222	. 0248	. 0248	. 0290	. 0290	. 0338	. 0368	. 0368	. 0408	. 0408	. 0408	. 0408	. 0408	. 0408	. 0408
Class 1, minor diameter	Max.[1]	. 6245	. 7356	. 8432	. 9458	1. 0708	1. 1661	1. 2911	1. 4994	1. 7217	1. 9717	2. 1869	2. 4369	2. 6869	2. 9369	3. 1869	3. 4369	3. 6869
Classes 2, 3, and 4, minor diameter	Max.[1]	. 6273	. 7387	. 8466	. 9497	1. 0747	1. 1705	1. 2955	1. 5046	1. 7274	1. 9774	2. 1933	2. 4433	2. 6933	2. 9433	3. 1933	3. 4433	3. 6933
Class 1, loose fit, pitch diameter	Max	. 6822	. 7997	. 9154	1. 0283	1. 1533	1. 2623	1. 3873	1. 6149	1. 8500	2. 1000	2. 3312	2. 5812	2. 8312	3. 0812	3. 3312	3. 5812	3. 8312
	Min	. 6730	. 7897	. 9043	1. 0159	1. 1409	1. 2478	1. 3728	1. 5980	1. 8316	2. 0816	2. 3108	2. 5608	2. 8108	3. 0608	3. 3108	3. 5608	3. 8108
	Tol	. 0092	. 0100	. 0111	. 0124	. 0124	. 0145	. 0145	. 0169	. 0184	. 0184	. 0204	. 0204	. 0204	. 0204	. 0204	. 0204	. 0204
Class 2, free fit, pitch diameter	Max	. 6850	. 8028	. 9188	1. 0322	1. 1572	1. 2667	1. 3917	1. 6201	1. 8557	2. 1057	2. 3376	2. 5876	2. 8376	3. 0876	3. 3376	3. 5876	3. 8376
	Min	. 6786	. 7958	. 9112	1. 0237	1. 1487	1. 2566	1. 3816	1. 6085	1. 8430	2. 0930	2. 3236	2. 5736	2. 8236	3. 0736	3. 3236	3. 5736	3. 8236
	Tol	. 0064	. 0070	. 0076	. 0085	. 0085	. 0101	. 0101	. 0116	. 0127	. 0127	. 0140	. 0140	. 0140	. 0140	. 0140	. 0140	. 0140
Class 3, medium fit, pitch diameter	Max	. 6850	. 8028	. 9188	1. 0322	1. 1572	1. 2667	1. 3917	1. 6201	1. 8557	2. 1057	2. 3376	2. 5876	2. 8376	3. 0876	3. 3376	3. 5876	3. 8376
	Min	. 6805	. 7979	. 9134	1. 0263	1. 1513	1. 2596	1. 3846	1. 6119	1. 8468	2. 0968	2. 3279	2. 5779	2. 8279	3. 0779	3. 3279	3. 5779	3. 8279
	Tol	. 0045	. 0049	. 0054	. 0059	. 0059	. 0071	. 0071	. 0082	. 0089	. 0089	. 0097	. 0097	. 0097	. 0097	. 0097	. 0097	. 0097
Class 4, close fit, pitch diameter	Max	. 6856	. 8034	. 9195	1. 0330	1. 1580	1. 2676	1. 3926	1. 6211	1. 8568	2. 1068	2. 3389	2. 5889	2. 8389	3. 0889	3. 3389	3. 5889	3. 8389
	Min	. 6833	. 8010	. 9168	1. 0300	1. 1550	1. 2640	1. 3890	1. 6170	1. 8524	2. 1024	2. 3341	2. 5841	2. 8341	3. 0841	3. 3341	3. 5841	3. 8341
	Tol	. 0023	. 0024	. 0027	. 0030	. 0030	. 0036	. 0036	. 0041	. 0044	. 0044	. 0048	. 0048	. 0048	. 0048	. 0048	. 0048	. 0048

NUTS AND TAPPED HOLES																	
Classes 1, 2, 3, and 4, major diameter Min.[2]	.7500	.8750	1.0000	1.1250	1.2500	1.3750	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500	4.0000
Classes 1, 2, 3, and 4, minor diameter Max.	.6553	.7689	.8795	.9858	1.1108	1.2126	1.3376	1.5551	1.7835	2.0335	2.2564	2.5064	2.7564	3.0064	3.2564	3.5064	3.7564
Min.	.6417	.7547	.8647	.9704	1.0954	1.1946	1.3196	1.5335	1.7594	2.0094	2.2294	2.4794	2.7294	2.9794	3.2294	3.4794	3.7294
Tol.	.0136	.0142	.0148	.0154	.0154	.0180	.0180	.0216	.0241	.0241	.0270	.0270	.0270	.0270	.0270	.0270	.0270
Classes 1, 2, 3, and 4, pitch diameter Min.	.6850	.8028	.9188	1.0322	1.1572	1.2667	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	3.0876	3.3376	3.5876	3.8376
Class 1, loose fit, pitch diameter Max.[3]	.6942	.8128	.9299	1.0446	1.1696	1.2812	1.4062	1.6370	1.8741	2.1241	2.3580	2.6080	2.8580	3.1080	3.3580	3.6080	3.8580
Tol.	.0092	.0100	.0111	.0124	.0124	.0145	.0145	.0169	.0184	.0184	.0204	.0204	.0204	.0204	.0204	.0204	.0204
Class 2, free fit, pitch diameter Max.[3]	.6914	.8098	.9264	1.0407	1.1657	1.2768	1.4018	1.6317	1.8684	2.1184	2.3516	2.6016	2.8516	3.1016	3.3516	3.6016	3.8516
Tol.	.0064	.0070	.0076	.0085	.0085	.0101	.0101	.0116	.0127	.0127	.0140	.0140	.0140	.0140	.0140	.0140	.0140
Class 3, medium fit, pitch diameter Max.[3]	.6895	.8077	.9242	1.0381	1.1631	1.2738	1.3988	1.6283	1.8646	2.1146	2.3473	2.5973	2.8473	3.0973	3.3473	3.5973	3.8473
Tol.	.0045	.0049	.0054	.0059	.0059	.0071	.0071	.0082	.0089	.0089	.0097	.0097	.0097	.0097	.0097	.0097	.0097
Class 4, close fit, pitch diameter Max.[3]	.6873	.8052	.9215	1.0352	1.1602	1.2703	1.3953	1.6242	1.8601	2.1101	2.3424	2.5924	2.8424	3.0924	3.3424	3.5924	3.8424
Tol.	.0023	.0024	.0027	.0030	.0030	.0036	.0036	.0041	.0044	.0044	.0048	.0048	.0048	.0048	.0048	.0048	.0048

[1] See footnote 1 on p. 49.

[2] See footnote 2 on p. 49.

[3] See footnote 3 on p. 49.

TABLE 16.—*Limiting dimensions and tolerances, classes 1, 2, 3, and 4 fits, American National fine-thread series*

		Machine screw number or nominal size													
		0	1	3	3	4	5	6	8	10	12	¼	5/16	⅜	7/16
		Threads per inch													
		80	72	64	56	48	44	40	36	32	28	28	24	24	20
BOLTS AND SCREWS		*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Class 1, major diameter	Max	0.0593	0.0723	0.0853	0.0982	0.1111	0.1241	0.1370	0.1629	0.1889	0.2148	0.2488	0.3112	0.3737	0.4360
	Min	.0545	.0673	.0801	.0926	.1049	.1177	.1302	.1557	.1813	.2062	.2402	.3020	.3645	.4258
	Tol	.0048	.0050	.0052	.0056	.0062	.0064	.0068	.0072	.0076	.0086	.0086	.0092	.0092	.0102
Classes 2, 3, and 4, major diameter	Max	.0600	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375
	Min	.0566	.0694	.0822	.0950	.1076	.1204	.1332	.1590	.1846	.2098	.2438	.3059	.3684	.4303
	Tol	.0034	.0036	.0038	.0040	.0044	.0046	.0048	.0050	.0054	.0062	.0062	.0066	.0066	.0072
Class 1, minor diameter	Max.[1]	.0440	.0553	.0661	.0763	.0855	.0962	.1063	.1288	.1506	.1710	.2050	.2601	.3226	.3747
Classes 2, 3, and 4, minor diameter	Max.[1]	.0447	.0560	.0668	.0771	.0864	.0971	.1073	.1299	.1517	.1722	.2062	.2614	.3239	.3762
Class 1, pitch diameter	Max	.0512	.0633	.0752	.0866	.0976	.1093	.1208	.1449	.1686	.1916	.2256	.2841	.3466	.4035
	Min	.0488	.0608	.0726	.0838	.0945	.1061	.1174	.1413	.1648	.1873	.2213	.2795	.3420	.3984
	Tol	.0024	.0025	.0026	.0028	.0031	.0032	.0034	.0036	.0038	.0043	.0043	.0046	.0046	.0051
Class 2, pitch diameter	Max	.0519	.0640	.0759	.0874	.0985	.1102	.1218	.1460	.1697	.1928	.2268	.2854	.3479	.4050
	Min	.0502	.0622	.0740	.0854	.0963	.1079	.1194	.1435	.1670	.1897	.2237	.2821	.3446	.4014
	Tol	.0017	.0018	.0019	.0020	.0022	.0023	.0024	.0025	.0027	.0031	.0031	.0033	.0033	.0036
Class 3, pitch diameter	Max	.0519	.0640	.0759	.0874	.0985	.1102	.1218	.1460	.1697	.1928	.2268	.2854	.3479	.4050
	Min	.0506	.0627	.0745	.0859	.0969	.1086	.1201	.1442	.1678	.1906	.2246	.2830	.3455	.4024
	Tol	.0013	.0013	.0014	.0015	.0016	.0016	.0017	.0018	.0019	.0022	.0022	.0024	.0024	.0026
Class 4, pitch diameter	Max											.2270	.2857	.3482	.4053
	Min											.2259	.2845	.3470	.4040
	Tol											.0011	.0012	.0012	.0013

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Classes 1, 2, 3, and 4, major diameter	Min.[2]	.0600	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375
Classes 1, 2, 3, and 4, minor diameter	Max.	.0492	.0610	.0724	.0834	.0937	.1049	.1158	.1391	.1618	.1833	.2173	.2739	.3364	.3906
	Min.	.0465	.0580	.0691	.0797	.0894	.1004	.1109	.1339	.1562	.1773	.2113	.2674	.3299	.3834
	Tol.	.0027	.0030	.0033	.0037	.0043	.0045	.0049	.0052	.0056	.0060	.0060	.0065	.0065	.0072
Classes 1, 2, 3, and 4, pitch diameter	Min.	.0519	.0640	.0759	.0874	.0985	.1102	.1218	.1460	.1697	.1928	.2268	.2854	.3479	.4050
Class 1, pitch diameter	Max.[3]	.0543	.0665	.0785	.0902	.1016	.1134	.1252	.1496	.1735	.1971	.2311	.2900	.3525	.4101
	Tol.	.0024	.0025	.0026	.0028	.0031	.0032	.0034	.0036	.0038	.0043	.0043	.0046	.0046	.0051
Class 2, pitch diameter	Max.[3]	.0536	.0658	.0778	.0894	.1007	.1125	.1242	.1485	.1724	.1959	.2299	.2887	.3512	.4086
	Tol.	.0017	.0018	.0019	.0020	.0022	.0023	.0024	.0025	.0027	.0031	.0031	.0033	.0033	.0036
Class 3, pitch diameter	Max.[3]	.0532	.0653	.0773	.0889	.1001	.1118	.1235	.1478	.1716	.1950	.2290	.2878	.3503	.4076
	Tol.	.0013	.0013	.0014	.0015	.0016	.0016	.0017	.0018	.0019	.0022	.0022	.0024	.0024	.0026
Class 4, pitch diameter	Max.[3]	------	------	------	------	------	------	------	------	------	------	.2279	.2866	.3491	.4063
	Tol.	------	------	------	------	------	------	------	------	------	------	.0011	.0012	.0012	.0013

[1] See footnote 1 on p. 49. [2] See footnote 2 on p. 49. [3] See footnote 3 on p. 49.

TABLE 16.—*Limiting dimensions and tolerances, classes 1, 2, 3, and 4 fits, American National fine-thread series*—Continued

		Sizes									
		½	9/16	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½
		Threads per inch									
		20	18	18	16	14	14	12	12	12	12
BOLTS AND SCREWS		*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*
Class 1, major diameter	Max	0.4985	0.5609	0.6234	0.7482	0.8729	0.9979	1.1226	1.2476	1.3726	1.4976
	Min	.4883	.5495	.6120	.7356	.8589	.9839	1.1068	1.2318	1.3568	1.4818
	Tol	.0102	.0114	.0114	.0126	.0140	.0140	.0158	.0158	.0158	.0158
Classes 2, 3, and 4, major diameter	Max	.5000	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.3750	1.5000
	Min	.4928	.5543	.6168	.7410	.8652	.9902	1.1138	1.2388	1.3638	1.4888
	Tol	.0072	.0082	.0082	.0090	.0098	.0098	.0112	.0112	.0112	.0112
Class 1, minor diameter	Max.[1]	.4372	.4927	.5552	.6715	.7853	.9103	1.0204	1.1454	1.2704	1.3954
Classes 2, 3, and 4, minor diameter	Max.[1]	.4387	.4943	.5568	.6733	.7874	.9124	1.0228	1.1478	1.2728	1.3978
Class 1, pitch diameter	Max	.4660	.5248	.5873	.7076	.8265	.9515	1.0685	1.1935	1.3185	1.4435
	Min	.4609	.5191	.5816	.7013	.8195	.9445	1.0606	1.1856	1.3106	1.4356
	Tol	.0051	.0057	.0057	.0063	.0070	.0070	.0079	.0079	.0079	.0079
Class 2, pitch diameter	Max	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.3209	1.4459
	Min	.4639	.5223	.5848	.7049	.8237	.9487	1.0653	1.1903	1.3153	1.4403
	Tol	.0036	.0041	.0041	.0045	.0049	.0049	.0056	.0056	.0056	.0056
Class 3, pitch diameter	Max	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.3209	1.4459
	Min	.4649	.5234	.5859	.7062	.8250	.9500	1.0669	1.1919	1.3169	1.4419
	Tol	.0026	.0030	.0030	.0032	.0036	.0036	.0040	.0040	.0040	.0040
Class 4, pitch diameter	Max	.4678	.5267	.5892	.7098	.8290	.9540	1.0714	1.1964	1.3214	1.4464
	Min	.4665	.5252	.5877	.7082	.8272	.9522	1.0694	1.1944	1.3194	1.4444
	Tol	.0013	.0015	.0015	.0016	.0018	.0018	.0020	.0020	.0020	.0020

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Classes 1, 2, 3, and 4, major diameter	Min.[2]	.5000	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.3750	1.5000
Classes 1, 2, 3, and 4, minor diameter	Max	.4531	.5100	.5725	.6903	.8062	.9312	1.0438	1.1688	1.2938	1.4188
	Min	.4459	.5024	.5649	.6823	.7977	.9227	1.0348	1.1598	1.2848	1.4098
	Tol	.0072	.0076	.0076	.0080	.0085	.0085	.0090	.0090	.0090	.0090
Classes 1, 2, 3, and 4, pitch diameter	Min	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.3209	1.4459
Class 1, pitch diameter	Max.[3]	.4726	.5321	.5946	.7157	.8356	.9606	1.0788	1.2038	1.3288	1.4538
	Tol	.0051	.0057	.0057	.0063	.0070	.0070	.0079	.0079	.0079	.0079
Class 2, pitch diameter	Max.[3]	.4711	.5305	.5930	.7139	.8335	.9585	1.0765	1.2015	1.3265	1.4515
	Tol	.0036	.0041	.0041	.0045	.0049	.0049	.0056	.0056	.0056	.0056
Class 3, pitch diameter	Max.[3]	.4701	.5294	.5919	.7126	.8322	.9572	1.0749	1.1999	1.3249	1.4499
	Tol	.0026	.0030	.0030	.0032	.0036	.0036	.0040	.0040	.0040	.0040
Class 4, pitch diameter	Max.[3]	.4688	.5279	.5904	.7110	.8304	.9554	1.0729	1.1979	1.3229	1.4479
	Tol	.0013	.0015	.0015	.0016	.0018	.0018	.0020	.0020	.0020	.0020

[1] Dimensions given for the maximum minor diameter of the screw are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the screw shall be that corresponding to a flat at the minor diameter of the minimum screw equal to $\frac{1}{8} \times p$, and may be determined by subtracting the basic thread depth, h (or 0.6495 p), from the minimum pitch diameter of the screw.

[2] Dimensions for the minimum major diameter of the nut correspond to the basic flat ($\frac{1}{8} \times p$) and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the nut shall be that corresponding to a flat at the major diameter of the maximum nut equal to $\frac{1}{24} \times p$, and may be determined by adding $1\frac{2}{9} \times h$ (or 0.7939 p) to the maximum pitch diameter of the nut.

[3] These dimensions are the minimum metal or "not go" size. The "go" or basic size is the one that should be placed on the component drawing with the tolerance.

5. GAGES

The art of measuring screw threads has developed very rapidly during the past two decades. This development still continues, so that it would be inadvisable to attempt to specify any definite method as standard for this purpose. The objects are to establish the fundamentals of this subject, and to point out practices now successfully used.

(a) FUNDAMENTALS

1. Object of Gaging.—The final results sought by gaging are to secure interchangeability; that is, the assembly of mating parts without selection or fitting of one part to another, and to insure that the product conforms to the specified dimensions within the limits of variation establishing the closest and loosest conditions of fit permissible in any given case, as provided for in the foregoing specifications. This requires the use of gages representing the limit of maximum metal, known as "go" gages, which control the minimum looseness or maximum tightness in the fit of mating parts, and which accordingly control interchangeability; and the use of gages representing the limit of minimum metal, known as "not go" gages, which limit the amount of looseness between mating parts, and thus control in large measure the proper functioning of the parts.

Gaging should be as much employed to prevent unsatisfactory parts from being produced as to sort out the correct from the incorrect parts.

2. Purpose of "Go" and "Not Go" Gages.—The "go" gages control the extent of the tolerance in the direction of the limit of maximum metal, and represent the maximum limit of the internal member and the minimum limit of the external member. To pass inspection, parts must be acceptable to proper "go" gages, and such mating parts will always assemble. Successful interchangeable manufacturing has been carried on for many years with the use of "go" gages only.

"Not go" gages control the extent of the tolerance in the direction of the limit of minimum metal, and represent the minimum limit of the internal member and the maximum limit of the external member. To be acceptable, parts must not enter or be entered by proper "not go" gages. It is general practice to permit "not go" thread gages to enter or be entered by the product not more than 1½ turns.

There is a broad, general principle in regard to limit gages which should be kept in mind; a "go" gage should check simultaneously as many elements as possible, a "not go" gage, to be effective, can check but one element. By effective inspection is meant assurance that specified requirements in regard to size are not exceeded. A "not go" thread gage made to check only the pitch diameter is usually sufficient for practical purposes. In order that the "not go" gage may check pitch diameter only, it is necessary that the crest of the thread be removed so that the major diameter of the plug gage shall never be greater than that specified for the "go" plug gage and the minor diameter of the ring gage shall never be less than that specified for the "go" ring gage. A correspondingly greater relief should be provided at the root of the thread of the "not go" gage than of the "go" gage. (See "thread form of thread plug and ring gages", p. 53.)

3. Gage Classification.—The limiting dimensions of the threaded parts to be produced should be represented in: (*a*) Gages used in checking the product as it is machined, known as "working gages"; (*b*) gages for use in the acceptance of the product, known as "inspection gages"; and (*c*) gages used to determine the accuracy of the two preceding classes of gages, known as "master gages".

4. Gages Used to Measure the Product.—The gages used to check the product may be divided into two general types: "Mechanical" and "optical". Both types, however, are controlled by the master gages. Most of the product accepted by one type of gaging with a correct gage will be accepted by the other. It should be pointed out, however, that those parts which are near either rejection point may be accepted by one system and rejected by the other.

(*a*) *Mechanical gages.*—Mechanical gages ordinarily comprise the inspection and working gages as above defined, and these two classes are generally of the same design. The dimensions of inspection gages are such that they represent very nearly the extreme limits of the part. It is recommended that, when successive inspections are required, the working gages, either by design or selection, be of such dimensions that they are inside the limits of the gages used in succeeding inspections.

Standard designs for certain types of mechanical gages are available in the report of the American Gage Design Committee, U.S. Department of Commerce Commercial Standard No. CS8-33, "Gage Blanks."[8]

(*b*) *Optical gages.*—When gages of the optical type are employed, the elements of wear and "feel" are not involved, hence no difference in size between inspection and working gages is necessary, but is desirable.

5. Gages for Reference.—(*a*) *Master gage.*—The master gage is a thread-plug gage which represents the physical dimensions of the nominal or basic size of the part. It clearly establishes the minimum size of the threaded hole and the maximum size of the screw at the point at which interference between mating parts begins. A master gage shall be accompanied by a record of its measurement. In case of question, the deviations of this gage from the basic size shall be ascertained by the Bureau of Standards at Washington, D.C.

(*b*) *Setting gage* (*check gage*).—A setting gage is a thread-plug gage to which adjustable thread-ring gages, thread-snap gages, and other thread comparators are adjusted for size. In adjusting thread-ring gages to size, the setting plug gage should control the pitch diameter, and it will do so if proper clearance is provided at the major diameter of the ring gage, and if the minor diameter is within the specified limits. The ring gage should be given further inspection as to these points. The minor diameter may be inspected by means of "go" and "not go" plain plug gages, and the major diameter by optical examination of a sulphur-graphite, plaster-of-paris, or other suitable cast of the thread.

6. Direction of Tolerances on Gages.—*The sizes for limit gages shall never be outside of the limits specified for the product. All variations in the gages, whatever their cause or purpose, shall bring these gages within these extreme limits.* Thus, a gage which represents a minimum limit may be larger, but never smaller, than the minimum

[8] For sale by the Superintendent of Documents, Government Printing Office, Washington, D.C.

size specified for the part, while the gage which represents a maximum limit may be smaller, but never larger, than the maximum size specified for the part.

7. Temperature at Which Gages Shall be Standard.—*The nominal dimensions of gages and product shall be correct at a temperature of 68° F. (20° C.).*—As gages and products are ordinarily checked at room temperature, whatever it may happen to be, it is desirable that the thermal coefficient of expansion of gages be the same as that of the product on which they are used. Inasmuch as the majority of threaded products consist of iron and steel, and as screw-thread gages are ordinarily made of hardened steel, because of its high wear-resisting qualities, this condition is ordinarily fulfilled without giving it special attention.

8. Measuring Pressure for Three-Wire Measurements.[9]—In measuring the pitch diameter of hardened screw-thread gages by means of wires, and in measuring the wires themselves, the same contact pressure should be used. A contact pressure of 14 to 16 ounces is recommended for pitches finer than 20 threads per inch and of 2¼ to 2½ pounds for 20 threads per inch and coarser. It is also recommended as standard practice that wires be measured between a flat contact and a cylindrical contact 0.750 inch in diameter.

(b) SPECIFICATIONS FOR GAGES

The following specifications are for the purpose of establishing definite limits for thread gages rather than for the purpose of specifying the gages required for the various inspection operations:

1. Classification of Gages, and Gage Tolerances.—Screw-thread gages for classes 1, 2, and 3 are classified according to accuracy into classes X, Y, and Z, the class X being the most accurate. Gages for class 4, close-fit product, are made to smaller tolerances and are designated as class W. The tolerance limits on classes Y and Z "go" gages are placed inside of the extreme product limits to provide allowance for wear of the gages. The tolerances on all "not go" gages, however, are applied from the extreme product limit as the starting point, as no allowance for wear is necessary. The selection of gages from among these classes for use in the inspection of threaded product depends entirely upon the specifications for the product. For example, in the production of parts to class 3, medium fit specifications, class X gages may be required for all purposes. On the other hand, for parts made to class 1, loose-fit specifications, class Z gages may be sufficiently accurate for all purposes.

(*a*) *Master gages.*—No fixed tolerances are specified for master gages. These should be made to the basic size as accurately as possible and be within the tolerances specified for class X gages. The variations from basic size shall be plus. Each master gage shall be marked with an identification number or symbol, and be accompanied by a record of its measurement on major diameter, pitch diameter, lead, and angle. In case of question, the deviations of such gages from the exact standard shall be ascertained by the Bureau of Standards at Washington, D.C.

(*b*) *Class X gages.*—Class X gages should be suitable for inspection and setting gages for classes 1, 2, and 3. The tolerances on these

[9] Methods of measuring pitch diameter of screw-thread gages are described in appendix 2, p. 129.

gages are given in table 18. In all cases the tolerances shall be such that the gage does not fall outside of the component tolerances. For example, if a thread-plug gage is used as the "go" gage for checking a tapped hole, it can be larger, but not smaller than the minimum size specified. On the other hand, if a thread-plug gage is used as the "go" setting plug for thread-ring gages or for optical or other comparators, it can be smaller, but never larger than the maximum size of the screw.

Class X tolerances, as given in table 18, are specified for all "not go" gages for classes 1, 2, and 3.

(c) *Class Y gages.*—Class Y gages should be suitable for inspection gages for classes 1, 2, and 3 fits. They may also be desired as working gages for classes 2 and 3 fits. The tolerances on these gages are given in table 19.

(d) *Class Z gages.*—Class Z gages should be suitable for working gages for class 1, loose fit. The tolerances on these gages are given in table 20.

(e) *Class W gages.*—For the inspection of class 4, close-fit product, gages made within especially close limits are necessary. The tolerances for such gages, designated as class W, are given in table 21.

(f) *Wear on gages.*—"Go" gages may be permitted to wear to the extreme product limits. It is desirable, however, that working and inspection gages be so selected that the dimensions of the working gages are inside of the limiting dimensions represented by the inspection gages, in order that all parts passed by the working gage will be accepted by the inspection gage.

As to wear on "not go" gages, it is purely a question of economy as to when the "not go" gage should be discarded. Continued use reduces the available working tolerance on the product, and the resulting loss must be balanced against the cost of a new gage.

(g) *Tolerances on lead.*—The tolerances on lead given in tables 18 to 21, inclusive, are specified as an allowable variation between any two threads not farther apart than the length of engagement of the assembled threaded product. When this length of engagement is equal to the diameter, the permissible progressive lead errors per inch may be determined by dividing these lead tolerances by the corresponding diameters.

(h) *Tolerances on angle of thread.*—The tolerances on angle of thread, as specified in tables 18 to 21, inclusive, for the various pitches, are tolerances on one half of the included angle. This insures that the bisector of the included angle will be perpendicular to the axis of the thread within proper limits. The equivalent deviation from the true thread form caused by such irregularities as convex or concave sides of thread, rounded crests, or slight projections on the thread form, should not exceed the tolerances permitted on angle of thread.

2. Thread Form of Thread Plug and Ring Gages.—The major diameter of the "go" thread plug gage is the same as the basic major diameter, with a plus gage tolerance. The minor diameter of the "go" thread ring gage is the same as the minimum minor diameter of the nut or tapped hole with a minus gage tolerance.

The crest of the thread of the "not go" plug gage is truncated below the basic major diameter an amount equal to one sixth of the basic thread depth with a plus gage tolerance. On a basic thread form the corresponding width of flat would be one fourth of the pitch. On a "not go" plug gage the flat is wider than one fourth of the pitch by an amount depending upon the product pitch diameter tolerance.

The crest of the thread of the "not go" ring gage is truncated above the basic minor diameter an amount equal to one third of the basic thread depth with a minus gage tolerance. On a basic thread form the corresponding width of flat would be three eighths of the pitch. On a "not go" ring gage the flat is wider than three eighths of the pitch by an amount depending upon the product pitch diameter tolerance. However, adjustable gages, such as thread snap gages,

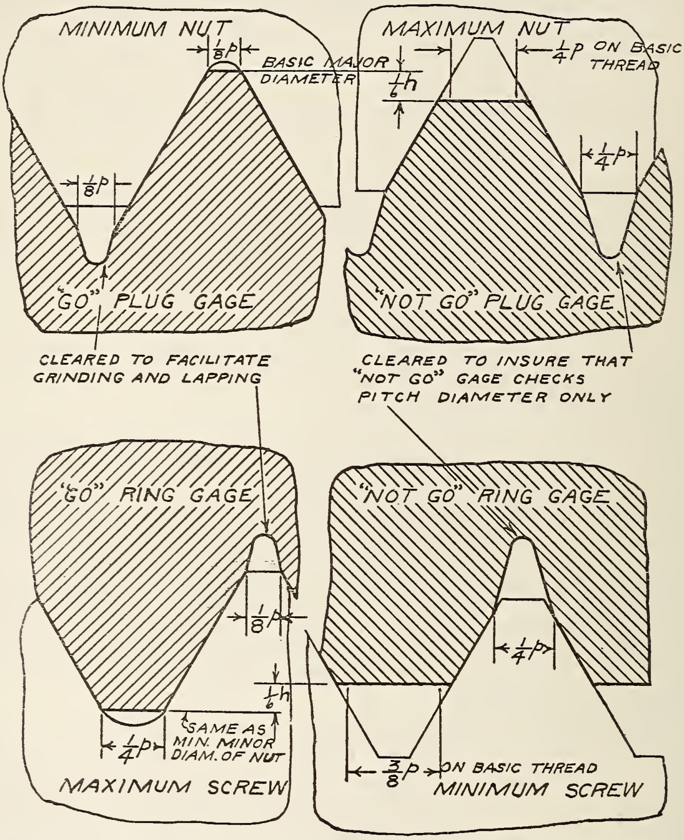

Figure 18.—*Thread form of "go" and "not go" thread plug and ring gages.*

which may be set to the "not go" limit of any class of fit should have a width of flat equal to three eighths of the pitch.

A relief is provided at the root of the "go" thread plug or ring gage, the width of which is not greater than one eighth of the pitch. Also a relief is provided at the root of the "not go" thread plug or ring gage, the width of which is approximately one fourth of the pitch.

Thus contact of the "not go" thread gage on the sides of the threads, rather than at the corners of the crest and root, is assured. Also the effect of angle error on the fit of the "not go" gage with the product is minimized.

The above requirements are illustrated in figure 18.

3. Tolerances for Plain Gages.—For plain plug gages, plain ring gages, and plain snap gages required for measuring diameters of screw-thread work, the gage tolerances specified in table 18 should be used. Attention is directed to the fact that the tolerances on thread diameters vary in accordance with the number of threads per inch. In manufacturing a plain plug, ring, or snap gage, in the absence of information as to the number of threads per inch of the screw to be made, or for gage dimensions other than thread diameters, the tolerances for plain gages given in table 22 may be used. This table contains recommended tolerances for plain gages, designated as classes X, Y, and Z, which have been tentatively adopted by the Sectional Committee on the Standardization of Plain Limit Gages for General Engineering Work. These tolerances are applicable to all classes of product.

4. Recommended Gage Practice.—There are given in table 17 the recommended uses for the foregoing classes of gages. Tables 23, 24, 25, and 26 give limiting dimensions of gages of the several classifications for the American National coarse and American National fine thread series.

Table 17.—*Recommended uses for classes W, X, Y, and Z "go" thread gages*

Class of fit	Setting gage	Inspection gage	Working gage
1	2	3	4
Class 1, loose fit	Class X, table 18	Class Y, table 19	Class Z, table 20.
Class 2, free fit	do	do	Class Y, table 19.
Class 3, medium fit	do	Class X, table 18	Do.
Class 4, close fit	Class W, table 21	Class W, table 21	Class W, table 21.

Note.—"Not go" thread gages for classes 1, 2, and 3 are class X, and for class 4 are class W.

TABLE 18.—*Tolerances for class X "go" thread gages, and "not go" thread gages for classes 1, 2, and 3, and all plain gages*

Threads per inch	Tolerance on pitch diameter [1]		Tolerance in lead [2]	Tolerance on half angle of thread		Tolerance on major or minor diameters [1]	
	From—	To—				From—	To—
1	2	3	4	5		6	7
	Inch	*Inch*	*Inch* ±	*Deg.* ±	*Min.*	*Inch*	*Inch*
80	0.0000	0.0002	0.0002	0	30	0.0000	0.0003
72	.0000	.0002	.0002	0	30	.0000	.0003
64	.0000	.0002	.0002	0	30	.0000	.0004
56	.0000	.0002	.0002	0	30	.0000	.0004
48	.0000	.0002	.0002	0	30	.0000	.0004
44	.0000	.0002	.0002	0	20	.0000	.0004
40	.0000	.0002	.0002	0	20	.0000	.0004
36	.0000	.0002	.0002	0	20	.0000	.0004
32	.0000	.0003	.0003	0	15	.0000	.0004
28	.0000	.0003	.0003	0	15	.0000	.0005
24	.0000	.0003	.0003	0	15	.0000	.0005
20	.0000	.0003	.0003	0	15	.0000	.0005
18	.0000	.0003	.0003	0	10	.0000	.0005
16	.0000	.0003	.0003	0	10	.0000	.0006
14	.0000	.0003	.0003	0	10	.0000	.0006
13	.0000	.0003	.0003	0	10	.0000	.0006
12	.0000	.0003	.0003	0	10	.0000	.0006
11	.0000	.0003	.0003	0	10	.0000	.0006
10	.0000	.0003	.0003	0	10	.0000	.0006
9	.0000	.0003	.0003	0	10	.0000	.0007
8	.0000	.0004	.0004	0	5	.0000	.0007
7	.0000	.0004	.0004	0	5	.0000	.0007
6	.0000	.0004	.0004	0	5	.0000	.0008
5	.0000	.0004	.0004	0	5	.0000	.0008
4½	.0000	.0004	.0004	0	5	.0000	.0008
4	.0000	.0004	.0004	0	5	.0000	.0009

[1] On "go" plugs the tolerance is plus, and on "go" rings the tolerance is minus. On "not go" plugs the tolerance is minus, and on "not go" rings the tolerance is plus.

[2] Allowable variation in lead between any two threads not farther apart than the standard length of engagement, which is equal to the basic major diameter.

It is suggested that, in case of question between the manufacturer and purchaser of threaded products in regard to their size, if the manufacturer produces limit gages which do not measure outside of the specified limits for the threaded components and which pass the parts in question, they be accepted as meeting the specifications for size. In case the dimensions of the gages are questioned, their sizes shall be determined by a disinterested third party, preferably the Bureau of Standards at Washington, D.C., which maintains a department for this service.

4. MARKING OF GAGES.—Each gage shall be plainly and permanently marked, for identification, with the diameter, pitch, thread series, and class of fit. See section II, division 3, "Symbols."

For example: A 1-inch, 8-pitch gage of the American National coarse-thread series, class 2, free fit, shall be marked 1″—8NC—2.

A 1-inch, 14-pitch gage of the American National fine-thread series, class 3, medium fit, shall be marked 1″—14NF—3.

TABLE 19.—*Tolerances for class Y "go" thread gages*

Threads per inch	Tolerance on pitch diameter [1]		Tolerance in lead [2]	Tolerance on half angle of thread		Tolerance on major or minor diameters [1]	
	From—	To—				From—	To—
1	2	3	4	5		6	7
	Inch	*Inch*	*Inch* ±	*Deg.* ±	*Min.*	*Inch*	*Inch*
80	0.0001	0.0003	0.0002	0	45	0.0000	0.0003
72	.0001	.0003	.0002	0	45	.0000	.0003
64	.0001	.0004	.0002	0	45	.0000	.0004
56	.0001	.0004	.0002	0	45	.0000	.0004
48	.0001	.0004	.0002	0	45	.0000	.0004
44	.0001	.0004	.0002	0	30	.0000	.0004
40	.0001	.0004	.0002	0	30	.0000	.0004
36	.0001	.0004	.0002	0	30	.0000	.0004
32	.0001	.0004	.0003	0	20	.0000	.0004
28	.0002	.0005	.0003	0	20	.0000	.0005
24	.0002	.0005	.0003	0	20	.0000	.0005
20	.0002	.0005	.0003	0	20	.0000	.0005
18	.0002	.0005	.0003	0	15	.0000	.0005
16	.0002	.0006	.0003	0	15	.0000	.0006
14	.0002	.0006	.0003	0	15	.0000	.0006
13	.0002	.0006	.0003	0	15	.0000	.0006
12	.0002	.0006	.0003	0	10	.0000	.0006
11	.0002	.0006	.0003	0	10	.0000	.0006
10	.0002	.0006	.0003	0	10	.0000	.0006
9	.0002	.0007	.0003	0	10	.0000	.0007
8	.0002	.0007	.0004	0	5	.0000	.0007
7	.0002	.0007	.0004	0	5	.0000	.0007
6	.0003	.0008	.0004	0	5	.0000	.0008
5	.0003	.0008	.0004	0	5	.0000	.0008
4½	.0003	.0008	.0004	0	5	.0000	.0008
4	.0003	.0009	.0004	0	5	.0000	.0009

[1] On "go" plugs the tolerance is plus and on "go" rings the tolerance is minus.
[2] Allowable variation in lead between any two threads not farther apart than the standard length of engagement, which is equal to the basic major diameter.

TABLE 20.—*Tolerances for class Z "go" thread gages*

Threads per inch	Tolerance on pitch diameter [1]		Tolerance in lead [2]	Tolerance on half angle of thread		Tolerance on major or minor diameters [1]	
	From—	To—				From—	To—
1	2	3	4	5		6	7
	Inch	*Inch*	*Inch* ±	*Deg.* ±	*Min.*	*Inch*	*Inch*
80	0.0002	0.0006	0.0002	0	45	0.0000	0.0003
72	.0002	.0006	.0002	0	45	.0000	.0003
64	.0002	.0006	.0002	0	45	.0000	.0004
56	.0002	.0007	.0002	0	45	.0000	.0004
48	.0002	.0007	.0002	0	45	.0000	.0004
44	.0002	.0007	.0002	0	30	.0000	.0004
40	.0002	.0007	.0002	0	30	.0000	.0004
36	.0003	.0008	.0002	0	30	.0000	.0004
32	.0003	.0008	.0003	0	20	.0000	.0004
28	.0003	.0008	.0003	0	20	.0000	.0005
24	.0003	.0009	.0003	0	20	.0000	.0005
20	.0003	.0009	.0003	0	20	.0000	.0005
18	.0004	.0010	.0004	0	15	.0000	.0005
16	.0004	.0010	.0004	0	15	.0000	.0006
14	.0004	.0010	.0004	0	15	.0000	.0006
13	.0004	.0011	.0004	0	15	.0000	.0006
12	.0004	.0011	.0004	0	10	.0000	.0006
11	.0004	.0011	.0004	0	10	.0000	.0006
10	.0005	.0012	.0004	0	10	.0000	.0006
9	.0005	.0012	.0004	0	10	.0000	.0007
8	.0006	.0013	.0005	0	5	.0000	.0007
7	.0006	.0013	.0005	0	5	.0000	.0007
6	.0006	.0014	.0005	0	5	.0000	.0008
5	.0007	.0015	.0005	0	5	.0000	.0008
4½	.0007	.0015	.0005	0	5	.0000	.0008
4	.0007	.0016	.0005	0	5	.0000	.0009

[1] On "go" plugs the tolerance is plus, and on "go" rings the tolerance is minus.
[2] Allowable variation in lead between any two threads not farther apart than the standard length of engagement, which is equal to the basic major diameter.

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TABLE 21.—*Tolerances for class W "go" and "not go" thread gages for class 4, close fit*

Threads per inch	Tolerance on pitch diameter [1]		Tolerance in lead [2]	Tolerance on half angle of thread		Total cumulative tolerance [3]	Tolerance on major or minor diameters	
	From—	To—					From—	To—
1	2	3	4	5		6	7	8
	Inch	*Inch*	*Inch* ±	*Deg.* ±	*Min.*	*Inch*	*Inch*	*Inch*
28	0.0000	0.0001	0.00015	0	8	0.00048	0.0000	0.0005
24	.0000	.0001	.00015	0	8	.00051	.0000	.0005
20	.0000	.0001	.00015	0	8	.00053	.0000	.0005
18	.0000	.0001	.00015	0	8	.00055	.0000	.0005
16	.0000	.0001	.00015	0	8	.00058	.0000	.0006
14	.0000	.00015	.0002	0	6	.00068	.0000	.0006
13	.0000	.00015	.0002	0	6	.00070	.0000	.0006
12	.0000	.00015	.0002	0	6	.00071	.0000	.0006
11	.0000	.00015	.0002	0	6	.00073	.0000	.0006
10	.0000	.0002	.00025	0	5	.00085	.0000	.0006
9	.0000	.0002	.00025	0	5	.00088	.0000	.0007
8	.0000	.0002	.00025	0	5	.00091	.0000	.0007
7	.0000	.00025	.0003	0	4	.00102	.0000	.0007
6	.0000	.00025	.0003	0	4	.00106	.0000	.0008
5	.0000	.00025	.0003	0	4	.00112	.0000	.0008
4½	.0000	.0003	.0003	0	4	.00121	.0000	.0008
4	.0000	.0003	.0003	0	4	.00126	.0000	.0009

[1] On "go" plugs the tolerance is plus, and on "go" rings the tolerance is minus. On "not go" plugs the tolerance is minus, and on "not go" rings the tolerance is plus.

[2] Allowable variation in lead between any two threads not farther apart than the standard length of engagement, which is equal to the basic major diameter.

[3] The tolerance for one element, namely pitch diameter, lead, or angle, as given above, may be exceeded provided that the errors in the other 2 elements are sufficiently small so that the total cumulative tolerance shown in column 6 is not exceeded.

TABLE 22.—*Tolerances for plain gages* [1]

Size of gage in inches	Class X [2]		Class Y		Class Z	
	From—	To—	From—	To—	From—	To—
1	2	3	4	5	6	7
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
0 to 1, inclusive	0.0000	0.0001	0.0001	0.0002	0.0002	0.0003
1 to 3, inclusive	.0000	.0002	.0001	.0003	.0003	.0005

[1] On "go" plugs the tolerance is plus, and on "go" rings the tolerance is minus. On "not go" plugs the tolerance is minus, and on "not go" rings the tolerance is plus.

[2] All "not go" gages are made to class X tolerances.

TABLE 23.—*Limiting dimensions of setting plug and thread ring gages for screws of classes 1, 2, 3, and 4 fits, American National coarse-thread series*

			Machine screw number or nominal size																	
			1	2	3	4	5	6	8	10	12	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞
			Threads per inch																	
			64	56	48	40	40	32	32	24	24	20	18	16	14	13	12	11	10	9
"GO" GAGES FOR SCREWS			*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Major diameter of setting plug.	Class 1	Max	0.0723	0.0852	0.0981	0.1110	0.1240	0.1369	0.1629	0.1887	0.2147	0.2485	0.3109	0.3732	0.4354	0.4978	0.5601	0.6224	0.7472	0.8719
		Min	.0719	.0848	.0977	.1106	.1236	.1365	.1625	.1882	.2142	.2480	.3104	.3726	.4348	.4972	.5595	.6218	.7466	.8712
	Classes 2, 3, and 4.	Max	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375	.5000	.5625	.6250	.7500	.8750
		Min	.0726	.0856	.0986	.1116	.1246	.1376	.1636	.1895	.2155	.2495	.3120	.3744	.4369	.4994	.5619	.6244	.7494	.8743
Pitch diameter of setting plug or ring gage.	Class 1, loose fit	Max., class X	.0622	.0736	.0846	.0948	.1078	.1166	.1426	.1616	.1876	.2160	.2748	.3326	.3890	.4478	.5060	.5634	.6822	.7997
		Min., class X	.0620	.0734	.0844	.0946	.1076	.1163	.1423	.1613	.1873	.2157	.2745	.3323	.3887	.4475	.5057	.5631	.6819	.7994
		Max., class Y	.0621	.0735	.0845	.0947	.1077	.1165	.1425	.1614	.1874	.2158	.2746	.3324	.3888	.4476	.5058	.5632	.6820	.7995
		Min., class Y	.0618	.0732	.0842	.0944	.1074	.1162	.1422	.1611	.1871	.2155	.2743	.3320	.3884	.4472	.5054	.5628	.6816	.7990
		Max., class Z	.0620	.0734	.0844	.0946	.1076	.1163	.1423	.1613	.1873	.2157	.2744	.3322	.3886	.4474	.5056	.5630	.6817	.7992
		Min., class Z	.0616	.0729	.0839	.0941	.1071	.1158	.1418	.1607	.1867	.2151	.2738	.3316	.3880	.4467	.5049	.5623	.6810	.7985
	Class, 2, free fit, and class 3, medium fit.	Max., class X	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500	.5084	.5660	.6850	.8028
		Min., class X	.0627	.0742	.0853	.0956	.1086	.1174	.1434	.1626	.1886	.2172	.2761	.3341	.3908	.4497	.5081	.5657	.6847	.8025
		Max., class Y	.0628	.0743	.0854	.0957	.1087	.1176	.1436	.1627	.1887	.2173	.2762	.3342	.3909	.4498	.5082	.5658	.6848	.8026
		Min., class Y	.0625	.0740	.0851	.0954	.1084	.1173	.1433	.1624	.1884	.2170	.2759	.3338	.3905	.4494	.5078	.5654	.6844	.8021
	Class 4, close fit	Max., class W	------	------	------	------	------	------	------	------	------	.2178	.2767	.3348	.3915	.4504	.5089	.5665	.6856	.8034
		Min., class W	------	------	------	------	------	------	------	------	------	.2177	.2766	.3347	.39135	.45025	.50875	.56635	.6854	.8032
Minor diameter of ring gage.	Classes 1, 2, 3, and 4.	Max. [1]	.0561	.0667	.0764	.0849	.0979	.1042	.1302	.1449	.1709	.1959	.2524	.3073	.3602	.4167	.4723	.5266	.6417	.7547
		Min	.0557	.0663	.0760	.0845	.0975	.1038	.1298	.1444	.1704	.1954	.2519	.3067	.3596	.4161	.4717	.5260	.6411	.7540
"NOT GO" GAGES FOR SCREWS																				
Major diameter of setting plug.	Class 1	Min	.0671	.0796	.0919	.1042	.1172	.1293	.1553	.1795	.2055	.2383	.2995	.3606	.4214	.4830	.5443	.6054	.7288	.8519
		Max	.0675	.0800	.0923	.1046	.1176	.1297	.1557	.1800	.2060	.2388	.3000	.3612	.4220	.4836	.5449	.6060	.7294	.8526
	Classes 2, 3, and 4.	Min	.0692	.0820	.0946	.1072	.1202	.1326	.1586	.1834	.2094	.2428	.3043	.3660	.4277	.4896	.5513	.6132	.7372	.8610
		Max	.0696	.0824	.0950	.1076	.1206	.1330	.1590	.1839	.2099	.2433	.3048	.3666	.4283	.4902	.5519	.6138	.7378	.8617
Pitch diameter of setting plug or ring gage.	Class 1, loose fit	Min	.0596	.0708	.0815	.0914	.1044	.1128	.1388	.1570	.1830	.2109	.2691	.3263	.3820	.4404	.4981	.5549	.6730	.7897
		Max	.0598	.0710	.0817	.0916	.1046	.1131	.1391	.1573	.1833	.2112	.2694	.3266	.3823	.4407	.4984	.5552	.6733	.7900
	Class 2, free fit	Min	.0610	.0724	.0833	.0934	.1064	.1150	.1410	.1596	.1856	.2139	.2723	.3299	.3862	.4448	.5028	.5601	.6786	.7958
		Max	.0612	.0726	.0835	.0936	.1066	.1153	.1413	.1599	.1859	.2142	.2726	.3302	.3865	.4451	.5031	.5604	.6789	.7961
	Class 3, medium fit.	Min	.0615	.0729	.0839	.0941	.1071	.1158	.1418	.1605	.1865	.2149	.2734	.3312	.3875	.4463	.5044	.5618	.6805	.7979
		Max	.0617	.0731	.0841	.0943	.1073	.1161	.1421	.1608	.1868	.2152	.2737	.3315	.3878	.4466	.5047	.5621	.6808	.7982
	Class 4, close fit	Min	------	------	------	------	------	------	------	------	------	.2165	.2752	.3332	.3897	.4485	.5069	.5644	.6833	.8010
		Max	------	------	------	------	------	------	------	------	------	.2166	.2753	.3333	.38985	.44865	.50705	.56455	.6835	.8012
Minor diameter of ring gage.	Classes 1, 2, 3, and 4.	Min. [2]	.0591	.0701	.0806	.0899	.1029	.1105	.1365	.1534	.1794	.2062	.2639	.3203	.3750	.4328	.4897	.5457	.6628	.7781
		Max. [2]	.0595	.0705	.0810	.0903	.1033	.1109	.1369	.1539	.1799	.2067	.2644	.3209	.3756	.4334	.4903	.5463	.6634	.7788

[1] [2] See footnotes on p. 63.

TABLE 23.—*Limiting dimensions of setting plug and thread ring gages for screws of classes 1, 2, 3, and 4 fits, American National coarse-thread series*—Continued

			Sizes: 1	1⅛	1¼	1⅜	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4
			Threads per inch: 8	7	7	6	6	5	4½	4½	4	4	4	4	4	4	4
"Go" Gages for Screws			*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Major diameter of setting plug	Class 1	Max	0.9966	1.1211	1.2461	1.3706	1.4956	1.7448	1.9943	2.2443	2.4936	2.7436	2.9936	3.2436	3.4936	3.7436	3.9936
		Min	.9959	1.1204	1.2454	1.3698	1.4948	1.7440	1.9935	2.2435	2.4927	2.7427	2.9927	3.2427	3.4927	3.7427	3.9927
	Classes 2, 3, and 4	Max	1.0000	1.1250	1.2500	1.3750	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500	4.0000
		Min	.9993	1.1243	1.2493	1.3742	1.4992	1.7492	1.9992	2.2492	2.4991	2.7491	2.9991	3.2491	3.4991	3.7491	3.9991
Pitch diameter of setting plug or ring gage.	Class 1, loose fit	Max., class X	.9154	1.0283	1.1533	1.2623	1.3873	1.6149	1.8500	2.1000	2.3312	2.5812	2.8312	3.0812	3.3312	3.5812	3.8312
		Min., class X	.9150	1.0279	1.1529	1.2619	1.3869	1.6145	1.8496	2.0996	2.3308	2.5808	2.8308	3.0808	3.3308	3.5808	3.8308
		Max., class Y	.9152	1.0281	1.1531	1.2620	1.3870	1.6146	1.8497	2.0997	2.3309	2.5809	2.8309	3.0809	3.3309	3.5809	3.8309
		Min., class Y	.9147	1.0276	1.1526	1.2615	1.3865	1.6141	1.8492	2.0992	2.3303	2.5803	2.8303	3.0803	3.3303	3.5803	3.8303
		Max., class Z	.9148	1.0277	1.1527	1.2617	1.3867	1.6142	1.8493	2.0993	2.3305	2.5805	2.8305	3.0805	3.3305	3.5805	3.8305
		Min., class Z	.9141	1.0270	1.1520	1.2609	1.3859	1.6134	1.8485	2.0985	2.3296	2.5796	2.8296	3.0796	3.3296	3.5796	3.8296
	Class 2, free fit, and class 3, medium fit.	Max., class X	.9188	1.0322	1.1572	1.2667	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	3.0876	3.3376	3.5876	3.8376
		Min., class X	.9184	1.0318	1.1568	1.2663	1.3913	1.6197	1.8553	2.1053	2.3372	2.5872	2.8372	3.0872	3.3372	3.5872	3.8372
		Max., class Y	.9186	1.0320	1.1570	1.2664	1.3914	1.6198	1.8554	2.1054	2.3373	2.5873	2.8373	3.0873	3.3373	3.5873	3.8373
		Min., class Y	.9181	1.0315	1.1565	1.2659	1.3909	1.6193	1.8549	2.1049	2.3367	2.5867	2.8367	3.0867	3.3367	3.5867	3.8367
	Class 4, close fit	Max., class W	.9195	1.0330	1.1580	1.2676	1.3926	1.6211	1.8568	2.1068	2.3389	2.5889	2.8389	3.0889	3.3389	3.5889	3.8389
		Min., class W	.9193	1.03275	1.15775	1.26735	1.39235	1.62085	1.8565	2.1065	2.3386	2.5886	2.8386	3.0886	3.3386	3.5886	3.8386
Minor diameter of ring gage	Classes 1, 2, 3, and 4	Max. [1]	.8647	.9704	1.0954	1.1946	1.3196	1.5335	1.7594	2.0094	2.2294	2.4794	2.7294	2.9794	3.2294	3.4794	3.7294
		Min	.8640	.9697	1.0947	1.1938	1.3188	1.5327	1.7586	2.0086	2.2285	2.4785	2.7285	2.9785	3.2285	3.4785	3.7285
"Not Go" Gages for Screws																	
Major diameter of setting plug	Class 1	Min	.9744	1.0963	1.2213	1.3416	1.4666	1.7110	1.9575	2.2075	2.4528	2.7028	2.9528	3.2028	3.4528	3.7028	3.9528
		Max	.9751	1.0970	1.2220	1.3424	1.4674	1.7118	1.9583	2.2083	2.4537	2.7037	2.9537	3.2037	3.4537	3.7037	3.9537
	Classes 2, 3, and 4	Min	.9848	1.1080	1.2330	1.3548	1.4798	1.7268	1.9476	2.2246	2.4720	2.7220	2.9720	3.2220	3.4720	3.7220	3.9720
		Max	.9855	1.1087	1.2337	1.3556	1.4806	1.7276	1.9754	2.2254	2.4729	2.7229	2.9729	3.2229	3.4729	3.7229	3.9729
Pitch diameter of setting plug or ring gage.	Class 1, loose fit	Min	.9043	1.0159	1.1409	1.2478	1.3728	1.5980	1.8316	2.0816	2.3108	2.5608	2.8108	3.0608	3.3108	3.5608	3.8108
		Max	.9047	1.0163	1.1413	1.2482	1.3732	1.5984	1.8320	2.0820	2.3112	2.5612	2.8112	3.0612	3.3112	3.5612	3.8112
	Class 2, free fit	Min	.9112	1.0237	1.1487	1.2566	1.3816	1.6085	1.8430	2.0930	2.3236	2.5736	2.8236	3.0736	3.3236	3.5736	3.8236
		Max	.9116	1.0241	1.1491	1.2570	1.3820	1.6089	1.8434	2.0934	2.3240	2.5740	2.8240	3.0740	3.3240	3.5740	3.8240
	Class 3, medium fit	Min	.9134	1.0263	1.1513	1.2596	1.3846	1.6119	1.8468	2.0968	2.3279	2.5779	2.8279	3.0779	3.3279	3.5779	3.8279
		Max	.9138	1.0267	1.1517	1.2690	1.3850	1.6123	1.8472	2.0972	2.3283	2.5783	2.8283	3.0783	3.3283	3.5783	3.8283
	Class 4, close fit	Min	.9168	1.0300	1.1550	1.2640	1.3890	1.6170	1.8524	2.1024	2.3341	2.5841	2.8341	3.0841	3.3341	3.5841	3.8341
		Max	.9170	1.03025	1.15525	1.26425	1.38925	1.61725	1.8527	2.1027	2.3344	2.5844	2.8344	3.0844	3.3344	3.5844	3.8344
Minor diameter of ring gage	Classes 1, 2, 3, and 4	Min. [2]	.8910	1.0006	1.1256	1.2299	1.3549	1.5760	1.8068	2.0568	2.2826	2.5326	2.7826	3.0326	3.2826	3.5326	3.7826
		Max. [2]	.8917	1.0013	1.1263	1.2307	1.3557	1.5768	1.8076	2.0576	2.2835	2.5335	2.7835	3.0335	3.2835	3.5335	3.7835

[1] [2] See footnotes on p. 63.

TABLE 24.—*Limiting dimensions of setting plug and thread ring gages for screws of classes 1, 2, 3, and 4 fits, American National fine-thread series*

			Machine screw number or nominal size											
			0	1	2	3	4	5	6	8	10	12	¼	5/16
			Threads per inch											
			80	72	64	56	48	44	40	36	32	28	28	24
"GO" GAGES FOR SCREWS			*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Major diameter of setting plug	Class 1	Max	0.0593	0.0723	0.0853	0.0982	0.1111	0.1241	0.1370	0.1629	0.1889	0.2148	0.2488	0.3112
		Min	.0590	.0720	.0849	.0978	.1107	.1237	.1366	.1625	.1885	.2143	.2483	.3107
	Classes 2, 3, and 4	Max	.0600	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125
		Min	.0597	.0727	.0856	.0986	.1116	.1246	.1376	.1636	.1896	.2155	.2495	.3120
Pitch diameter of setting plug or ring gage.	Class 1, loose fit	Max., class X	.0512	.0633	.0752	.0866	.0976	.1093	.1208	.1449	.1686	.1916	.2256	.2841
		Min., class X	.0510	.0631	.0750	.0864	.0974	.1091	.1206	.1447	.1683	.1913	.2253	.2838
		Max., class Y	.0511	.0632	.0751	.0865	.0975	.1092	.1207	.1448	.1685	.1914	.2254	.2839
		Min., class Y	.0509	.0630	.0748	.0862	.0972	.1089	.1204	.1445	.1682	.1911	.2251	.2836
		Max., class Z	.0510	.0631	.0750	.0864	.0974	.1091	.1206	.1446	.1683	.1913	.2253	.2838
		Min., class Z	.0506	.0627	.0746	.0859	.0969	.1086	.1201	.1441	.1678	.1908	.2248	.2832
	Class 2, free fit, and class 3, medium fit.	Max., class X	.0519	.0640	.0759	.0874	.0985	.1102	.1218	.1460	.1697	.1928	.2268	.2854
		Min., class X	.0517	.0638	.0757	.0872	.0983	.1100	.1216	.1458	.1694	.1925	.2265	.2851
		Max., class Y	.0518	.0639	.0758	.0873	.0984	.1101	.1217	.1459	.1696	.1926	.2266	.2852
		Min., class Y	.0516	.0637	.0755	.0870	.0981	.1098	.1214	.1456	.1693	.1933	.2263	.2849
	Class 4, close fit	Max., class W	----	----	----	----	----	----	----	----	----	----	.2270	.2857
		Min., class W	----	----	----	----	----	----	----	----	----	----	.2269	.2856
Minor diameter of ring gage	Classes 1, 2, 3, and 4.	Max.[1]	.0465	.0580	.0691	.0797	.0894	.1004	.1109	.1339	.1562	.1773	.2113	.2674
		Min	.0462	.0577	.0687	.0793	.0890	.1000	.1105	.1335	.1558	.1768	.2108	.2669
"NOT GO" GAGES FOR SCREWS														
Major diameter of setting plug	Class 1	Min	.0545	.0673	.0801	.0926	.1049	.1177	.1302	.1557	.1813	.2062	.2402	.3020
		Max	.0548	.0676	.0805	.0930	.1053	.1181	.1306	.1561	.1817	.2067	.2407	.3025
	Class 2, 3, and 4	Min	.0566	.0694	.0822	.0950	.1076	.1204	.1332	.1590	.1846	.2098	.2438	.3059
		Max	.0569	.0697	.0826	.0954	.1080	.1208	.1336	.1594	.1850	.2103	.2443	.3064
Pitch diameter of setting plug or ring gage.	Class 1, loose fit	Min	.0488	.0608	.0726	.0838	.0945	.1061	.1174	.1413	.1648	.1873	.2213	.2795
		Max	.0490	.0610	.0728	.0840	.0947	.1063	.1176	.1415	.1651	.1876	.2216	.2798
	Class 2, free fit	Min	.0502	.0622	.0740	.0854	.0963	.1079	.1194	.1435	.1670	.1897	.2237	.2821
		Max	.0504	.0624	.0742	.0856	.0965	.1081	.1196	.1437	.1673	.1900	.2240	.2824
	Class 3, medium fit.	Min	.0506	.0627	.0745	.0859	.0969	.1086	.1201	.1442	.1678	.1906	.2246	.2830
		Max	.0508	.0629	.0747	.0861	.0971	.1088	.1203	.1444	.1681	.1909	.2249	.2833
	Class 4, close fit	Min	----	----	----	----	----	----	----	----	----	----	.2259	.2845
		Max	----	----	----	----	----	----	----	----	----	----	.2260	.2846
Minor diameter of ring gage	Classes 1, 2, 3, and 4.	Min.[2]	.0489	.0607	.0721	.0831	.0936	.1049	.1159	.1395	.1625	.1846	.2186	.2759
		Max.[2]	.0492	.0610	.0725	.0835	.0940	.1053	.1163	.1399	.1629	.1851	.2191	.2764

[1] [2] See footnotes, p. 63.

TABLE 24.—*Limiting dimensions of setting plug and thread ring gages for screws of classes 1, 2, 3, and 4 fits, American National fine-thread series*—Continued

"Go" gages for screws			3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Threads per inch			24	20	20	18	18	16	14	14	12	12	12	12
			Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*
Major diameter of setting plug	Class 1	Max	0.3737	0.4360	0.4985	0.5609	0.6234	0.7482	0.8729	0.9979	1.1226	1.2476	1.3726	1.4976
		Min	.3732	.4355	.4980	.5604	.6229	.7476	.8723	.9973	1.1220	1.2470	1.3720	1.4970
	Classes 2, 3, and 4	Max	.3750	.4375	.5000	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.3750	1.5000
		Min	.3745	.4370	.4995	.5620	.6245	.7494	.8744	.9994	1.1244	1.2494	1.3744	1.4994
Pitch diameter of setting plug or ring gage.	Class 1, loose fit	Max., class X	.3466	.4035	.4660	.5248	.5873	.7076	.8265	.9515	1.0685	1.1935	1.3185	1.4435
		Min., class X	.3463	.4032	.4657	.5245	.5870	.7073	.8262	.9512	1.0682	1.1932	1.3182	1.4432
		Max., class Y	.3464	.4033	.4658	.5246	.5871	.7074	.8263	.9513	1.0683	1.1933	1.3183	1.4433
		Min., class Y	.3461	.4030	.4655	.5243	.5868	.7070	.8259	.9509	1.0679	1.1929	1.3179	1.4429
		Max., class Z	.3463	.4032	.4657	.5244	.5869	.7072	.8261	.9511	1.0681	1.1931	1.3181	1.4431
		Min., class Z	.3457	.4026	.4651	.5238	.5863	.7066	.8255	.9505	1.0674	1.1924	1.3176	1.4424
	Class 2, free fit, and class 3, medium fit.	Max., class X	.3479	.4050	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.3209	1.4459
		Min., class X	.3476	.4047	.4672	.5261	.5886	.7091	.8283	.9533	1.0706	1.1956	1.3206	1.4456
		Max., class Y	.3477	.4048	.4673	.5262	.5887	.7092	.8284	.9534	1.0707	1.1957	1.3207	1.4457
		Min., class Y	.3474	.4045	.4670	.5259	.5884	.7088	.8280	.9530	1.0703	1.1953	1.3203	1.4453
	Class 4, close fit	Max., class W	.3482	.4053	.4678	.5267	.5892	.7098	.8290	.9540	1.0714	1.1964	1.3214	1.4464
		Min., class W	.3481	.4052	.4677	.5266	.5891	.7097	.82885	.95385	1.07125	1.19625	1.32125	1.44625
Minor diameter of ring gage	Classes 1, 2, 3, and 4.	Max.[1]	.3299	.3834	.4459	.5024	.5649	.6823	.7977	.9227	1.0348	1.1598	1.2848	1.4098
		Min	.3294	.3829	.4454	.5019	.5644	.6817	.7971	.9221	1.0342	1.1592	1.2842	1.4092

"NOT GO" GAGES FOR SCREWS

Major diameter of setting plug	Class 1	Min	.3645	.4258	.4883	.5495	.6120	.7356	.8589	.9839	1.1068	1.2318	1.3568	1.4818
		Max	.3650	.4263	.4888	.5500	.6125	.7362	.8595	.9845	1.1074	1.2324	1.3574	1.4824
	Classes 2, 3, and 4	Min	.3684	.4303	.4928	.5543	.6168	.7410	.8652	.9902	1.1138	1.2388	1.3638	1.4888
		Max	.3689	.4308	.4933	.5548	.6173	.7416	.8658	.9908	1.1144	1.2394	1.3644	1.4894
Pitch diameter of setting plug or ring gage.	Class 1, loose fit	Min	.3420	.3984	.4609	.5191	.5816	.7013	.8195	.9445	1.0606	1.1856	1.3106	1.4356
		Max	.3423	.3987	.4612	.5194	.5819	.7016	.8198	.9448	1.0609	1.1859	1.3109	1.4359
	Class 2, free fit	Min	.3446	.4014	.4639	.5223	.5848	.7049	.8237	.9487	1.0653	1.1903	1.3153	1.4403
		Max	.3449	.4017	.4642	.5226	.5851	.7052	.8240	.9490	1.0656	1.1906	1.3156	1.4406
	Class 3, medium fit.	Min	.3455	.4024	.4649	.5234	.5859	.7062	.8250	.9500	1.0669	1.1919	1.3169	1.4419
		Max	.3458	.4027	.4652	.5237	.5862	.7065	.8253	.9503	1.0672	1.1922	1.3172	1.4422
	Class 4, close fit	Min	.3470	.4040	.4665	.5252	.5877	.7082	.8272	.9522	1.0694	1.1944	1.3194	1.4444
		Max	.3471	.4041	.4666	.5253	.5878	.7083	.82735	.95235	1.06955	1.19455	1.31955	1.4445
Minor diameter of ring gage	Classes 1, 2, 3, and 4.	Min.[2]	.3384	.3937	.4562	.5139	.5764	.6953	.8125	.9375	1.0522	1.1772	1.3022	1.4272
		Max.[2]	.3389	.3942	.4567	.5144	.5769	.6959	.8131	.9381	1.0528	1.1778	1.3028	1.4278

[1] The maximum minor diameter of the "go" thread ring gage is the same as the minimum minor diameter of the tapped hole.

[2] In order that the "not go" gage may check pitch diameter only, it is necessary that the minor diameter of the "not go" ring gage shall never be less than that specified for the "go" ring gage. Furthermore, it is desirable that the crest of the "not go" gage be truncated a considerable amount, as shown in fig. 18, in order to minimize the effect of angle error on the fit of the "not go" gage with the product. A truncation from the basic dimension corresponding to a width of flat equal to $\frac{3}{8} \times p$ is recommended. The limiting dimensions given in this table for the minor diameter of the "not go" ring gage represent these conditions.

TABLE 25.—*Limiting dimensions of thread plug gages for nuts of classes 1, 2, 3, and 4 fits, American National coarse-thread series*

		Machine screw number or nominal size																	
		1	2	3	4	5	6	8	10	12	¼	5⁄16	⅜	7⁄16	½	9⁄16	⅝	¾	⅞
		Threads per inch																	
		64	56	48	40	40	32	32	24	24	20	18	16	14	13	12	11	10	9
"Go" Gages for Nuts		*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Major diameter of plug gage, classes 1, 2, 3, and 4.	Min	0.0730	0.0860	0.0990	0.1120	0.1250	0.1380	0.1640	0.1900	0.2160	0.2500	0.3125	0.3750	0.4375	0.5000	0.5625	0.6250	0.7500	0.8750
	Max	.0734	.0864	.0994	.1124	.1254	.1384	.1644	.1905	.2165	.2505	.3130	.3756	.4381	.5006	.5631	.6256	.7506	.8757
Pitch diameter of plug gage. Class 4	Min., class W										.2175	.2764	.3344	.3911	.4500	.5084	.5660	.6850	.8028
	Max., class W										.2176	.2765	.3345	.39125	.45015	.50855	.56615	.6852	.8030
Classes 1, 2, and 3	Min., class X	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500	.5084	.5660	.6850	.8028
	Max., class X	.0631	.0746	.0857	.0960	.1090	.1180	.1440	.1632	.1892	.2178	.2767	.3347	.3914	.4503	.5087	.5663	.6853	.8031
Classes 1, 2, and 3	Min., class Y	.0630	.0745	.0856	.0959	.1089	.1178	.1438	.1631	.1891	.2177	.2766	.3346	.3913	.4502	.5086	.5662	.6852	.8030
	Max., class Y	.0633	.0748	.0859	.0962	.1092	.1181	.1441	.1634	.1894	.2180	.2769	.3350	.3917	.4506	.5090	.5666	.6856	.8035
Class 1	Min., class Z	.0631	.0746	.0857	.0960	.1090	.1180	.1440	.1632	.1892	.2178	.2768	.3348	.3915	.4504	.5088	.5664	.6855	.8033
	Max., class Z	.0635	.0751	.0862	.0965	.1095	.1185	.1445	.1638	.1898	.2184	.2774	.3354	.3921	.4511	.5095	.5671	.6862	.8040
"Not Go" Gages for Nuts																			
Major diameter of plug gage, classes 1, 2, 3, and 4	Max.[1]	.0700	.0825	.0949	.1070	.1200	.1316	.1576	.1815	.2075	.2397	.3010	.3621	.4226	.4839	.5451	.6059	.7289	.8516
	Min.[1]	.0696	.0821	.0945	.1066	.1196	.1312	.1572	.1810	.2070	.2392	.3005	.3615	.4220	.4833	.5445	.6053	.7283	.8509
Pitch diameter of plug gage. Class 1, loose fit	Max	.0655	.0772	.0886	.0992	.1122	.1215	.1475	.1675	.1935	.2226	.2821	.3407	.3981	.4574	.5163	.5745	.6942	.8128
	Min	.0653	.0770	.0884	.0990	.1120	.1212	.1472	.1672	.1932	.2223	.2818	.3404	.3978	.4571	.5160	.5742	.6939	.8125
Class 2, free fit	Max	.0648	.0764	.0877	.0982	.1112	.1204	.1464	.1662	.1922	.2211	.2805	.3389	.3960	.4552	.5140	.5719	.6914	.8098
	Min	.0646	.0762	.0875	.0980	.1110	.1201	.1461	.1659	.1919	.2208	.2802	.3386	.3957	.4549	.5137	.5716	.6911	.8095
Class 3, medium fit	Max	.0643	.0759	.0871	.0975	.1105	.1196	.1456	.1653	.1913	.2201	.2794	.3376	.3947	.4537	.5124	.5702	.6895	.8077
	Min	.0641	.0757	.0869	.0973	.1103	.1193	.1453	.1650	.1910	.2198	.2791	.3373	.3944	.4534	.5121	.5699	.6892	.8074
Class 4, close fit	Max										.2188	.2779	.3360	.3929	.4519	.5104	.5681	.6873	.8052
	Min										.2187	.2778	.3359	.39275	.45175	.51025	.56795	.6871	.8050

		Sizes														
		1	1⅛	1¼	1⅜	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4
		Threads per inch														
		8	7	7	6	6	5	4½	4½	4	4	4	4	4	4	4
"Go" Gages for Nuts		*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Major diameter of plug gage, classes 1, 2, 3, and 4	Min	1.0000	1.1250	1.2500	1.3750	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500	4.0000
	Max	1.0007	1.1257	1.2507	1.3758	1.5008	1.7508	2.0008	2.2508	2.5009	2.7509	3.0009	3.2509	3.5009	3.7509	4.0009
Pitch diameter of plug gage: Class 4	Min., class W	.9188	1.0322	1.1572	1.2667	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	3.0876	3.3376	3.5876	3.8376
	Max., class W	.9190	1.03245	1.15745	1.26695	1.39195	1.62035	1.8560	2.1060	2.3379	2.5879	2.8379	3.0879	3.3379	3.5879	3.8379
Classes 1, 2, and 3	Min., class X	.9188	1.0322	1.1572	1.2667	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	3.0876	3.3376	3.5876	3.8376
	Max., class X	.9192	1.0326	1.1576	1.2671	1.3921	1.6205	1.8561	2.1061	2.3380	2.5880	2.8380	3.0880	3.3380	3.5880	3.8380
Classes 1, 2, and 3	Min., class Y	.9190	1.0324	1.1574	1.2670	1.3920	1.6204	1.8560	2.1060	2.3379	2.5879	2.8379	3.0879	3.3379	3.5879	3.8379
	Max., class Y	.9195	1.0329	1.1579	1.2675	1.3925	1.6209	1.8565	2.1065	2.3385	2.5885	2.8385	3.0885	3.3385	3.5885	3.8385
Class 1	Min., class Z	.9194	1.0328	1.1578	1.2673	1.3923	1.6208	1.8564	2.1064	2.3383	2.5883	2.8383	3.0883	3.3383	3.5883	3.8383
	Max., class Z	.9201	1.0335	1.1585	1.2681	1.3931	1.6216	1.8572	2.1072	2.3392	2.5892	2.8392	3.0892	3.3392	3.5892	3.8392
"Not Go" Gages for Nuts																
Major diameter of plug gage, classes 1, 2, 3, and 4	Max.[1]	.9736	1.0948	1.2198	1.3397	1.4647	1.7075	1.9527	2.2027	2.4468	2.6968	2.9468	3.1968	3.4468	3.6968	3.9468
	Min.[1]	.9729	1.0941	1.2191	1.3389	1.4639	1.7067	1.9519	2.2019	2.4459	2.6959	2.9459	3.1959	3.4459	3.6959	3.9459
Pitch diameter of plug gage: Class 1, loose fit	Max	.9299	1.0446	1.1696	1.2812	1.4062	1.6370	1.8741	2.1241	2.3580	2.6080	2.8580	3.1080	3.3580	3.6080	3.8580
	Min	.9295	1.0442	1.1692	1.2808	1.4058	1.6366	1.8737	2.1237	2.3576	2.6076	2.8576	3.1076	3.3576	3.6076	3.8576
Class 2, free fit	Max	.9264	1.0407	1.1657	1.2768	1.4018	1.6317	1.8684	2.1184	2.3516	2.6016	2.8516	3.1016	3.3516	3.6016	3.8516
	Min	.9260	1.0403	1.1653	1.2764	1.4014	1.6313	1.8680	2.1180	2.3512	2.6012	2.8512	3.1012	3.3512	3.6012	3.8512
Class 3, medium fit	Max	.9242	1.0381	1.1631	1.2738	1.3988	1.6283	1.8646	2.1146	2.3473	2.5973	2.8473	3.0973	3.3473	3.5973	3.8473
	Min	.9238	1.0377	1.1627	1.2734	1.3984	1.6279	1.8642	2.1142	2.3469	2.5969	2.8469	3.0969	3.3469	3.5969	3.8469
Class 4, close fit	Max	.9215	1.0352	1.1602	1.2703	1.3953	1.6242	1.8601	2.1101	2.3424	2.5924	2.8424	3.0924	4.3424	3.5924	3.8424
	Min	.9213	1.03495	1.15995	1.27005	1.39505	1.62395	1.8598	2.1098	2.3421	2.5921	2.8421	3.0921	3.3421	3.5921	3.8421

[1] See footnote on p. 67.

TABLE 26.—*Limiting dimensions of thread plug gages for nuts of classes 1, 2, 3, and 4 fits, American National fine-thread series*

			Machine screw number or nominal size: 0	1	2	3	4	5	6	8	10	12	1/4	5/16
			Threads per inch: 80	72	64	56	48	44	40	36	32	28	28	24
"Go" Gages for Nuts														
			Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Major diameter, classes 1, 2, 3, and 4		Min	0.0600	0.0730	0.0860	0.0990	0.1120	0.1250	0.1380	0.1640	0.1900	0.2160	0.2500	0.3125
		Max	.0603	.0733	.0864	.0994	.1124	.1254	.1384	.1644	.1904	.2165	.2505	.3130
Pitch diameter of plug gage	Class 4	Min., class W											.2268	.2854
		Max., class W											.2269	.2855
	Classes 1, 2, and 3	Min., class X	.0519	.0640	.0759	.0874	.0985	.1102	.1218	.1460	.1697	.1928	.2268	.2854
		Max., class X	.0521	.0642	.0761	.0876	.0987	.1104	.1220	.1462	.1700	.1931	.2271	.2857
	Classes 1, 2, and 3	Min., class Y	.0520	.0641	.0760	.0875	.0986	.1103	.1219	.1461	.1698	.1930	.2270	.2856
		Max., class Y	.0522	.0643	.0763	.0878	.0989	.1106	.1222	.1464	.1701	.1933	.2273	.2859
	Class 1	Min., class Z	.0521	.0642	.0761	.0876	.0987	.1104	.1220	.1463	.1700	.1931	.2271	.2857
		Max., class Z	.0525	.0646	.0765	.0881	.0992	.1109	.1225	.1468	.1705	.1936	.2276	.2863
"Not Go" Gages for Nuts														
Major diameter of plug gage, classes 1, 2, 3, and 4		Max.[1]	.0576	.0703	.0830	.0955	.1079	.1205	.1330	.1584	.1836	.2088	.2428	.3040
		Min.[1]	.0573	.0700	.0826	.0951	.1075	.1201	.1326	.1580	.1832	.2083	.2423	.3035
Pitch diameter of plug gage	Class 1, loose fit	Max	.0543	.0665	.0785	.0902	.1016	.1134	.1252	.1496	.1735	.1971	.2311	.2900
		Min	.0541	.0663	.0783	.0900	.1014	.1132	.1250	.1494	.1732	.1968	.2308	.2897
	Class 2, free fit	Max	.0536	.0658	.0778	.0894	.1007	.1125	.1242	.1485	.1724	.1959	.2299	.2887
		Min	.0534	.0656	.0776	.0892	.1005	.1123	.1240	.1483	.1721	.1956	.2296	.2884
	Class 3, medium fit	Max	.0532	.0653	.0773	.0889	.1001	.1118	.1235	.1478	.1716	.1950	.2290	.2878
		Min	.0530	.0651	.0771	.0887	.0999	.1116	.1233	.1476	.1713	.1947	.2287	.2875
	Class 4, close fit	Max											.2279	.2866
		Min											.2278	.2865

			Sizes											
			3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
			Threads per inch											
			24	20	20	18	18	16	14	14	12	12	12	12
"Go" Gages for Nuts														
			Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Major diameter, classes 1, 2, 3, and 4		Min	0.3750	0.4375	0.5000	0.5625	0.6250	0.7500	0.8750	1.0000	1.1250	1.2500	1.3750	1.5000
		Max	.3755	.4380	.5005	.5630	.6255	.7506	.8756	1.0006	1.1256	1.2506	1.3756	1.5006
Pitch diameter of plug gage	Class 4	Min., class W	.3479	.4050	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.3209	1.4459
		Max., class W	.3480	.4051	.4676	.5265	.5890	.7095	.82875	.95375	1.07105	1.19605	1.32105	1.44605
	Classes 1, 2, and 3	Min., class X	.3479	.4050	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.3209	1.4459
		Max., class X	.3482	.4053	.4678	.5267	.5892	.7097	.8289	.9539	1.0712	1.1962	1.3212	1.4462
	Classes 1, 2, and 3	Min., class Y	.3481	.4052	.4677	.5266	.5891	.7096	.8288	.9538	1.0711	1.1961	1.3211	1.4461
		Max., class Y	.3484	.4055	.4680	.5269	.5894	.7100	.8292	.9542	1.0715	1.1965	1.3215	1.4465
	Class 1	Min., class Z	.3482	.4053	.4678	.5268	.5893	.7098	.8290	.9540	1.0713	1.1963	1.3213	1.4463
		Max., class Z	.3488	.4059	.4684	.5274	.5899	.7104	.8296	.9546	1.0720	1.1970	1.3220	1.4470
"Not Go" Gages for Nuts														
Major diameter of plug gage, classes 1, 2, 3, and 4		Max.[1]	.3665	.4272	.4897	.5510	.6135	.7371	.8601	.9851	1.1076	1.2326	1.3576	1.4826
		Min.[1]	.3660	.4267	.4892	.5505	.6130	.7365	.8595	.9845	1.1070	1.2320	1.3570	1.4820
Pitch diameter of plug gage	Class 1, loose fit	Max	.3525	.4101	.4726	.5321	.5946	.7157	.8356	.9606	1.0788	1.2038	1.3288	1.4538
		Min	.3522	.4098	.4723	.5318	.5943	.7154	.8353	.9603	1.0785	1.2035	1.3285	1.4535
	Class 2, free fit	Max	.3512	.4086	.4711	.5305	.5930	.7139	.8335	.9585	1.0765	1.2015	1.3265	1.4515
		Min	.3509	.4083	.4708	.5302	.5927	.7136	.8332	.9582	1.0762	1.2012	1.3262	1.4512
	Class 3, medium fit	Max	.3503	.4076	.4701	.5294	.5919	.7126	.8322	.9572	1.0749	1.1999	1.3249	1.4499
		Min	.3500	.4073	.4698	.5291	.5916	.7123	.8319	.9569	1.0746	1.1996	1.3246	1.4496
	Class 4, close fit	Max	.3491	.4063	.4688	.5279	.5904	.7110	.8304	.9554	1.0729	1.1979	1.3229	1.4479
		Min	.3490	.4062	.4687	.5278	.5903	.7109	.83025	.95525	1.07275	1.19775	1.32275	1.44775

[1] In order that the "not go" gage may check pitch diameter only, it is necessary that the crest of the thread be removed so that the major diameter of the "not go" plug gage shall never be greater than that specified for the "go" plug gage. Furthermore, it is desirable that the crest of the "not go" gage be truncated a considerable amount, as shown in fig. 18, in order to minimize the effect of angle error on the fit of the "not go" gage with the product. A truncation from basic dimensions corresponding to a width of flat equal to $\frac{1}{4} \times p$ is recommended. The limiting dimensions given in this table for the major diameter of the "not go" plug gage represent these conditions.

SECTION IV.—UNIFORM PITCH SCREW-THREAD SERIES FOR HIGH-PRESSURE FASTENINGS, RAILROAD APPLICATIONS, MACHINERY COMPONENTS, ETC.

1. FORM OF THREAD

The American National form of thread profile as specified in section III shall be used.

2. THREAD SERIES

Where special threads are required, it is sometimes essential to select a certain pitch as standard for a range of sizes. Also, in general practice, where the pitch of a special thread is optional, the uniform use of a selected pitch is advantageous. For such applications 8, 12, and 16 threads per inch are widely used.

(a) AMERICAN NATIONAL 8-PITCH THREAD SERIES

In table 27 are specified the nominal sizes and basic dimensions of the "American National 8-pitch thread series."

Bolts for high-pressure pipe flanges, cylinder-head studs, and similar fastenings against pressure require that an initial tension be set up in the fastening, by elastic deformation of the fastening and the components held together, such that the joint will not open up when the steam or other pressure is applied. To secure a proper initial tension it is not practicable that the pitch should increase with the diameter of the thread, as the torque required to assemble the fastening would be excessive. Accordingly, for such purposes the 8-pitch thread has come into general use.

(b) AMERICAN NATIONAL 12-PITCH THREAD SERIES

The nominal sizes and basic dimensions of the "American National 12-pitch thread series" are specified in table 28.

Sizes of 12-pitch threads from one-half inch to and including one and three-fourths inches are used in railroad practice, which require that worn stud holes be retapped with a tap of the next larger size, the increment being one-sixteenth inch throughout most of the range. Die-head chasers for sizes up to 3 inches are stocked by manufacturers.[10]

The 12-pitch threads are also widely used in machine construction, as for thin nuts on shafts and sleeves. From the standpoints of good design and simplification of practice, it is desirable to maintain shoulder diameters to one-eighth-inch steps. The 12 pitch is the coarsest in general use, which will permit a threaded collar which screws onto a threaded shoulder to slip over a shaft, the difference in diameter between shoulder and shaft being one-eighth inch.

(c) AMERICAN NATIONAL 16-PITCH THREAD SERIES

The nominal sizes and basic dimensions of the American National 16-pitch thread series are specified in table 29.

The 16-pitch series is a uniform pitch series for such applications as require a relatively fine thread. It is intended primarily for use on thread adjusting collars and bearing retaining nuts.

[10] See U.S. Department of Commerce Simplified Practice Recommendation R51-29, Die Head Chasers.

3. CLASSIFICATION, TOLERANCES, AND LIMITING DIMENSIONS

The general specifications and classification of fits given in section V, herein, are applicable to the American National 8-pitch, 12-pitch, and 16-pitch thread series. The dimensions and tolerances for two classes of fit derived from tables 35 and 60 are given in tables 30, 31, and 32.

TABLE 27.—*American National 8-pitch thread series*

Identification		Basic diameters			Thread data			
Sizes	Threads per inch	Major diameter, *D*	Pitch diameter, *E*	Minor diameter, *K*	Metric equivalent of major diameter	Helix angle at basic pitch diameter, *s*		Basic area of section at root of thread, $\frac{\pi K^2}{4}$
1	2	3	4	5	6	7		8
		Inches	*Inches*	*Inches*	*mm*	*Deg.*	*Min.*	*Square inches*
1 [1]	8	1. 0000	0. 9188	0. 8376	25. 400	2	29	0. 5510
1⅛	8	1. 1250	1. 0438	. 9626	28. 575	2	11	. 7277
1¼	8	1. 2500	1. 1688	1. 0876	31. 750	1	57	. 9290
1⅜	8	1. 3750	1. 2938	1. 2126	34. 925	1	46	1. 1548
1½	8	1. 5000	1. 4188	1. 3376	38. 100	1	36	1. 4052
1⅝	8	1. 6250	1. 5438	1. 4626	41. 275	1	29	1. 6801
1¾	8	1. 7500	1. 6688	1. 5876	44. 450	1	22	1. 9796
1⅞	8	1. 8750	1. 7938	1. 7126	47. 625	1	16	2. 3036
2	8	2. 0000	1. 9188	1. 8376	50. 800	1	11	2. 6521
2⅛	8	2. 1250	2. 0438	1. 9626	53. 975	1	7	3. 0252
2¼	8	2. 2500	2. 1688	2. 0876	57. 150	1	3	3. 4228
2½	8	2. 5000	2. 4188	2. 3376	63. 500	0	57	4. 2917
2¾	8	2. 7500	2. 6688	2. 5876	69. 850	0	51	5. 2588
3	8	3. 0000	2. 9188	2. 8376	76. 200	0	47	6. 3240
3¼	8	3. 2500	3. 1688	3. 0876	82. 550	0	43	7. 4874
3½	8	3. 5000	3. 4188	3. 3376	88. 900	0	40	8. 7490
3¾	8	3. 7500	3. 6688	3. 5876	95. 250	0	37	10. 1088
4	8	4. 0000	3. 9188	3. 8376	101. 600	0	35	11. 5667
4¼	8	4. 2500	4. 1688	4. 0876	107. 950	0	33	13. 1228
4½	8	4. 5000	4. 4188	4. 3376	114. 300	0	31	14. 7771
4¾	8	4. 7500	4. 6688	4. 5876	120. 650	0	29	16. 5295
5	8	5. 0000	4. 9188	4. 8376	127. 000	0	28	18. 3802
5¼	8	5. 2500	5. 1688	5. 0876	133. 350	0	26	20. 3290
5½	8	5. 5000	5. 4188	5. 3376	139. 700	0	25	22. 3760
5¾	8	5. 7500	5. 6688	5. 5876	146. 050	0	24	24. 5211
6	8	6. 0000	5. 9188	5. 8376	152. 400	0	23	26. 7645

[1] Standard size of the American National coarse-thread series.

NOTE.—Pitch, p=0.12500 inch; depth of thread, h=0.08119 inch; basic width of flat, $p/8$=0.01562 inch; minimum width of flat at major diameter of nut, $p/24$=0.00521 inch.

TABLE 28.—*American National 12-pitch thread series*

Identification		Basic diameters			Thread data			
Sizes	Threads per inch	Major diameter, D	Pitch diameter, E	Minor diameter, K	Metric equivalent of major diameter	Helix angle at basic pitch diameter, s		Basic area of section at root of thread $\frac{\pi K^2}{4}$
1	2	3	4	5	6	7		8
		Inches	*Inches*	*Inches*	*mm*	*Deg.*	*Min.*	*Square inches*
1/2	12	0.5000	0.4459	0.3917	12.700	3	24	0.1205
9/16 [1]	12	.5625	.5084	.4542	14.288	2	59	.1620
5/8	12	.6250	.5709	.5167	15.875	2	40	.2097
11/16	12	.6875	.6334	.5792	17.463	2	24	.2635
3/4	12	.7500	.6959	.6417	19.050	2	11	.3234
13/16	12	.8125	.7584	.7042	20.638	2	0	.3895
7/8	12	.8750	.8209	.7667	22.225	1	51	.4617
15/16	12	.9375	.8834	.8292	23.813	1	43	.5400
1	12	1.0000	.9459	.8917	25.400	1	36	.6245
1 1/16	12	1.0625	1.0084	.9542	26.988	1	30	.7151
1 1/8 [2]	12	1.1250	1.0709	1.0167	28.575	1	25	.8118
1 3/16	12	1.1875	1.1334	1.0792	30.163	1	20	.9147
1 1/4 [2]	12	1.2500	1.1959	1.1417	31.750	1	16	1.0237
1 5/16	12	1.3125	1.2584	1.2042	33.338	1	12	1.1389
1 3/8 [2]	12	1.3750	1.3209	1.2667	34.925	1	9	1.2602
1 7/16	12	1.4375	1.3834	1.3292	36.513	1	6	1.3876
1 1/2 [2]	12	1.5000	1.4459	1.3917	38.100	1	3	1.5212
1 5/8	12	1.6250	1.5709	1.5167	41.275	0	58	1.8067
1 3/4	12	1.7500	1.6959	1.6417	44.450	0	54	2.1168
1 7/8	12	1.8750	1.8209	1.7667	47.625	0	50	2.4514
2	12	2.0000	1.9459	1.8917	50.800	0	47	2.8106
2 1/4	12	2.2500	2.1959	2.1417	57.150	0	42	3.6025
2 1/2	12	2.5000	2.4459	2.3917	63.500	0	37	4.4927
2 3/4	12	2.7500	2.6959	2.6417	69.850	0	34	5.4810
3	12	3.0000	2.9459	2.8917	76.200	0	31	6.5674
3 1/4	12	3.2500	3.1959	3.1417	82.550	0	29	7.7521
3 1/2	12	3.5000	3.4459	3.3917	88.900	0	26	9.0349
3 3/4	12	3.7500	3.6959	3.6417	95.250	0	25	10.4159
4	12	4.0000	3.9459	3.8917	101.600	0	23	11.8951
4 1/4	12	4.2500	4.1959	4.1417	107.950	0	22	13.4725
4 1/2	12	4.5000	4.4459	4.3917	114.300	0	21	15.1480
4 3/4	12	4.7500	4.6959	4.6417	120.650	0	19	16.9217
5	12	5.0000	4.9459	4.8917	127.000	0	18	18.7936
5 1/4	12	5.2500	5.1959	5.1417	133.350	0	18	20.7636
5 1/2	12	5.5000	5.4459	5.3917	139.700	0	17	22.8319
5 3/4	12	5.7500	5.6959	5.6417	146.050	0	16	24.9983
6	12	6.0000	5.9459	5.8917	152.400	0	15	27.2628

[1] Standard size of the American National coarse-thread series.
[2] Standard size of the American National fine-thread series.

NOTE.—Pitch, p=0.08333 inch; depth of thread, h=0.05413 inch; basic width of flat, $p/8$=0.01042 inch; minimum width of flat at major diameter of nut, $p/24$=0.00347 inch.

Table 29.—*American National 16-pitch thread series*

Identification		Basic diameters			Thread data		
Sizes	Threads per inch	Major diameter, D	Pitch diameter, E	Minor diameter, K	Metric equivalent of major diameter	Helix angle at basic pitch diameter, s	Basic area of section at root of thread, $\frac{\pi K^2}{4}$
1	2	3	4	5	6	7	8
		Inches	*Inches*	*Inches*	*mm*	*Deg. Min.*	*Square inches*
¾ [1]	16	0.7500	0.7094	0.6688	19.050	1 36	0.3513
⅞	16	.8750	.8344	.7938	22.225	1 22	.4949
1	16	1.0000	.9594	.9188	25.400	1 11	.6630
1⅛	16	1.1250	1.0844	1.0438	28.575	1 3	.8557
1¼	16	1.2500	1.2094	1.1688	31.750	0 57	1.0729
1⅜	16	1.3750	1.3344	1.2938	34.925	0 51	1.3147
1½	16	1.5000	1.4594	1.4188	38.100	0 47	1.5810
1⅝	16	1.6250	1.5844	1.5438	41.275	0 43	1.8719
1¾	16	1.7500	1.7094	1.6688	44.450	0 40	2.1873
1⅞	16	1.8750	1.8344	1.7938	47.625	0 37	2.5272
2	16	2.0000	1.9594	1.9188	50.800	0 35	2.8917
2⅛	16	2.1250	2.0844	2.0438	53.975	0 33	3.2807
2¼	16	2.2500	2.2094	2.1688	57.150	0 31	3.6943
2½	16	2.5000	2.4594	2.4188	63.500	0 28	4.5950
2¾	16	2.7500	2.7094	2.6688	69.850	0 25	5.5940
3	16	3.0000	2.9594	2.9188	76.200	0 23	6.6911
3¼	16	3.2500	3.2094	3.1688	82.550	0 21	7.8864
3½	16	3.5000	3.4594	3.4188	88.900	0 20	9.1799
3¾	16	3.7500	3.7094	3.6688	95.250	0 18	10.5715
4	16	4.0000	3.9594	3.9188	101.600	0 17	12.0614

[1] Standard size of the American National fine-thread series.

Note.—Pitch, p=0.06250 inch; depth of thread, h=0.04059 inch; basic width of flat, $p/8$=0.00781 inch; minimum width of flat at major diameter of nut, $p/24$=0.00260 inch.

Table 30.—*Limiting dimensions and tolerances, classes 2 and 3 fits, American National 8-pitch thread series*

Dimensions and tolerances [1]		Size (inches)								
		1 [2]	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2
Bolts and Screws		*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Classes 2 and 3, major diameter	Max	1.0000	1.1250	1.2500	1.3750	1.5000	1.6250	1.7500	1.8750	2.0000
	Min	.9848	1.1098	1.2348	1.3598	1.4848	1.6098	1.7348	1.8598	1.9848
	Tol	.0152	.0152	.0152	.0152	.0152	.0152	.0152	.0152	.0152
Classes 2 and 3, minor diameter	Max. [3]	.8466	.9716	1.0966	1.2216	1.3466	1.4716	1.5966	1.7216	1.8466
Class 2, pitch diameter (for general use)	Max	.9188	1.0438	1.1688	1.2938	1.4188	1.5438	1.6688	1.7938	1.9188
	Min	.9112	1.0359	1.1605	1.2852	1.4098	1.5345	1.6591	1.7838	1.9084
	Tol	.0076	.0079	.0083	.0086	.0090	.0093	.0097	.0100	.0104
Class 3, pitch diameter	Max	.9188	1.0438	1.1688	1.2938	1.4188	1.5438	1.6688	1.7938	1.9188
	Min	.9134	1.0383	1.1630	1.2877	1.4125	1.5373	1.6620	1.7868	1.9115
	Tol	.0054	.0055	.0058	.0061	.0063	.0065	.0068	.0070	.0073
Nuts and Tapped Holes										
Classes 2 and 3, major diameter	Min. [4]	1.0000	1.1250	1.2500	1.3750	1.5000	1.6250	1.7500	1.8750	2.0000
Classes 2 and 3, minor diameter	Min	.8647	.9897	1.1147	1.2397	1.3647	1.4897	1.6147	1.7397	1.8647
	Max	.8795	1.0032	1.1282	1.2532	1.3782	1.5032	1.6282	1.7532	1.8782
	Tol	.0148	.0135	.0135	.0135	.0135	.0135	.0135	.0135	.0135
Classes 2 and 3, pitch diameter	Min	.9188	1.0438	1.1688	1.2938	1.4188	1.5438	1.6688	1.7938	1.9188
Class 2, pitch diameter (for general use)	Max. [5]	.9264	1.0517	1.1771	1.3024	1.4278	1.5531	1.6785	1.8038	1.9292
	Tol	.0076	.0079	.0083	.0086	.0090	.0093	.0097	.0100	.0104
Class 3, pitch diameter	Max. [5]	.9242	1.0493	1.1746	1.2999	1.4251	1.5503	1.6756	1.8008	1.9261
	Tol	.0054	.0055	.0058	.0061	.0063	.0065	.0068	.0070	.0073

Footnotes at end of table.

Table 30.—*Limiting dimensions and tolerances, classes 2 and 3 fits, American National 8-pitch thread series*—Continued

Dimensions and tolerances[1]		Size (inches)								
		2⅛	2¼	2½	2¾	3	3¼	3½	3¾	4
Bolts and Screws		*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Classes 2 and 3, major diameter	Max	2.1250	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500	4.0000
	Min	2.1098	2.2348	2.4848	2.7348	2.9848	3.2348	3.4848	3.7348	3.9848
	Tol	.0152	.0152	.0152	.0152	.0152	.0152	.0152	.0152	.0152
Classes 2 and 3, minor diameter	Max.[3]	1.9716	2.0966	2.3466	2.5966	2.8466	3.0966	3.3466	3.5966	3.8466
Class 2, pitch diameter (for general use)	Max	2.0438	2.1688	2.4188	2.6688	2.9188	3.1688	3.4188	3.6688	3.9188
	Min	2.0331	2.1578	2.4071	2.6564	2.9058	3.1556	3.4055	3.6554	3.9053
	Tol	.0107	.0110	.0117	.0124	.0130	.0132	.0133	.0134	.0135
Class 3, pitch diameter	Max	2.0438	2.1688	2.4188	2.6688	2.9188	3.1688	3.4188	3.6688	3.9188
	Min	2.0363	2.1611	2.4106	2.6601	2.9096	3.1595	3.4095	3.6594	3.9093
	Tol	.0075	.0077	.0082	.0087	.0092	.0093	.0093	.0094	.0095
Nuts and Tapped Holes										
Classes 2 and 3, major diameter	Min.[4]	2.1250	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500	4.0000
Classes 2 and 3, minor diameter	Min	1.9897	2.1147	2.3647	2.6147	2.8647	3.1147	3.3647	3.6147	3.8647
	Max	2.0032	2.1282	2.3782	2.6282	2.8782	3.1282	3.3782	3.6282	3.8782
	Tol	.0135	.0135	.0135	.0135	.0135	.0135	.0135	.0135	.0135
Classes 2 and 3, pitch diameter	Min	2.0438	2.1688	2.4188	2.6688	2.9188	3.1688	3.4188	3.6688	3.9188
Class 2, pitch diameter (for general use)	Max.[5]	2.0545	2.1798	2.4305	2.6812	2.9318	3.1820	3.4321	3.6822	3.9323
	Tol	.0107	.0110	.0117	.0124	.0130	.0132	.0133	.0134	.0135
Class 3, pitch diameter	Max.[5]	2.0513	2.1765	2.4270	2.6775	2.9280	3.1781	3.4281	3.6782	3.9283
	Tol	.0075	.0077	.0082	.0087	.0092	.0093	.0093	.0094	.0095

Dimensions and tolerances		Size (inches)							
		4¼	4½	4¾	5	5¼	5½	5¾	6
Bolts and Screws		*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Classes 2 and 3, major diameter	Max	4.2500	4.5000	4.7500	5.0000	5.2500	5.5000	5.7500	6.0000
	Min	4.2348	4.4848	4.7348	4.9848	5.2348	5.4848	5.7348	5.9848
	Tol	.0152	.0152	.0152	.0152	.0152	.0152	.0152	.0152
Classes 2 and 3, minor diameter	Max.[3]	4.0966	4.3466	4.5966	4.8466	5.0966	5.3466	5.5966	5.8466
Class 2, pitch diameter (for general use)	Max	4.1688	4.4188	4.6688	4.9188	5.1688	5.4188	5.6688	5.9188
	Min	4.1551	4.4050	4.6549	4.9048	5.1547	5.4046	5.6545	5.9044
	Tol	.0137	.0138	.0139	.0140	.0141	.0142	.0143	.0144
Class 3, pitch diameter	Max	4.1688	4.4188	4.6688	4.9188	5.1688	5.4188	5.6688	5.9188
	Min	4.1592	4.4091	4.6590	4.9089	5.1589	5.4088	5.6587	5.9086
	Tol	.0096	.0097	.0098	.0099	.0099	.0100	.0101	.0102
Nuts and Tapped Holes									
Classes 2 and 3, major diameter	Min.[4]	4.2500	4.5000	4.7500	5.0000	5.2500	5.5000	5.7500	6.0000
Classes 2 and 3, minor diameter	Min	4.1147	4.3647	4.6147	4.8647	5.1147	5.3647	5.6147	5.8647
	Max	4.1282	4.3782	4.6282	4.8782	5.1282	5.3782	5.6282	5.8782
	Tol	.0135	.0135	.0135	.0135	.0135	.0135	.0135	.0135
Classes 2 and 3, pitch diameter	Min	4.1688	4.4188	4.6688	4.9188	5.1688	5.4188	5.6688	5.9188
Class 2, pitch diameter (for general use)	Max.[5]	4.1825	4.4326	4.6827	4.9328	5.1829	5.4330	5.6831	5.9332
	Tol	.0137	.0138	.0139	.0140	.0141	.0142	.0143	.0144
Class 3, pitch diameter	Max.[5]	4.1784	4.4285	4.6786	4.9287	5.1787	5.4288	5.6789	5.9290
	Tol	.0096	.0097	.0098	.0099	.0099	.0100	.0101	.0102

[1] Pitch diameter tolerances include errors of lead and angle. The class 2 tolerances are based on the formulas in table 60 and a length of engagement equal to the basic major diameter for sizes from 1⅛ to 3 inches, inclusive, and a length of engagement of 3 inches for sizes over the 3-inch. The class 3 tolerances are 70 percent of the class 2 tolerances. The 1-inch size being in the American National coarse-thread series, the tolerances for this size correspond to that series.

[2] Standard size screw and nut of the American National coarse-thread series.

[3] Dimensions given for the maximum minor diameter of the screw are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the screw shall be that corresponding to a flat at the minor diameter of the minimum screw equal to $\frac{1}{8} \times p$, and may be determined by subtracting 0.0812 inch from the minimum pitch diameter of the screw.

[4] Dimensions for the minimum major diameter of the nut correspond to the basic flat ($\frac{1}{8} \times p$), and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the nut shall be that corresponding to a flat at the major diameter of the maximum nut equal to $\frac{1}{24} \times p$, and may be determined by adding 0.0992 inch to the maximum pitch diameter of the nut.

[5] These dimensions are the minimum metal or "not go" size. The "go" or basic size is the one that should be placed on the component drawing with the tolerance.

Table 31.—*Limiting dimensions and tolerances, classes 2 and 3 fits, American National 12-pitch thread series*

Dimensions and tolerances [1]		Size (inches)									
		½	9/16 [2]	5/8	11/16	¾	13/16	7/8	15/16	1	1 1/16
BOLTS AND SCREWS		*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*
Classes 2 and 3, major diameter	Max	0.5000	0.5625	0.6250	0.6875	0.7500	0.8125	0.8750	0.9375	1.0000	1.0625
	Min	.4888	.5513	.6138	.6763	.7388	.8013	.8638	.9263	.9888	1.0513
	Tol	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112
Classes 2 and 3, minor diameter	Max. [4]	.3978	.4603	.5228	.5853	.6478	.7103	.7728	.8353	.8978	.9603
Class 2, pitch diameter (for general use)	Max	.4459	.5084	.5709	.6334	.6959	.7584	.8209	.8834	.9459	1.0084
	Min	.4403	.5028	.5653	.6278	.6903	.7528	.8153	.8778	.9403	1.0028
	Tol	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056
Class 3, pitch diameter	Max	.4459	.5084	.5709	.6334	.6959	.7584	.8209	.8834	.9459	1.0084
	Min	.4419	.5044	.5669	.6294	.6919	.7544	.8169	.8794	.9419	1.0044
	Tol	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040
NUTS AND TAPPED HOLES											
Classes 2 and 3, major diameter	Min. [5]	.5000	.5625	.6250	.6875	.7500	.8125	.8750	.9375	1.0000	1.0625
Classes 2 and 3, minor diameter	Min	.4098	.4723	.5348	.5973	.6598	.7223	.7848	.8473	.9098	.9723
	Max	.4225	.4850	.5438	.6063	.6688	.7313	.7938	.8563	.9188	.9813
	Tol	.0127	.0127	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090
Classes 2 and 3, pitch diameter	Min	.4459	.5084	.5709	.6334	.6959	.7584	.8209	.8834	.9459	1.0084
Class 2, pitch diameter (for general use)	Max. [6]	.4515	.5140	.5765	.6390	.7015	.7640	.8265	.8890	.9515	1.0140
	Tol	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056
Class 3, pitch diameter	Max. [6]	.4499	.5124	.5749	.6374	.6999	.7624	.8249	.8874	.9499	1.0124
	Tol	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040

Dimensions and tolerances [1]		Size (inches)								
		1 1/8 [3]	1 3/16	1 1/4 [3]	1 5/16	1 3/8 [3]	1 7/16	1 1/2 [3]	1 5/8	1 3/4
BOLTS AND SCREWS		*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Classes 2 and 3, major diameter	Max	1.1250	1.1875	1.2500	1.3125	1.3750	1.4375	1.5000	1.6250	1.7500
	Min	1.1138	1.1763	1.2388	1.3013	1.3638	1.4263	1.4888	1.6138	1.7388
	Tol	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112
Classes 2 and 3, minor diameter	Max. [4]	1.0228	1.0853	1.1478	1.2103	1.2728	1.3353	1.3978	1.5228	1.6478
Class 2, pitch diameter (for general use)	Max	1.0709	1.1334	1.1959	1.2584	1.3209	1.3834	1.4459	1.5709	1.6959
	Min	1.0653	1.1278	1.1903	1.2528	1.3153	1.3778	1.4403	1.5645	1.6894
	Tol	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0064	.0065
Class 3, pitch diameter	Max	1.0709	1.1334	1.1959	1.2584	1.3209	1.3834	1.4459	1.5709	1.6959
	Min	1.0669	1.1294	1.1919	1.2544	1.3169	1.3794	1.4419	1.5664	1.6913
	Tol	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0045	.0046
NUTS AND TAPPED HOLES										
Classes 2 and 3, major diameter	Min. [5]	1.1250	1.1875	1.2500	1.3125	1.3750	1.4375	1.5000	1.6250	1.7500
Classes 2 and 3, minor diameter	Min	1.0348	1.0973	1.1598	1.2223	1.2848	1.3473	1.4098	1.5348	1.6598
	Max	1.0438	1.1063	1.1688	1.2313	1.2938	1.3563	1.4188	1.5438	1.6688
	Tol	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090
Classes 2 and 3, pitch diameter	Min	1.0709	1.1334	1.1959	1.2584	1.3209	1.3834	1.4459	1.5709	1.6959
Class 2, pitch diameter (for general use)	Max. [6]	1.0765	1.1390	1.2015	1.2640	1.3265	1.3890	1.4515	1.5773	1.7024
	Tol	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0064	.0065
Class 3, pitch diameter	Max. [6]	1.0749	1.1374	1.1999	1.2624	1.3249	1.3874	1.4499	1.5754	1.7005
	Tol	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0045	.0046

Footnotes at end of table.

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TABLE 31.—*Limiting dimensions and tolerances, classes 2 and 3 fits, American National 12-pitch thread series*—Continued

Dimensions and tolerances [1]		Size (inches)								
		1⅞	2	2¼	2½	2¾	3	3¼	3½	3¾
BOLTS AND SCREWS		*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Classes 2 and 3, major diameter	Max	1.8750	2.0000	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500
	Min	1.8638	1.9888	2.2388	2.4888	2.7388	2.9888	3.2388	3.4888	3.7388
	Tol	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112
Classes 2 and 3, minor diameter	Max.[4]	1.7728	1.8978	2.1478	2.3978	2.6478	2.8978	3.1478	3.3978	3.6478
Class 2, pitch diameter (for general use)	Max	1.8209	1.9459	2.1959	2.4459	2.6959	2.9459	3.1959	3.4459	3.6959
	Min	1.8143	1.9392	2.1890	2.4388	2.6887	2.9385	3.1884	3.4383	3.6881
	Tol	.0066	.0067	.0069	.0071	.0072	.0074	.0075	.0076	.0078
Class 3, pitch diameter	Max	1.8209	1.9459	2.1959	2.4459	2.6959	2.9459	3.1959	3.4459	3.6959
	Min	1.8163	1.9412	2.1911	2.4410	2.6909	2.9408	3.1907	3.4406	3.6905
	Tol	.0046	.0047	.0048	.0049	.0050	.0051	.0052	.0053	.0054
NUTS AND TAPPED HOLES										
Classes 2 and 3, major diameter	Min.[5]	1.8750	2.0000	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500
Classes 2 and 3, minor diameter	Min	1.7848	1.9098	2.1598	2.4098	2.6598	2.9098	3.1598	3.4098	3.6598
	Max	1.7938	1.9188	2.1688	2.4188	2.6688	2.9188	3.1688	3.4188	3.6688
	Tol	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090
Classes 2 and 3, pitch diameter	Min	1.8209	1.9459	2.1959	2.4459	2.6959	2.9459	3.1959	3.4459	3.6959
Class 2, pitch diameter (for general use)	Max.[6]	1.8275	1.9526	2.2028	2.4530	2.7031	2.9533	3.2034	3.4535	3.7037
	Tol	.0066	.0067	.0069	.0071	.0072	.0074	.0075	.0076	.0078
Class 3, pitch diameter	Max.[6]	1.8255	1.9506	2.2007	2.4508	2.7009	2.9510	3.2011	3.4512	3.7013
	Tol	.0046	.0047	.0048	.0049	.0050	.0051	.0052	.0053	.0054

Dimensions and tolerances [1]		Size								
		4	4¼	4½	4¾	5	5¼	5½	5¾	6
BOLTS AND SCREWS		*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Classes 2 and 3, major diameter	Max	4.0000	4.2500	4.5000	4.7500	5.0000	5.2500	5.5000	5.7500	6.0000
	Min	3.9888	4.2388	4.4888	4.7388	4.9888	5.2388	5.4888	5.7388	5.9888
	Tol	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112
Classes 2 and 3, minor diameter	Max.[4]	3.8978	4.1478	4.3978	4.6478	4.8978	5.1478	5.3978	5.6478	5.8978
Class 2, pitch diameter (for general use)	Max	3.9459	4.1959	4.4459	4.6959	4.9459	5.1959	5.4459	5.6959	5.9459
	Min	3.9380	4.1879	4.4378	4.6876	4.9375	5.1874	5.4373	5.6872	5.9371
	Tol	.0079	.0080	.0081	.0083	.0084	.0085	.0086	.0087	.0088
Class 3, pitch diameter	Max	3.9459	4.1959	4.4459	4.6959	4.9459	5.1959	5.4459	5.6959	5.9459
	Min	3.9404	4.1903	4.4402	4.6901	4.9400	5.1900	5.4399	5.6898	5.9397
	Tol	.0055	.0056	.0057	.0058	.0059	.0059	.0060	.0061	.0062
NUTS AND TAPPED HOLES										
Classes 2 and 3, major diameter	Min.[5]	4.0000	4.2500	4.5000	4.7500	5.0000	5.2500	5.5000	5.7500	6.0000
Classes 2 and 3, minor diameter	Min	3.9098	4.1598	4.4098	4.6598	4.9098	5.1598	5.4098	5.6598	5.9098
	Max	3.9188	4.1688	4.4188	4.6688	4.9188	5.1688	5.4188	5.6688	5.9188
	Tol	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090
Classes 2 and 3, pitch diameter	Min	3.9459	4.1959	4.4459	4.6959	4.9459	5.1959	5.4459	5.6959	5.9459
Class 2, pitch diameter (for general use)	Max.[6]	3.9538	4.2039	4.4540	4.7042	4.9543	5.2044	5.4545	5.7046	5.9547
	Tol	.0079	.0080	.0081	.0083	.0084	.0085	.0086	.0087	.0088
Class 3, pitch diameter	Max.[6]	3.9514	4.2015	4.4516	4.7017	4.9518	5.2018	5.4519	5.7020	5.9521
	Tol	.0055	.0056	.0057	.0058	.0059	.0059	.0060	.0061	.0062

[1] Pitch diameter tolerances include errors of lead and angle. The class 2 tolerances for sizes above 1½ inches are based on the formulas in table 60 and a length of engagement of 6 threads or ½ inch. The class 3 tolerances are 70 percent of the class 2 tolerances. For lengths of engagement of 1 inch, 0.0010 inch may be added to these tolerances. As certain sizes up to 1½ inches are included in the American National coarse or fine thread series, the tolerances to and including 1½ inches correspond to those series.

[2] Standard size screw and nut of the American National coarse thread series.

[3] Standard size screw and nut of the American National fine thread series.

[4] Dimensions given for the maximum minor diameter of the screw are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the screw shall be that corresponding to a flat at the minor diameter of the minimum screw equal to $\frac{1}{8} \times p$, and may be determined by subtracting 0.0541 inch from the minimum pitch diameter of the screw.

[5] Dimensions for the minimum major diameter of the nut correspond to the basic flat, ($\frac{1}{8} \times p$), and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the nut shall be that corresponding to a flat at the major diameter of the maximum nut equal to $\frac{1}{24} \times p$, and may be determined by adding 0.0662 inch to the maximum pitch diameter of the nut.

[6] These dimensions are the minimum metal or "not go" size. The "go" or basic size is the one that should be placed on the component drawing with the tolerance.

TABLE 32.—*Limiting dimensions and tolerances, class 3 fit, American National 16-pitch thread series*

Dimensions and tolerances [1]		Size (inches)									
		¾ [2]	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞
BOLTS AND SCREWS		*In.*	*In.*	*In.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
Major diameter	Max	0.7500	0.8750	1.0000	1.1250	1.2500	1.3750	1.5000	1.6250	1.7500	1.8750
	Min	.7410	.8660	.9910	1.1160	1.2410	1.3660	1.4910	1.6160	1.7410	1.8660
	Tol	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090
Minor diameter	Max.[3]	.6733	.7983	.9233	1.0483	1.1733	1.2983	1.4233	1.5483	1.6733	1.7983
Pitch diameter	Max	.7094	.8344	.9594	1.0844	1.2094	1.3344	1.4594	1.5844	1.7094	1.8344
	Min	.7062	.8308	.9557	1.0806	1.2056	1.3305	1.4554	1.5803	1.7053	1.8302
	Tol	.0032	.0036	.0037	.0038	.0038	.0039	.0040	.0041	.0041	.0042
NUTS AND TAPPED HOLES											
Major diameter	Min.[4]	.7500	.8750	1.0000	1.1250	1.2500	1.3750	1.5000	1.6250	1.7500	1.8750
Minor diameter	Min	.6823	.8073	.9323	1.0573	1.1823	1.3073	1.4323	1.5573	1.6823	1.8073
	Max	.6993	.8141	.9391	1.0641	1.1891	1.3141	1.4391	1.5641	1.6891	1.8141
	Tol	.0080	.0068	.0068	.0068	.0068	.0068	.0068	.0068	.0068	.0068
Pitch diameter	Min	.7094	.8344	.9594	1.0844	1.2094	1.3344	1.4594	1.5844	1.7094	1.8344
	Max	.7126	.8380	.9631	1.0882	1.2132	1.3383	1.4634	1.5885	1.7135	1.8386
	Tol	.0032	.0036	.0037	.0038	.0038	.0039	.0040	.0041	.0041	.0042

Dimensions and tolerances [1]		Size (inches)									
		2	2⅛	2¼	2½	2¾	3	3¼	3½	3¾	4
BOLTS AND SCREWS		*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Major diameter	Max	2.0000	2.1250	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500	4.0000
	Min	1.9910	2.1160	2.2410	2.4910	2.7410	2.9910	3.2410	3.4910	3.7410	3.9910
	Tol	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090
Minor diameter	Max.[3]	1.9233	2.0483	2.1733	2.4233	2.6733	2.9233	3.1733	3.4233	3.6733	3.9233
Pitch diameter	Max	1.9594	2.0844	2.2094	2.4594	2.7094	2.9594	3.2094	3.4594	3.7094	3.9594
	Min	1.9551	2.0801	2.2050	2.4549	2.7048	2.9547	3.2046	3.4545	3.7044	3.9543
	Tol	.0043	.0043	.0044	.0045	.0046	.0047	.0048	.0049	.0050	.0051
NUTS AND TAPPED HOLES											
Major diameter	Min.[4]	2.0000	2.1250	2.2500	2.5000	2.7500	3.0000	3.2500	3.5000	3.7500	4.0000
Minor diameter	Min	1.9323	2.0573	2.1823	2.4323	2.6823	2.9323	3.1823	3.4323	3.6823	3.9323
	Max	1.9391	2.0641	2.1891	2.4391	2.6891	2.9391	3.1891	3.4391	3.6891	3.9391
	Tol	.0068	.0068	.0068	.0068	.0068	.0068	.0068	.0068	.0068	.0068
Pitch diameter	Min	1.9594	2.0844	2.2094	2.4594	2.7094	2.9594	3.2094	3.4594	3.7094	3.9594
	Max	1.9637	2.0887	2.2138	2.4639	2.7140	2.9641	3.2142	3.4643	3.7144	3.9545
	Tol	.0043	.0043	.0044	.0045	.0046	.0047	.0048	.0049	.0050	.0051

[1] Pitch diameter tolerances include errors of lead and angle, and are 70 percent of the tolerances for class 2 based on the formulas in table 60 and a length of engagement of 6 threads or ⅜ inch. The ¾-inch size being in the American National fine-thread series, the tolerance for this size corresponds to that series.

[2] Standard size screw and nut of the American National fine-thread series.

[3] Dimensions given for the maximum minor diameter of the screw are figured to the intersection of the worn-tool arc with a center line through crest and root. The minimum minoı diameter of the screw shall be that corresponding to a flat at the minor diameter of the minimum screw equal to $\frac{1}{8} \times p$, and may be determined by subtracting 0.0406 inch from the minimum pitch diameter of the screw.

[4] Dimensions for the minimum major diameter of the nut correspond to the basic flat ($\frac{1}{8} \times p$) and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the nut shall be that corresponding to a flat at the major diameter of the maximum nut equal to $\frac{1}{24} \times p$, and may be determined by adding 0.0496 inch to the maximum pitch diameter of the nut.

4. GAGES

The specifications for gages given in section III are applicable to the American National 8-, 12-, and 16-pitch thread series. Tolerances on diameter, lead, and angle for classes *W*, *X*, *Y*, and *Z* gages, as specified in section III, are given in table 33.

Each gage shall be marked for identification, with the diameter, pitch, and class of fit as specified in section II, division 3, "Symbols."

TABLE 33.—*Tolerances for thread gages, American National 8-, 12-, and 16-pitch thread series*

Class of gage	Tolerance on pitch diameter [1]		Tolerance on lead [2]	Tolerance on half angle of thread		Tolerance on major or minor diameters [1]	
	From—	To—				From—	To—
	Inch	*Inch*	*Inch*	*Deg.*	*Min.*	*Inch*	*Inch*
8-PITCH							
Class W	0.0000	0.0002	0.00025	0	5	0.0000	0.0007
Class X and "not go"	.0000	.0004	.0004	0	5	.0000	.0007
Class Y	.0002	.0007	.0004	0	5	.0000	.0007
Class Z	.0006	.0013	.0005	0	5	.0000	.0007
12-PITCH							
Class W	0.0000	0.00015	0.0002	0	6	0.0000	0.0006
Class X and "not go"	.0000	.0003	.0003	0	10	.0000	.0006
Class Y	.0002	.0006	.0003	0	10	.0000	.0006
Class Z	.0004	.0011	.0004	0	10	.0000	.0006
16-PITCH							
Class W	0.0000	0.0001	0.00015	0	8	0.0000	0.0006
Class X and "not go"	.0000	.0003	.0003	0	10	.0000	.0006
Class Y	.0002	.0006	.0003	0	15	.0000	.0006
Class Z	.0004	.0010	.0004	0	15	.0000	.0006

[1] On "go" plugs the tolerance is plus, and on "go" rings the tolerance is minus. On "not go" plugs the tolerance is minus, and on "not go" rings the tolerance is plus.
[2] Allowable variation in lead between any 2 threads not farther apart than the standard length of engagement.

SECTION V. SCREW THREADS OF SPECIAL DIAMETERS, PITCHES, AND LENGTHS OF ENGAGEMENT

The tolerances specified in section III of this report apply in general to bolts, nuts, and tapped holes of standard pitches and diameters. They are based on the pitch of the thread and a length of engagement equal to the basic major diameter, but are used for lengths of engagement up to 1½ diameters.

In addition to the foregoing threaded components, there are large quantities of threaded parts produced, such as hub and radiator caps in the automotive industry, threaded collars on machine tools, etc., where the diameters are larger, the pitches finer, and the lengths of engagement shorter than for bolt and nut practice. The following specifications have been adopted for such threaded parts, and the tolerances are based on the diameter, pitch, and length of engagement of the components.

1. FORM OF THREAD

The American National form of thread profile as specified in section III shall be used.

2. THREAD SERIES

In section IV there are given the limiting dimensions for an 8-pitch, a 12-pitch, and a 16-pitch thread series. The use of these series, wherever possible, is recommended for all applications requiring other than American National coarse or fine threads.

Whenever sizes and pitches in the American National coarse or fine, or the 8-, 12-, or 16-pitch thread series are not suitable, it is recommended that one of the following pitches be selected: 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 28, 32, 36, 40, 48, 56, 64 threads per inch. Basic thread data for these pitches are given in table 34.

3. CLASSIFICATION AND TOLERANCES

There are established herein for general use four classes of screw-thread fits, which are named and numbered to correspond to the regular classification of fits given in section III. These four classes, together with the accompanying specifications, are intended to insure a uniform practice for screw threads not included in the American National coarse or fine thread series, nor in the 8-, 12-, or 16-pitch thread series.

TABLE 34.—*Thread data for recommended pitches for special threads*

Threads per inch, *n*	Pitch, *h*	Depth of thread, *p*	Basic width of flat, *p*/8	Minimum width of flat at major diameter of nut, *p*/24
1	2	3	4	5
	Inch	*Inch*	*Inch*	*Inch*
64	0.01562	0.01015	0.00195	0.00065
56	.01786	.01160	.00223	.00074
48	.02083	.01353	.00260	.00087
40	.02500	.01624	.00312	.00104
36	.02778	.01804	.00347	.00116
32	.03125	.02030	.00391	.00130
28	.03571	.02320	.00446	.00149
24	.04167	.02706	.00521	.00174
20	.05000	.03248	.00625	.00208
18	.05556	.03608	.00694	.00231
16	.06250	.04059	.00781	.00260
14	.07143	.04639	.00893	.00298
12	.08333	.05413	.01042	.00347
10	.10000	.06495	.01250	.00417
8	.12500	.08119	.01562	.00521
6	.16667	.10825	.02083	.00694
4	.25000	.16238	.03125	.01042

It is not the intention of the Commission arbitrarily to place a general class or grade of work in a specific class of fit. Each manufacturer and user of screw threads is free to select the class of fit best adapted to his particular needs.

(a) GENERAL SPECIFICATIONS

The following general specifications apply to all classes of fit specified for screw threads of special diameters, pitches, and lengths of engagement.

1. UNIFORM MINIMUM NUT.—The pitch diameter of the minimum threaded hole or nut corresponds to the basic size.[11]

[11] Special cases will arise, however, when a class 1 thread is required on finished drawn tubing with thin walls, and in such cases the allowance should be made on the nut.

2. Tolerances.[12]—(*a*) The tolerances specified represent the extreme variations allowed on the product.

(*b*) The tolerance on the nut is plus, and is applied from the basic size to above basic size.

(*c*) The tolerance on the screw is minus, and is applied from the maximum screw size to below the maximum screw size.

(*d*) The pitch diameter tolerances for a screw and nut of a given class of fit are the same.

(*e*) Pitch diameter tolerances include all errors of pitch diameter, lead, and angle. The full tolerance cannot, therefore, be used on pitch diameter unless the lead and angle of the thread are perfect.

(*f*) The pitch diameter tolerances are obtained by adding three values, or increments; one dependent upon the basic major diameter, another upon the length of engagement, and the third upon the pitch of the thread. These increments are based on formulas given in appendix 1. However, where tolerance values so obtained exceed those given in section III for corresponding pitches of the American National coarse or fine thread series, and for any diameters equal to or less than these standard sizes and lengths of engagement equal to or less than one diameter, the tolerances given in section III are used. (See rules for using tolerance tables on p. 81.)

(*g*) The tolerances on the major diameters of the screws and minor diameters of the nuts are based on the pitch of the thread, as these control the depth of engagement; they are, therefore, based on the pitch alone.

(*h*) The minimum minor diameter of a screw of a given pitch is such as to result in a basic flat ($\frac{1}{8} \times p$) at the root when the pitch diameter of the screw is at its minimum value. When the maximum screw is basic, the minimum minor diameter of the screw will be below the basic minor diameter by the amount of the specified pitch diameter tolerance.

(*i*) The maximum minor diameter of a screw of a given pitch may be such as results from the use of a worn or rounded threading tool, when the pitch diameter is at its maximum value. In no case, however, should the form of the screw, as results from tool wear, be such as to cause the screw to be rejected on the maximum minor diameter by a "go" ring gage, the minor diameter of which is equal to the minimum minor diameter of the nut.

(*j*) The maximum major diameter of the nut of a given pitch is such as to result in a flat equal to one third of the basic flat ($\frac{1}{24} \times p$) when the pitch diameter of the nut is at its maximum value. When the minimum nut is basic, its maximum major diameter will be above the basic major diameter by the amount of the specified pitch diameter tolerance plus two ninths of the basic thread depth.

(*k*) The nominal minimum major diameter of a nut is the basic major diameter. In no case, however, should the minimum major diameter of the nut, as results from a worn tap or cutting tool, be such as to cause the nut to be rejected on the minimum major diameter by a "go" plug gage made to the standard form at the crest.

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[12] Recommendations and explanations regarding the application of tolerances are given in appendix 1, p. 127.

(*l*) The tolerance on minor diameter of a nut of a given pitch is one sixth of the basic thread depth regardless of the class of fit.[13]

(b) CLASSIFICATION OF FITS

1. Class 1, Loose Fit.—This class is intended to cover the manufacture of threaded parts where quick and easy assembly is necessary and a considerable amount of shake or play is not objectionable.

This class is made with an allowance on the screw, so as to permit ready assembly, even when the threads are slightly bruised or dirty, in conformity with the practice in section III.[14]

Tables 35 and 36 give the limiting dimensions and tolerances for major, pitch, and minor diameters of threads of special diameters, pitches, and lengths of engagement.

2. Class 2, Free Fit.—This class is intended to cover the manufacture of threaded parts which are to assemble nearly or entirely with the fingers, and where a slight amount of shake or play between the assembled threaded members is not objectionable. It is the same in every particular as class 1 except that it has no allowance and the tolerances are smaller.

Tables 35 and 37 give the limiting dimensions and tolerances for major, pitch, and minor diameters of threads of special diameters, pitches, and lengths of engagement.

3. Class 3, Medium Fit.—This class is intended to cover the manufacture of the higher grade of threaded parts which are to assemble nearly or entirely with the fingers, and must have the minimum amount of shake or play between the threaded members. It is the same as class 2 in every particular except that the tolerances are smaller.

Tables 35 and 38 give the limiting dimensions and tolerances for major, pitch, and minor diameters of threads of special diameters, pitches, and lengths of engagement.

4. Class 4, Close Fit.—This class is intended to cover the manufacture of threaded parts of the finest commercial quality, where very little shake or play is desirable, and where a screw driver or wrench may be necessary for assembly.

In the manufacture of screw-thread products belonging to this class it may be necessary to use precision tools, gages made to special tolerances for this class (see table 21, p. 58), and other refinements. This quality of work should, therefore, be used only in cases where requirements of the mechanism being produced are exacting. In order to secure the fit desired, it may be necessary in some cases to select the parts when the product is being assembled.

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[13] Special threads having a length of engagement considerably less than one diameter will not develop the full strength of the screw. The minimum minor diameter of the nut of the American National form of thread is such as to provide a minimum clearance on diameter at the minor diameter equal to two ninths of the basic thread depth. If this clearance is reduced by providing a greater percentage of thread depth in the nut, the strength of such a fastening is increased. In such cases when the screw is subject to considerable tension, it is permissible to make the minor diameter of the nut less than the minimum specified in order to give the necessary depth of engagement.

On the other hand, when the length of engagement is exceptionally long the minor diameter of the nut may be greater than the maximum specified without impairing the strength of the fastening.

[14] See footnote 11, p. 77.

The maximum pitch diameters of the screws are slightly larger than the minimum pitch diameters of the nuts determined from table 35.

Tables 35 and 39 give the limiting dimensions and tolerances for major, pitch, and minor diameters, of threads of special diameters, pitches, and lengths of engagement.

4. TABLES OF DIMENSIONS

In order to simplify the specification of dimensions of special fastening screw threads, tables 35, 36, 37, 38, and 39 are arranged herein, and are intended to cover all practical combinations of diameter, pitch, length of engagement, and class of fit. The use of these tables instead of the application of formulas to determine limiting dimensions of a special thread facilitates placing dimensions on drawings. Also, in cases of special threads of the same diameter, pitch, and class of fit, but slightly different lengths of engagement, the threads may be gaged by a single set of gages, as identical pitch diameter tolerances will be applied.

(*a*) Arrangement of Tables.—The arrangement of dimensions and tolerances given in these tables has the following features:

All thread dimensions of threads of special diameters, pitches, and lengths of engagement, except pitch diameter tolerances, are derived from table 35.

Pitch diameter tolerances are taken from tables 36, 37, 38, or 39, depending upon the class of fit required. These pitch diameter tolerances were obtained by adding increments [15] corresponding to the major diameters at the top, the threads per inch at the side of the table, and mean lengths of engagement of ¼, 1, and 2¼ inches for pitches from 64 to 12 threads per inch, inclusive, and ½, 2, and 4½ inches for pitches from 10 to 4 threads per inch, inclusive. Thus, the increments of the pitch diameter tolerances based on length of engagement and on diameter vary by definite steps instead of continuously. However, in order that the tolerances given in these tables might be wholly consistent with those given in section III, certain values as listed are greater or less than those yielded by the above method. This modification was made by inserting in the tables, in the positions corresponding to standard sizes, pitches, and lengths of engagement of the American National coarse-and fine-thread series, the pitch diameter tolerances listed in section III. Then, wherever necessary, all values above and to the left of these inserted values were reduced so that none of them should exceed these standard values, and those below and to the right were increased so that none should be less than the standard values. This has the important advantage that in a series of sizes, frequently occurring in practice, consisting partly of standard sizes and partly of special sizes, there will be no undue irregularity in the progression of the pitch diameter tolerance, with consequent difficulties in securing gages, etc.

[15] The formulas for determining such increments are listed on p. 128.

The maximum pitch diameter tolerances listed are equal to the tolerances on the major diameter of the screws of the same pitch, as given in table 35.

(*b*) Rules for Use of Tables.—For consistent application of these pitch diameter tolerance tables to all cases, adherence to the following rules relative to the use of the tables is necessary:

1. Tolerances on pitch diameter corresponding to major diameters between those for which values are given in the tables shall be those of the next larger diameter.

2. Tolerances on pitch diameter for pitches between those for which values are given in the tables shall be those of the next coarser pitch, except that for screws having 80, 72, 44, 13, 11, 9, 7, 5, or 4½ threads per inch, lengths of engagement of one and one half diameters or less, and diameters less than the standard diameters for the respective pitches as given in section III, the tolerances given in section III shall be used.

3. Tolerances on pitch diameter for pitches coarser than 4 threads per inch shall be the same as those for 4 threads per inch.

4. Tolerances on pitch diameter when the length of engagement is exactly ½, or 1½, inches for 12 threads per inch and finer, or 1, or 3, inches for pitches coarser than 12 threads per inch, shall correspond to the interval of which these are the upper limits.

5. Tolerances on pitch diameter for lengths of engagement greater than those for which values are given shall be the maximum values listed for the pitch concerned.

(*c*) Examples.—The following examples illustrate the use of these tables:

Example: 3¼-inch, 16-thread, class 1, with allowance on screw, one-half inch length of engagement:

From table 36:
 Pitch diameter tolerance .... =0. 0095
Also from table 35, for the screw:
 Maximum major diameter=3. 2500−0. 0018=3. 2482
 Minimum major diameter =3. 2482− . 0126=3. 2356
 Maximum minor diameter =3. 2500− . 0785=3. 1715
 Maximum pitch diameter =3. 2500− . 0424=3. 2076
 Minimum pitch diameter =3. 2076− . 0095=3. 1981
And for the nut:
 Minimum major diameter .... =3. 2500
 Minimum minor diameter =3. 2500− . 0677=3. 1823
 Maximum minor diameter=3. 1823+ . 0068=3. 1891
 Minimum pitch diameter =3. 2500− . 0406=3. 2094
 Maximum pitch diameter =3. 2094+ . 0095=3. 2189

Example: 3-inch, 24-thread, class 2, free fit, five-eighths inch length of engagement:

From table 37:
 Pitch diameter tolerance .... =0. 0066

In this instance the pitch diameter tolerance is printed in italics. In accordance with the footnote under table 35 it is desirable to avoid the use of tolerances set in italics as the combination of class of fit, length of engagement, pitch, and diameter is disproportionate. If it is decided to use a closer fit, class 3-medium fit or class 4-close fit may be chosen. Assuming the choice of class 3-medium fit, the following dimensions are obtained:

From table 38:
Pitch diameter tolerance = 0. 0065
From table 35 for the screw:
Maximum major diameter = 3. 0000
Minimum major diameter = 3. 0000 − 0. 0066 = 2. 9934
Maximum minor diameter = 3. 0000 − . 0511 = 2. 9489
Maximum pitch diameter = 3. 0000 − . 0271 = 2. 9729
Minimum pitch diameter = 2. 9729 − . 0065 = 2. 9664
And for the nut:
Minimum major diameter = 3. 0000
Minimum minor diameter = 3. 0000 − . 0451 = 2. 9549
Maximum minor diameter = 2. 9549 + . 0045 = 2. 9594
Minimum pitch diameter = 3. 0000 − . 0271 = 2. 9729
Maximum pitch diameter = 2. 9729 + . 0065 = 2. 9794

If, instead, it is decided to reduce the length of engagement to one-half inch, the following dimensions are obtained:

From table 37:
Pitch diameter tolerance = 0. 0060
From table 35 for the screw:
Maximum major diameter = 3. 0000
Minimum major diameter = 3. 0000 − 0. 0066 = 2. 9934
Maximum minor diameter = 3. 0000 − 0. 0511 = 2. 9489
Maximum pitch diameter = 3. 0000 − 0. 0271 = 2. 9729
Minimum pitch diameter = 2. 9729 − 0. 0060 = 2. 9669
And for the nut:
Minimum major diameter = 3. 0000
Minimum minor diameter = 3. 0000 − 0. 0451 = 2. 9549
Maximum minor diameter = 2. 9549 + 0. 0045 = 2. 9594
Minimum pitch diameter = 3. 0000 − 0. 0271 = 2. 9729
Maximum pitch diameter = 2. 9729 + 0. 0060 = 2. 9789

5. GAGES

The classification of gages and gage tolerances, as well as the thread form of plug and ring thread gages presented in section III, division 5, "Gages" apply also to gages for special threads. In ordering gages for a special thread, the length of engagement of the component thread (as distinct from the length of the gage), and the diameter, pitch, and class of fit, should be stated.

With regard to the marking of gages, each gage shall be plainly marked, for identification, with the diameter, pitch, thread series—that is, "NS" to indicate a special thread of American National form—and class of fit. See section II, division 3, "Symbols." For example, a 1-inch, 16-pitch gage of American National form of thread, class 3, medium fit, shall be marked: 1″—18NS—3.

TABLE 35.—*Values for obtaining thread dimensions of special screw threads, classes 1, 2, 3, and 4 fits*

SCREW SIZES: To obtain maximum dimensions for major, pitch, and minor diameters, subtract the values in the "maximum" columns from the basic major diameter. Apply tolerances minus. See tables 36, 37, 38, and 39 for pitch diameter tolerances.

NUT SIZES: To obtain minimum dimensions for minor, pitch, and major diameters, subtract the values in the "minimum" columns from the basic major diameter. Apply tolerances plus. See tables 36, 37, 38, and 39 for pitch diameter tolerances.

Threads per inch	Screw sizes: Major diameter				Screw sizes: Pitch diameter, maximum			Screw sizes: Minor diameter,[1] maximum		Nut sizes: Minor diameter		Nut sizes: Pitch diameter, minimum	Nut sizes: Major diameter,[2] minimum
	Maximum		Tolerance							Minimum	Tolerance		
	Class 1	Classes 2, 3, 4	Class 1	Classes 2, 3, 4	Class 1	Classes 2, 3	Class 4	Class 1	Classes 2, 3, 4	Classes 1, 2, 3, and 4			
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
64	0.0007	0.0000	0.0052	0.0038	0.0108	0.0101	0.0100	0.0199	0.0192	0.0169	0.0017	0.0101	0.0000
56	.0008	.0000	.0056	.0040	.0124	.0116	.0114	.0227	.0219	.0193	.0019	.0116	.0000
48	.0009	.0000	.0062	.0044	.0144	.0135	.0133	.0265	.0256	.0226	.0023	.0135	.0000
40	.0010	.0000	.0068	.0048	.0172	.0162	.0160	.0317	.0307	.0271	.0027	.0162	.0000
36	.0011	.0000	.0072	.0050	.0191	.0180	.0178	.0352	.0341	.0301	.0030	.0180	.0000
32	.0011	.0000	.0076	.0054	.0214	.0203	.0201	.0394	.0383	.0338	.0034	.0203	.0000
28	.0012	.0000	.0086	.0062	.0244	.0232	.0230	.0450	.0438	.0387	.0039	.0232	.0000
24	.0013	.0000	.0092	.0066	.0284	.0271	.0268	.0524	.0511	.0451	.0045	.0271	.0000
20	.0015	.0000	.0102	.0072	.0340	.0325	.0322	.0628	.0613	.0541	.0054	.0325	.0000
18	.0016	.0000	.0114	.0082	.0377	.0361	.0358	.0698	.0682	.0601	.0060	.0361	.0000
16	.0018	.0000	.0126	.0090	.0424	.0406	.0402	.0785	.0767	.0677	.0068	.0406	.0000
14	.0021	.0000	.0140	.0098	.0485	.0464	.0460	.0897	.0876	.0773	.0077	.0464	.0000
12	.0024	.0000	.0158	.0112	.0565	.0541	.0536	.1046	.1022	.0902	.0090	.0541	.0000
10	.0028	.0000	.0184	.0128	.0678	.0650	.0644	.1255	.1227	.1083	.0109	.0650	.0000
8	.0034	.0000	.0222	.0152	.0846	.0812	.0805	.1568	.1534	.1353	.0135	.0812	.0000
6	.0044	.0000	.0290	.0202	.1127	.1083	.1074	.2089	.2045	.1804	.0180	.1083	.0000
4	.0064	.0000	.0408	.0280	.1688	.1624	.1611	.3131	.3067	.2706	.0270	.1624	.0000

[1] Dimensions given for the maximum minor diameter of the screw are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the screw shall be that corresponding to a flat at the minor diameter of the minimum screw equal to $\frac{1}{8} \times p$, and may be determined by subtracting the basic thread depth, h (or $0.6495p$) from the minimum pitch diameter of the screw.

[2] Dimensions for the minimum major diameter of the nut correspond to the basic flat ($\frac{1}{8} \times p$), and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the nut shall be that corresponding to a flat at the major diameter of the maximum nut equal to $\frac{1}{24} \times p$, and may be determined by adding $1\frac{2}{9} \times h$ (or $0.7939p$) to the maximum pitch diameter of the nut.

Table 36.—*Pitch diameter tolerances for special screw threads, class 1, loose fit*

Threads per inch	Lengths of engagement: From—	Lengths of engagement: To and including—	Pitch diameter tolerances for diameters up to and including—: 1/16 inch	1/8 inch	3/16 inch	1/4 inch	3/8 inch	1/2 inch	3/4 inch	1 inch	1 1/2 inches	2 inches	3 inches	4 inches	6 inches	8 inches	10 inches	12 inches	14 inches	16 inches	18 inches	20 inches	24 inches
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
64	------	½	0.0026	0.0026	0.0034	0.0038	0.0042	0.0044	0.0047	0.0050	0.0052	------	------	------	------	------	------	------	------	------	------	------	------
56	------	½	.0028	.0028	.0034	.0038	.0044	.0046	.0049	.0052	.0056	------	------	------	------	------	------	------	------	------	------	------	------
	½	1½	.0052	.0054	.0055	.0056	*.0056*	*.0056*	*.0056*	*.0056*	*.0056*	------	------	------	------	------	------	------	------	------	------	------	------
48	------	½	.0031	.0031	.0034	.0038	.0046	.0048	.0051	.0054	.0058	0.0062	------	------	------	------	------	------	------	------	------	------	------
	½	1½	.0054	.0056	.0057	.0057	.0057	.0057	.0057	.0062	*.0062*	*.0062*	------	------	------	------	------	------	------	------	------	------	------
40	------	½	.0034	[1].0034	.0034	.0038	.0046	.0051	.0054	.0057	.0061	.0065	------	------	------	------	------	------	------	------	------	------	------
	½	1½	.0057	.0057	.0057	.0057	.0057	.0057	.0057	.0068	*.0068*	*.0068*	------	------	------	------	------	------	------	------	------	------	------
36	------	½	------	.0036	.0036	.0038	.0046	.0051	.0056	.0058	.0063	.0067	0.0072	------	------	------	------	------	------	------	------	------	------
	½	1½	------	.0057	.0057	.0057	.0057	.0057	.0057	.0070	.0072	*.0072*	*.0072*	------	------	------	------	------	------	------	------	------	------
32	------	½	------	.0038	.0038	.0038	.0046	.0051	.0057	.0060	.0065	.0069	.0075	------	------	------	------	------	------	------	------	------	------
	½	1½	------	.0057	.0057	.0057	.0057	.0057	.0057	.0070	.0076	*.0076*	*.0076*	------	------	------	------	------	------	------	------	------	------
28	------	½	------	------	.0043	[2].0043	.0046	.0051	.0057	.0063	.0067	.0071	.0077	0.0083	------	------	------	------	------	------	------	------	------
	½	1½	------	------	.0057	.0057	.0057	.0057	.0057	.0070	.0079	.0086	*.0086*	*.0086*	------	------	------	------	------	------	------	------	------
24	------	½	------	------	.0046	.0046	[2].0046	.0051	.0057	.0066	.0070	.0074	.0080	.0086	------	------	------	------	------	------	------	------	------
	½	1½	------	------	.0057	.0057	.0057	.0057	.0057	.0070	.0079	.0089	.0092	*.0092*	------	------	------	------	------	------	------	------	------
20	------	½	------	------	.0051	[1].0051	.0051	[2].0051	.0057	.0070	.0074	.0078	.0084	.0090	0.0099	------	------	------	------	------	------	------	------
	½	1½	------	------	.0057	.0057	.0057	.0057	.0057	.0070	.0079	.0093	.0099	.0102	*.0102*	------	------	------	------	------	------	------	------
	1½	3	------	------	.0098	.0100	.0102	*.0102*	*.0102*	*.0102*	*.0102*	*.0102*	*.0102*	*.0102*	*.0102*	------	------	------	------	------	------	------	------

18	------	1/2	------	------	------	.0057	.0057	.0057	.0057	.0070	.0077	.0080	.0087	.0092	.0101	0.0109	0.0114	------	------	------	------	------	------
	1/2	1 1/2	------	------	------	.0057	.0057	.0057	.0057	.0070	.0079	.0095	.0102	.0107	.0114	*.0114*	*.0114*	------	------	------	------	------	------
	1 1/2	3	------	------	------	.0102	.0104	.0106	.0109	.0112	.0114	*.0114*	*.0114*	*.0114*	*.0114*	*.0114*	*.0114*	------	------	------	------	------	------
16	------	1/2	------	------	------	.0063	[1].0063	.0063	.0063	.0070	.0079	.0083	.0090	.0095	.0104	.0112	.0118	0.0124	------	------	------	------	------
	1/2	1 1/2	------	------	------	.0063	.0063	.0063	[2].0063	.0070	.0079	.0098	.0105	.0110	.0119	.0126	*.0126*	*.0126*	------	------	------	------	------
	1 1/2	3	------	------	------	.0105	.0107	.0109	.0112	.0115	.0120	.0123	.0126	*.0126*	*.0126*	*.0126*	*.0126*	*.0126*	------	------	------	------	------
14	------	1/2	------	------	------	------	.0070	.0070	.0070	.0070	.0079	.0087	.0093	.0099	.0108	.0115	.0122	.0128	0.0133	0.0138	------	------	------
	1/2	1 1/2	------	------	------	------	.0070	.0070	.0070	[2].0070	.0079	.0102	.0108	.0114	.0123	.0130	.0137	.0140	*.0140*	*.0140*	------	------	------
	1 1/2	3	------	------	------	------	.0111	.0113	.0116	.0119	.0123	.0127	.0133	.0139	.0140	*.0140*	*.0140*	*.0140*	*.0140*	*.0140*	------	------	------
12	------	1/2	------	------	------	------	.0075	.0077	.0079	.0079	.0079	.0091	.0097	.0103	.0112	.0119	.0126	.0132	.0138	.0143	0.0148	0.0152	------
	1/2	1 1/2	------	------	------	------	.0079	.0079	.0079	.0079	[2].0079	.0106	.0112	.0118	.0127	.0134	.0141	.0147	.0153	.0158	*.0158*	*.0158*	------
	1 1/2	3	------	------	------	------	.0115	.0117	.0120	.0123	.0127	.0131	.0137	.0143	.0152	.0158	*.0158*	*.0158*	*.0158*	*.0158*	*.0158*	*.0158*	------
10	------	1	------	------	------	------	------	.0087	[1].0092	.0098	.0102	.0106	.0112	.0118	.0127	.0134	.0141	.0147	.0153	.0158	.0158	.0163	.0171
	1	3	------	------	------	------	------	.0117	.0120	.0123	.0128	.0132	.0138	.0143	.0152	.0160	.0166	.0172	.0178	.0183	*.0184*	*.0184*	*.0184*
	3	6	------	------	------	------	------	.0167	.0171	.0173	.0178	.0181	.0184	*.0184*	*.0184*	*.0184*	*.0184*	*.0184*	*.0184*	*.0184*	*.0184*	*.0184*	*.0184*
8	------	1	------	------	------	------	------	.0095	.0098	[1].0111	.0111	.0111	.0115	.0121	.0130	.0137	.0144	.0150	.0156	.0161	.0166	.0170	.0179
	1	3	------	------	------	------	------	.0125	.0128	.0131	.0135	.0139	.0145	.0151	.0160	.0167	.0174	.0180	.0186	.0191	.0196	.0200	.0209
	3	6	------	------	------	------	------	.0175	.0178	.0181	.0185	.0189	.0195	.0201	.0210	.0217	.0222	*.0222*	*.0222*	*.0222*	*.0222*	*.0222*	*.0222*
6	------	1	------	------	------	------	------	------	.0109	.0112	.0116	.0120	.0126	.0132	.0141	.0148	.0155	.0161	.0166	.0172	.0176	.0181	.0190
	1	3	------	------	------	------	------	------	.0139	.0142	[1].0145	.0150	.0156	.0162	.0171	.0178	.0185	.0191	.0196	.0202	.0206	.0211	.0220
	3	6	------	------	------	------	------	------	.0189	.0192	.0196	.0200	.0206	.0212	.0221	.0228	.0235	.0241	.0246	.0252	.0256	.0261	.0270
4	------	1	------	------	------	------	------	------	------	.0130	.0134	.0138	.0145	.0150	.0159	.0167	.0173	.0179	.0185	.0190	.0195	.0199	.0208
	1	3	------	------	------	------	------	------	------	.0160	.0164	.0168	[1].0204	.0204	.0204	.0204	.0204	.0209	.0215	.0220	.0225	.0229	.0238
	3	6	------	------	------	------	------	------	------	.0210	.0215	.0218	.0225	.0230	.0239	.0247	.0253	.0259	.0265	.0270	.0275	.0279	.0288

[1] Standard size of the American National coarse-thread series. [2] Standard size of the American National fine-thread series.

NOTE.—It is preferable to avoid the use of tolerances set in italics by choosing a closer fit, shorter length of engagement, coarser pitch, or smaller diameter.

TABLE 37.—*Pitch diameter tolerances for special screw threads, class 2, free fit*

Threads per inch	Lengths of engagement		Pitch diameter tolerances for diameters up to and including—																				
	From—	To and including—	1/16 inch	1/8 inch	3/16 inch	1/4 inch	3/8 inch	1/2 inch	3/4 inch	1 inch	1½ inches	2 inches	3 inches	4 inches	6 inches	8 inches	10 inches	12 inches	14 inches	16 inches	18 inches	20 inches	24 inches
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
64	------	½	0.0019	0.0019	0.0024	0.0027	0.0030	0.0032	0.0035	0.0038	------	------	------	------	------	------	------	------	------	------	------	------	------
56	------	½	.0020	.0020	.0024	.0027	.0031	.0033	.0036	.0038	0.0040	------	------	------	------	------	------	------	------	------	------	------	------
	½	1½	.0038	.0040	*.0040*	*.0040*	*.0040*	*.0040*	*.0040*	*.0040*	*.0040*	------	------	------	------	------	------	------	------	------	------	------	------
48	------	½	.0022	.0022	.0024	.0027	.0032	.0034	.0037	.0039	.0044	------	------	------	------	------	------	------	------	------	------	------	------
	½	1½	.0039	.0041	.0041	.0041	.0041	.0041	.0041	.0044	*.0044*	------	------	------	------	------	------	------	------	------	------	------	------
40	------	½	.0024	[1] .0024	.0024	.0027	.0033	.0035	.0038	.0041	.0045	0.0048	------	------	------	------	------	------	------	------	------	------	------
	½	1½	.0041	.0041	.0041	.0041	.0041	.0041	.0041	.0048	*.0048*	*.0048*	------	------	------	------	------	------	------	------	------	------	------
36	------	½	------	.0025	.0025	.0027	.0033	.0036	.0039	.0042	.0046	.0050	------	------	------	------	------	------	------	------	------	------	------
	½	1½	------	.0041	.0041	.0041	.0041	.0041	.0041	.0049	.0050	*.0050*	------	------	------	------	------	------	------	------	------	------	------
32	------	½	------	.0027	.0027	.0027	.0033	.0036	.0040	.0043	.0047	.0051	0.0054	------	------	------	------	------	------	------	------	------	------
	½	1½	------	.0041	.0041	.0041	.0041	.0041	.0041	.0049	.0054	*.0054*	*.0054*	------	------	------	------	------	------	------	------	------	------
28	------	½	------	------	.0031	[2] .0031	.0033	.0036	.0041	.0044	.0048	.0052	.0058	0.0062	------	------	------	------	------	------	------	------	------
	½	1½	------	------	.0041	.0041	.0041	.0041	.0041	.0049	.0056	.0062	*.0062*	*.0062*	------	------	------	------	------	------	------	------	------
24	------	½	------	------	.0033	.0033	[2] .0033	.0036	.0041	.0045	.0050	.0054	.0060	.0065	------	------	------	------	------	------	------	------	------
	½	1½	------	------	.0041	.0041	.0041	.0041	.0041	.0049	.0056	.0066	*.0066*	*.0066*	------	------	------	------	------	------	------	------	------
20	------	½	------	------	.0036	[1] .0036	.0036	[2] .0036	.0041	.0047	.0052	.0056	.0062	.0067	0.0072	------	------	------	------	------	------	------	------
	½	1½	------	------	.0041	.0041	.0041	.0041	.0041	.0049	.0056	.0071	.0072	*.0072*	*.0072*	------	------	------	------	------	------	------	------
18	------	½	------	------	------	.0039	.0041	.0041	.0041	.0049	.0053	.0057	.0063	.0069	.0078	0.0082	------	------	------	------	------	------	------
	½	1½	------	------	------	.0041	.0041	.0041	.0041	.0049	.0056	.0072	.0078	.0082	*.0082*	*.0082*	------	------	------	------	------	------	------
	1½	3	------	------	------	.0079	.0081	.0082	*.0082*	*.0082*	*.0082*	*.0082*	*.0082*	*.0082*	*.0082*	*.0082*	------	------	------	------	------	------	------
16	------	½	------	------	------	.0040	[1] .0045	.0045	.0045	.0049	.0054	.0058	.0065	.0070	.0079	.0087	0.0090	------	------	------	------	------	------
	½	1½	------	------	------	.0045	.0045	.0045	[2] .0045	.0049	.0056	.0073	.0080	.0085	.0090	*.0090*	*.0090*	------	------	------	------	------	------
	1½	3	------	------	------	.0080	.0082	.0084	.0087	.0090	*.0090*	*.0090*	*.0090*	*.0090*	*.0090*	*.0090*	*.0090*	------	------	------	------	------	------
14	------	½	------	------	------	------	.0045	.0048	.0049	.0049	.0056	.0060	.0066	.0072	.0081	.0088	.0095	0.0098	------	------	------	------	------
	½	1½	------	------	------	------	.0049	.0049	.0049	[2] .0049	.0056	.0075	.0081	.0087	.0096	.0098	*.0098*	*.0098*	------	------	------	------	------
	1½	3	------	------	------	------	.0084	.0086	.0089	.0092	.0096	.0098	*.0098*	*.0098*	*.0098*	*.0098*	*.0098*	*.0098*	------	------	------	------	------

12	------	½	------	------	------	------	.0046	.0048	.0051	.0054	.0056	.0062	.0068	.0074	.0083	.0090	.0097	.0103	0.0109	0.0112	------	------	------
	½	1½	------	------	------	------	.0056	.0056	.0056	.0056	[2].0056	.0077	.0083	.0089	.0098	.0105	.0112	*.0112*	*.0112*	*.0112*	------	------	------
	1½	3	------	------	------	------	.0086	.0088	.0091	.0094	.0098	.0100	.0108	.0112	*.0112*	*.0112*	*.0112*	*.0112*	*.0112*	*.0112*	------	------	------
10	------	1	------	------	------	------	------	.0056	[1].0064	.0069	.0073	.0077	.0083	.0089	.0098	.0105	.0112	.0112	.0116	.0122	0.0126	0.0128	------
	1	3	------	------	------	------	------	.0088	.0091	.0094	.0098	.0100	.0108	.0112	.0121	.0128	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	------
	3	6	------	------	------	------	------	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	------
8	------	1	------	------	------	------	------	.0060	.0064	[1].0076	.0076	.0077	.0083	.0089	.0098	.0105	.0112	.0115	.0120	.0125	.0130	.0135	0.0143
	1	3	------	------	------	------	------	.0090	.0093	.0095	.0100	.0104	.0110	.0115	.0124	.0132	.0139	.0145	.0150	.0152	*.0152*	*.0152*	*.0152*
	3	6	------	------	------	------	------	.0140	.0143	.0145	.0150	.0152	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*
6	------	1	------	------	------	------	------	------	.0068	.0071	.0075	.0079	.0085	.0091	.0100	.0107	.0114	.0120	.0126	.0131	.0136	.0140	.0149
	1	3	------	------	------	------	------	------	.0098	.0101	[1].0101	.0109	.0115	.0121	.0130	.0137	.0144	.0150	.0156	.0161	.0166	.0170	.0179
	3	6	------	------	------	------	------	------	.0148	.0151	.0155	.0159	.0165	.0171	.0180	.0187	.0194	.0200	.0202	*.0202*	*.0202*	*.0202*	*.0202*
4	------	1	------	------	------	------	------	------	------	.0080	.0084	.0088	.0095	.0100	.0109	.0117	.0123	.0129	.0135	.0140	.0145	.0149	.0158
	1	3	------	------	------	------	------	------	------	.0110	.0114	.0118	[1].0140	.0140	.0140	.0147	.0153	.0159	.0165	.0170	.0175	.0179	.0188
	3	6	------	------	------	------	------	------	------	.0160	.0164	.0168	.0175	.0180	.0189	.0197	.0203	.0209	.0215	.0220	.0225	.0229	.0238

[1] Standard size of the American National coarse-thread series.

[2] Standard size of the American National fine-thread series.

NOTE.—It is preferable to avoid the use of tolerances set in italics by choosing a closer fit, shorter length of engagement, coarser pitch, or smaller diameter.

Table 38.—*Pitch diameter tolerances for special screw threads, class 3, medium fit*

Threads per inch	Lengths of engagement		Pitch diameter tolerances for diameters up to and including—																				
	From—	To and including—	1/16 inch	1/8 inch	3/16 inch	1/4 inch	3/8 inch	1/2 inch	3/4 inch	1 inch	1½ inches	2 inches	3 inches	4 inches	6 inches	8 inches	10 inches	12 inches	14 inches	16 inches	18 inches	20 inches	24 inches
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
64		½	0.0014	0.0014	0.0017	0.0019	0.0023	0.0025	0.0028	0.0031	0.0036	0.0038											
	½	1½	.0030	.0030	.0030	.0030	.0030	.0030	.0030	.0036	.0038	*.0038*											
56		½	.0015	.0015	.0017	.0019	.0024	.0026	.0029	.0032	.0036	.0040											
	½	1½	.0030	.0030	.0030	.0030	.0030	.0030	.0030	.0036	.0040	*.0040*											
48		½	.0016	.0016	.0017	.0019	.0024	.0026	.0029	.0032	.0037	.0041	0.0044										
	½	1½	.0030	.0030	.0030	.0030	.0030	.0030	.0030	.0036	.0040	.0044	*.0044*										
40		½	.0017	[1].0017	.0017	.0019	.0024	.0026	.0030	.0033	.0037	.0041	.0048										
	½	1½	.0030	.0030	.0030	.0030	.0030	.0030	.0030	.0036	.0040	.0048	*.0048*										
36		½		.0018	.0018	.0019	.0224	.0026	.0030	.0033	.0038	.0042	.0048	0.0050									
	½	1½		.0030	.0030	.0030	.0030	.0030	.0030	.0036	.0040	.0050	*.0050*	*.0050*									
32		½		.0019	.0019	.0019	.0024	.0026	.0030	.0034	.0038	.0042	.0048	.0054									
	½	1½		.0030	.0030	.0030	.0030	.0030	.0030	.0036	.0040	.0054	*.0054*	*.0054*									
28		½			.0022	[2].0022	.0024	.0026	.0030	.0034	.0039	.0043	.0049	.0054	0.0062								
	½	1½			.0030	.0030	.0030	.0030	.0030	.0036	.0040	.0058	.0062	*.0062*	*.0062*								
24		½			.0024	.0024	[2].0024	.0026	.0030	.0035	.0040	.0044	.0050	.0055	.0064								
	½	1½			.0030	.0030	.0030	.0030	.0030	.0036	.0040	.0059	.0065	.0066	*.0066*								
20		½			.0025	[1].0026	.0026	[2].0026	.0030	.0036	.0040	.0045	.0051	.0056	.0065	0.0072							
	½	1½			.0030	.0030	.0030	.0030	.0030	.0036	.0040	.0060	.0066	.0071	.0072	*.0072*							
	1½	3			.0065	.0066	.0068	.0070	.0071	*.0071*	*.0071*	*.0072*	*.0072*	*.0072*	*.0072*	*.0072*							
18		½				.0027	.0030	.0030	.0030	.0036	.0040	.0045	.0051	.0057	.0066	.0073	0.0080						
	½	1½				.0030	.0030	.0030	.0030	.0036	.0040	.0060	.0066	.0072	.0081	.0082	*.0082*						
	1½	3				.0067	.0069	.0071	.0071	.0071	.0071	.0082	*.0082*	*.0082*	*.0082*	*.0082*	*.0082*						
16		½				.0028	[1].0032	.0032	.0032	.0036	.0040	.0046	.0052	.0058	.0066	.0074	.0081	0.0087					
	½	1½				.0032	.0032	.0032	[2].0032	.0036	.0040	.0061	.0067	.0073	.0081	.0089	.0090	*.0090*					
	1½	3				.0068	.0070	.0071	.0071	.0071	.0071	.0084	.0090	*.0090*	*.0090*	*.0090*	*.0090*	*.0090*					

14	------	½	------	------	------	------	.0032	.0036	.0036	.0036	.0040	.0047	.0053	.0058	.0067	.0075	.0082	.0088	0.0093	0.0098	------	------	------
	½	1½	------	------	------	------	.0036	.0036	.0036	[2].0036	.0040	.0062	.0068	.0073	.0082	.0090	.0097	.0098	*.0098*	*.0098*	------	------	------
	1½	3	------	------	------	------	.0071	.0071	.0071	.0071	.0071	.0084	.0092	.0098	*.0098*	*.0098*	*.0098*	*.0098*	*.0098*	*.0098*	------	------	------
12	------	½	------	------	------	------	.0032	.0036	.0040	.0040	.0040	.0048	.0054	.0059	.0068	.0076	.0083	.0089	.0094	.0099	0.0104	0.0109	------
	½	1½	------	------	------	------	.0040	.0040	.0040	.0040	[2].0040	.0063	.0069	.0074	.0083	.0091	.0098	.0104	.0109	.0112	*.0112*	*.0112*	------
	1½	3	------	------	------	------	.0071	.0071	.0071	.0071	.0071	.0084	.0092	.0099	.0108	.0112	*.0112*	*.0112*	*.0112*	*.0112*	*.0112*	*.0112*	------
10	------	1	------	------	------	------	------	.0040	[1].0045	.0054	.0059	.0063	.0069	.0074	.0083	.0091	.0098	.0104	.0109	.0112	.0112	.0115	0.0124
	1	3	------	------	------	------	------	.0071	.0071	.0071	.0071	.0084	.0092	.0099	.0108	.0112	.0119	.0125	.0128	*.0128*	*.0128*	*.0128*	*.0128*
	3	6	------	------	------	------	------	.0120	.0123	.0126	.0128	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*	*.0128*
8	------	1	------	------	------	------	------	.0042	.0045	[1].0054	.0059	.0063	.0069	.0074	.0083	.0091	.0098	.0104	.0109	.0112	.0113	.0117	.0126
	1	3	------	------	------	------	------	.0071	.0071	.0071	.0071	.0086	.0092	.0099	.0108	.0114	.0121	.0127	.0132	.0138	.0143	.0147	.0152
	3	6	------	------	------	------	------	.0128	.0125	.0128	.0132	.0136	.0142	.0148	.0152	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*
6	------	1	------	------	------	------	------	------	.0048	.0054	.0059	.0063	.0069	.0074	.0083	.0091	.0098	.0104	.0109	.0112	.0115	.0120	.0128
	1	3	------	------	------	------	------	------	.0071	.0071	[1].0071	.0089	.0095	.0100	.0109	.0117	.0124	.0130	.0135	.0140	.0145	.0150	.0158
	3	6	------	------	------	------	------	------	.0122	.0130	.0135	.0139	.0145	.0150	.0159	.0167	.0174	.0180	.0185	.0190	.0195	.0200	.0202
4	------	1	------	------	------	------	------	------	------	.0055	.0059	.0063	.0070	.0075	.0084	.0092	.0098	.0104	.0110	.0115	.0120	.0124	.0133
	1	3	------	------	------	------	------	------	------	.0085	.0089	.0093	[1].0097	.0105	.0114	.0122	.0128	.0134	.0140	.0145	.0150	.0154	.0163
	3	6	------	------	------	------	------	------	------	.0135	.0139	.0143	.0150	.0155	.0164	.0172	.0178	.0184	.0190	.0195	.0200	.0204	.0213

[1] Standard size of the American National coarse-thread series.

[2] Standard size of the American National fine-thread series.

NOTE.—It is preferable to avoid the use of tolerances set in italics by choosing a closer fit, shorter length of engagement, coarser pitch, or smaller diameter.

TABLE 39.—*Pitch diameter tolerances for special screw threads, class 4, close fit*

Threads per inch	Lengths of engagement		Pitch diameter tolerances for diameters up to and including—																	
	From—	To and including—	¼ inch	⅜ inch	½ inch	¾ inch	1 inch	1½ inches	2 inches	3 inches	4 inches	6 inches	8 inches	10 inches	12 inches	14 inches	16 inches	18 inches	20 inches	24 inches
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
28	-------	½	[1]0.0011	0.0012	0.0013	0.0015	0.0017	0.0019	0.0021	0.0024	0.0027	0.0032	0.0036	0.0039	0.0042	0.0045	0.0047	0.0050	0.0052	0.0056
	½	1½	.0015	.0015	.0015	.0015	.0018	.0020	.0029	.0032	.0035	.0039	.0043	.0046	.0049	.0052	.0055	.0057	.0059	.0062
	1½	3	.0032	.0033	.0034	.0036	.0036	.0036	.0041	.0044	.0047	.0052	.0056	.0059	.0062	*.0062*	*.0062*	*.0062*	*.0062*	*.0062*
24	-------	½	.0012	[1].0012	.0013	.0015	.0018	.0020	.0022	.0025	.0028	.0032	.0036	.0039	.0042	.0045	.0048	.0050	.0052	.0057
	½	1½	.0015	.0015	.0015	.0015	.0018	.0020	.0029	.0032	.0035	.0040	.0043	.0047	.0050	.0052	.0055	.0057	.0060	.0064
	1½	3	.0033	.0034	.0035	.0036	.0036	.0036	.0042	.0045	.0048	.0052	.0056	.0059	.0062	.0065	.0066	*.0066*	*.0066*	*.0066*
20	-------	½	[2].0013	.0013	[1].0013	.0015	.0018	.0020	.0022	.0025	.0028	.0033	.0036	.0040	.0043	.0046	.0048	.0050	.0053	.0057
	½	1½	.0015	.0015	.0015	.0015	.0018	.0020	.0030	.0033	.0036	.0040	.0044	.0047	.0050	.0053	.0056	.0058	.0060	.0065
	1½	3	.0033	.0034	.0035	.0036	.0036	.0036	.0042	.0045	.0048	.0053	.0056	.0060	.0063	.0066	.0068	.0070	.0072	.0072
18	-------	½	.0013	.0015	.0015	.0015	.0018	.0020	.0023	.0026	.0028	.0033	.0037	.0040	.0043	.0046	.0048	.0051	.0053	.0057
	½	1½	.0015	.0015	.0015	.0015	.0018	.0020	.0030	.0033	.0036	.0040	.0044	.0047	.0050	.0053	.0056	.0058	.0061	.0065
	1½	3	.0033	.0034	.0035	.0036	.0036	.0036	.0042	.0046	.0048	.0053	.0057	.0060	.0063	.0066	.0068	.0071	.0073	.0077
16	-------	½	.0014	[2].0016	.0016	.0016	.0018	.0020	.0023	.0026	.0029	.0033	.0037	.0040	.0043	.0046	.0049	.0051	.0053	.0058
	½	1½	.0016	.0016	.0016	[1].0016	.0018	.0020	.0030	.0033	.0036	.0041	.0044	.0048	.0051	.0054	.0056	.0059	.0061	.0065
	1½	3	.0034	.0035	.0036	.0036	.0036	.0036	.0042	.0046	.0049	.0053	.0057	.0060	.0063	.0066	.0069	.0071	.0073	.0078
14	-------	½	-------	.0016	.0018	.0018	.0018	.0020	.0023	.0026	.0029	.0034	.0038	.0041	.0044	.0047	.0049	.0052	.0054	.0058
	½	1½	-------	.0018	.0018	.0018	[1].0018	.0020	.0031	.0034	.0037	.0041	.0045	.0048	.0051	.0054	.0057	.0059	.0061	.0066
	1½	3	-------	.0035	.0036	.0036	.0036	.0036	.0042	.0046	.0049	.0054	.0058	.0061	.0064	.0067	.0069	.0072	.0074	.0078
12	-------	½	-------	.0016	.0018	.0020	.0020	.0020	.0024	.0027	.0030	.0034	.0038	.0041	.0044	.0047	.0050	.0052	.0054	.0059
	½	1½	-------	.0020	.0020	.0020	.0020	[1].0020	.0031	.0034	.0037	.0042	.0046	.0049	.0052	.0055	.0057	.0060	.0062	.0066
	1½	3	-------	.0036	.0036	.0036	.0036	.0036	.0042	.0046	.0050	.0054	.0058	.0061	.0064	.0067	.0070	.0072	.0074	.0079
10	-------	1	-------	-------	.0020	[2].0023	.0023	.0023	.0031	.0034	.0037	.0042	.0046	.0049	.0052	.0055	.0057	.0060	.0062	.0066
	1	3	-------	-------	.0036	.0036	.0036	.0036	.0042	.0046	.0050	.0054	.0058	.0061	.0064	.0067	.0070	.0072	.0074	.0079
	3	6	-------	-------	.0060	.0062	.0063	.0065	.0067	.0070	.0073	.0077	.0081	.0084	.0088	.0090	.0093	.0095	.0098	.0102
8	-------	1	-------	-------	.0021	.0023	[2].0027	.0027	.0031	.0034	.0037	.0042	.0046	.0049	.0052	.0055	.0057	.0060	.0062	.0066
	1	3	-------	-------	.0036	.0036	.0036	.0036	.0043	.0046	.0050	.0054	.0058	.0061	.0064	.0067	.0070	.0072	.0074	.0079
	3	6	-------	-------	.0061	.0062	.0064	.0066	.0068	.0071	.0074	.0078	.0082	.0085	.0088	.0091	.0094	.0096	.0099	.0103
6	-------	1	-------	-------	-------	.0024	.0027	.0027	.0031	.0034	.0037	.0042	.0046	.0049	.0052	.0055	.0057	.0060	.0062	.0066
	1	3	-------	-------	-------	.0036	.0036	[2].0036	.0044	.0047	.0050	.0055	.0058	.0062	.0065	.0068	.0070	.0073	.0075	.0079
	3	6	-------	-------	-------	.0064	.0065	.0067	.0069	.0072	.0075	.0080	.0083	.0087	.0090	.0093	.0095	.0098	.0100	.0104
4	-------	1	-------	-------	-------	-------	.0028	.0030	.0032	.0035	.0038	.0042	.0046	.0049	.0052	.0055	.0058	.0060	.0062	.0066
	1	3	-------	-------	-------	-------	.0043	.0045	.0047	[2].0048	.0053	.0057	.0061	.0064	.0067	.0070	.0073	.0075	.0077	.0082
	3	6	-------	-------	-------	-------	.0068	.0070	.0072	.0075	.0078	.0082	.0086	.0089	.0092	.0095	.0098	.0100	.0102	.0106

[1] Standard size of the American National fine-thread series.

[2] Standard size of the American National coarse-thread series.

NOTE.—It is preferable to avoid the use of tolerances set in italics by choosing a shorter length of engagement, coarser pitch, or smaller diameter.

SECTION VI. AMERICAN NATIONAL HOSE-COUPLING AND FIRE-HOSE COUPLING THREADS

Several years ago specifications for American National standard fire-hose coupling threads were approved by the National Board of Fire Underwriters, National Fire Protection Association, American Society of Mechanical Engineers, American Society of Municipal Improvements, New England Water Works Association, American Water Works Association, the Bureau of Standards, and other interested organizations. These specifications were published in 1911 as the Specifications of the National Board of Fire Underwriters, recommended by the National Fire Protection Association and approved by the various other organizations. They were also published in 1914 as Circular No. 50 of the Bureau of Standards. This circular was revised and republished in 1917.

When the National Screw Thread Commission took up its work on the standardization of screw threads, the specifications for fire-hose coupling threads above referred to were accepted as the basis of its work on fire-hose coupling threads. It was found, however, that the specifications as originally drawn were inadequate in that they specified nominal dimensions only, with no maximum and minimum limits. The limiting dimensions herein specified have met with general approval, including adoption as "American" standards by the American Standards Association. State-wide adoption of the American National fire-hose coupling threads is completed or under effective headway in 36 States, and their use has been made compulsory by State legislative acts in California, Massachusetts, Oregon, and Texas.

With regard to the American National hose-coupling threads, the purpose of this specification is to provide a standard which will be recognized and adopted at once by a majority of manufacturers and consumers and toward which the minority may be brought, thus eliminating many threads now in use and the confusion and misunderstandings that now prevail.

As in other lines of work, current practice in use and manufacture must be recognized as well as the specific advantages of certain thread proportions for specific uses. This prevents the adoption of a single specification for each one of the nominal sizes.

These standards apply to the threaded parts of hose couplings, valves, nozzles, and all other fittings used in direct connection with hose intended for fire protection or for domestic, industrial, and general service in nominal sizes of ½, ⅝, ¾, 1, 1¼, 1½, and 2 inches.

In ordering threading tools [16] for producing American National hose-coupling and fire-hose coupling threads, it should be pointed out that new taps should be near the maximum permissible size of the coupling, and new dies near the minimum permissible size of the nipple, in order that reasonable wear may be provided. As the threading tools wear by use, the couplings will become smaller and the nipples larger

[16] In the interest of the universal adoption of the American National fire-hose threads throughout the United States, attention is directed to the fact that sets of tools for rethreading existing hydrants and hose couplings are commercially available. Such sets comprise roughing and finishing taps, roughing and finishing dies, expanders for expanding undersize externally threaded fittings preparatory to rethreading, gages, and various accessories. The tools are applicable where existing threaded fittings do not differ so widely from the American National standards as to leave insufficient stock for the new thread. By the use of such tools a considerable number of municipalities have at small expense converted their existing equipment, and thus availed themselves of the important advantages which standardization affords.

until the limiting dimensions are reached. These must not be exceeded. When the product reaches, or comes dangerously close to the limiting size, the threading tools should be readjusted or replaced.

1. FORM OF THREAD

1. Angle of Thread.—The basic angle of thread (A) between the sides 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. Flat at Crest and Root.—The flat at the root and crest of the basic thread form is $\frac{1}{8} \times p$, or $0.125 \times p$.

3. Depth of Thread.—The depth of the basic thread form is

$$h = 0.649519 \times p, \text{ or } h = \frac{0.649519}{n}$$

where

p = pitch in inches
n = number of threads per inch
h = basic depth of thread

2. THREAD SERIES

(*a*) American National Hose-Coupling Threads.—There are specified in table 40 a thread series and basic dimensions for hose-coupling threads which apply to the threaded parts of hose couplings, valves, nozzles, and all other fittings used in direct connection with hose intended for fire protection or for domestic, industrial, and general service in nominal sizes of ½, ⅝, ¾, 1, 1¼, 1½, and 2 inches.

Table 40.—*American National hose-coupling threads*

Nominal size of hose (in inches)	Service	Number of threads per inch	Pitch	Depth of thread	Major diameter	Pitch diameter	Minor diameter	Allowance
1	2	3	4	5	6	7	8	9
	BASIC MINIMUM COUPLING DIMENSIONS							
			Inch	*Inch*	*Inches*	*Inches*	*Inches*	*Inch*
½, ⅝, ¾	Garden hose	11½	0.08696	0.05648	1.0725	1.0160	0.9595	------
¾, 1	Chemical engine and booster hose	8	.12500	.08119	1.3870	1.3058	1.2246	------
1½	Fire-protection hose	9	.11111	.07217	2.0020	1.9298	1.8577	------
½	Steam, air, water, and all other hose connections.	14	.07143	.04639	.8323	.7859	.7395	------
¾		14	.07143	.04639	1.0428	.9964	.9500	------
1		11½	.08696	.05648	1.3051	1.2486	1.1921	------
1¼		11½	.08696	.05648	1.6499	1.5934	1.5369	------
1½		11½	.08696	.05648	1.8888	1.8323	1.7758	------
2		11½	.08696	.05648	2.3628	2.3063	2.2498	------
	BASIC MAXIMUM NIPPLE DIMENSIONS							
½, ⅝, ¾	Garden hose	11½	0.08696	0.05648	1.0625	1.0060	0.9495	0.0100
¾, 1	Chemical-engine and booster hose	8	.12500	.08119	1.3750	1.2938	1.2126	.0120
1½	Fire-protection hose	9	.11111	.07217	1.9900	1.9178	1.8457	.0120
½	Steam, air, water, and all other hose connections.	14	.07143	.04639	.8248	.7784	.7320	.0075
¾		14	.07143	.04639	1.0353	.9889	.9425	.0075
1		11½	.08696	.05648	1.2951	1.2386	1.1821	.0100
1¼		11½	.08696	.05648	1.6399	1.5834	1.5269	.0100
1½		11½	.08696	.05648	1.8788	1.8223	1.7658	.0100
2		11½	.08696	.05648	2.3528	2.2963	2.2398	.0100

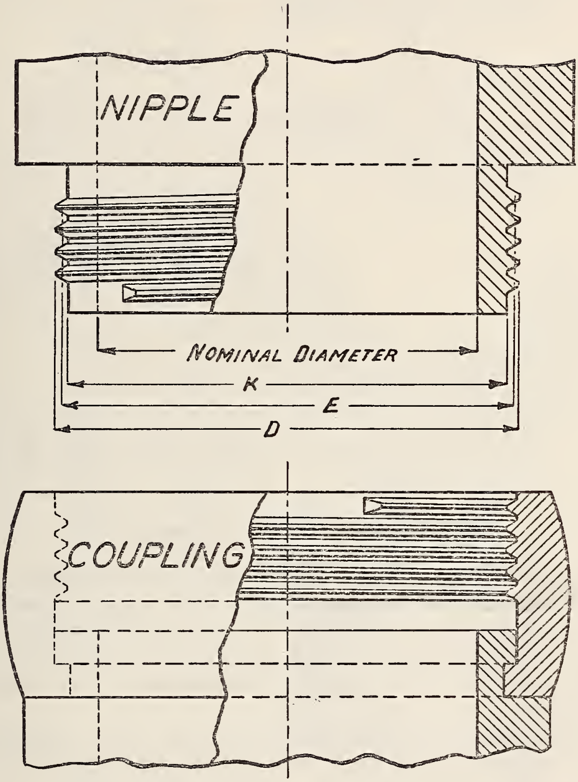


Figure 19.—*American National hose-coupling and American National fire-hose coupling threads.*

See tables 42, 43, 44, and 45 for dimensions and tolerances.

(*b*) American National Fire-Hose Coupling Threads.—There are specified in table 41 a thread series and basic dimensions for fire-hose couplings from 2½ to 4½ inches in diameter which will be known as the "American National fire-hose threads." These basic sizes and dimensions correspond in all details to those recommended by the National Fire Protection Association and by the Bureau of Standards.

The American National fire-hose coupling thread is recommended for use on all couplings and hydrant connections for fire-protection systems, and for all other purposes where hose couplings and connections are required in sizes between 2½ and 4½ inches in diameter.

Table 41.—*American National fire-hose coupling threads*

BASIC MINIMUM COUPLING DIMENSIONS

Nominal size of hose (in inches)	Number of threads per inch	Pitch	Depth of thread	Major diameter	Pitch diameter	Minor diameter	Allowance
1	2	3	4	5	6	7	8
		Inch	*Inch*	*Inches*	*Inches*	*Inches*	*Inch*
2½	7½	0.13333	0.08660	3.0836	2.9970	2.9104	-------
3	6	.16667	.10825	3.6389	3.5306	3.4223	-------
3½	6	.16667	.10825	4.2639	4.1556	4.0473	-------
4½	4	.25000	.16238	5.7859	5.6235	5.4611	-------

BASIC MAXIMUM NIPPLE DIMENSIONS

Nominal size of hose (in inches)	Number of threads per inch	Pitch	Depth of thread	Major diameter	Pitch diameter	Minor diameter	Allowance
2½	7½	0.13333	0.08660	3.0686	2.9820	2.8954	0.0150
3	6	.16667	.10825	3.6239	3.5156	3.4073	.0150
3½	6	.16667	.10825	4.2439	4.1356	4.0273	.0200
4½	4	.25000	.16238	5.7609	5.5985	5.4361	.0250

3. ALLOWANCES AND TOLERANCES

(*a*) Specified allowances and tolerances, given in table 42, apply to American National hose coupling and American National fire-hose coupling threads. The tolerances represent extreme variations permitted on the product. There are shown, in figure 20, the relations between nipple and coupling dimensions and thread form as specified herein.

(*b*) The tolerance on the coupling is plus, and is applied from the minimum coupling dimension to above the minimum coupling dimension.

(*c*) The tolerance on the nipple is minus, and is applied from the maximum nipple dimension to below the maximum nipple dimension.

(*d*) The pitch diameter tolerances provided for a mating nipple and coupling are the same.

(*e*) Pitch diameter tolerances include lead and angle variations. (See footnote 1, table 42.)

(*f*) The tolerance on the major diameter is twice the tolerance on the pitch diameter.

(*g*) The tolerance on the minor diameter of the nipple is equal to the tolerance on pitch diameter plus two ninths of the basic thread depth. The minimum minor diameter of a nipple is such as to result in a flat equal to one third of the basic flat ($\frac{1}{24} \times p$) at the root when the pitch diameter of the nipple is at its minimum value. The maximum minor diameter is basic, but may be such as results from the use of a worn or rounded threading tool.

(*h*) The tolerance on major diameter of the coupling is equal to the tolerance on pitch diameter plus two ninths of the basic thread depth. The minimum major diameter of the coupling is such as to result in a basic flat ($\frac{1}{8} \times p$) when the pitch diameter of the coupling

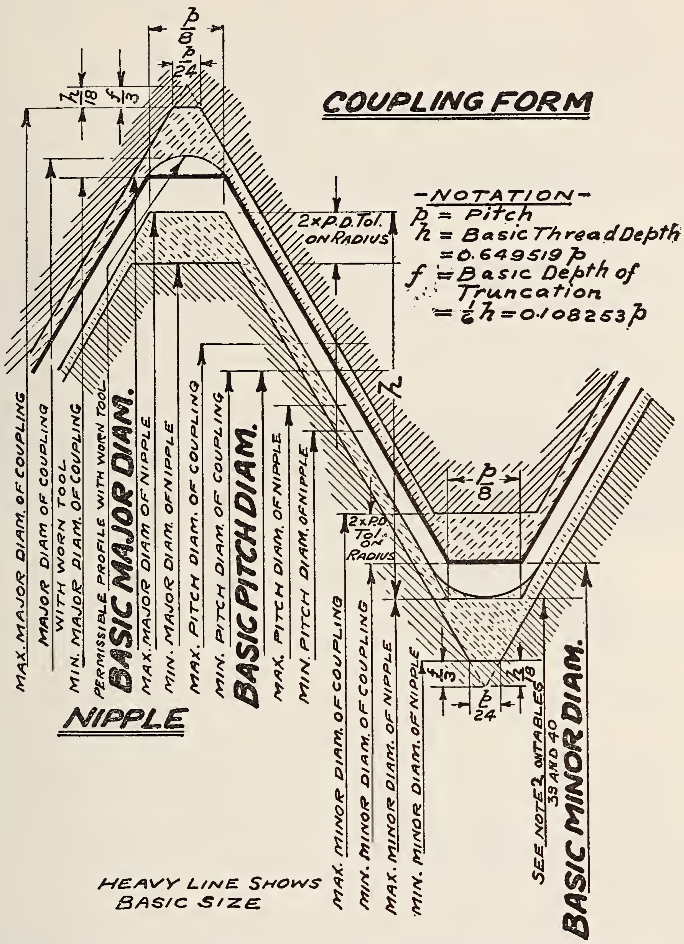


FIGURE 20.—*American National hose-coupling and American National fire-hose coupling threads.*

is at its minimum value. The maximum major diameter of the coupling is that corresponding to a flat equal to one third the basic flat ($\frac{1}{24} \times p$).

(*i*) The tolerance on the minor diameter of the coupling is twice the tolerance on pitch diameter of the coupling. The minimum minor diameter of a coupling is such as to result in a basic flat ($\frac{1}{8} \times p$) at the crest when the pitch diameter of the coupling is at its minimum value.

TABLE 42.—*Tolerances and allowances for American National hose coupling and American National fire-hose coupling threads*

Nominal size of hose (in inches)	Service	Threads per inch	Allowances	Tolerances on pitch diameter [1]	Lead errors consuming one half of pitch-diameter tolerances [2]	Errors in half angle consuming one half of pitch-diameter tolerances	
1	2	3	4	5	6	7	
			Inch	*Inch*	*Inch*	*Deg.*	*Min.*
½, ⅝, ¾	Garden hose	11½	0.0100	0.0085	0.0025	1	52
¾, 1	Chemical engine and booster hose.	8	.0120	.0111	.0032	1	42
1½	Fire protection hose	9	.0120	.0111	.0032	1	54
½	Steam, air, water, and all other hose connections.	14	.0075	.0070	.0020	1	52
¾	Steam, air, water, and all other hose connections.	14	.0075	.0070	.0020	1	52
1	Steam, air, water, and all other hose connections.	11½	.0100	.0085	.0025	1	52
1¼	Steam, air, water, and all other hose connections.	11½	.0100	.0085	.0025	1	52
1½	Steam, air, water, and all other hose connections.	11½	.0100	.0085	.0025	1	52
2	Steam, air, water, and all other hose connections.	11½	.0100	.0085	.0025	1	52
2½	Fire hose	7½	.0150	.0160	.0046	2	17
3	Fire hose	6	.0150	.0180	.0052	2	4
3½	Fire hose	6	.0200	.0180	.0052	2	4
4½	Fire hose	4	.0250	.0250	.0072	1	55

[1] The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance cannot, therefore, be used on pitch diameter unless the lead and angle of the thread are perfect. Columns 6 and 7 give, for information, the errors in lead (per length of thread engaged) and in angle, each of which can be compensated for by half the tolerance on the pitch diameter given in column 5. If lead and angle errors both exist to the amount tabulated, the pitch diameter of a nipple, for example, must be reduced by the full tolerance or it will not enter the "go" gage.

[2] Between any two threads not farther apart than the length of engagement.

4. TABLES OF LIMITING DIMENSIONS

TABLE 43.—*Limiting dimensions and tolerances, American National hose coupling threads*

COUPLING THREAD

Nominal size of hose (in inches)	Service	Threads per inch	Pitch	Depth of thread	Major diameter			Pitch diameter			Minor diameter		
					Maximum	Tolerance	Minimum	Maximum	Tolerance	Minimum	Maximum	Tolerance	Minimum
1	2	3	4	5	6	7	8	9	10	11	12	13	14
			Inch	*Inch*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
½, ⅝, ¾	Garden hose	11½	0.08696	0.05648			[1] 1.0725	1.0245	0.0085	1.0160	0.9765	0.0170	0.9595
¾, 1	Chemical engine and booster hose.	8	.12500	.08119			[1] 1.3870	1.3169	.0111	1.3058	1.2468	.0222	1.2246
1½	Fire protection hose.	9	.11111	.07217			[1] 2.0020	1.9409	.0111	1.9298	1.8799	.0222	1.8577
½	Steam, air, water and all other hose connections.	14	.07143	.04639			[1] .8323	.7929	.0070	.7859	.7535	.0140	.7395
¾	Steam, air, water and all other hose connections.	14	.07143	.04639			[1] 1.0428	1.0034	.0070	.9964	.9640	.0140	.9500
1	Steam, air, water and all other hose connections.	11½	.08696	.05648			[1] 1.3051	1.2571	.0085	1.2486	1.2091	.0170	1.1921
1¼	Steam, air, water and all other hose connections.	11½	.08696	.05648			[1] 1.6499	1.6019	.0085	1.5934	1.5539	.0170	1.5369
1½	Steam, air, water and all other hose connections.	11½	.08696	.05648			[1] 1.8888	1.8408	.0085	1.8323	1.7928	.0170	1.7758
2	Steam, air, water and all other hose connections.	11½	.08696	.05648			[1] 2.3628	2.3148	.0085	2.3063	2.2668	.0170	2.2498

[1] Dimensions for the minimum major diameter of the coupling correspond to the basic flat ($\frac{1}{8}\times p$), and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the coupling shall be that corresponding to a flat at the major diameter of the maximum coupling equal to $\frac{1}{24}\times p$, and may be determined by adding $1\frac{2}{9}\times h$ (or $0.7939p$) to the maximum pitch diameter of the coupling.

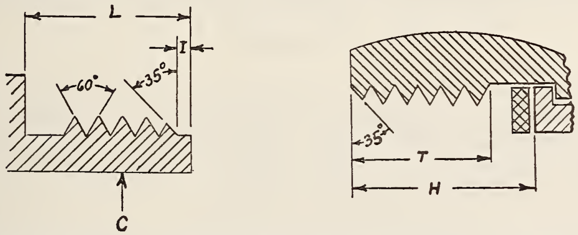
TABLE 43.—*Limiting dimensions and tolerances, American National hose coupling threads*—Continued

NIPPLE THREAD

Nominal size of hose (in inches)	Service	Threads per inch	Pitch	Depth of thread	Major diameter: Maximum	Major diameter: Talerance	Major diameter: Minimum	Pitch diameter: Maximum	Pitch diameter: Tolerance	Pitch diameter: Minimum	Minor diameter: Maximum	Minor diameter: Tolerance	Minor diameter: Minimum
1	2	3	4	5	6	7	8	9	10	11	12	13	14
			Inch	*Inch*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
½, ⅝, ¾	Garden hose	11½	0.08696	0.05648	1.0625	0.0170	1.0455	1.0060	0.0085	0.9975	[2] 0.9495	------	------
¾, 1	Chemical engine and booster hose.	8	.12500	.08119	1.3750	.0222	1.3528	1.2938	.0111	1.2827	[2] 1.2126	------	------
1½	Fire protection hose.	9	.11111	.07217	1.9900	.0222	1.9678	1.9178	.0111	1.9067	[2] 1.8457	------	------
½	Steam, air, water and all other hose connections.	14	.07143	.04639	.8248	.0140	.8108	.7784	.0070	.7714	[2] .7320	------	------
¾		14	.07143	.04639	1.0353	.0140	1.0213	.9889	.0070	.9819	[2] .9425	------	------
1		11½	.08696	.05648	1.2951	.0170	1.2781	1.2386	.0085	1.2301	[2] 1.1821	------	------
1½		11½	.08696	.05648	1.6399	.0170	1.6229	1.5834	.0085	1.5749	[2] 1.5269	------	------
1½		11½	.08696	.05648	1.8788	.0170	1.8618	1.8223	.0085	1.8138	[2] 1.7658	------	------
2		11½	.08696	.05648	2.3528	.0170	2.3358	2.2963	.0085	2.2878	[2] 2.2398	------	------

[2] Dimensions given for the maximum minor diameter of the nipple are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the nipple shall be that corresponding to a flat at the minor diameter of the minimum nipple equal to $\frac{1}{24} \times p$, and may be determined by subtracting $1\frac{3}{8} \times h$ (or $0.7939p$) from the minimum pitch diameter of the nipple.

TABLE 44.—*Lengths of threads for American National hose-coupling threads*



Nominal size of hose (in inches)	Service	Threads per inch, *n*	Length of nipple, *L*	Depth of coupling, *H*	Thread length for coupling, *T*	Length of pilot, *I*	Inside diameter of nipple, *C*	Approximate number of threads in length *T*
			Inch	*Inch*	*Inch*	*Inch*	*Inches*	
½, ⅝, ¾	Garden hose	11½	9/16	17/32	⅜	⅛	25/32	4¼
¾, 1	Chemical engine and booster hose.	8	⅝	19/32	15/32	5/32	1 1/32	3¾
1½	Fire protection hose	9	⅝	19/32	15/32	5/32	1 17/32	4¼
½	Steam, air, water, and all other hose connections.	14	½	15/32	5/16	⅛	17/32	4¼
¾		14	9/16	17/32	⅜	⅛	25/32	5¼
1		11½	9/16	17/32	⅜	5/32	1 1/32	4¼
1¼		11½	⅝	19/32	15/32	5/32	1 9/32	5½
1½		11½	⅝	19/32	15/32	5/32	1 17/32	5½
2		11½	¾	23/32	19/32	3/16	2 1/32	6¾

Table 45.—*Limiting dimensions and tolerances, American National fire-hose coupling threads*

COUPLING THREAD

Nominal size of hose (in inches)	Threads per inch	Pitch	Depth of thread	Major diameter			Pitch diameter			Minor diameter		
				Maximum	Tolerance	Minimum	Maximum	Tolerance	Minimum	Maximum	Tolerance	Minimum
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inch	*Inch*	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*	*Inches*
2½	7½	0. 13333	0. 08660	-------	-------	[1] 3. 0836	3. 0130	0. 0160	2. 9970	2. 9424	0. 0320	2. 9104
3	6	. 16667	. 10825+	-------	-------	[1] 3. 6389	3. 5486	. 0180	3. 5306	3. 4583	. 0360	3. 4223
3½	6	. 16667	. 10825+	-------	-------	[1] 4. 2639	4. 1736	. 0180	4. 1556	4. 0833	. 0360	4. 0473
4½	4	. 25000	. 16238	-------	-------	[1] 5. 7859	5. 6485	. 0250	5. 6235	5. 5111	. 0500	5. 4611

NIPPLE THREAD

2½	7½	0. 13333	0. 08660	3. 0686	0. 0320	3. 0366	2. 9820	0. 0160	2. 9660	[2] 2. 8954	-------	-------
3	6	. 16667	. 10825+	3. 6239	. 0360	3. 5879	3. 5156	. 0180	3. 4976	[2] 3. 4073	-------	-------
3½	6	16667	. 10825+	4. 2439	. 0360	4. 2079	4. 1356	. 0180	4. 1176	[2] 4. 0273	-------	-------
4½	4	. 25000	. 16238	5. 7609	. 0500	5. 7109	5. 5985	. 0250	5. 5735	[2] 5. 4361	-------	-------

[1] Dimensions for the minimum major diameter of the coupling correspond to the basic flat ($\frac{1}{8}\times p$), and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the coupling shall be that corresponding to a flat at the major diameter of the maximum coupling equal to $\frac{1}{24}\times p$, and may be determined by adding $1\frac{1}{9}\times h$ (or $0.7939p$) to the maximum pitch diameter of the coupling.

[2] Dimensions given for the maximum minor diameter of the nipple are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the nippl shall be that corresponding to a flat at the minor diameter of the minimum nipple equal to $\frac{1}{24}\times p$, and may be determined by subtracting $1\frac{1}{9}\times h$ (or $0.7939p$) from the minimum pitch diameter of the nipplee

5. GAGES

(*a*) Gages for American National Fire-Hose Coupling Threads.—It is recommended that American National fire-hose coupling threads be inspected in the field by means of gages made within the tolerances given in table 46. Limiting dimensions for these gages are given in tables 47 and 48.

It is further recommended that American National fire-hose coupling threads be given final inspection by the manufacturer by means of gages made within the limiting dimensions given in tables 47 and 48, by whatever amount may be desired, in order to avoid, as far as possible, disagreements which might otherwise arise as the result of slight differences in the sizes of gages.

Table 46.—*Tolerances on gages for American National fire-hose coupling threads*

Allowable variation in lead between any two threads not farther apart than length of engagement	Allowable variation in one half angle of thread	Tolerance on diameter of minimum thread gage	Tolerance on diameter of maximum thread gage
1	2	3	4
Inch	*Deg. Min.*	*Inch*	*Inch*
±0. 0005	±0 10	{ −0. 000 +. 001	+0. 000 −. 001

TABLE 47.—*Limiting dimensions of field inspection thread plug gages for couplings (internal threads)* [1]

Nominal size of hose	Threads per inch	"Go" or minimum gage				"Not go" or maximum gage			
		Major diameter		Pitch diameter		Major diameter		Pitch diameter	
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
1	2	3	4	5	6	7	8	9	10
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
2.500	7½	3. 0846	3. 0836	2. 9980	2. 9970	3. 0836	3. 0826	3. 0130	3. 0120
3.000	6	3. 6399	3. 6389	3. 5316	3. 5306	3. 6389	3. 6379	3. 5486	3. 5476
3.500	6	4. 2649	4. 2639	4. 1566	4. 1556	4. 2639	4. 2629	4. 1736	4. 1726
4.500	4	5. 7869	5. 7859	5. 6245	5. 6235	5. 7859	5. 7849	5. 6485	5. 6475

[1] The minor diameters of plug gages and the major diameters of ring gages are undercut beyond the nominal diameters to give a clearance for grinding or lapping. The allowable variation in lead between any two threads not farther apart than the length of engagement is ±0.0005 inch. The allowable variation in one half angle of thread is ±10 minutes.

TABLE 48.—*Limiting dimensions of field inspection thread ring gages for coupling nipples (external threads)* [1]

Nominal size of hose	Threads per inch	"Go" or maximum gage				"Not go" or minimum gage			
		Pitch diameter		Minor diameter		Pitch diameter		Minor diameter	
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
1	2	3	4	5	6	7	8	9	10
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
2.500	7½	2. 9820	2. 9810	2. 9104	2. 9094	2. 9670	2. 9660	2. 9114	2. 9104
3.000	6	3. 5156	3. 5146	3. 4223	3. 4213	3. 4986	3. 4976	3. 4233	3. 4223
3.500	6	4. 1356	4. 1346	4. 0473	4. 0463	4. 1186	4. 1176	4. 0483	4. 0473
4.500	4	5. 5985	5. 5975	5. 4611	5. 4601	5. 5745	5. 5735	5. 4621	5. 4611

[1] The minor diameters of plug gages and the major diameters of ring gages are undercut beyond the nominal diameters to give clearance for grinding or lapping. The allowable variation in lead between any two threads not farther apart than the length of engagement is ±0.0005 inch. The allowable variation in one half angle of thread is ±10 minutes.

SECTION VII. AMERICAN NATIONAL PIPE THREADS

The material on the subject of pipe threads presented herewith is essentially the same as that in the report prepared by a special committee of the Committee of Manufacturers on Standardization of Fittings and Valves, acting in cooperation with pipe and gage manufacturers and the A.S.M.E. Committee on International Standards for Pipe Threads. It was published in October 1919, under the title "Manual on American Standard Pipe Threads." It has been endorsed by the American Society of Mechanical Engineers and the American Gas Association, and is adopted by the commission with only such changes as are necessary to bring it into conformity with the remainder of the report. The material on gages for pipe threads has, however, been extensively revised.

The American National pipe-thread standard for taper threaded pipe joints was formulated prior to the year 1882 by Robert Briggs, of Philadelphia, Pa. This standard, with certain modifications and additions, is now in general use throughout the United States and Canada.

1. FORM OF THREAD

(*a*) SPECIFICATIONS.—*1. Angle of thread.*—The angle between the sides of the thread is 60° when measured in an axial plane, and the line bisecting this angle is perpendicular to the axis of the pipe for either taper or straight threads.

2. Depth of thread.[17]—The crest and root of the thread form are truncated an amount equal to $0.0330p$; the depth of thread is, therefore, equal to $0.8p$.

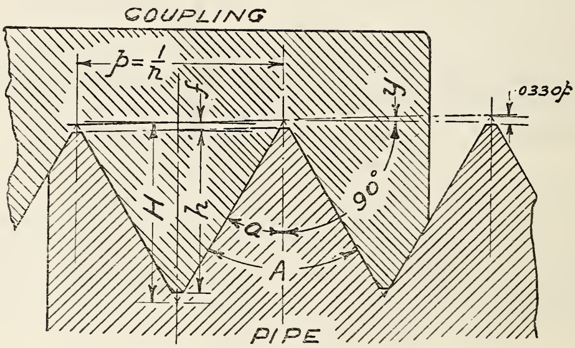


FIGURE 21.—*American National taper pipe thread form and notation.*

NOTATION

$A = 60°$ angle of thread
$a = 30°$ one half angle of thread
$y = 1° 47'$ approx. taper angle = one sixteenth inch per inch on diameter
$H = 0.866025p$ depth of 60° sharp V thread [18]
$h \begin{cases} = 0.800000p \\ = 0.923761H \end{cases}$ depth of thread on work
$f \begin{cases} = 0.033012p \\ = 0.038120H \\ = 0.041266h \end{cases}$ depth of truncation
$p = 1/n$ pitch (measured parallel to axis)
n = number of threads per inch

3. Taper of thread.—The taper of the thread is 1 in 16, or three fourths inch per foot, measured on the diameter.

(*b*) ILLUSTRATION.—There are shown in figure 21 the relations as specified herein for form of thread, and general notation. Special notation is given in figures 22, 23, and 25.

[17] While Mr. Briggs originally advocated a slightly rounded crest and root, cutting tools are actually slightly flattened at the crest and root.

[18] For a symmetrical straight screw thread, $H = \frac{p}{2} \cot a$. For a symmetrical taper screw thread $H = \frac{p}{2} (\cot a - \tan^2 y \tan a)$, so that the exact value for an American National taper pipe thread is $H = 0.865743p$ as against $H = 0.866025p$, the value given above. For an 8-pitch thread, which is the coarsest standard taper pipe thread pitch, the corresponding values of H are 0.108218 inch and 0.108253 inch, respectively, the difference being 0.000035 inch. This difference being too small to be significant, the value of $H = 0.866025p$ continues in use for threads of three fourths inch, or less, taper per foot.

2. SYMBOLS

The list of symbols given in section II, 3, together with additional symbols given below, should be used in formulas for expressing relations of pipe threads, on drawings, etc.

Pitch diameter of thread at end of pipe	E_0
Pitch diameter of thread at gaging notch	E_1
Pitch diameter of thread at L_2 from end of pipe	E_2
Maximum pitch diameter, external locknut thread	E_e
Minimum pitch diameter, internal locknut thread	E_i
Distance from gaging notch to end of pipe=normal engagement by hand	L_1
Length of effective thread	L_2
Outside diameter of pipe=major diameter of pipe thread at L_2 from end of pipe	D
Internal diameter of pipe	d

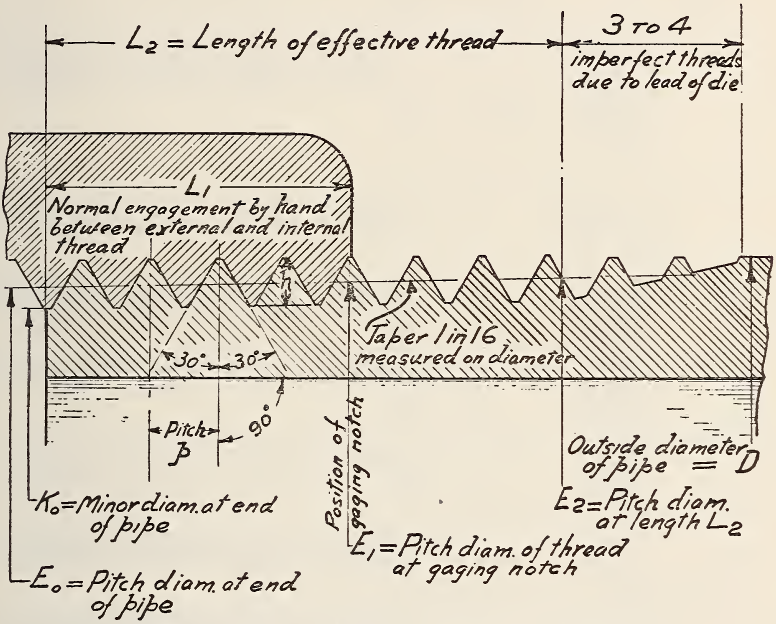


FIGURE 22.—*American National taper pipe thread notation.*

NOTATION

$E_0 = D-(0.05D+1.1)p$
$E_1 = E_0+0.0625L_1$
$L_2 = p\ (0.8D+6.8)$
$h = 0.8p$

3. THREAD SERIES

(*a*) AMERICAN NATIONAL TAPER PIPE THREADS.—Taper external and internal pipe threads are recommended for threaded pipe joints and pipe fittings for any service. The sizes and basic dimensions of the "American National taper pipe threads" are specified in table 49.

1. *Outside diameter of pipe.*—The outside diameters of pipe are given in column 5 of table 49.

2. *Diameters of taper threads.*—The pitch diameters of the taper threads are determined by formulas based on the outside diameter

Table 49.—*Dimensions of American National taper pipe threads*

[For notation, see fig. 22]

Nominal size of pipe in inches	Number of threads per inch, n	Pitch, p	Depth of thread, h	Outside diameter of pipe, D	Length of normal engagement by hand, L_1	Length of effective thread, L_2	Increase in diameter per thread, $\frac{0.0625}{n}$	Pitch diameters: At end of pipe, or at length L_1 from end of coupling, $E_0=D-\frac{0.05D+1.1}{n}$ — Basic	Pitch diameters: At length L_1 on pipe, or at end of coupling, $E_1=E_0+\frac{L_1}{16}$ — Maximum	Basic	Minimum	Basic minor diameter at small end of pipe,[1] K_0
1	2	3	4	5	6	7	8	9	10	11	12	13
		Inch	*Inch*	*Inches*	*Inches*	*Inches*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
⅛	27	0.03704	0.02963	0.405	0.180	0.26385	0.00231	0.36351	0.37823	0.37476	0.37129	0.33388
¼	18	.05556	.04444	.540	.200	.40178	.00347	.47739	.49510	.48989	.48468	.43294
⅜	18	.05556	.04444	.675	.240	.40778	.00347	.61201	.63222	.62701	.62181	.56757
½	14	.07143	.05714	.840	.320	.53371	.00446	.75843	.78513	.77843	.77173	.70129
¾	14	.07143	.05714	1.050	.339	.54571	.00446	.96768	.99556	.98887	.98217	.91054
1	11½	.08696	.06957	1.315	.400	.68278	.00543	1.21363	1.24678	1.23863	1.23048	1.14407
1¼	11½	.08696	.06957	1.660	.420	.70678	.00543	1.55713	1.59153	1.58338	1.57523	1.48757
1½	11½	.08696	.06957	1.900	.420	.72348	.00543	1.79609	1.83049	1.82234	1.81418	1.72652
2	11½	.08696	.06957	2.375	.436	.75652	.00543	2.26902	2.30442	2.29627	2.28812	2.19946
2½	8	.12500	.10000	2.875	.682	1.13750	.00781	2.71953	2.77388	2.76216	2.75044	2.61953
3	8	.12500	.10000	3.500	.766	1.20000	.00781	3.34062	3.40022	3.38850	3.37678	3.24063
3½	8	.12500	.10000	4.000	.821	1.25000	.00781	3.83750	3.90053	3.88881	3.87709	3.73750
4	8	.12500	.10000	4.500	.844	1.30000	.00781	4.33438	4.39884	4.38712	4.37541	4.23438
4½	8	.12500	.10000	5.000	.875	1.35000	.00781	4.83125	4.89766	4.88594	4.87422	4.73125
5	8	.12500	.10000	5.563	.937	1.40630	.00781	5.39073	5.46101	5.44929	5.43757	5.29073
6	8	.12500	.10000	6.625	.958	1.51250	.00781	6.44609	6.51769	6.50597	6.49425	6.34609
7	8	.12500	.10000	7.625	1.000	1.61250	.00781	7.43984	7.51406	7.50234	7.49062	7.33984
8	8	.12500	.10000	8.625	1.063	1.71250	.00781	8.43359	8.51175	8.50003	8.48831	8.33359
9	8	.12500	.10000	9.625	1.130	1.81250	.00781	9.42734	9.50969	9.49797	9.48625	9.32734
10		.12500	.10000	10.750	1.210	1.92500	.00781	10.54531	10.63266	10.62094	10.60922	10.44531

11	8	0.12500	0.10000	11.750	1.285	2.02500	0.00781	11.53906	11.63109	11.61938	11.60766	11.43906
12	8	.12500	.10000	12.750	1.360	2.12500	.00781	12.53281	12.62953	12.61781	12.60609	12.43281
14 O.D	8	.12500	.10000	14.000	1.562	2.25000	.00781	13.77500	13.88434	13.87262	13.86091	13.67500
15 O.D	8	.12500	.10000	15.000	1.687	2.35000	.00781	14.76875	14.88591	14.87419	14.86247	14.66875
16 O.D	8	.12500	.10000	16.000	1.812	2.45000	.00781	15.76250	15.88747	15.87575	15.86403	15.66250
17 O.D	8	.12500	.10000	17.000	1.900	2.55000	.00781	16.75625	16.88672	16.87500	16.86328	16.65625
18 O.D	8	.12500	.10000	18.000	2.000	2.65000	.00781	17.75000	17.88672	17.87500	17.86328	17.65000
20 O.D	8	.12500	.10000	20.000	2.125	2.85000	.00781	19.73750	19.88203	19.87031	19.85859	19.63750
22 O.D	8	.12500	.10000	22.000	2.250	3.05000	.00781	21.72500	21.87734	21.86562	21.85391	21.62500
24 O.D	8	.12500	.10000	24.000	2.375	3.25000	.00781	23.71250	23.87266	23.86094	23.84922	23.61250
26 O.D	8	.12500	.10000	26.000	2.500	3.45000	.00781	25.70000	25.86797	25.85625	25.84453	25.60000
28 O.D	8	.12500	.10000	28.000	2.625	3.65000	.00781	27.68750	27.86328	27.85156	27.83984	27.58750
30 O.D	8	.12500	.10000	30.000	2.750	3.85000	.00781	29.67500	29.85859	29.84688	29.83516	29.57500

[1] Given as information for use in selecting tap drills.

of pipe and the pitch of thread. These are as follows [19] (see Symbols above):

$$E_0 = D - (0.05D + 1.1)p$$

$$E_1 = E_0 + 0.0625L_1$$

3. Length of thread.—The length of the taper external thread is determined by a formula based on the outside diameter of pipe and the pitch of the thread. This is as follows [19] (see Symbols above):

$$L_2 = (0.8D + 6.8)p$$

4. Length of engagement.—The normal length of engagement between taper external and internal threads, when screwed together by hand, is shown in column 6 of table 49. This length is controlled by means of gages.

5. Tolerances.—The tolerance on diameter is the equivalent of the variation in diameter due to taper over one and one half turns either way from the basic dimensions.[20]

(*b*) American National Straight Pipe Threads.—The specified sizes and basic dimensions on the "American National straight pipe threads" are given in table 50.

1. Diameters of straight threads.—The basic pitch diameter of the straight thread is equal to the diameter at the gaging notch of American National taper pipe thread, and is determined by the following formula based on the outside diameter of pipe and the pitch of thread (see Symbols above):

$$E_1 = D - (0.05D + 1.1)p + 0.0625L_1$$

2. Tolerances.—The tolerance on pitch diameter of a straight pipe thread is the equivalent of the variation in diameter over one and one half turns either way from the gaging notch of the American National taper pipe thread.[21] (See columns 4 and 6 of table 50.)

[19] These formulas are not expressed in the same terms as the formulas originally established by Mr. Briggs, because they are used to determine directly the pitch diameter and the length of effective thread, which includes two threads slightly imperfect at the crest; whereas the Briggs formulas determined the major diameter and the length of perfect thread, the two threads imperfect on the crest not being included in the formula. However, both forms give identical results.

[20] See figs. 29 and 30.

[21] The coupling thread may be gaged with a taper threaded plug gage. On account of the gage tolerance of one half turn on working taper pipe thread gages, the working tolerance is equivalent to one turn either way from the gaging notch. In gaging, care must be taken to gage at the first thread scratch and not at the end of the coupling when the thread is chamfered.

3. Application to internal threads.—Straight threaded internal wrought iron or wrought steel couplings of the weight known as "standard" may be used with taper threaded pipe for ordinary

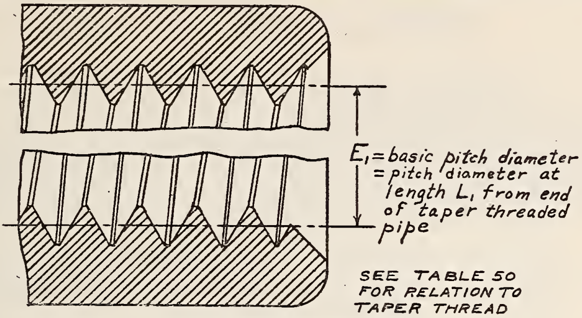


FIGURE 23.—*American National straight pipe thread notation (internal).*

NOTE.—This thread is gaged with the taper threaded plug gage and should gage flush at the bottom of the chamfer (first thread scratch) with the gaging notch, allowing a maximum variation of one and one-half turns plus or minus from the notch.

pressures, as they are sufficiently ductile to adjust themselves to the taper external thread when properly screwed together.

For high pressures, only taper external and internal threads should be used.

4. Application to external threads.—Straight external threads are recognized only for special applications, such as long screws and tank nipples.

TABLE 50.—*Dimensions of American National straight pipe threads (for couplings)*

[For notation see fig. 23]

Nominal sizes (in inches)	Threads per inch	Major diameter [1] basic	Pitch diameter, E_1			Minor diameter [1]
			Maximum	Basic	Minimum	Basic
1	2	3	4	5	6	7
		Inches	*Inches*	*Inches*	*Inches*	*Inches*
⅛	27	0.40439	0.37823	0.37476	0.37129	0.34513
¼	18	.53433	.49510	.48989	.48468	.44544
⅜	18	.67145	.63222	.62701	.62181	.58257
½	14	.83557	.78513	.77843	.77173	.72129
¾	14	1.04600	.99556	.98887	.98217	.93172
1	11½	1.30819	1.24678	1.23863	1.23048	1.16907
1¼	11½	1.65294	1.59153	1.58338	1.57523	1.51382
1½	11½	1.89190	1.83049	1.82234	1.81418	1.75277
2	11½	2.36583	2.30442	2.29627	2.28812	2.22671
2½	8	2.86216	2.77388	2.76216	2.75044	2.66216
3	8	2.48850	3.40022	3.38850	3.37678	3.28850
3½	8	3.98881	3.90053	3.88881	3.87709	3.78881
4	8	4.48713	4.39884	4.38712	4.37541	4.28713
4½	8	4.98594	4.89766	4.88594	4.87422	4.78594
5	8	5.54929	5.46101	5.44929	5.43757	5.34929
6	8	6.60597	6.51769	6.50597	6.49425	6.40597

[1] The American National pipe thread form is maintained; therefore, the major and minor diameters vary with the pitch diameter and are determined by the threading tools.

5. Application to long screw joints.—Long screw joints are used to a limited extent. This joint is not considered satisfactory when subjected to high temperature or pressure. In this application the coupling has a straight thread and must make a joint with an American National taper pipe thread. (See fig. 23.) It is necessary that the coupling be screwed on the straight external thread for the full length of the coupling and then back until it engages the taper external thread. The straight thread on the pipe enters the coupling freely

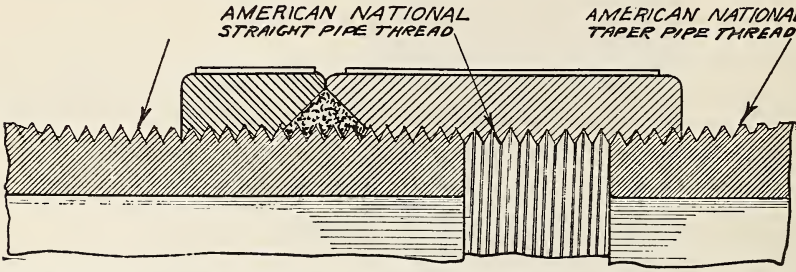


FIGURE 24.—*Illustration of "long screw" joint between straight threaded coupling and taper threaded pipe.*

by hand, the joint being made by a packing material between the locknut and the coupling. (See fig. 24.)

On account of the long engagement of thread, imperfections in pitch affect the fit when the coupling is screwed on the pipe its full length. Refinements of manufacture and gaging to insure a properly interchangeable product are more costly than the commercial

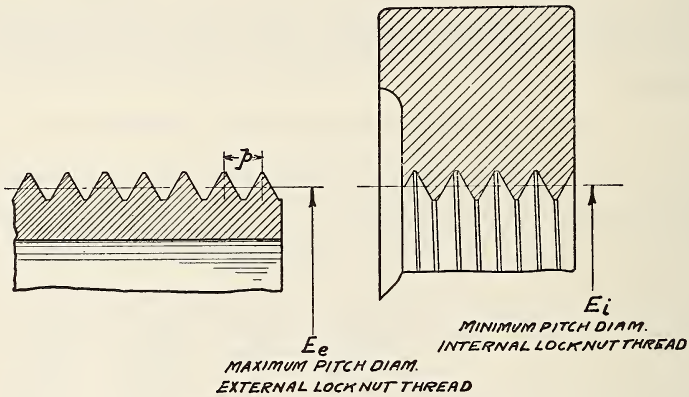


FIGURE 25.—*American National locknut thread notation.*

NOTATION

E_1=pitch diameter at gaging notch of American National taper plug gage
$E_e=E_1+(4p\times0.0625)$
$E_i=E_1+(5p\times0.0625)$

NOTE.—See table 51 for relation to taper pipe thread.

use warrants; therefore, the use of this type of joint is not recommended. For this reason, specifications for tolerances and gaging are not included herein.

(*c*) AMERICAN NATIONAL LOCKNUT THREADS.—Occasional requirements make it advisable to have a straight thread of the largest diameter it is possible to cut on a pipe. This practice has been standardized and is known as "maximum external and minimum internal locknut threads." For dimensions, see table 51. The "tank nipple" shown in figure 26 is an example of this thread. In this application an American National standard taper pipe thread is cut on the end of the pipe after having first cut the "external locknut thread."

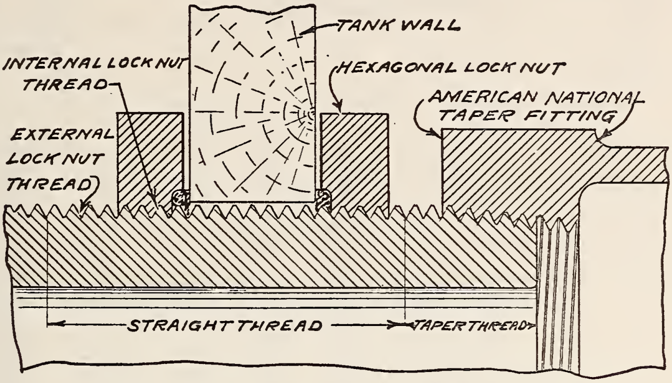


FIGURE 26.—*Illustration of "tank nipple" thread.*

TABLE 51.—*Dimensions of American National locknut threads*

[For notation, see fig. 25]

Nominal sizes (in inches)	Threads per inch	E_o (maximum)[1]	E_i (minimum)[1]	Depth of thread
1	2	3	4	5
		Inches	*Inches*	*Inch*
1/8	27	0.38402	0.38633	0.02963
1/4	18	.50378	.50725	.04444
3/8	18	.64090	.64437	.04444
1/2	14	.79629	.80075	.05714
3/4	14	1.00672	1.01119	.05714
1	11½	1.26037	1.26580	.06957
1¼	11½	1.60512	1.61055	.06957
1½	11½	1.84408	1.84951	.06957
2	11½	2.31801	2.32345	.06957
2½	8	2.79341	2.80122	.10000
3	8	3.41975	3.42756	.10000
3½	8	3.92006	3.92787	.10000
4	8	4.41838	4.42619	.10000
4½	8	4.91719	4.92500	.10000
5	8	5.48054	5.48836	.10000
6	8	6.53722	6.54503	.10000
7	8	7.53359	7.54141	.10000
8	8	8.53128	8.53909	.10000
9	8	9.52922	9.53703	.10000
10	8	10.65219	10.66000	.10000
11	8	11.65063	11.65844	.10000
12	8	12.64906	12.65688	.10000

[1] A tolerance equivalent to one and one half turns of the American National taper pipe thread is recommended, the tolerance being minus on E_o and plus on E_i.

4. TABLES OF PIPE DIMENSIONS

Tables 52, 53, 54, and 55, which follow, are not a part of the thread standard, but are reprinted as part of the Manual on American Standard Pipe Threads.

TABLE 52.—*Dimensions of standard wrought pipe*

Nominal sizes (in inches)	Inside diameter	Outside diameter	Nominal thickness	Transverse areas		Length of pipe per square foot of external surface	Nominal weight per foot threaded and coupled
				Internal	Metal		
1	2	3	4	5	6	7	8
	Inches	*Inches*	*Inch*	*Square inches*	*Square inches*	*Feet*	*Pounds*
⅛	0.269	0.405	0.068	0.057	0.072	9.431	0.245
¼	.364	.540	.088	.104	.125	7.073	.425
⅜	.493	.675	.091	.191	.167	5.658	.568
½	.622	.840	.109	.304	.250	4.547	.852
¾	.824	1.050	.113	.533	.333	3.637	1.134
1	1.049	1.315	.133	.864	.494	2.904	1.684
1¼	1.380	1.660	.140	1.495	.669	2.301	2.281
1½	1.610	1.900	.145	2.036	.799	2.010	2.731
2	2.067	2.375	.154	3.355	1.075	1.608	3.678
2½	2.469	2.875	.203	4.788	1.704	1.328	5.819
3	3.068	3.500	.216	7.393	2.228	1.091	7.616
3½	3.548	4.000	.226	9.886	2.680	.954	9.202
4	4.026	4.500	.237	12.730	3.174	.848	10.889
4½ [1]	4.506	5.000	.247	15.947	3.688	.763	12.642
5	5.047	5.563	.258	20.006	4.300	.686	14.810
6	6.065	6.625	.280	28.891	5.581	.576	19.185
7 [1]	7.023	7.625	.301	38.738	6.926	.500	23.769
8 [1]	8.071	8.625	.277	51.161	7.265	.442	25.000
8	7.981	8.625	.322	50.027	8.399	.442	28.809
9 [1]	8.941	9.625	.342	62.786	9.974	.396	34.188
10 [1]	10.192	10.750	.279	81.585	9.178	.355	32.000
10 [1]	10.136	10.750	.307	80.691	10.072	.355	35.000
10	10.020	10.750	.365	78.855	11.908	.355	41.132
11 [1]	11.000	11.750	.375	95.033	13.401	.325	46.247
12 [1]	12.090	12.750	.330	114.800	12.876	.299	45.000
12	12.000	12.750	.375	113.097	14.579	.299	50.706

[1] Not included in simplified list of sizes as given in Department of Commerce Simplified Practice Recommendation R57-32.

TABLE 53.—*Dimensions of extra strong wrought pipe*

Nominal sizes (in inches)	Inside diameter	Outside diameter	Nominal thickness	Transverse areas		Length of pipe per square foot of external surface	Nominal weight per foot, plain ends
				Internal	Metal		
1	2	3	4	5	6	7	8
	Inches	*Inches*	*Inch*	*Square inches*	*Square inches*	*Feet*	*Pounds*
⅛	0.215	0.405	0.095	0.036	0.093	9.431	0.314
¼	.302	.540	.119	.072	.157	7.073	.535
⅜	.423	.675	.126	.141	.217	5.658	.738
½	.546	.840	.147	.234	.320	4.547	1.087
¾	.742	1.050	.154	.433	.433	3.637	1.473
1	.957	1.315	.179	.719	.639	2.904	2.171
1¼	1.278	1.660	.191	1.283	.881	2.301	2.996
1½	1.500	1.900	.200	1.767	1.068	2.010	3.631
2	1.939	2.375	.218	2.953	1.477	1.608	5.022
2½	2.323	2.875	.276	4.238	2.254	1.328	7.661
3	2.900	3.500	.300	6.605	3.016	1.091	10.252
3½	3.364	4.000	.318	8.888	3.678	.954	12.505
4	3.826	4.500	.337	11.497	4.407	.848	14.983
4½ [1]	4.290	5.000	.355	14.455	5.180	.763	17.611
5	4.813	5.563	.375	18.194	6.112	.686	20.787
6	5.761	6.625	.432	26.067	8.405	.576	28.573
7 [1]	6.625	7.625	.500	34.472	11.192	.500	38.048
8	7.625	8.625	.500	45.663	12.763	.442	43.388
9 [1]	8.625	9.625	.500	58.426	14.334	.396	48.728
10	9.750	10.750	.500	74.662	16.101	.355	54.735
11 [1]	10.750	11.750	.500	90.763	17.671	.325	60.075
12	11.750	12.750	.500	108.434	19.242	.299	65.415

[1] Not included in simplified list of sizes as given in Department of Commerce Simplified Practice Recommendation R57-32.

TABLE 54.—*Dimensions of double extra strong wrought pipe*

Nominal sizes (in inches)	Inside diameter	Outside diameter	Nominal thickness	Transverse areas		Length of pipe per square foot of external surface	Nominal weight per foot, plain ends
				Internal	Metal		
1	2	3	4	5	6	7	8
	Inches	*Inches*	*Inch*	*Square inches*	*Square inches*	*Feet*	*Pounds*
½	0.252	0.840	0.294	0.050	0.504	4.547	1.714
¾	.434	1.050	.308	.148	.718	3.637	2.440
1	.599	1.315	.358	.282	1.076	2.904	3.659
1¼	.896	1.660	.382	.630	1.534	2.301	5.214
1½	1.100	1.900	.400	.950	1.885	2.010	6.408
2	1.503	2.375	.436	1.774	2.656	1.608	9.029
2½	1.771	2.875	.552	2.464	4.028	1.328	13.695
3 [1]	2.300	3.500	.600	4.155	5.466	1.091	18.583
3½	2.728	4.000	.636	5.845	6.721	.954	22.850
4	3.152	4.500	.674	7.803	8.101	.848	27.541
4½ [1]	3.580	5.000	.710	10.066	9.569	.763	32.530
5	4.063	5.563	.750	12.966	11.340	.686	38.552
6	4.897	6.625	.864	18.835	15.637	.576	53.160
7 [1]	5.875	7.625	.875	27.109	18.555	.500	63.079
8	6.875	8.625	.875	37.122	21.304	.442	72.424

[1] Not included in simplified list of sizes as given in Department of Commerce Simplified Practice Recommendation R57-32.

TABLE 55.—*Diameters of large O.D. pipe*

Nominal sizes (in inches)	Outside diameter	Inside diameter								
		¼ inch thick	5/16 inch thick	⅜ inch thick	7/16 inch thick	½ inch thick	9/16 inch thick	⅝ inch thick	¾ inch thick	1 inch thick
1	2	3	4	5	6	7	8	9	10	11
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
14	14	13½	13⅜	13¼	13⅛	13	12⅞	12¾	12½	12
15	15	14½	14⅜	14¼	14⅛	14	13⅞	13¾	13½	13
16	16	15½	15⅜	15¼	15⅛	15	14⅞	14¾	14½	14
17	17	16½	16⅜	16¼	16⅛	16	15⅞	15¾	15½	15
18	18	17½	17⅜	17¼	17⅛	17	16⅞	16¾	16½	16
20	20	--------	19⅜	19¼	19⅛	19	18⅞	18¾	18½	18
22	22	--------	21⅜	21¼	21⅛	21	20⅞	20¾	20½	--------
24	24	--------	--------	23¼	23⅛	23	22⅞	22¾	22½	--------
26	26	--------	--------	25¼	25⅛	25	24⅞	24¾	24½	--------
28	28	--------	--------	--------	27⅛	27	27⅞	26¾	26½	--------
30	30	--------	--------	--------	29⅛	29	28⅞	28¾	28½	--------

5. GAGES

(a) FUNDAMENTALS

The same fundamentals apply as those outlined in section III covering gages for fastening screws, with the single exception that, with taper threaded gages, separate "go" and "not go" gages are not necessary.

(b) SPECIFICATIONS FOR GAGES

The following specifications are for the purpose of establishing definite limits for thread gages rather than for the purpose of specifying the design of gages required for the various inspection operations.

Basic dimensions of taper pipe thread gages are given in table 57

All such gages should be made to the basic dimensions within the tolerances for each element given in table 56 and footnotes thereto. It is possible for taper thread plug and ring gages, which come within the tolerances specified for each element, to vary from being flush with each other at the gaging end, or at the gaging notch, when screwed together tightly by hand. The maximum variation which might occur and be permissible, expressed in terms of longitudinal distance or stand-off, is given in column 9 of table 56.

In order properly to maintain interchangeability of pipe threads, gages should consist of "master," "checking," "inspection," and "working" gages.

1. Classification of Gages—(*a*) *Master gage.*—The master gage is a taper threaded plug gage. (See fig. 27.) It is the gage to which all other gages are ultimately referred, either by transfer of measure-

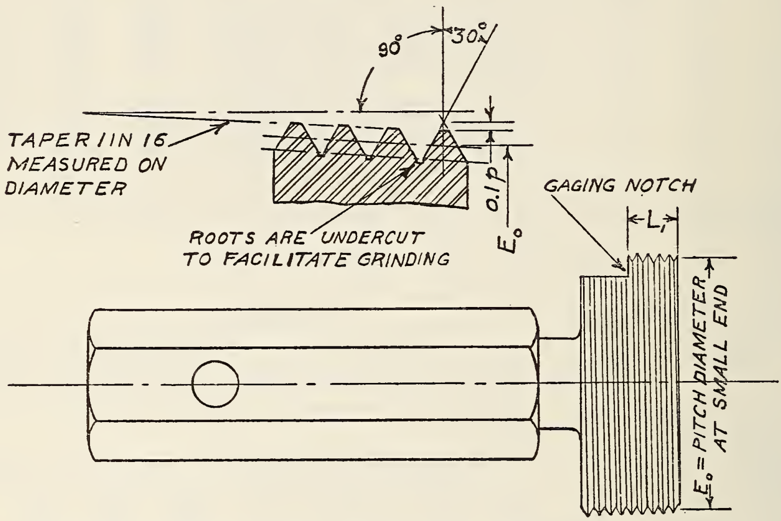


Figure 27.—*Master gage or check gage for checking inspection gages.*

ments or direct comparison by engagement. It is intended primarily for the use of gage and thread tool manufacturers. It should be made to the basic size as accurately as possible and be within the tolerances given in table 56.

Each master gage shall be marked with an identification number or symbol, and be accompanied by a report showing the error on each of the elements of thread and a statement of the accumulative error derived from the errors in the various elements. In case of question, the deviations of this gage from the basic size shall be ascertained by the Bureau of Standards at Washington, D.C.

(*b*) *Checking plug gage.*—The checking plug gage is similar in all respects to the master gage, and is used to inspect inspection and working taper threaded ring gages.

(*c*) *Inspection gages.*—Inspection gages consist of one taper threaded plug gage and one taper threaded ring gage.

Inspection gages are for the use of the purchaser of pipe thread products. When used, the extreme tolerances on the work should be applied. This tolerance is one and one-half turns either way from the gaging notch in the case of internal threads inspected with the inspection plug gage, and when inspecting external threads the tolerance is one and one-half turns either way from the small end of the inspection ring. Inspection gages should be checked frequently and in use their errors should be taken into account.

(d) *Working gages.*—The working gages consist of one taper threaded plug and one taper threaded ring gage. These gages are similar in all respects to the inspection plug and ring gages. The working gages are used by the manufacturer to inspect his product. In using the working gages, the tolerance to be applied is one turn either way from the gaging notch in the case of internal threads inspected with the plug gage, and in the case of external threads the tolerance is one turn either way from the small end of the working ring gage.

2. Thread Form of Taper Pipe Thread Plug and Ring Gages.—The roots of the threads of all taper pipe thread gages are

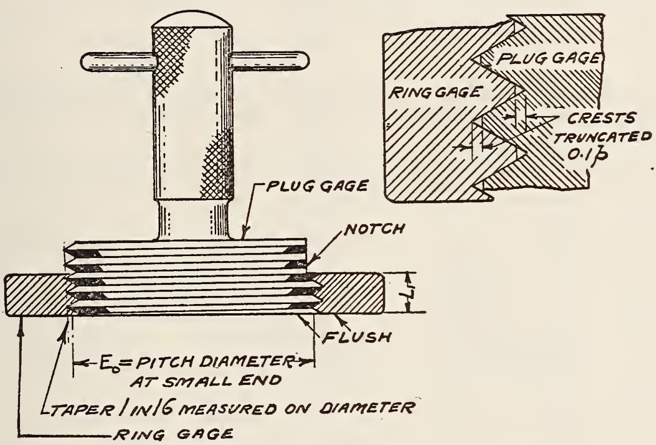


Figure 28.—*Inspection or working gages for checking product.*

cut to sharp V or may be undercut to facilitate making the thread. The crests are truncated an amount equal to $0.1p$, but otherwise the gages are made to the dimensions given in table 49.[22]

(c) GAGING PRACTICES

A common practice in the gaging of taper pipe threads is illustrated in figures 27, 28, 29, and 30. However, other practices, some of which may be equally satisfactory, are widely used.

The basic gaging length is equal to the dimension L_1. In figures 27 and 28 this dimension is shown as the thickness of the ring gage, and as the distance from the small end to the gaging notch of the plug gage.

1. Gaging Internal Threads.—The inspection and working plug gages, figure 29, should screw tight by hand into the fitting or coupling until the notch is flush with the face. When the thread is chamfered, the notch should be flush with the bottom of the chamfer, (first thread scratch). The fitting or coupling is within the working or net tolerance if the working gage notcn is within one turn of the

[22] The object of truncating the crests on gages (truncation $0.1p$) is to insure that, when gaging commercial threads cut with a slightly dull tool, the gage bears on the sides of the thread instead of on the roots.

coupling or fitting face when screwed in tight by hand. In the same way the coupling or fitting is within the inspection or extreme tolerance if the inspection gage notch is within one and one-half turns of the coupling or fitting face when screwed on tight by hand.

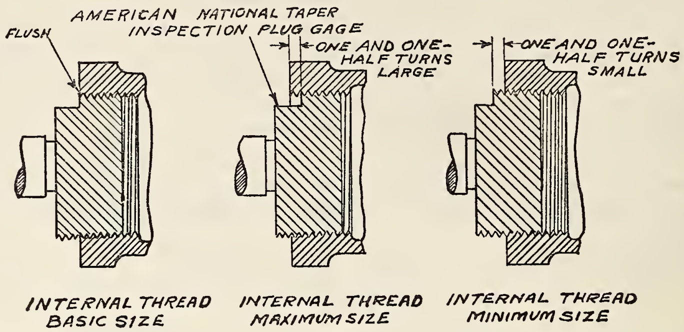


FIGURE 29.—*Gaging of internal American National taper pipe threads.*

This method of gaging is used either for taper internal threads or for straight internally threaded couplings which screw together with taper external threads.

2. GAGING TAPER EXTERNAL THREADS.—The ring gage, figure 30, should screw tight by hand on the pipe or external thread until the

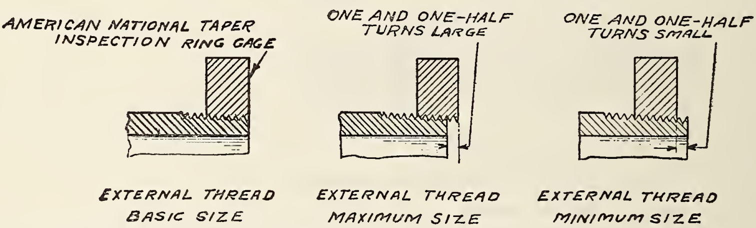


FIGURE 30.—*Gaging of external American National taper pipe threads.*

small end of the gage is flush with the end of the thread. The pipe or external thread is within the working or net tolerance if the working ring gage screws on until the end of pipe or external thread is within one turn of the small end of the gage. The pipe or external thread is within the inspection or extreme tolerance if the inspection ring screws on until the end of pipe is within one and one-half turns of the small end of the gage.

TABLE 56.—*Tolerances for American National taper pipe thread plug and ring gages*

Nominal sizes (in inches)	Number of threads per inch	Tolerance on pitch diameter [1] [2] (including taper)	Tolerance on lead [3]	Tolerance on half angle of thread	Tolerance on major diameter of plug gage	Tolerance on minor diameter of ring gage	Maximum longitudinal variation from basic for plug or ring gage	Maximum stand-off between plug and ring gages at gaging end when screwed together tightly by hand
1	2	3	4	5	6	7	8	9
		Inch	*Inch* ±	*Deg. Min.* ±	*Inch* +	*Inch* −	*Inch*	*Inch*
1/8	27	0.0002	0.0002	0 10	0.0005	0.0005	0.0115	0.0230
1/4	18	.0003	.0002	0 10	.0005	.0005	.0144	.0288
3/8	18	.0003	.0002	0 10	.0005	.0005	.0144	.0288
1/2	14	.0003	.0002	0 8	.0010	.0010	.0146	.0292
3/4	14	.0003	.0002	0 8	.0010	.0010	.0146	.0292
1	11½	.0003	.0003	0 8	.0010	.0010	.0181	.0362
1¼	11½	.0003	.0003	0 8	.0010	.0010	.0181	.0362
1½	11½	.0003	.0003	0 8	.0010	.0010	.0181	.0362
2	11½	.0003	.0003	0 8	.0010	.0010	.0181	.0362
2½	8	.0004	.0004	0 5	.0015	.0015	.0219	.0438
3	8	.0004	.0004	0 5	.0015	.0015	.0219	.0438
3½	8	.0004	.0004	0 5	.0015	.0015	.0219	.0438
4	8	.0004	.0004	0 5	.0015	.0015	.0219	.0438
4½	8	.0004	.0004	0 5	.0015	.0015	.0219	.0438
5	8	.0004	.0004	0 5	.0015	.0015	.0219	.0438
6	8	.0004	.0004	0 5	.0015	.0015	.0219	.0438
8	8	.0005	.0005	0 5	.0020	.0020	.0264	.0528
10	8	.0005	.0005	0 5	.0020	.0020	.0264	.0528
12	8	.0005	.0005	0 5	.0020	.0020	.0264	.0528
14 O.D	8	.0006	.0006	0 5	.0025	.0025	.0307	.0614
16 O.D	8	.0006	.0006	0 5	.0025	.0025	.0307	.0614
18 O.D	8	.0006	.0006	0 5	.0025	.0025	.0307	.0614
20 O.D	8	.0006	.0006	0 5	.0025	.0025	.0307	.0614
24 O.D	8	.0006	.0006	0 5	.0025	.0025	.0307	.0614

[1] The taper of the pitch diameter cone shall be such that the pitch diameter will be within the tolerance given at all points. For example, if the gage is to maximum size at the small end, the taper shall not be greater than 0.750 inch taper per foot. If a gage is to minimum size at the small end, the taper shall not be less than 0.750 inch taper per foot.

[2] Pitch diameter tolerance is to be applied plus on plug gages (other than checking plug gages); minus on checking plug gages and ring gages.

[3] Allowable variation in lead between any 2 threads.

NOTE.—The tolerance for the height from the gaging end to notch of all plug gages shall be plus 0.000 inch, minus 0.001 inch for sizes 1/8 inch to 2 inches, inclusive, and plus 0.000 inch, minus 0.002 inch for sizes 2½ to 24 inches, inclusive.

The tolerance for the over-all thread length of plug gages shall be plus 1/32 inch, minus 0.000 inch for sizes 1/8 inch to 2 inches, inclusive, and plus 1/16 inch, minus 0.000 inch for sizes 2½ to 24 inches, inclusive.

The thickness of the ring gage shall be held within a tolerance of plus 0.001 inch, minus 0.000 inch for sizes 1/8 inch to 2 inches, inclusive, and plus 0.002 inch, minus 0.000 inch for sizes 2½ to 24 inches, inclusive

TABLE 57.—*Basic dimensions of threaded plug and ring gages for American National taper pipe threads*

Nominal size of pipe (in inches)	Number of threads per inch, n	Pitch, p	Major diameters of plug gages[1]			Pitch diameters of plug and ring gages			Minor diameters of ring gages[1]			Increase in diameter per thread, $\frac{0.0625}{n}$	Thickness of thin ring, L_1	Thickness of full ring, L_2
			At small end, $E_0+\frac{0.666025}{n}$	At gaging notch, $E_1+\frac{0.666025}{n}$	At large end, full ring, $E_2+\frac{0.666025}{n}$	At small end, E_0	At gaging notch, E_1	At large end, full ring, E_2	At small end, $E_0-\frac{0.666025}{n}$	At gaging notch, $E_1-\frac{0.666025}{n}$	At large end, full ring, $E_2-\frac{0.666025}{n}$			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Inch	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inch*	*Inches*	*Inches*
⅛	27	0.03704	0.38818	0.39943	0.40467	0.36351	0.37476	0.38000	0.33884	0.35009	0.35533	0.00231	0.180	0.26385
¼	18	.05556	.51439	.52689	.53950	.47739	.48989	.50250	.44039	.45289	.46550	.00347	.200	.40178
⅜	18	.05556	.64902	.66402	.67450	.61201	.62701	.63750	.57501	.59001	.60050	.00347	.240	.40778
½	14	.07143	.80600	.82600	.83936	.75843	.77843	.79179	.71086	.73086	.74421	.00446	.320	.53371
¾	14	.07143	1.01525	1.03644	1.04936	.96768	.98887	1.00179	.92011	.94129	.95421	.00446	.339	.54571
1	11½	.08696	1.27155	1.29655	1.31422	1.21363	1.23863	1.25630	1.15571	1.18072	1.19839	.00543	.400	.68278
1¼	11½	.08696	1.61505	1.64130	1.65922	1.55713	1.58338	1.60130	1.49921	1.52547	1.54339	.00543	.420	.70678
1½	11½	.08696	1.85400	1.88025	1.89922	1.79609	1.82234	1.84130	1.73817	1.76442	1.78339	.00543	.420	.72348
2	11½	.08696	2.32694	2.35419	2.37422	2.26902	2.29627	2.31630	2.21111	2.23836	2.25839	.00543	.436	.75652
2½	8	.12500	2.80278	2.84541	2.87388	2.71953	2.76216	2.79062	2.63628	2.67890	2.70737	.00781	.682	1.13750
3	8	.12500	3.42388	3.47175	3.49888	3.34062	3.38850	3.41562	3.25737	3.30525	3.33237	.00781	.766	1.20000
3½	8	.12500	3.92075	3.97207	3.99888	3.83750	3.88881	3.91562	3.75425	3.80556	3.83237	.00781	.821	1.25000
4	8	.12500	4.41763	4.47038	4.49888	4.33438	4.38712	4.41562	4.25112	4.30387	4.33237	.00781	.844	1.30000
4½	8	.12500	4.91450	4.96919	4.99888	4.83125	4.88594	4.91562	4.74800	4.80268	4.83237	.00781	.875	1.35000
5	8	.12500	5.47398	5.53255	5.56188	5.39073	5.44929	5.47862	5.30748	5.36604	5.39537	.00781	.937	1.40630
6	8	.12500	6.52935	6.58922	6.62388	6.44609	6.50597	6.54062	6.36284	6.42272	6.45737	.00781	.958	1.51250
7	8	.12500	7.52310	7.58560	7.62388	7.43984	7.50234	7.54062	7.35659	7.41909	7.45737	.00781	1.000	1.61250
8	8	.12500	8.51685	8.58328	8.62388	8.43359	8.50003	8.54062	8.35034	8.41678	8.45737	.00781	1.063	1.71250
9	8	.12500	9.51060	9.58122	9.62388	9.42734	9.49797	9.54062	9.34409	9.41472	9.45737	.00781	1.130	1.81250
10	8	.12500	10.62857	10.70419	10.74888	10.54531	10.62094	10.66562	10.46206	10.53768	10.58237	.00781	1.210	1.92500
11	8	.12500	11.62232	11.70263	11.74888	11.53906	11.61938	11.66562	11.45581	11.53612	11.58237	.00781	1.285	2.02500
12	8	.12500	12.61607	12.70107	12.74888	12.53281	12.61781	12.66562	12.44956	12.53456	12.58237	.00781	1.360	2.12500
14 O.D	8	.12500	13.85825	13.95588	13.99888	13.77500	13.87262	13.91562	13.69175	13.78937	13.83237	.00781	1.562	2.25000
15 O.D	8	.12500	14.85200	14.95744	14.99888	14.76875	14.87419	14.91562	14.68550	14.79093	14.83237	.00781	1.687	2.35000
16 O.D	8	.12500	15.84575	15.95900	15.99888	15.76250	15.87575	15.91562	15.67925	15.79250	15.83237	.00781	1.812	2.45000

17 O.D.	8	0. 12500	16. 83950	16. 95825	16. 99888	16. 75625	16. 87500	16. 91562	16. 67300	16. 79175	16. 83237	0. 00781	1. 900	2. 55000
18 O.D.	8	. 12500	17. 83325	17. 95825	17. 99888	17. 75000	17. 87500	17. 91562	17. 66675	17. 79175	17. 83237	. 00781	2. 000	2. 65000
20 O.D.	8	. 12500	19. 82075	19. 95357	19. 99888	19. 73750	19. 87031	19. 91562	19. 65425	19. 78706	19. 83237	. 00781	2. 125	2. 85000
22 O.D.	8	. 12500	21. 80825	21. 94888	21. 99888	21. 72500	21. 86562	21. 91562	21. 64175	21. 78237	21. 83237	. 00781	2. 250	3. 05000
24 O.D.	8	. 12500	23. 79575	23. 94419	23. 99888	23. 71250	23. 86094	23. 91562	23. 62925	23. 77768	23. 83237	. 00781	2. 375	3. 25000
26 O.D.	8	. 12500	25. 78325	25. 93950	25. 99888	25. 70000	25. 85625	25. 91562	25. 61675	25. 77300	25. 83237	. 00781	2. 500	3. 45000
28 O.D.	8	. 12500	27. 77075	27. 93482	27. 99888	27. 68750	27. 85156	27. 91562	27. 60425	27. 76831	27. 83237	. 00781	2. 625	3. 65000
30 O.D.	8	. 12500	29. 75825	29. 93013	29. 99888	29. 67500	29. 84688	29. 91562	29. 59175	29. 76362	29. 83237	. 00781	2. 750	3. 85000

[1] These dimensions are based on a crest truncation of $0.1p$ for pipe thread gages, which insures bearing of the gage on the sides of the thread, when cut with a slightly dull tool, instead of at the roots of the thread.

SECTION VIII. AMERICAN NATIONAL SCREW, BOLT, AND NUT PROPORTIONS [23]

A project to which the Commission gave early attention was the standardization of bolt and nut proportions. A subcommittee of the Commission and subcommittee no. 2 of the Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions organized under the procedure of the American Standards Association, worked in close cooperation in developing standards for wrench-head bolts and nuts which are referred to below.

The Commission endorses the standards for proportions of the following threaded products as listed in the references below:

	Reference
Bolt heads:	
Heavy	2
Regular	1, 2
Cap screw heads, hexagon	2
Cap screws, slotted head	3, 4
Carriage bolts:	
Countersunk	5
Fin-neck	5
Ribbed	5
Square-neck	1, 5
Castellated nuts	1, 2
Heavy nuts	2
Jam nuts	1, 2
Jam nuts, heavy	2
Light nuts	1, 2
Regular nuts	1, 2
Machine bolts	1
Machine bolts, button-head	1, 5
Machine screws, slotted-head	3, 4
Machine screw nuts	2
Plow bolts	8
Set screws	2, 3
Step bolts	5
Stove bolts	3
Stove bolt nuts	2
Tap rivets	1
Track bolts	7
Track bolt nuts	7
Wood screws	4, 6

1. Federal Specification for Bolts, Nuts, Studs, and Tap Rivets (and material for same), No. FF-B-571, October 13, 1931. Promulgated by the Federal Specifications Board. Sold by the Superintendent of Documents, Washington, D.C. Price 10 cents.
2. American Standard Wrench-head Bolts and Nuts and Wrench Openings. Report No. B18.2–1932, issued and sold by the American Standards Association, 29 West Thirty-ninth Street, New York, N.Y. Price, 50 cents.
3. Federal Specification for Screws, Machine, and Set; and Bolts, Stove, No. FF-S-91, April 22, 1933. Available at the Bureau of Standards in mimeographed form.
4. American Standard Slotted Head Proportions—Machine Screws, Cap Screws, and Wood Screws. Report No. B18c–1930, issued and sold by the American Standards Association, 29 West Thirty-ninth Street, New York, N.Y. Price, 45 cents.
5. American Standard Round Unslotted Head Bolts—Carriage, Step, and Machine Bolts. Report No. B18e–1928, issued and sold by the American Standards Association, 29 West Thirty-ninth Street, New York, N.Y. Price, 40 cents.
6. Federal Specifications for Screws, Wood, No. FF-S-111, April 28, 1931. Promulgated by the Federal Specifications Board. Sold by the Superintendent of Documents, Washington, D.C. Price, 5 cents.

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[23] See also appendix 5, p. 161.

7. American standard track bolts and nuts. Report No. B18d–1930, issued and sold by the American Standards Association, 29 West Thirty-ninth Street, New York, N.Y. Price, 40 cents.
8. Plow Bolts. United States Department of Commerce Simplified Practice Recommendation R23, February 19, 1924. Issued by the Bureau of Standards and sold by the Superintendent of Documents, Washington, D.C. Price, 5 cents. Also published as Report No. B18f–1928, American Standard for Plow Bolts. Issued and sold by the American Standards Association, 29 West Thirty-ninth Street, New York, N.Y. Price, 35 cents.

SECTION IX. MISCELLANEOUS SPECIAL THREADS

Section IX A. Screw Threads for Oil-Well Drilling Equipment

The Commission, through its subcommittee on oil-well casing threads and the staff of the Bureau of Standards, has at various times extended assistance to the American Petroleum Institute in those parts of its program of standardization of oil-field equipment which deal with specifications for screw threads and methods of gaging screw threads.

The first problem in this field brought to the attention of the Commission was the great need for standardization of oil-well casing threads. Definite work toward such standardization was initiated by the Mid-Continent Oil and Gas Association in 1921, but this was complicated by a proposal to simplify casing sizes and weights, and provide new standard sizes of nesting casing required for the deeper well drilling which is now necessary. Certain manufacturers had also endeavored to come to an agreement on thread standards. Through the cooperative efforts of the American Petroleum Institute, the Standardization Committee of the Mid-Continent Oil and Gas Association, and the Commission, certain agreements as to diameters, pitches, and tapers were effected. The complete standard for casing threads, together with standards for drill pipe and tubing, are now published as A.P.I. Standard No. 5-A, "Pipe Specifications", issued by the division of standardization, American Petroleum Institute, 1508 Kirby Building, Dallas, Tex.

The Commission endorses the screw thread and screw-thread gage specifications included in the following American Petroleum Institute standards:

No. 3. A.P.I. dimensional standards for cable drilling tools.
No. 5–A. A.P.I. pipe specifications.
No. 5–L. A.P.I. line pipe specifications.
No. 7–B. A.P.I. specifications for rotary drilling taper joints.
No. 11–A. A.P.I. specifications for oil-well pumps (barrels, plungers, valves, etc.).
No. 11–B. A.P.I. sucker rod specifications.

Section IX B. American National Standard Hose Connections for Welding and Cutting Torches

The specifications given herein, covering hose connections for welding and cutting torches, were approved and adopted by the Commission June 28, 1926. These specifications were formulated and adopted in 1925, in essentially the same form, by the International Acetylene Association and the Gas Products Association, and have been adopted by various manufacturers.

Dimensions essential to the interchangeability of parts have been standardized. Other dimensions and details of design are optional, so that manufacturers may use their own judgment and follow their usual practice as much as possible. Two sizes of connections are specified, as illustrated in figures 31 and 32.

1. STANDARD DIMENSIONS

1. Screw threads corresponding to the American National fine-thread series, and class 3, medium fit, are specified in figures 31 and 32, for which dimensions are given in table 13. *Right-hand threads are specified for oxygen and left-hand threads for fuel gas.*
2. Angle and outside diameter of internal seat.
3. Radius and distance of radius center of external seat from shank shoulder.
4. Diameter of shank shoulder.
5. Diamter of hole in nut.
6. Small and large diameters of shank.
7. Diameter of hole through shank.

2. OPTIONAL FEATURES

1. Material.—Strength equal to or greater than that of free-turning high brass.
2. Diameter of hole through nipple.
3. Form of end of shank, except seating section as covered in *C*, figures 31 and 32.
4. Length of shank.
5. Type and number of serrations on shank.
6. A second shoulder equal to the large diameter of the largest shank to extend through the hole in the nut for appearance, to be used or omitted for smaller diameter shanks.
7. Length and location of hexagon section on nut.

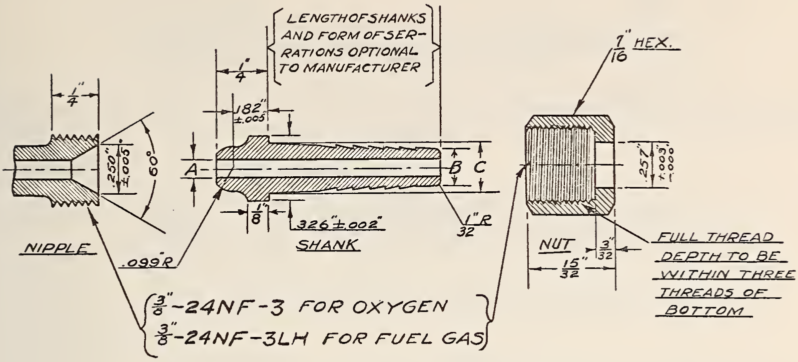
3. GAGES

Dimensions and designs of gages for maintaining the hose connection standards for welding and cutting torches are recommended as follows:

Note.—In connection with screw-thread gages see also section III, division 5.

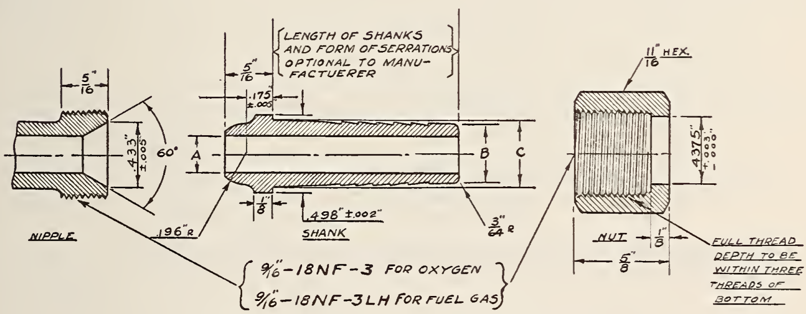
Gage no.

1. "Go" and "not go" gage for depth of threaded recess and shank bore:
    - A size hose connection, as shown in figure 33.
    - B size hose connection, as shown in figure 38.
2. "Go" adjustable thread-ring gage for right-hand nipple thread:
    - A size, 3/8-24NF-3:
        - Minor diameter, maximum, 0.3299; minimum, 0.3294 inch.
        - Pitch diameter, maximum, 0.3477; minimum, 0.3474 inch.
    - B size, 9/16-18NF-3:
        - Minor diameter, maximum, 0.5024; minimum, 0.5019 inch.
        - Pitch diameter, maximum, 0.5262; minimum, 0.5259 inch.
3. "Go" adjustable thread-ring gage for left-hand nipple thread:
    - A size, 3/8-24NF-3LH:
        - Minor diameter, maximum, 0.3299; minimum, 0.3294 inch.
        - Pitch diameter, maximum, 0.3477; minimum, 0.3474 inch.
    - B size, 9/16-18NF-3LH:
        - Minor diameter, maximum, 0.5024; minimum, 0.5019 inch.
        - Pitch diameter, maximum 0.5262; minimum, 0.5259 inch.
4. "Not go" adjustable thread-ring gage for right-hand nipple thread:
    - A size, 3/8-24NF-3:
        - Minor diameter, maximum, 0.3304; minimum, 0.3299 inch.
        - Pitch diameter, maximum, 0.3458; minimum, 0.3455 inch.
    - B size, 9/16-18NF-3:
        - Minor diameter, maximum, 0.5029; minimum, 0.5024 inch.
        - Pitch diameter, maximum, 0.5237; minimum, 0.5234 inch.



Hose	A	B	C
Inch	*Inch*	*Inch*	*Inch*
3/16	3/32	3/16	0. 248 +0. 000 − .005
1/8	1/16	1/8	. 187 + .000 − .005

Figure 31.—*"A" size of standard hose connections for welding and cutting torches.*



Hose	A	B	C
Inch	*Inch*	*Inch*	*Inch*
3/8	1/4	3/8	0. 430 +0. 000 − .005
5/16	3/16	5/16	. 375 +0. 000 − .005
1/4	1/8	1/4	. 312 + .000 − .005
3/16	3/32	3/16	. 250 + .000 − .005
1/8	1/16	1/8	. 187 + .000 − .005

Figure 32.—*"B" size of standard hose connections for welding and cutting torches.*

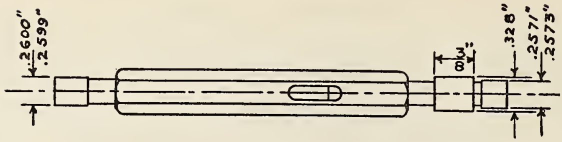


Figure 33.—*"Go" and "not go" gage for depth of threaded recess, and shank bore, A size.*

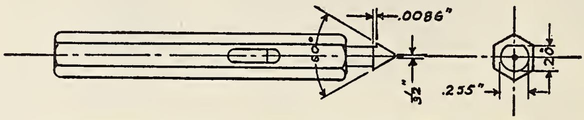


Figure 34.—*Taper gage for nipple seat, A size.*

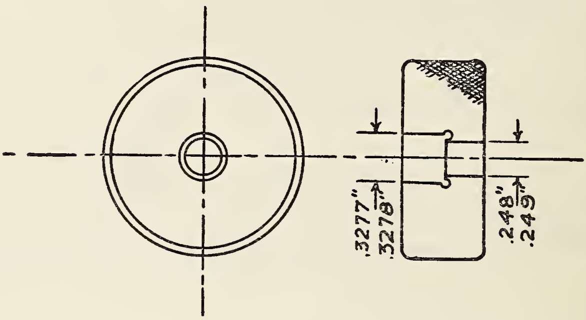


Figure 35.—*"Go" ring gage for diameter of shank shoulder and concentricity of serrated portion, A size.*

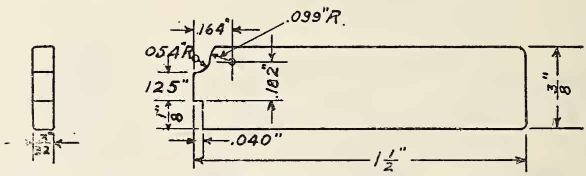


Figure 36.—*Master template for nose of shank, A size.*

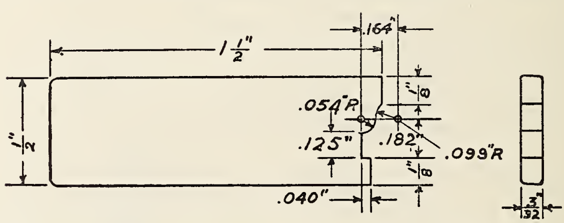


Figure 37.—*Template gage for nose of shank, A size.*

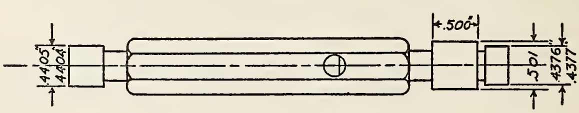


Figure 38.—*"Go" and "not go" gage for depth of threaded recess, and shank bore, B size.*

Gage no.

5. "Not go" adjustable thread-ring gage for left-hand nipple thread—
   - A size, 3/8-24NF-3LH:
     - Minor diameter, maximum, 0.3304; minimum, 0.3299 inch.
     - Pitch diameter, maximum, 0.3458; minimum, 0.3455 inch.
   - B size, 9/16-18NF-3LH:
     - Minor diameter, maximum, 0.5029; minimum, 0.5024 inch.
     - Pitch diameter, maximum, 0.5237; minimum, 0.5234 inch.
6. "Go" and "not go" double-end threaded setting-plug gage for nos. 2 and 4:
   - A size, 3/8-24NF-3:
     - "Go" end:
       - Major diameter, maximum, 0.3750; minimum, 0.3740 inch.
       - Pitch diameter, maximum, 0.3477; minimum, 0.3474 inch.
     - "Not go" end:
       - Major diameter, maximum, 0.3689; minimum, 0.3684 inch.
       - Pitch diameter, maximum, 0.3458; minimum, 0.3455 inch.
   - B size, 9/16-18NF-3:
     - "Go" end:
       - Major diameter, maximum, 0.5625; minimum, 0.5620 inch.
       - Pitch diameter, maximum, 0.5262; minimum, 0.5259 inch.
     - "Not go" end:
       - Major diameter, maximum, 0.5548; minimum, 0.5543 inch.
       - Pitch diameter, maximum, 0.5237; minimum, 0.5234 inch.
7. "Go" and "not go" double-end threaded setting-plug gage for nos. 3 and 5:
   - A size, 3/8-24NF-3LH:
     - "Go" end:
       - Major diameter, maximum, 0.3750; minimum, 0.3745 inch.
       - Pitch diameter, maximum, 0.3477; minimum, 0.3474 inch.
     - "Not go" end:
       - Major diameter, maximum, 0.3689; minimum, 0.3684 inch.
       - Pitch diameter, maximum, 0.3458; minimum, 0.3455 inch.
   - B size, 9/16-18NF-3LH:
     - "Go" end:
       - Major diameter, maximum, 0.5625; minimum, 0.5620 inch.
       - Pitch diameter, maximum, 0.5262; minimum, 0.5259 inch.
     - "Not go" end:
       - Major diameter, maximum, 0.5548; minimum, 0.5543 inch.
       - Pitch diameter, maximum, 0.5237; minimum, 0.5234 inch.
8. "Go" and "not go" double-end thread plug gage for right-hand nut thread:
   - A size, 3/8-24NF-3:
     - "Go" end:
       - Major diameter, maximum, 0.3755; minimum, 0.3750 inch.
       - Pitch diameter, maximum, 0.3484; minimum, 0.3481 inch.
       - Gaging notch, 0.125 inch from back.
     - "Not go" end:
       - Major diameter, maximum, 0.3665; minimum, 0.3660 inch.
       - Pitch diameter, maximum, 0.3503; minimum, 0.3500 inch.
   - B size, 9/16-18NF-3:
     - "Go" end:
       - Major diameter, maximum, 0.5630; minimum, 0.5625 inch.
       - Pitch diameter, maximum, 0.5269; minimum, 0.5266 inch.
       - Gaging notch, 0.125 inch from back.
     - "Not go" end:
       - Major diameter, maximum, 0.5510; minimum, 0.5505 inch.
       - Pitch diameter, maximum, 0.5294; minimum, 0.5291 inch.
9. "Go" and "not go" double-end thread plug gage for left-hand nut thread:
   - A size, 3/8-24NF-3LH:
     - "Go" end:
       - Major diameter, maximum, 0.3755; minimum, 0.3750 inch.
       - Pitch diameter, maximum, 0.3784; minimum, 0.3481 inch.
       - Gaging notch, 0.125 inch from back.
     - "Not go" end:
       - Major diameter, maximum, 0.3665; minimum, 0.3660 inch.
       - Pitch diameter, maximum, 0.3503; minimum, 0.3500 inch.

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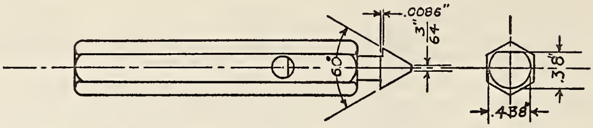

Figure 39.—*Taper gage for nipple seat, B size.*

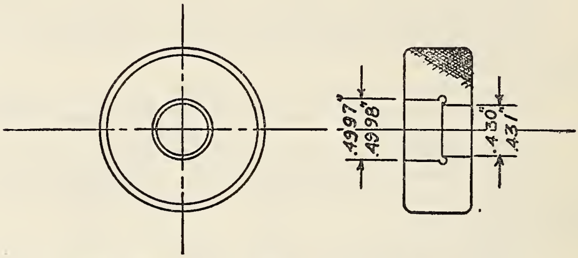

Figure 40.—*"Go" ring gage for diameter of shank shoulder and concentricity of serrated portion, B size.*

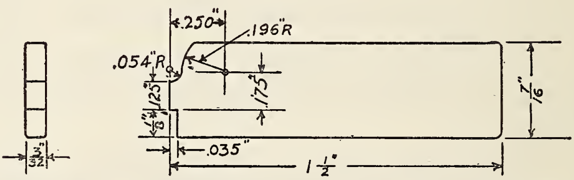

Figure 41.—*Master template for nose of shank, B size.*

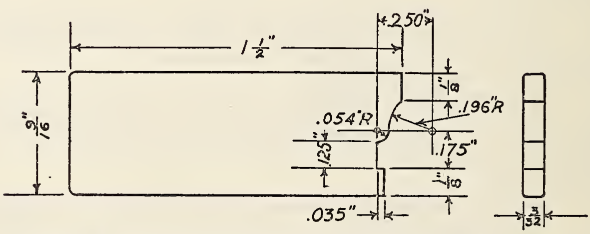

Figure 42.—*Template gage for nose of shank, B size.*

Gage no.

9. "Go" and "not go" double-end thread plug gage for left-hand nut thread—Continued.
   - B size, 9/16-18NF-3LH:
     - "Go" end:
       - Major diameter, maximum, 0.5630; minimum, 0.5625 inch.
       - Pitch diameter, maximum, 0.5269; minimum, 0.5266 inch.
       - Gaging notch, 0.125 inch from back.
     - "Not go" end:
       - Major diameter, maximum, 0.5510; minimum, 0.5505 inch.
       - Pitch diameter, maximum, 0.5294; minimum, 0.5291 inch.
10. Taper gage for nipple seat:
    - A size, as shown in figure 34.
    - B size, as shown in figure 39.
11. "Go" ring gage for diameter of shank shoulder and concentricity of serrated portion:
    - A size, as shown in figure 35.
    - B size, as shown in figure 40.
12. "Not go" snap gage for shank shoulder diameter:
    - A size, maximum, 0.3241; minimum, 0.3240 inch.
    - B size, maximum, 0.4961; minimum, 0.4960 inch.
13. "Go" and "not go" snap gage for diameter of 3/8-inch shank:
    - B size:
      - "Go" end, maximum, 0.4298; minimum, 0.4297 inch.
      - "Not go" end, maximum, 0.4251; minimum, 0.4250 inch.
14. "Go" and "not go" snap gage for diameter of 5/16-inch shank:
    - B size:
      - "Go" end, maximum, 0.3748; minimum, 0.3747 inch.
      - "Not go" end, maximum, 0.3701; minimum, 0.3700 inch.
15. "Go" and "not go" snap gage for diameter of 1/4-inch shank:
    - B size:
      - "Go" end, maximum, 0.3118; minimum, 0.3117 inch.
      - "Not go" end, maximum, 0.3071; minimum, 0.3070 inch.
16. "Go" and "not go" snap gage for diameter of 3/16-inch shank:
    - A size:
      - "Go" end, maximum, 0.2478; minimum, 0.2477 inch.
      - "Not go" end, maximum, 0.2431; minimum, 0.2430 inch.
    - B size:
      - "Go" end, maximum, 0.2498; minimum, 0.2497 inch.
      - "Not go" end, maximum, 0.2451; minimum, 0.2450 inch.
17. "Go" and "not go" snap gage for diameter of 1/8-inch shank:
    - A and B sizes:
      - "Go" end, maximum, 0.1868; minimum, 0.1867 inch.
      - "Not go" end, maximum, 0.1821; minimum, 0.1820 inch.
18. Master template for nose of shank:
    - A size, as shown in figure 36.
    - B size, as shown in figure 41.
19. Template gage for nose of shank:
    - A size, as shown in figure 37.
    - B size, as shown in figure 42.

Section IX C. American National Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases

The specifications given herein for American National rolled threads for screw shells of electric sockets and lamp bases, with the exception of the recently adopted intermediate size, were published in Bulletin No. 1474 of the American Society of Mechanical Engineers entitled "Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases", which was a report of the A.S.M.E. Committee on Standardization of Special Threads for Fixtures and Fittings.

1. FORM OF THREAD

The thread form is composed of two circular segments tangent to each other and of equal radii, as shown in figure 43.

2. THREAD SERIES

The sizes for which standard dimensions and tolerances have been adopted are designated as follows: "Miniature, candelabra, intermediate, medium, and mogul".

The threads per inch, radii of thread form, and diameter limits for these sizes of lamp base screw shells, which are used on lamp bases, fuse plugs, attachment plugs, and similar devices, are given in table 58.

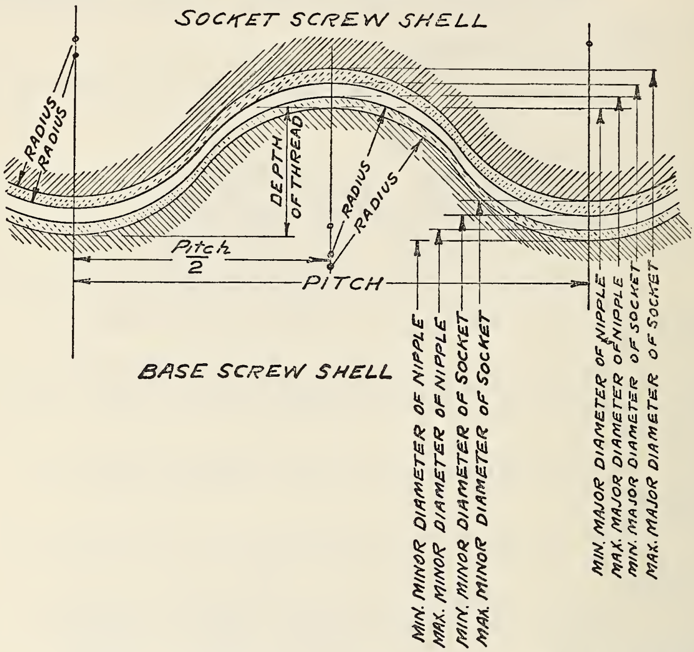

FIGURE 43.—*Illustration of allowance and tolerances, American National rolled threads for screw shells of electric sockets and lamp bases.*

The corresponding dimensions and limits for socket screw shells, which are used in electric sockets, receptacles, and similar devices, are given in table 59.

TABLE 58.—*American National rolled threads for lamp base screw shells*

Size	Threads per inch	Pitch	Depth of thread	Radius	Major diameter		Minor diameter	
					Maximum	Minimum	Maximum	Minimum
1	2	3	4	5	6	7	8	9
		Inch	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*
Miniature	14	0.07143	0.020	0.0210	0.375	0.370	0.335	0.330
Candelabra	10	.10000	.025	.0312	.465	.460	.415	.410
Intermediate	9	.11111	.027	.0353	.651	.645	.597	.591
Medium	7	.14286	.033	.0470	1.037	1.031	.971	.965
Mogul	4	.25000	.050	.0906	1.555	1.545	1.455	1.445

TABLE 59.—*American National rolled threads for socket screw shells*

Size	Threads per inch	Pitch	Depth of thread	Radius	Major diameter		Minor diameter	
					Maximum	Minimum	Maximum	Minimum
1	2	3	4	5	6	7	8	9
		Inch	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*
Miniature	14	0.07143	0.020	0.0210	0.3835	0.3775	0.3435	0.3375
Candelabra	10	.10000	.025	.0312	.476	.470	.426	.420
Intermediate	9	.11111	.027	.0353	.664	.657	.610	.603
Medium	7	.14286	.033	.0470	1.053	1.045	.987	.979
Mogul	4	.25000	.050	.0906	1.577	1.565	1.477	1.465

3. GAGES

Gages are necessary to control dimensions in manufacture and to insure interchangeability and proper assembly.

(*a*) GAGING OF LAMP BASE SCREW SHELLS—(1) *Working gages.*—For each size of lamp base screw shell there should be provided for control in manufacture, a "go" and a "not go" threaded ring gages to govern the minor diameter and thread form, and "go" and "not go" plain ring gages to govern major diameter.

(2) *Inspection gages.*—For purposes of inspection in the final acceptance of the product, a "go" threaded ring gage governing minor diameter and thread form, and a "not go" plain ring gage governing major diameter are sufficient.

(*b*) GAGING OF SOCKET SCREW SHELLS—(1) *Working gages.*—For each size of socket screw shell there should be provided, for control in manufacture, a "go" and a "not go" thread plug gages to govern the major diameter and thread form, and "go" and "not go" plain plug gages to govern minor diameter.

(2) *Inspection gages.*—For the final acceptance of the product, a "go" threaded plug gage governing the major diameter and thread form, and a "not go" plain plug governing minor diameter are sufficient.

(*c*) TOLERANCES ON GAGES.—Manufacturing tolerances on inspection or working gages should not exceed 10 percent of the tolerance on the product, and should be applied in such direction that the limiting dimensions of the screw shells which they are intended to gage are never exceeded.

Radii at the crest of the thread on gages should not exceed values given in column 5, tables 58 and 59, and should not be more than 10 percent less than these radii; also, radii at the root of the thread on gages should not be less than the values given in column 5 nor more than 10 percent greater.

APPENDIX 1. DERIVATION OF TOLERANCES

1. PITCH DIAMETER TOLERANCES

(*a*) Tolerances for Fastening Screws.—The tolerances for fastening screws specified in section III were arrived at by combining two factors, known as the net pitch diameter tolerance and the gage tolerance. The theoretical net tolerances for all screws and nuts of a given class of fit bear a definite mathematical relationship to each other, and it was intended that these should in no way be reduced by permissible manufacturing tolerances for master gages; that is, gages within class X tolerances. Consequently the net tolerances were increased by the equivalent diametrical space required to provide for the class X tolerances on diameter, lead, and angle, to produce the extreme tolerances specified for the product. In practice, the actual net tolerances will depend upon the method of gaging and upon the accuracy of the gages used.

1. *Basis of net tolerances.*—The net pitch diameter tolerances for the various classes of fit are based on the following series for a pitch of $\frac{1}{20}$ inch:

	Inch
Class 1, loose fit	0.0045
Class 2, free fit	.0030
Class 3, medium fit	.0020
Class 4, close fit	.0010

Pitch diameter tolerances for pitches finer than $\frac{1}{20}$ inch are to each other and to the tolerance for $\frac{1}{20}$ inch as the 0.6th power of their respective pitches.

Pitch diameter tolerances for pitches coarser than $\frac{1}{20}$ inch are to each other and to the tolerance for $\frac{1}{20}$ inch as the 0.9th power of their respective pitches.

The exponent 0.6 was chosen for pitches finer than $\frac{1}{20}$ inch because the resulting tolerances, except in two instances, do not vary more than 0.0001 inch from the pitch diameter tolerances specified in the A.S.M.E. Machine Screw Standard.

2. *Gage tolerance.*—The gage tolerance to be added to the net tolerance to obtain the extreme tolerance, which determines the absolute limits within which all variations of the work must be kept, is determined as follows:

Add together the following:

Pitch diameter tolerance of "go" gage.
Diametrical equivalent of lead tolerance of "go" gage.
Diametrical equivalent of angle tolerance of "go" gage.
Pitch diameter tolerance of "not go" gage.

Then subtract the following from the above sum:

One half diametrical equivalent of lead tolerance of "not go" gage.
Diametrical equivalent of angle tolerance of "not go" gage.

(*b*) Tolerances for Screw Threads of Special Diameters, Pitches, and Lengths of Engagement.—As stated in section V, the pitch diameter tolerances for special sizes of threads of American National form as given in tables 36, 37, 38, and 39 were obtained by adding three values, or increments, one dependent upon the basic major diameter, another upon the length of engagement, and the third upon the pitch, except that pitch diameter tolerances listed in section III were inserted in the tables in the positions corresponding to standard sizes, pitches, and lengths of engagement of the American National coarse and fine thread series, and values above and to the left of these inserted values were reduced where necessary so that none should exceed these standard values. Likewise values below and to the right of these inserted values were increased where necessary so that none should be less than these standard values. The formulas from which the increments are derived are given in table 60.

TABLE 60.—*Schedule of tolerance increments for special threads*

Class of fit	Diameter increment	Length of engagement increment	Pitch increment
1	2	3	4
Class 1, loose fit	$0.002\sqrt{D}$	$0.002Q$	$0.020\sqrt{p}$
Class 2, free fit	$.002\sqrt{D}$	$.002Q$	$.010\sqrt{p}$
Class 3, medium fit	$.002\sqrt{D}$	$.002Q$	$.005\sqrt{p}$
Class 4, close fit	$.001\sqrt{D}$	$.001Q$	$.0025\sqrt{p}$

2. RELATION OF LEAD AND ANGLE ERRORS TO PITCH DIAMETER TOLERANCES

It has been stated in various sections of the report that the tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. Also, there were tabulated the errors in lead and angle, each of which could be compensated for by one half of the specified pitch diameter tolerances. These equivalents were derived from definite mathematical relations, which are given below. A rigorous mathematical analysis upon which these formulas are based is presented in appendix 3 of Letter Circular No. 23, issued by the Bureau of Standards.

(*a*) DIAMETER EQUIVALENT OF LEAD ERROR.—The formula expressing the relation between lead error between any two threads within the length of engagement and its diameter equivalent is as follows:

$$E' = (\pm p') \cot a$$

in which

E' = pitch diameter increment due to lead error
p' = the maximum lead error between any two of the threads engaged
a = half angle of thread

The quantity E' is always added to the measured pitch diameter in the case of an external thread, and it is always subtracted in the case of an internal thread, regardless of the sign introduced by the lead error p'.

For threads of American National form, the above formula reduces to—

$$E' = 1.7321\ p'$$

(*b*) DIAMETER EQUIVALENT OF ANGLE ERROR.—The general formula expressing the relation between error in the half angle of thread and its diameter equivalent—that is, the amount of the pitch diameter tolerance absorbed by such an error—is:

$$\cot a' = \frac{h}{E'' \sin a \cos a} \pm \cot a$$

in which

E'' = pitch diameter increment due to error in half angle
h = basic thread depth
a = basic half angle of thread
a' = error in half angle of thread

In solving for E'' the average value of a' for the two sides of the thread, regardless of their signs, should be taken. The sign of cot a is plus when the half angle of thread is less than basic, and minus when the half angle is greater than basic. By omitting $\pm$ cot a from the formula an approximate mean value for a' or E'' is obtained which differs very little from either extreme value. The Commission has, therefore, adopted for general use the formula:

$$\cot a' = \frac{h}{E'' \sin a \cos a}$$

For threads of American National form this formula reduces to—

$$\cot a' = \frac{3p}{2E''}$$

or

$$E'' = 1.5\ p \tan a'$$

For the form of thread recommended for pipe-thread gages the formula becomes—

$$\cot a' = \frac{1.53812p}{E''}$$

or

$$E'' = \frac{1.53812}{n} \tan a'$$

APPENDIX 2. WIRE METHODS OF MEASUREMENT OF PITCH DIAMETER

Throughout this report emphasis has been placed on pitch diameter tolerances and limits, as upon these the fit of a screw thread largely depends. The maintenance of these tolerances and limits requires the use of limit thread gages, and these, in turn, depend upon the absolute values or measurements of master gages. The measurement of pitch diameter presents certain difficulties which may result in an uncertainty as to its true value. The adoption of a uniform practice in making such measurement is, therefore, desirable. The so-called "three-wire method" of measuring pitch diameter, as here outlined, has been found to be the most accurate and satisfactory when properly carried out, and is recommended for universal use in the direct measurement of thread-plug gages.

1. SIZE OF WIRES

In the three-wire method of measuring pitch diameter small hardened steel cylinders or wires of correct size are placed in the thread groove, two on one side of the screw and one on the opposite side, as shown in figure 44. The contact face of the micrometer anvil or spindle over the two wires must be sufficiently large in diameter to touch both wires; that is, it must be greater than the pitch of the thread. It is best to select wires of such a size that they touch the sides of the thread at the mid slope, for the reason that the measurement of pitch diameter is least affected by any error in thread angle which may be present when such size is used. The size of wire which touches exactly at the mid slope of a perfect thread of a given pitch is termed the "best-size" wire for that pitch. Any size, however, may be used which will permit the wires to rest on the sides of the thread and also project above the top of the thread.

The depth at which a wire of given diameter will rest in a thread groove depends primarily on the pitch and included angle of the thread; and secondarily, on the angle made by the helix, at the point of contact of the wire and the thread, with a plane perpendicular to the axis of the screw. Inasmuch as variation in the helix angle has a very small effect in determining the diameter of the wire which touches at the mid slope of the thread, and as it is desirable to use one size of wire to measure all threads of a given pitch and included angle, the best size wire is taken as that size which will touch at the mid slope of a groove cut around a cylinder perpendicular to the axis of the cylinder, and of the same angle and depth as the thread of the given pitch. This is equivalent to a thread of zero helix angle. The size of wire touching at the mid slope, or "best-size" wire, is given by the formula:

$$G = \frac{p}{2} \sec a$$

in which

G = diameter of wire
p = pitch
a = ½ included angle of thread

This formula reduces to—

$$G = 0.57735 \times p, \text{ for } 60° \text{ threads}$$

It is frequently desirable, as, for example, when a best-size wire is not available, to measure pitch diameter by means of wires of other than the best size.

The minimum size which may be used is limited to that permitting the wire to project above the crest of the thread, and the maximum to that permitting the wire to rest on the sides of the thread just below the crest, and not ride on the creast of the thread. The diameters of the best size, maximum, and minimum wires for American National coarse, fine, hose-coupling, and pipe threads are given in tables 61 and 62.

2. SPECIFICATION FOR WIRES

A suitable specification for wires is as follows:

1. The wires should be cylinders of steel with working surfaces glass hard and accurately finished.

2. The working surface should be about 1 inch in length, and the wire may have a suitable handle which is provided at one end with an eye or other suitable

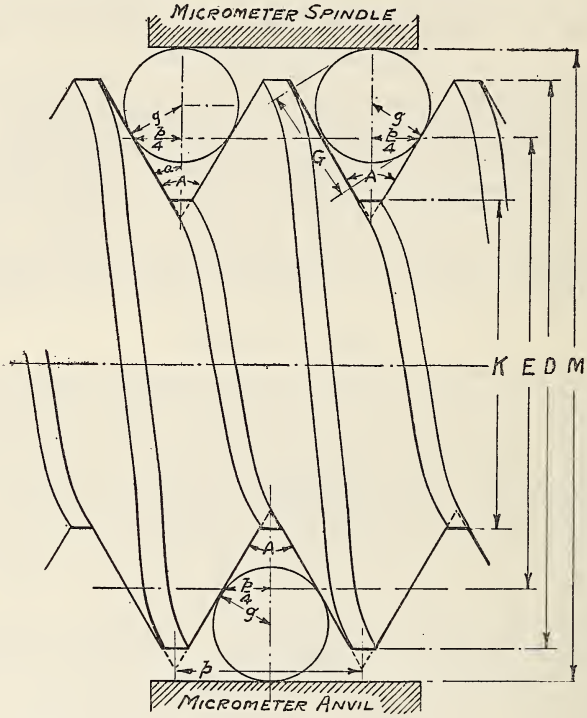

FIGURE 44.—*Three-wire method of measuring pitch diameter of thread plug gages.*

means of suspension. One side of the handle, which should be flattened, should be marked with the pitch for which the wire is the best size, and with the diameter of the working part of the wire as determined by measurements under standard conditions as specified below.

3. A suitable container should be provided for each set of wires, and if wires are furnished without handles, the pitch for which the wires are the best size and the diameter of the working part of the wires as determined by measurements under standard conditions as specified below, should be marked on the container.

4. The wire should be round within 0.00002 inch and should be straight to 0.00002 inch over any quarter-inch interval.

5. One set of wires should consist of three wires which should have the same diameter within 0.00003 inch, and this common diameter should be within 0.0001 inch of that corresponding to the best size for the pitch for which the wire is to be used.

3. METHODS OF MEASURING AND USING WIRES

In order to measure the pitch diameter of a screw-thread gage to an accuracy of 0.0001 inch by means of wires, it is necessary to know the wire diameters to 0.00002 inch. The micrometer to be used for measuring wires should be one which is graduated to ten-thousandths of an inch and upon which hundred-thousandths of an inch can be estimated. Such micrometers are available in various forms of precision bench micrometers, and measuring machines. Care should be taken to make sure that the measuring faces of the micrometer are flat and parallel to within 0.00002 inch. The taper of wires can best be determined by measuring between a flat micrometer contact and a cylindrical anvil. Any pits or worn spots on the wires can be detected with the same arrangement. Variations in roundness and straightness are usually determined by rotating the wire between flat contacts one fourth inch in diameter. However, one form of variation in roundness can only be detected by rotating the wire in a V groove against a flat micrometer contact. The V groove may be the thread space in a hardened and well-finished thread plug gage.

The contact pressure used in making measurements is also an important factor, since the wires, when in use, rest on the sides of the thread, and a given pressure exerted on the top of the thread has a magnified effect in distorting the wire and causing the measurement of the pitch diameter to be slightly less than it should be. In making measurements over the wires inserted in the thread groove, it has been common shop practice to hold the wires down into the thread by means of elastic bands. This has a tendency to prevent the wires from adjusting themselves to the proper position in the thread grooves; thus a false measurement is obtained. In some cases it has also been the practice to support the screw being measured on two wires, which are in turn supported on a horizontal surface, and measuring from this surface to the top of a wire placed in a thread over the gage. If the screw is of large diameter, its weight causes a distortion of the wires and an inaccurate reading is obtained. For these reasons these practices should be avoided and subsidiary apparatus for supporting the wires and micrometer should be used.

For consistent results a standard practice as to contact pressure in making wire measurements of hardened screw thread gages is necessary. The computed value for the pitch diameter of a screw thread gage obtained from readings over wires will depend upon the accuracy of the measuring instrument used, the contact pressure, and the value of the diameter of the wires used in the computations. The use of different contact pressures will cause a difference in the readings over the wires, and such errors can only be compensated by the use of a value for the diameter of the wires depending on the contact pressure used. The effect of variation in contact pressure in measuring threads of fine pitches is indicated by the difference in readings obtained with 2 and 5 pounds pressure on a 24-pitch thread plug gage. The reading over the wires with 5 pounds pressure was 0.00013 inch less than with 2 pounds pressure.

A wire presses on the sides of a 60° thread with the pressure that is applied to the wire by the measuring instrument. This fact would indicate that the diameter of the wire should be determined by readings made on the wire over a hardened and lapped cylinder having a radius equal to the radius of curvature of the helical surface of the thread at the point of contact, using the pressure to be used in determining the pitch diameter of the gage. However, it is not practical to employ such a variety of cylinders as would be required, and it is recommended for standard practice that wires be measured between a flat contact and a 0.750-inch hardened and accurately ground and lapped steel cylinder with the pressure used in measuring the pitch diameter of the gage. Furthermore, to avoid a permanent deformation of the material of the wires and gages it is necessary to limit the contact pressure. For pitches finer than 20 threads per inch a pressure of 14 to 16 ounces is recommended. For pitches of 20 threads per inch and coarser a pressure of 2¼ to 2½ pounds is recommended.

Measurements of a thread plug gage made in accordance with these instructions, with wires which conform to the above specifications, should be accurate to 0.0001 inch. If the diameters of the wires are known only to an accuracy of 0.0001 inch, an accuracy better than 0.0003 inch in the measurement of pitch diameter cannot be expected.

4. MEASUREMENT OF PITCH DIAMETER OF AMERICAN NATIONAL STRAIGHT THREADS

The general formula for determining the pitch diameter of any thread whose sides are symmetrical with respect to a line drawn through the vertex and perpendicular to the axis of the thread, in which the very slight effect of helix angle is not taken into account, is:[1]

$$E=M+\frac{\cot a}{2n}-G\ (1+\operatorname{cosec} a)$$

in which

E=pitch diameter
M=measurement over wires
a=one half included angle of thread
n=number of threads per inch
G=diameter of wires

This formula differs from those formerly given in engineering handbooks in that the latter, as generally given, yield a result which should check with the major diameter of the screw measured, while the pitch diameter itself is not mentioned. For a 60° thread of correct angle and thread form this formula simplifies to—

$$E=M+\frac{0.86603}{n}-3G$$

For a given set of best-size wires

$$E=M-X$$

when

$$X=G\ (1+\operatorname{cosec} a)-\frac{\cot a}{2n}$$

The quantity X is a constant for a given thread angle, and, when the wires are used for measuring threads of the pitch and angle for which they are the best size, the pitch diameter is obtained by the simple operation of subtracting this constant or factor from the measurement taken over the wires. In fact, when best-size wires are used, this factor is changed very little by a moderate variation or error in the angle of the thread. Consequently, the factors for the various sets of wires in use may be tabulated, thus saving a considerable amount of time in the inspection of gages. However, when wires of other than the best size are used, this factor changes quite appreciably with a variation in the angle of the thread.

It has been shown that, with the exception of coarse pitch screws, variation in angle from the basic value causes no appreciable change in the quantity X for the best-size wires. On the other hand, when a wire near the maximum or minimum allowable size is used, a considerable change occurs, and the values of the cotangent and cosecant of the actual measured half angle are to be used. It is apparent, therefore, that there is a great advantage in using wires very closely approximating the best size. For convenience in carrying out computations, the values of $\frac{\cot a}{2n}$ for standard pitches are given in table 61.

[1] The general formula, in which the helix angle is taken into account, is:

$$E=M+\frac{\cot a}{2n}-G(1+\operatorname{cosec} a+\frac{S^2}{2}\cos a \cot a)$$

in which S=tangent of the helix angle.

The value of S, the tangent of the helix angle, is given by the formula

$$S=\frac{L}{3.1416E}=\frac{1}{3.1416\ NE}$$

in which

L=lead
N=number of turns per inch
E=nominal pitch diameter

In commercial practice the term $\left(\frac{G\ S^2}{2}\cos a \cot a\right)$ is neglected, as its value is small, being in all cases less than 0.00015 inch for standard fastening screws when the best-size wire is used, and the above formula takes the simplified form given above. The practice is permissible provided that it is uniformly followed, and in order to maintain uniformity of practice, and thus avoid confusion, the Bureau of Standards uses the latter formula except when the value of the term $\left(\frac{G\ S^2}{2}\cos a \cot a\right)$ exceeds 0.00015 inch, as in the case of Acme and multiple threads, or other threads having exceptionally large helix angles.

5. MEASUREMENT OF PITCH DIAMETER OF AMERICAN NATIONAL TAPER THREADS

The pitch diameter of a taper thread plug gage is measured in much the same manner as that of a straight thread gage, except that a definite position at which the measurement is to be made must be located. A point at a known distance *L* from the end of the gage is located by means of a combination of precision gage blocks and the cone point furnished as an accessory with these blocks, as

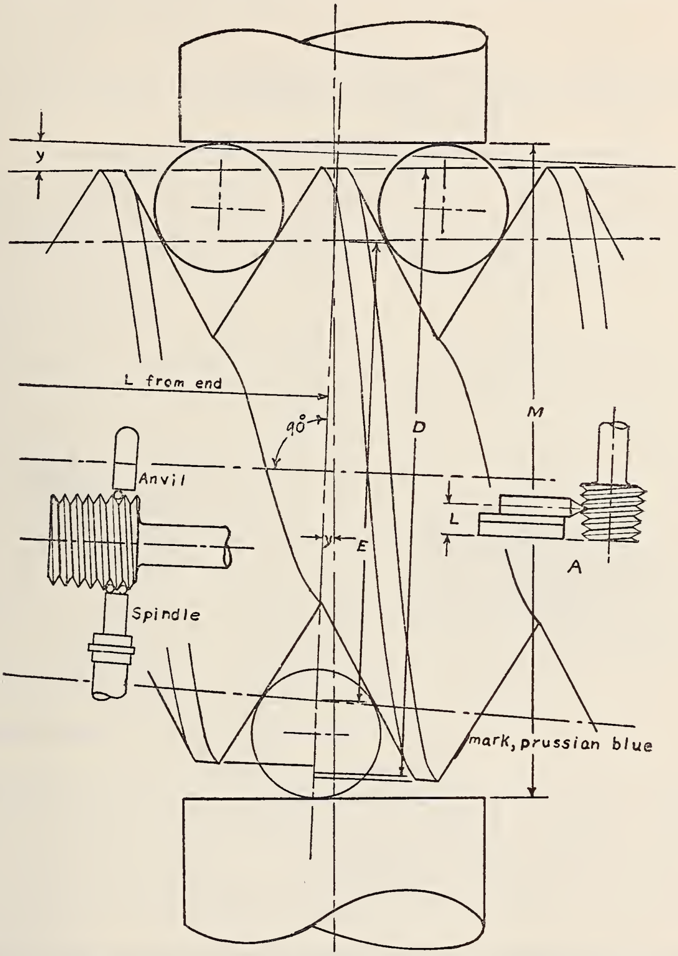

Figure 45.—*Measurement of pitch diameter of taper thread gages by the 3-wire method.*

shown in figure 45 at *A*. The gage is set vertically on a surface plate, the cone point is placed with its axis horizontal at the desired height, and the plug is turned until the point fits accurately into the thread. The position of this point is marked by placing a bit of prussian blue or wax immediately above it. Measurement is made over the wires in the usual manner, but care must be taken that the contact surfaces of the micrometer make contact with all three wires, since the micrometer is not perpendicular to the axis of the screw when there is proper contact. (See fig. 45.) On account of this inclination, the measurement over the wires must be multiplied by the secant of the half angle of the taper of the thread. The formula for the pitch diameter of any taper thread plug gage, the

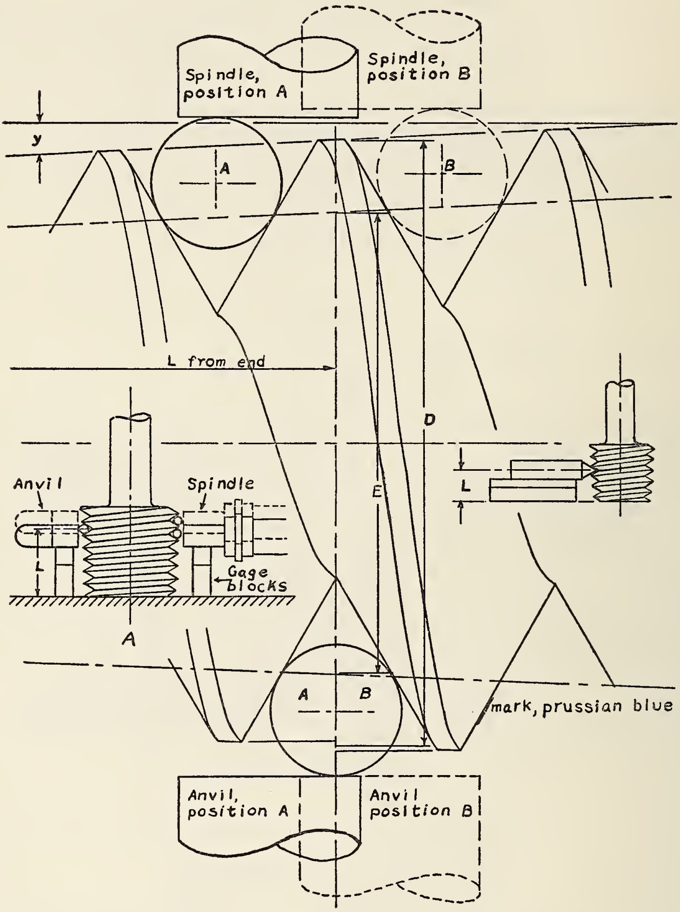

FIGURE 46.—*Measurement of pitch diameter of taper thread gages by the 2-wire method.*

threads of which are symmetrical with respect to a line perpendicular to the axis, then has the form:[3]

$$E = M \sec y + \frac{\cot a}{2n} - G\ (1 + \operatorname{cosec} a)$$

in which

E=pitch diameter
M=measurement over wires
y=half angle of taper of thread
n=number of threads per inch=$1/p$
a=half angle of thread
G=diameter of wires

Thus the pitch diameter of an American National standard pipe-thread gage having correct angle (60°) and taper (¾ inch per foot) is then given by the formula:

$$E = 1.00049\ M + 0.86603\ p - 3G$$

The pitch diameter at any other point along the thread, as at the gaging notch, is obtained by multiplying the distance parallel to the axis of the thread, between this point and the point at which the measurement was taken, by the taper per inch, then adding the product to or subtracting it from the measured pitch diameter according to the direction in which the second point is located with respect to the first.

In recent years measuring machines have replaced micrometer calipers generally for the measurement of taper thread plug gages, and the following method, illustrated in figure 46, is applied: This method has a theoretical advantage over the first method in that it is independent of the taper of the thread, and, therefore, requires less computation; or if the taper is not measured, but assumed to be correct, it is more accurate. The axis of the gage and the line of measurement are constrained perpendicular to each other. This is easily done on a measuring machine if the gage is supported on centers mounted on a slide whose ways are perpendicular to the line of measurement. If a micrometer caliper is used, its spindle is constrained perpendicular to the axis of the screw. One method is to place the gage on a surface plate with its axis vertical, and support the micrometer in a horizontal position with its anvil and spindle resting on two equal combinations of gage blocks as shown in figure 46 at *A*. A single wire is inserted in the thread at the point located as in the previous method, and one other wire is placed in the upper thread on the opposite side. A measurement is taken over the two wires; the second wire is then moved to the thread immediately below and a second reading is taken. The mean of these two readings is substituted in any of the above formulas in the place of $M \sec y$, or $1.00049\ M$.

6. MEASUREMENT OF PITCH DIAMETER OF THREAD RING GAGES

The application of direct methods of measurement to determine the pitch diameter of thread ring gages presents serious difficulties, particularly in securing proper contact pressure when a high degree of precision is required. The usual practice is to fit the ring gage to a master setting plug. When the thread ring gage is of correct lead, angle, and thread form, within close limits, this method is quite satisfactory and represents standard American practice. It is the only method available for small sizes of threads. For the larger sizes, various more or less satisfactory methods have been devised, but none of these have found wide application.

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[3] See footnotes 18 and 1, pp. 100, 132. In the above formula for the value of E, the term $\frac{\cot a}{2n}$ is an approximation for the value of H. The exact value of H is used when the value of the term $\frac{\tan^2 y \tan a}{2n}$ exceeds 0.00004 inch, which ordinarily occurs only on special taper threads of coarse pitch or steep taper. Also the multiplication of the measurement over the wires by the secant of the half angle of the taper of the thread is not an exact correction for the inclination of the measurement. The complete formula is—

$$E = (M - G) \sec y + \frac{\cot a - \tan^2 y \tan a}{2n} - G\ \left(\operatorname{cosec} a + \frac{S^2}{2} \cos a \cot a\right)$$

This formula gives a value of E which is 0.000081 inch smaller than that given by the simplified formula for the 2½-inch-8 American National taper pipe thread, the worst case in this thread series.

TABLE 61.—*Wire sizes and constants, American National coarse, fine, hose-coupling, and pipe threads*

Wire sizes [1]			Threads per inch	Pitch	$\frac{\text{Pitch}}{2}$	Depth of V thread
Best 0.577350p	Maximum 1.010363p	Minimum 0.505182p	n	$p=\frac{1}{n}$	$\frac{p}{2}=\frac{1}{2n}$	$\frac{\cot 30°}{2n}$
1	2	3	4	5	6	7
Inch	*Inch*	*Inch*		*Inch*	*Inch*	
0.00722	0.01263	0.00631	80	0.01250	0.00625	0.01083
.00802	.01403	.00702	72	.01389	.00694	.01203
.00902	.01579	.00789	64	.01562	.00781	.01353
.01031	.01804	.00902	56	.01786	.00893	.01546
.01203	.02105	.01052	48	.02083	.01042	.01804
.01312	.02296	.01148	44	.02273	.01136	.01968
.01443	.02526	.01263	40	.02500	.01250	.02165
.01604	.02807	.01403	36	.02778	.01389	.02406
.01804	.03157	.01579	32	.03125	.01562	.02706
.02062	.03608	.01804	28	.03571	.01786	.03093
.02138	.03742	.01871	27	.03704	.01852	.03208
.02406	.04210	.02105	24	.04167	.02083	.03608
.02887	.05052	.02526	20	.05000	.02500	.04330
.03208	.05613	.02807	18	.05556	.02778	.04811
.03608	.06315	.03157	16	.06250	.03125	.05413
.04124	.07217	.03608	14	.07143	.03571	.06186
.04441	.07772	.03886	13	.07692	.03846	.06662
.04811	.08420	.04210	12	.08333	.04167	.07217
.05020	.08786	.04393	11½	.08696	.04348	.07531
.05249	.09185	.04593	11	.09091	.04545	.07873
.05773	.10104	.05052	10	.10000	.05000	.08660
.06415	.11226	.05613	9	.11111	.05556	.09623
.07217	.12630	.06315	8	.12500	.06250	.10825
.07698	.13472	.06736	7½	.13333	.06667	.11547
.08248	.14434	.07217	7	.14286	.07143	.12372
.09623	.16839	.08420	6	.16667	.08333	.14434
.11547	.20207	.10104	5	.20000	.10000	.17321
.12830	.22453	.11226	4½	.22222	.11111	.19245
.14434	.25259	.12630	4	.25000	.12500	.21651

[1] These wire sizes are based on zero helix angle. Also maximum and minimum sizes are based on a width of flat at the crest equal to ⅛×p. The width of flat of American National pipe thread gages is slightly less than this, so that the minimum size listed is slightly too small for such gages. In any case the use of wires of either extreme size is to be avoided.

TABLE 62.—*Relation of best wire diameters and pitches* [1]—*wires for American National coarse, fine, hose-coupling, and pipe threads*

Best wire sizes (in inches)	Threads per inch																												
	80	72	64	56	48	44	40	36	32	28	27	24	20	18	16	14	13	12	11½	11	10	9	8	7½	7	6	5	4½	4
0.00722	⊗	×																											
0.00802	×	⊗	×																										
0.00902	×	×	⊗																										
0.01031	×	×	×	⊗																									
0.01203	×	×	×	×	⊗	×																							
0.01312		×	×	×	×	⊗	×																						
0.01443			×	×	×	×	⊗	×																					
0.01604				×	×	×	×	⊗	×																				
0.01804					×	×	×	×	⊗																				
0.02062					×	×	×	×	×	⊗	×																		
0.02138						×	×	×	×	×	⊗	×																	
0.02406							×	×	×	×	×	⊗																	
0.02887									×	×	×	×	⊗	×															
0.03208										×	×	×	×	⊗	×														
0.03608											×	×	×	×	⊗														
0.04124												×	×	×	×	⊗	×												
0.04441													×	×	×	×	⊗	×	×										
0.04811													×	×	×	×	×	⊗	×	×									
0.05020													×	×	×	×	×	×	⊗	×									
0.05249														×	×	×	×	×	×	⊗	×								
0.05773															×	×	×	×	×	×	⊗	×							
0.06415																×	×	×	×	×	×	⊗	×						
0.07217																	×	×	×	×	×	×	⊗	×					
0.07698																	×	×	×	×	×	×	×	⊗	×				
0.08248																		×	×	×	×	×	×	×	⊗				
0.09623																					×	×	×	×	×	⊗			
0.11547																							×	×	×	×	⊗	×	
0.12830																								×	×	×	×	⊗	×
0.14434																										×	×	×	⊗

[1] The crosses (×) indicate those wire diameters which can be used for each pitch. An encircled cross (⊗) indicates the "best wire" diameter for that pitch which heads the column.

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7. WIRE METHODS OF MEASUREMENT OF THREAD THICKNESS OF ACME THREADED PLUG GAGES

For threads having a thread angle less than 45° the quality of fit can be more accurately controlled by checking the element of thread thickness, in relation to the basic major diameter (that is, the thread thickness at the nominal pitch diameter), than by checking pitch diameter. For this purpose the 3-wire method may be applied in the same manner as for measuring pitch diameter, but the method of computation is slightly different. On account of the small thread angle, the cotangent of which is large, it is always necessary to take the helix angle into account in measuring thread thickness by the 3-wire method. The general formula to be applied in determining thread thickness is as follows:

$$t=p-\tan a\ [D-2B-M+G(1+\operatorname{cosec} a+\frac{S^2}{2}\cos a \cot a)]$$

in which

D=basic major diameter of screw
M=measurement over wires
G=diameter of wires
a=half angle of thread
S=tangent of helix angle at pitch line
p=pitch
B=depth at which thread thickness is measured
t=thread thickness at depth B

On Acme screw threads

$$B=p/4$$

and the thread angle being 29°, the above formula reduces to—

$$t=1.12931p+0.25862(M-D)-G(1.29152+0.48407S^2)$$

The same formula applies to taps for Acme threads, although the major diameter is larger than basic, since the formula is based on the basic major diameter.

The diameters of the best size, maximum, and minimum wires for standard pitches of Acme threads are listed in table 63. Also, for convenience in carrying out computations, the values of $1.12931p$ and of $1.29152+0.48407S^2$ for various diameters and pitches of single, double, triple, and quadruple threads are given in tables 64, 65, 66, and 67.

TABLE 63.—*Wire sizes and constants, American National Acme threads (29°)*

Threads per inch	Pitch $p=\frac{1}{n}$	Wire sizes [1]		
		Best 0.516450p	Maximum, 0.650013p	Minimum, 0.487263p
1	2	3	4	5
	Inch	*Inch*	*Inch*	*Inch*
1	1.00000	0.51645	0.65001	0.48726
1⅓	.75000	.38734	.48751	.36545
1½	.66667	.34430	.43334	.32484
2	.50000	.25822	.32501	.24363
2½	.40000	.20658	.26001	.19491
3	.33333	.17215	.21667	.16242
4	.25000	.12911	.16250	.12182
5	.20000	.10329	.13000	.09745
6	.16667	.08608	.10834	.08121
8	.12500	.06456	.08125	.06091
10	.10000	.05164	.06500	.04873
12	.08333	.04304	.05417	.04061
14	.07143	.03689	.04643	.03480
16	.06250	.03228	.04063	.03045

[1] Based on zero helix angle.

TABLE 64.—*Values of 1.12931p and 1.29152+0.48407S² for various diameters and pitches, Acme threads*

SINGLE THREADS

Basic major diameter (inches)	Threads per inch, $n=1/p$											
	12	10	8	6	5	4	3	2½	2	1½	1⅓	1
	1.12931p											
	0.09411	0.11293	0.14116	0.18822	0.22586	0.28233	0.37644	0.45172	0.56465	0.75287	0.84698	1.12931
	1.291518+0.484074S^2											
¼												
5/16												
⅜	1.29458											
7/16	369	1.29478										
½	314	394	1.29552									
9/16	277	339	458									
⅝	252	300	394									
11/16	233	272	348									
¾	220	252	314	1.29458								
13/16	209	236	288	408								
⅞	201	224	268	369	1.29478							
15/16	194	214	252	339	432							
1	189	206	239	314	394							
1⅛	181	194	220	277	339	1.29458						
1¼	175	186	206	252	300	394						
1⅜	171	180	196	233	272	348						
1½	168	175	189	220	252	314	1.29458					
1⅝	165	172	183	209	236	288	408					
1¾	163	169	179	201	224	268	369	1.29478				
1⅞	162	167	175	194	214	252	339	431				
2	161	165	172	189	206	239	314	394				
2⅛	160	163	170	184	200	228	294	364				
2¼	159	162	168	181	194	220	277	339	1.29458			
2⅜	158	161	166	178	190	212	264	318	423			
2½	157	160	165	175	186	206	252	300	394			
2⅝	157	159	163	173	183	201	242	285	369			
2¾	156	159	162	171	180	196	233	272	348			
2⅞	156	158	161	169	177	192	226	261	330			
3	156	157	161	168	175	189	220	252	314	1.29458		
3⅛	155	157	160	167	173	186	214	244	300	431		
3¼	155	157	159	165	172	183	209	236	288	408		
3⅜	155	156	159	164	170	181	205	230	277	387		
3½	155	156	158	163	169	179	201	224	268	369	1.29434	
3⅝	154	156	158	163	168	177	197	219	259	353	413	
3¾	154	155	157	162	167	175	194	214	252	339	394	
3⅞	154	155	157	161	166	174	191	210	245	326	377	
4	154	155	157	161	165	172	189	206	239	314	362	
4⅛	154	155	156	160	164	171	187	203	233	303	348	
4¼	154	155	156	160	163	170	184	200	228	294	336	
4⅜	154	154	156	159	163	169	183	197	224	285	324	
4½	154	154	156	159	162	168	181	194	220	277	314	1.29458
4⅝	153	154	155	158	161	167	179	192	216	270	305	440
4¾	153	154	155	158	161	166	178	190	212	264	296	423
4⅞	153	154	155	158	160	165	176	188	209	257	288	408
5	153	154	155	157	160	165	175	186	206	252	281	394
5¼	153	154	155	157	159	163	173	183	201	242	268	369
5½	153	153	154	156	159	162	171	180	196	233	257	348
5¾	153	153	154	156	158	161	169	177	192	226	247	330
6	153	153	154	156	157	161	168	175	189	220	239	314
6¼	153	153	154	155	157	160	167	173	186	214	232	300
6½	153	153	154	155	157	159	165	172	183	209	225	288
6¾	153	153	154	155	156	159	164	170	181	205	220	277
7	152	153	153	155	156	158	163	169	179	201	215	268
7¼	152	153	153	154	156	158	163	168	177	197	210	259
7½	152	153	153	154	155	157	162	167	175	194	206	252
7¾	152	153	153	154	155	157	161	166	174	191	203	245
8	152	153	153	154	155	157	161	165	172	189	199	239
8¼	152	153	153	154	155	156	160	164	171	187	196	233
8½	152	152	153	154	155	156	160	163	170	184	194	228
8¾	152	152	153	154	154	156	159	163	169	183	191	224
9	152	152	153	154	154	156	159	162	168	181	189	220
9¼	152	152	153	153	154	155	158	161	167	179	187	216
9½	152	152	153	153	154	155	158	161	166	178	185	212
9¾	152	152	153	153	154	155	158	160	165	176	183	209
10	1.29152	1.29152	1.29153	1.29153	1.29154	1.29155	1.29157	1.29160	1.29165	1.29175	1.29182	1.29206

Table 65.—*Values of* $1.12931p$ *and* $1.29152+0.48407S^2$ *for various diameters and pitches, Acme threads*

DOUBLE THREADS

Basic major diameter (inches)	Threads per inch, $n=1/p$											
	12	10	8	6	5	4	3	2½	2	1½	1⅓	1
	$1.12931p$											
	0.09411	0.11293	0.14116	0.18822	0.22586	0.28233	0.37644	0.45172	0.56465	0.75287	0.84698	1.12931
	$1.291518+0.484074S^2$											
¼	1.32291	1.34056	1.37871									
5/16	1.31009	1.31999	1.34056									
⅜	1.30378	1.31009	1.32291	1.35558								
7/16	1.30021	1.30458	1.31332	1.33496	1.36041							
½	1.29800	1.30121	1.30753	1.32291	1.34056	1.37871						
9/16	654	1.29899	1.30378	1.31525	1.32820	1.35558						
⅝	552	745	1.30121	1.31009	1.31999	1.34056						
11/16	478	635	1.29937	1.30645	1.31425	1.33027	1.37188					
¾	423	552	800	1.30378	1.31009	1.32291	1.35558					
13/16	381	489	697	1.30177	1.30698	1.31746	1.34378	1.37519				
⅞	348	440	616	1.30021	1.30458	1.31332	1.33496	1.36041				
15/16	322	401	552	1.29899	1.30271	1.31009	1.32820	1.34923				
1	300	369	501	800	1.30121	1.30753	1.32291	1.34056	1.37871			
1⅛	268	322	423	654	1.29899	1.30378	1.31525	1.32820	1.35558			
1¼	245	288	369	552	745	1.30121	1.31009	1.31999	1.34056			
1⅜	228	264	330	478	635	1.29937	1.30645	1.31425	1.33027	1.37188		
1½	216	245	300	423	552	800	1.30378	1.31009	1.32291	1.35558	1.37871	
1⅝	206	231	277	381	489	697	1.30177	1.30698	1.31746	1.34378	1.36215	
1¾	198	220	259	348	440	616	1.30021	1.30458	1.31332	1.33496	1.34989	
1⅞	192	211	245	322	401	552	1.29899	1.30271	1.31009	1.32821	1.34057	
2	187	203	234	300	369	501	800	1.30121	1.30753	1.32291	1.33331	1.37871
2⅛	183	197	224	283	343	458	720	1.29999	1.30547	1.31868	1.32755	1.36581
2¼	180	192	216	268	322	423	654	899	1.30378	1.31525	1.32291	1.35558
2⅜	177	188	209	256	303	394	599	815	1.30238	1.31244	1.31911	1.34732
2½	174	184	203	245	288	369	552	745	1.30121	1.31009	1.31596	1.34056
2⅝	172	181	198	236	275	348	513	686	1.30021	1.30812	1.31332	1.33496
2¾	170	179	194	228	264	330	478	635	1.29937	1.30645	1.31108	1.33027
2⅞	169	176	191	222	254	314	449	590	864	1.30502	1.30917	1.32630
3	167	174	187	216	245	300	423	552	800	1.30378	1.30753	1.32291
3⅛	166	173	184	211	238	288	401	519	745	1.30271	1.30611	1.31999
3¼	165	171	182	206	231	277	381	489	697	1.30177	1.30487	1.31746
3⅜	164	170	180	202	225	268	364	463	654	1.30094	1.30378	1.31525
3½	163	168	178	198	220	259	348	440	616	1.30021	1.30282	1.31332
3⅝	162	167	176	195	215	252	334	419	582	1.29957	1.30197	1.31161
3¾	162	166	174	192	211	245	322	401	552	899	1.30121	1.31009
3⅞	161	165	173	190	207	239	310	384	525	847	1.30053	1.30874
4	160	164	172	187	203	234	300	369	501	800	1.29992	1.30753
4⅛	160	164	170	185	200	228	291	356	478	758	937	1.30645
4¼	159	163	169	183	197	224	283	343	458	720	887	1.30547
4⅜	159	162	168	181	195	220	275	332	440	686	842	1.30458
4½	159	162	167	180	192	216	268	322	423	654	800	1.30378
4⅝	158	161	167	178	190	212	261	312	408	625	763	1.30305
4¾	158	161	166	177	188	209	256	303	394	599	728	1.30238
4⅞	158	160	165	176	186	206	250	295	381	575	697	1.30177
5	157	160	164	174	184	203	245	288	369	552	668	1.30121
5¼	157	159	163	172	181	198	236	275	348	513	616	1.30021
5½	156	158	162	170	179	194	228	264	330	478	572	1.29937
5¾	156	158	161	169	176	191	222	254	314	449	534	864
6	156	157	160	167	174	187	216	245	300	423	501	800
6¼	155	157	160	166	173	184	211	238	288	401	472	745
6½	155	157	159	165	171	182	206	231	277	381	446	697
6¾	155	156	159	164	170	180	202	225	268	364	423	654
7	155	156	158	163	168	178	198	220	259	348	403	616
7¼	154	156	158	162	167	176	195	215	252	334	385	582
7½	154	155	157	162	166	174	192	211	245	322	369	552
7¾	154	155	157	161	165	173	190	207	239	310	355	525
8	154	155	157	160	164	172	187	203	234	300	342	501
8¼	154	155	156	160	164	170	185	200	228	291	330	478
8½	154	155	156	159	163	169	183	197	224	283	319	458
8¾	154	154	156	159	162	168	181	195	220	275	309	440
9	153	154	156	159	162	167	180	192	216	268	300	423
9¼	153	154	155	158	161	167	178	190	212	261	292	408
9½	153	154	155	158	161	166	177	188	209	256	284	394
9¾	153	154	155	158	160	165	176	186	206	250	277	381
10	1.29153	1.29154	1.29155	1.29157	1.29160	1.29164	1.29174	1.29184	1.29203	1.29245	1.29271	1.29369

TABLE 66.—*Values of* $1.12931p$ *and* $1.29152+0.48407S^2$ *for various diameters and pitches, Acme threads*

TRIPLE THREADS

Basic major diameter (inches)	Threads per inch, $n=1/p$											
	12	10	8	6	5	4	3	2½	2	1½	1⅓	1
	$1.12931p$											
	0.09411	0.11293	0.14116	0.18822	0.22586	0.28233	0.37644	0.45172	0.56465	0.75287	0.84698	1.12931
	$1.291518+0.484074S^2$											
¼	1.36215	1.40187	1.48771	-------	-------	-------	-------	-------	-------	-------	-------	-------
5/16	1.33331	1.35558	1.40187	-------	-------	-------	-------	-------	-------	-------	-------	-------
⅜	1.31911	1.33331	1.36215	1.43565	-------	-------	-------	-------	-------	-------	-------	-------
7/16	1.31108	1.32092	1.34057	1.38927	1.44653	-------	-------	-------	-------	-------	-------	-------
½	1.30611	1.31332	1.32755	1.36215	1.40187	1.48771	-------	-------	-------	-------	-------	-------
9/16	1.30282	1.30832	1.31911	1.34492	1.37406	1.43566	-------	-------	-------	-------	-------	-------
⅝	1.30053	1.30487	1.31332	1.33331	1.35558	1.40187	-------	-------	-------	-------	-------	-------
11/16	1.29887	1.30238	1.30918	1.32511	1.34267	1.37871	1.47233	-------	-------	-------	-------	-------
¾	763	1.30053	1.30611	1.31911	1.33331	1.36215	1.43566	-------	-------	-------	-------	-------
13/16	668	1.29911	1.30378	1.31458	1.32630	1.34989	1.40911	1.47978	-------	-------	-------	-------
⅞	593	800	1.30197	1.31108	1.32092	1.34057	1.38927	1.44653	-------	-------	-------	-------
15/16	534	712	1.30053	1.30832	1.31669	1.33331	1.37406	1.42137	-------	-------	-------	-------
1	486	641	1.29937	1.30611	1.31332	1.32755	1.36215	1.40187	1.48771	-------	-------	-------
1⅛	413	534	763	1.30282	1.30832	1.31911	1.34492	1.37406	1.43566	-------	-------	-------
1¼	362	458	641	1.30053	1.30487	1.31332	1.33331	1.35558	1.40187	-------	-------	-------
1⅜	324	403	552	1.29887	1.30238	1.30918	1.32511	1.34267	1.37871	1.47233	-------	-------
1½	296	362	486	763	1.30053	1.30611	1.31911	1.33331	1.36215	1.43565	1.48771	-------
1⅝	274	330	434	668	1.29911	1.30378	1.31458	1.32630	1.34989	1.40911	1.45043	-------
1¾	257	305	394	593	800	1.30197	1.31108	1.32092	1.34057	1.38927	1.42285	-------
1⅞	243	284	362	534	712	1.30053	1.30832	1.31669	1.33331	1.37406	1.40188	-------
2	232	268	336	486	641	1.29937	1.30611	1.31332	1.32755	1.36215	1.38555	1.48771
2⅛	222	254	314	446	582	842	1.30431	1.31058	1.32291	1.35263	1.37260	1.45868
2¼	215	243	296	413	534	763	1.30282	1.30832	1.31911	1.34492	1.36214	1.43566
2⅜	208	233	281	385	493	697	1.30158	1.30645	1.31596	1.33858	1.35359	1.41708
2½	203	225	268	362	458	641	1.30053	1.30487	1.31332	1.33331	1.34650	1.40187
2⅝	198	218	257	342	429	593	1.29963	1.30353	1.31108	1.32887	1.34056	1.38927
2¾	194	212	247	324	403	552	887	1.30238	1.30918	1.32511	1.33554	1.37871
2⅞	190	207	239	309	381	517	820	1.30139	1.30753	1.32189	1.33125	1.36977
3	187	203	232	296	362	486	763	1.30053	1.30611	1.31911	1.32755	1.36215
3⅛	184	199	225	284	345	458	712	1.29977	1.30487	1.31669	1.32435	1.35558
3¼	182	195	220	274	330	434	668	911	1.30378	1.31458	1.32156	1.34989
3⅜	179	192	215	265	316	413	628	852	1.30282	1.31272	1.31911	1.34493
3½	177	189	210	257	305	394	593	800	1.30197	1.31108	1.31694	1.34056
3⅝	176	186	206	250	294	377	562	754	1.30121	1.30962	1.31502	1.33672
3¾	174	184	203	243	284	362	534	712	1.30053	1.30832	1.31332	1.33331
3⅞	173	182	199	237	276	348	508	675	1.29992	1.30716	1.31179	1.33027
4	171	180	196	232	268	336	486	641	937	1.30611	1.31041	1.32755
4⅛	170	178	194	227	261	324	465	610	887	1.30516	1.30917	1.32511
4¼	169	177	191	222	254	314	446	582	842	1.30431	1.30805	1.32291
4⅜	168	175	189	218	248	305	429	557	800	1.30353	1.30704	1.32091
4½	167	174	187	215	243	296	413	534	763	1.30282	1.30611	1.31911
4⅝	166	173	185	211	238	288	399	513	738	1.30217	1.30526	1.31746
4¾	166	172	183	208	233	281	385	493	697	1.30158	1.30449	1.31595
4⅞	165	171	182	205	229	274	373	475	668	1.30103	1.30378	1.31458
5	164	170	180	203	225	268	362	458	641	1.30053	1.30313	1.31332
5¼	163	168	177	198	218	257	342	429	593	1.29963	1.30197	1.31108
5½	162	167	175	194	212	247	324	403	552	887	1.30097	1.30918
5¾	161	165	173	190	207	239	309	381	517	820	1.30011	1.30753
6	160	164	171	187	203	232	296	362	486	763	1.29937	1.30611
6¼	160	163	170	184	199	225	284	345	458	712	871	1.30487
6½	159	162	168	182	195	220	274	330	434	668	814	1.30378
6¾	159	162	167	179	192	215	265	316	413	628	763	1.30282
7	158	161	166	177	189	210	257	305	394	593	717	1.30197
7¼	158	160	165	176	186	206	250	294	377	562	677	1.30121
7½	157	160	164	174	184	202	243	284	362	534	641	1.30053
7¾	157	159	163	173	182	199	237	276	348	509	608	1.29991
8	157	159	163	171	180	196	232	268	336	486	579	937
8¼	156	158	162	170	178	194	227	261	324	465	552	887
8½	156	158	162	169	177	191	222	254	314	446	528	842
8¾	156	158	161	168	175	189	218	248	305	429	506	800
9	156	157	160	167	174	187	215	243	296	413	486	763
9¼	155	157	160	166	173	185	211	238	288	399	467	728
9½	155	157	160	166	172	183	208	233	281	385	450	697
9¾	155	156	159	165	171	182	205	229	274	373	434	668
10	1.29155	1.29156	1.29159	1.29164	1.29170	1.29180	1.29202	1.29225	1.29268	1.29362	1.29420	1.29641

TABLE 67.—*Values of 1.12931p and 1.29152+0.48407S² for various diameters and pitches, Acme threads*

QUADRUPLE THREADS

Basic major diameter (inches)	Threads per inch, $n=1/p$											
	12	10	8	6	5	4	3	2½	2	1½	1⅓	1
	1.12931p											
	0.09411	0.11293	0.14116	0.18822	0.22586	0.28233	0.37644	0.45172	0.56465	0.75287	0.84698	1.12931
	1.291518+0.484074S^2											
¼	1.41708	1.48771	1.64030									
5/16	1.36582	1.40540	1.48771									
⅜	1.34057	1.36581	1.41708	1.54776								
7/16	1.32630	1.34378	1.37871	1.46530	1.56710							
½	1.31746	1.33027	1.35558	1.41708	1.48771	1.64030						
9/16	1.31161	1.32139	1.34056	1.38646	1.43827	1.54776						
⅝	1.30753	1.31525	1.33027	1.36581	1.40540	1.48771						
11/16	1.30458	1.31083	1.32291	1.35124	1.38246	1.44653	1.61295					
¾	1.30238	1.30753	1.31746	1.34056	1.36581	1.41708	1.54777					
13/16	1.30069	1.30502	1.31332	1.33252	1.35335	1.39529	1.50057	1.62621				
⅞	1.29937	1.30305	1.31009	1.32630	1.34378	1.37871	1.46531	1.56710				
15/16	831	1.30148	1.30753	1.32139	1.33627	1.36581	1.43827	1.52237				
1	745	1.30021	1.30547	1.31746	1.33027	1.35558	1.41708	1.48771	1.64030			
1⅛	616	1.29831	1.30238	1.31161	1.32139	1.34056	1.38646	1.43826	1.54776			
1¼	525	697	1.30021	1.30753	1.31525	1.33027	1.36581	1.40540	1.48771			
1⅜	458	599	1.29864	1.30458	1.31083	1.32291	1.35124	1.38246	1.44653	1.61295		
1½	408	525	745	1.30238	1.30753	1.31746	1.34056	1.36581	1.41708	1.54776	1.64030	
1⅝	369	468	654	1.30069	1.30502	1.31332	1.33252	1.35335	1.39529	1.50056	1.57403	
1¾	339	423	582	1.29937	1.30305	1.31009	1.32630	1.34378	1.37871	1.46530	1.52499	
1⅞	314	387	525	831	1.30148	1.30753	1.32140	1.33627	1.36581	1.43827	1.48771	
2	294	358	478	745	1.30021	1.30547	1.31746	1.33027	1.35558	1.41708	1.45868	1.64030
2⅛	277	334	440	675	1.29917	1.30378	1.31425	1.32540	1.34732	1.40017	1.43566	1.58870
2¼	263	314	408	616	831	1.30238	1.31161	1.32139	1.34056	1.38646	1.41708	1.54776
2⅜	252	297	381	567	758	1.30121	1.30940	1.31806	1.33496	1.37519	1.40187	1.51473
2½	242	283	358	525	697	1.30021	1.30753	1.31525	1.33027	1.36581	1.38927	1.48771
2⅝	233	270	339	489	644	1.29937	1.30595	1.31287	1.32630	1.35793	1.37871	1.46530
2¾	226	259	322	458	599	864	1.30458	1.31083	1.32291	1.35124	1.36977	1.44653
2⅞	220	250	307	431	559	800	1.30341	1.30907	1.31999	1.34551	1.36215	1.43064
3	214	242	294	408	525	745	1.30238	1.30753	1.31746	1.34056	1.35558	1.41708
3⅛	209	235	283	387	495	697	1.30148	1.30619	1.31525	1.33627	1.34989	1.40540
3¼	205	228	272	369	468	654	1.30069	1.30502	1.31332	1.33252	1.34493	1.39529
3⅜	201	223	263	353	444	616	1.29999	1.30397	1.31161	1.32922	1.34056	1.38647
3½	197	218	256	339	423	582	937	1.30305	1.31009	1.32630	1.33672	1.37871
3⅝	194	213	248	326	404	552	881	1.30222	1.30874	1.32371	1.33331	1.37188
3¾	191	209	242	314	387	525	831	1.30148	1.30753	1.32139	1.33027	1.36581
3⅞	189	205	236	303	372	501	786	1.30081	1.30645	1.31932	1.32755	1.36041
4	187	202	231	294	358	478	745	1.30021	1.30547	1.31746	1.32511	1.35558
4⅛	184	199	226	285	346	458	708	1.29967	1.30458	1.31578	1.32291	1.35124
4¼	183	196	222	277	334	440	675	917	1.30378	1.31426	1.32091	1.34732
4⅜	181	194	218	270	324	423	644	872	1.30305	1.31287	1.31911	1.34377
4½	179	191	214	264	314	408	616	831	1.30238	1.31161	1.31746	1.34056
4⅝	178	189	211	257	305	394	591	793	1.30177	1.31045	1.31595	1.33764
4¾	176	187	208	252	297	381	567	758	1.30121	1.30940	1.31458	1.33495
4⅞	175	186	205	247	289	369	545	726	1.30069	1.30843	1.31331	1.33251
5	174	184	202	242	283	358	525	697	1.30021	1.30753	1.31215	1.33027
5¼	172	181	197	233	270	339	489	644	1.29937	1.30595	1.31009	1.32630
5½	170	178	193	226	259	322	458	599	864	1.30458	1.30832	1.32291
5¾	169	176	190	220	250	307	431	559	800	1.30340	1.30680	1.31999
6	167	174	187	214	242	294	408	525	745	1.30238	1.30547	1.31746
6¼	166	172	184	209	235	283	387	495	697	1.30148	1.30431	1.31525
6½	165	171	181	205	228	272	369	468	654	1.30069	1.30329	1.31332
6¾	164	169	179	201	223	263	353	444	616	1.29999	1.30238	1.31161
7	163	168	177	197	218	256	339	423	582	937	1.30157	1.31009
7¼	162	167	175	194	213	248	326	404	552	881	1.30086	1.30874
7½	162	166	174	191	209	242	314	387	525	831	1.30021	1.30753
7¾	161	165	173	189	205	236	303	372	501	786	1.29963	1.30644
8	160	164	171	187	202	231	294	358	478	745	911	1.30547
8¼	160	163	170	184	199	226	285	346	458	708	863	1.30458
8½	159	163	169	183	196	222	277	334	440	675	821	1.30378
8¾	159	162	168	181	194	218	270	324	423	644	781	1.30305
9	159	162	167	179	191	214	264	314	408	616	745	1.30238
9¼	158	161	166	178	189	211	257	305	394	591	712	1.30177
9½	158	161	166	176	187	208	252	297	381	567	682	1.30121
9¾	158	160	165	175	186	205	247	289	369	545	654	1.30069
10	1.29157	1.29160	1.29164	1.29174	1.29184	1.29202	1.29242	1.29283	1.29358	1.29525	1.29629	1.30021

APPENDIX 3. CONTROL OF ACCURACY OF THREAD ELEMENTS IN THE PRODUCTION OF THREADED PRODUCT

1. INTRODUCTION

In order to maintain the dimensions of threaded product within the limiting sizes specified, it is essential that the tools used and the processes applied be suitable for the particular requirements. An analysis of the various factors controlling the accuracy of the individual thread elements is here presented. In this analysis, the fundamental factors controlling the accuracy of the elements of a screw thread are stated, and are followed by a brief discussion of the relationship of these factors to each of the prevailing commercial methods of producing screw threads. It is recognized, however, that certain varying factors are involved, such as lubrication, method of holding the work or tool, sharpness of cutting edges, etc., so that it is not always possible to predetermine the exact sizes of the tools required to accomplish the desired results.

Screw threads are usually produced either by cutting or rolling. Five general methods of cutting, two of rolling, and two of finishing screw threads are in common use.

Screws or external threads are commonly produced by lathe tools, solid or adjustable dies, adjustable or opening die heads with removable chasers, thread milling cutters, threading hobs, and roller dies.

Of these, the dies, die-head chasers, and hobs are all multiple toothed, cutting in several thread spaces simultaneously, and finishing the operation at one pass. Lathe tools are ordinarily single-pointed and operate in a single thread, which is finished by repeated passes; but multiple-pointed chasers for use as lathe tools are sometimes made.

All rolled threads and many cut threads are produced with dies, chasers, or hobs made with master tools, such as hobs, taps, or milling cutters. These master tools are frequently made with forming cutters or other tools, but the primary tool is always made with a single-point tool. Angle and pitch errors tend to accumulate in a series of master tools and must be carefully considered in the design and use of this single-point tool.

Internal threads or tapped holes are commonly produced by means of taps and sometimes by lathe tools. Much progress has been made in the standardization of the dimensions and tolerances for cut and ground thread taps.[3]

2. FUNDAMENTAL FACTORS

The accuracy of the individual elements of a thread is controlled mainly as follows:

Angle by the angle between, and contour of the cutting edges of the tool used for cutting, or of the sides of the grooves of the die used for rolling.

Lead by the rate of the longitudinal motion of the tool with respect to the rate of revolution of the part to be threaded.

Major diameter of external thread by the outside diameter of the stock, or by the forming tool.

Minor diameter of internal thread by the diameter of the hole in the work before threading. In the case of a drilled hole, this depends on the diameter and accuracy of grinding of the tap drill used.

Pitch diameter by the radial setting of the forming surface of the tool.

Thread form by the form and position of the tool, and the conditions under which it is used.

(*a*) CONTROL OF TOOTH OUTLINES.—Inspection of the angle and profile of the thread-forming tool is essential to control the accuracy of the thread produced. All threading tools, whether for use in a lathe, die head, thread miller, or roller, and whether single or multiple pointed, must produce the proper tooth profile on an axial section of the work. The final test of accuracy in any threading tool is its ability to produce a thread of the proper axial section as defined in the body of this report.

Most cutting tools for standard threads have their cutting edges in the axial plane of the work, so that the shape of those edges tends to reproduce itself on the screw thread. In forming and inspecting the cutting edges of these tools, their forms may be directly compared with standard outlines. This can be done by means of accurately formed templets, carefully applied under the microscope. A more satisfactory and practical way is to draw the desired outline on a chart

[3] See Report No. B5e-1930, "Taps: Cut and Ground Threads" of the American Standards Association.

to a magnification of 50 or 15 times, and then project on this chart the image of the cutting tool under inspection magnified to the corresponding degree. By this means the tool shape may be quickly compared with the standard shape to a degree of accuracy much greater than that required for commercial work. Care must be taken to use a lens system free from distortion. Optical projection machines and comparators are available for this work in commercial designs. (See "Thread comparators," p. 151.)

In table 68 are given useful data for drawing the charts for any standard pitch.

TABLE 68.—*Dimensions for determining shape of cutter, chaser, hob, or tap teeth American National coarse, fine, and hose coupling threads*

Threads per inch, n	Pitch, p	$\frac{1}{2}\times p$	$\frac{1}{8}\times p$	$\frac{1}{24}\times p$	Depth of thread, h	$\frac{1}{2}\times h$	$\frac{1}{3}\times h$	$R=\frac{2}{9}\times h$	$\frac{1}{6}\times h$	$\frac{1}{18}\times h$	One half pitch diameter tolerance for class 2 fit, $\frac{1}{2}\times T$	$h+\frac{1}{2}\times T$
1	2	3	4	5	6	7	8	9	10	11	12	13
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
80	0.01250	0.00625	0.00156	0.00052	0.00812	0.00406	0.00271	0.00180	0.00135	0.00045	0.00085	0.00897
72	.01389	.00694	.00174	.00058	.00902	.00451	.00301	.00200	.00150	.00050	.00090	.00992
64	.01562	.00781	.00195	.00065	.01015	.00507	.00338	.00226	.00169	.00056	.00095	.01110
56	.01786	.00893	.00223	.00074	.01160	.00580	.00387	.00258	.00193	.00064	.00100	.01260
48	.02083	.01042	.00260	.00087	.01353	.00677	.00451	.00301	.00226	.00075	.00110	.01463
44	.02273	.01136	.00284	.00095	.01476	.00738	.00492	.00328	.00246	.00082	.00115	.01591
40	.02500	.01250	.00312	.00104	.01624	.00812	.00541	.00361	.00271	.00090	.00120	.01744
36	.02778	.01389	.00347	.00116	.01804	.00902	.00601	.00401	.00301	.00100	.00125	.01929
32	.03125	.01562	.00391	.00130	.02030	.01015	.00677	.00451	.00338	.00113	.00135	.02165
28	.03571	.01786	.00446	.00149	.02320	.01160	.00773	.00515	.00387	.00129	.00155	.02475
24	.04167	.02083	.00521	.00174	.02706	.01353	.00902	.00601	.00451	.00150	.00165	.02871
20	.05000	.02500	.00625	.00208	.03248	.01624	.01083	.00722	.00541	.00180	.00180	.03428
18	.05556	.02778	.00694	.00231	.03608	.01804	.01203	.00802	.00601	.00200	.00205	.03813
16	.06250	.03125	.00781	.00260	.04059	.02030	.01353	.00902	.00677	.00226	.00225	.04284
14	.07143	.03571	.00893	.00298	.04639	.02320	.01546	.01031	.00773	.00258	.00245	.04884
13	.07692	.03846	.00962	.00321	.04996	.02498	.01665	.01110	.00833	.00278	.00260	.05256
12	.08333	.04167	.01042	.00347	.05413	.02706	.01804	.01203	.00902	.00301	.00280	.05693
11½	.08696	.04348	.01087	.00362	.05648	.02824	.01883	.01255	.00941	.00314	[1].00425	.06073
11	.09091	.04545	.01136	.00379	.05905	.02952	.01968	.01312	.00984	.00328	.00295	.06200
10	.10000	.05000	.01250	.00417	.06495	.03248	.02165	.01443	.01083	.00361	.00320	.06815
9	.11111	.05556	.01389	.00463	.07217	.03608	.02406	.01604	.01203	.00401	.00350	.07567
8	.12500	.06250	.01562	.00521	.08119	.04059	.02706	.01804	.01353	.00451	.00380	.08499
7½	.13333	.06667	.01667	.00556	.08660	.04330	.02887	.01925	.01443	.00481	[1].00800	.09460
7	.14286	.07143	.01786	.00595	.09279	.04639	.03093	.02062	.01546	.00515	.00425	.09704
6	.16667	.08333	.02083	.00694	.10825	.05413	.03608	.02406	.01804	.00601	.00505	.11330
5	.20000	.10000	.02500	.00833	.12990	.06495	.04330	.02887	.02165	.00722	.00580	.13570
4½	.22222	.11111	.02778	.00926	.14434	.07217	.04811	.03208	.02406	.00802	.00635	.15069
4	.25000	.12500	.03125	.01042	.16238	.08119	.05413	.03608	.02706	.00902	.00700	.16938

[1] Based on hose-coupling thread tolerances.

(*b*) CONTROL OF LEAD ERRORS.—The sources of lead errors require special consideration and for this purpose the methods of producing screw threads may be considered under two headings, namely, those in which relative longitudinal motion of the tool and product is controlled by means of a lead screw and those in which the tool is self-leading.

(*1*) *Tool controlled by lead screw.*—In cutting a thread on a lathe or other machine embodying a lead screw, using a single point cutting tool or single milling cutter, progressive lead errors are caused by (1) a progressive lead error in the lead screw; (2) lack of parallelism of the motion of the cutting tool, the axis of the lead screw, and the axis of the part to be threaded; and (3) incorrect ratio of the rate of revolution of the spindle to that of the lead screw, due to an incorrect or approximate combination of gears.

Local lead errors are caused by (1) local lead errors in the lead screw; (2) lost motion in the action of the lead screw or connecting mechanism; (3) varying frictional resistance in the mechanism; (4) when a live center is used, irregular play of its spindle in the bearings; and (5) variations in the amount of metal removed by the cutting tool.

Periodic lead errors are caused by (1) periodic lead errors in the lead screw; (2) eccentricity of motion of the lead screw; (3) thrust bearings of spindle or lead screw running out of true; (4) variations in the spacing of gear teeth, or eccentric gears or mountings; (5) when a live center is used, eccentricity of motion of its spindle; and (6) periodic variations in the amount of metal removed, due to lack of uniformity of the material in diameter, straightness, or physical properties.

When a multiple-toothed threading tool is controlled by a lead screw, variations from correct spacing of the teeth of the tool are superimposed on the lead errors resulting from any of the above causes in that portion of the thread not passed over by every tooth of the tool. In the portion of the thread completely passed over by the tool, the effect of the difference in lead between the tool and lead screw is to produce a thin thread.

The simplest method of inspecting a machine tool to determine whether it will cut a screw thread within satisfactory limits is to cut carefully a sample screw on the machine and measure the lead errors of the screw. The obvious remedy for errors from such sources is the careful inspection of the various elements of the machine, and correction of the errors thus located, either by improving the design or by carefully refinishing or remaking the parts to a greater degree of accuracy.

(*2*) *Self-leading threading tool.*—When a thread is cut by means of a tap or die, which, as ordinarily used, are self-leading and not controlled by a lead screw, lead errors may occur as the result of (1) incorrect lead of the tap or die; (2) too much or too little relief at the throat of the die or on the chamfer at the end of the tap; (3) the setting of an adjustable die or tap chaser to cut a thread considerably larger or smaller than that for which the tool was intended—that is, to cut a helix angle considerably different from the helix angle of the chaser; (4) excessive resistance to longitudinal motion; (5) improper alinement of the axis of the tap or die with that of the work, etc.; and (6) excessive angle relief.

The control of accuracy of the lead of the tap or of the chasers in the die is the most difficult of these sources of error, and indeed presents serious difficulties. There is, first, the difficulty of cutting a tap or chaser which is free from lead errors resulting from any of the causes outlined above; and second, the distortion which the steel composing the tap or die undergoes in hardening.

When especially accurate work is required, as in producing threaded product to class 4, close-fit specifications, it is very desirable, and sometimes necessary, that the feed of the tap or die be controlled by means of a lead screw.

In the inspection of such thread-forming tools practically the same means and methods can be applied as in the measurement of screw-thread gages. For checking the lead, indicating gages or some of the usual lead-measuring devices for screw-thread gages may be used. To measure the lead of a die chaser, the chaser must be held in a fixture in such a position that the direction of measurement corresponds to the direction of longitudinal motion of the chaser threads when cutting a thread.

3. CUTTING OF SCREW THREADS

(*a*) Single-Point Tool.—A screw thread may be produced by traversing a single-point threading tool—shaped to correspond to the shape of the thread space in an axial plane, and so placed as to cut an angle, equal to the angle of the top surface of the tool, in correct relation to the axis of the thread—along the revolving part to be threaded at such a rate as to produce a thread of the desired lead. This is the common method of cutting screws in an engine lathe, a lead screw driven by gearing being the usual means for imparting to the tool the longitudinal motion at the desired rate. This method is used commercially only when special conditions make it necessary, as when the thread to be cut is not standard, or when it is not practicable to apply other methods.

Various forms of single-point cutting tools for cutting threads of American National form are illustrated in figure 47 at A, B, C, and D. The circular tool shown at C has the advantage that it can be reground indefinitely without destroying its correct form. The diagram at D shows the method for calculating the angle X of the cutting tool, having a clearance angle V, in a plane perpendicular to the edge MN; and the formula for determining the clearance angle V, of a tool for cutting a thread of helix angle s, is also given. Such tools usually consist of hardened tool steel, ground to the correct form after hardening; special alloys such as "stellite" are also used for this purpose.

(*b*) Thread Chaser.—A screw thread may be produced by successively traversing a multiple-point thread tool, known as a chaser, along the part to be threaded, each tooth following in the thread in the same manner as a single-point thread tool. Two forms of chasers are shown in figure 47 at *E* and *F*, the one at *F* being especially suitable for cutting fine threads. Chasers are well adapted to roughing out threads, as they cut rapidly, and may be used for finishing threads accurately if the teeth are ground after hardening.

(*c*) Tap or Die.—A screw thread may be produced by using a tap for internal threads or a die for external threads. These tools occur in considerable variety in their commercial forms, but consist essentially of a number of multiple-point cutters or chasers, usually four, arranged circumferentially. They may be either solid or adjustable, and collapsible or self-opening, respectively, for withdrawing quickly from the work after threading. By their use a thread is generally finished by one passage of the tool, although a second or finishing cut is some-

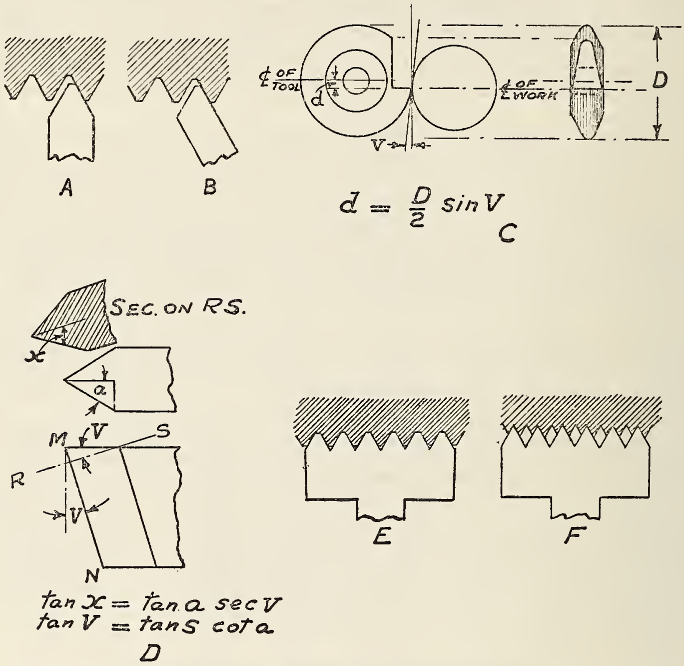

Figure 47.—*Single point and multiple point thread cutting tools.*

times made to secure greater accuracy. Dies [4] are applied, in general, to threading screws, bolts, and studs; and taps to nuts or other internal threads within the usual range of sizes. They are also applied to the threading of pipe and pipe fittings. The rapidity with which threading operations may be performed by the use of taps and dies, within the limits of accuracy suitable for a large percentage of commercial work, makes them most efficient and widely used threading tools. It is only in cutting large sizes or coarse pitches, or where a high degree of accuracy is desired, that their use may be less economical than other means of cutting threads.

Aside from lead errors, which have been previously considered, the accuracy of the thread produced depends on the form of the cutting teeth, character of the cutting edges, clearance or relief for cutting edges, construction of the tool, and the conditions under which it is used.

(*d*) Milling Cutter.—A screw thread may be produced by feeding in to the depth of the thread and then traversing a rapidly revolving single milling cutter

[4] Simplified lists of sizes and varieties, for threads of American National form, of die-head chasers for self-opening and adjustable die heads, as adopted at general conferences of representative manufacturers, distributors, and users, are promulgated in United States Department of Commerce Simplified Practice Recommendation R51–29.

along the slower revolving part to be threaded at such a rate as to produce a thread of the desired lead; the profile of the cutting edges of the cutter conforming approximately to the shape of the thread groove in an axial plane, and the axis of the cutter being set at an angle to the axis of the thread, in a plane parallel to the axis of the thread, equal to the mean helix angle of the thread cut. The single-cutter method of thread milling is especially applicable to the cutting of large threads of coarse pitch, multiple threads, and the heavier classes of work. When the amount of metal to be removed is large, as compared with the size of the screw, this method is especially suitable because the torsional strain is much smaller than that produced by a die, and consequently the accuracy of the screw produced is greater.[5]

(*e*) Threading Hob.—A screw thread may be produced by feeding in to the depth of the thread, and then traversing a rapidly revolving multiple milling cutter or thread hob, somewhat longer than the length of the thread to be cut—which consists of annular rows of teeth, whose centers lie in planes perpendicular to the axis of the cutter (in effect a series of single cutters formed into one solid piece), and the axis of which is parallel to the axis of the thread—along the slowly revolving part to be threaded slightly more than either one or two complete revolutions of the work, at a rate per revolution of the work equal to the pitch of the thread. The multiple-cutter method of thread milling is used largely for cutting comparatively short threads, usually of fine or medium pitches, when smoothness or a considerable degree of accuracy is desired, or when the thread must maintain a fixed relation with a point or surface on the work.

The error introduced in the form of thread produced by cutter teeth having the same form as that of the intended form of thread, as the result of the axes of cutter and thread being parallel, is usually not serious except when the helix angle is large.[6]

4. ROLLING OF SCREW THREADS

The second general process for forming screw threads—namely, that of rolling—is a cold-forging process. It may be defined as an impression or displacement method whereby the threads are formed by means of a die or roll having threads or ridges, which are forced into the material to be threaded, and, by displacing it, produce a thread of the required form and pitch. In this process no material is removed, but the metal is displaced from the thread space and forced up on each side above the original surface of the piece to be threaded. Thus, the major diameter of a V-shaped 60° thread so produced is found in practice to be greater than the original diameter of the blank by an amount varying from 65 percent of the single depth of thread for small screws to 85 percent for large screws. An approximate formula, based on geometrical considerations only, for the diameter of a blank to be threaded to American National form is as follows:

$$D_1=\sqrt{D^2-1.3Dp+0.63p^2}$$

in which

D_1 = diameter of blank
D = major diameter of thread
p = pitch of thread

In case the thread required must be accurate within close limits, the exact value of D_1 necessary in any given case must be determined experimentally, as its value is affected by the physical properties of the material.[7]

The thread-rolling process is the most rapid and economical method of forming screw threads in quantity production, when the part to be threaded is of such form as to permit its use. It is used only for external threads and is not regarded as being feasible for internal threads, since the area of contact of the roll in an internal thread is relatively much larger than on an external thread, and in order to displace the metal a very heavy pressure is required. It is difficult to support

[5] For refinements in connection with the determination of the profile of cutting edge of a thread milling cutter, see The Milling of Screw Threads and Other Problems in the Theory of Screw Threads, by H. H. Jeffcott. Proceedings of the Institution of Mechanical Engineers, 1922–I, pp. 515–528, and discussion pp. 529–562; or Engineering (London), vol. 113, Apr. 7, 1922, pp. 441–442, and discussion pp. 412–414.

[6] For formulas which may be applied in such cases to determine and plot the exact contour of the cutting edges to produce, as nearly as possible, the thread form required, see Side-Cutting of Thread Milling Hobs, by Earle Buckingham. Transactions of the American Society of Mechanical Engineers, vol. 42, 1920, pp. 569–593; also the reference cited in footnote 5, for thread milling cutter profile.

[7] This formula is derived in Size of Stock for Bolts Having Rolled Threads, by F. Webster. American Machinist, vol. 30, Oct. 31, 1907, p. 630.

the work with the necessary rigidity to withstand the heavy pressure, and to provide a bearing for the roll which will withstand the stress.

Screw threads may be rolled by either of two methods, as follows:

(*a*) THREADING ROLL.—By forcing a cylindrical disk or roll, having a threaded periphery and being free to rotate on the pin or bolt on which it is mounted, against the piece to be threaded while the latter is revolving. The cylindrical roll is used when the work is in an automatic screw machine or turret lathe, and it is impossible to cut the thread required by means of a thread-cutting die, or when an additional operation would be necessary before cutting the thread. The thread on the roll corresponds in pitch, and approximately in form, to the thread to be rolled. The roll may be presented to the work in either a tangential direction as shown at *A*, figure 48, or radially as shown at *B;* a satisfactory thread is formed in either case.

(*b*) THREAD-ROLLING DIES.—By rolling the blank between dies, which may be either flat or cylindrical in form, when performed by machines designed exclusively for this work. When flat dies are used, as shown in figure 48 at *C*, one die, *M*, remains stationary and the other die, *N*, which is parallel or nearly parallel to *M*, has a reciprocating movement. The faces of the dies have parallel milled or planed grooves of approximately the same form as that of the required thread

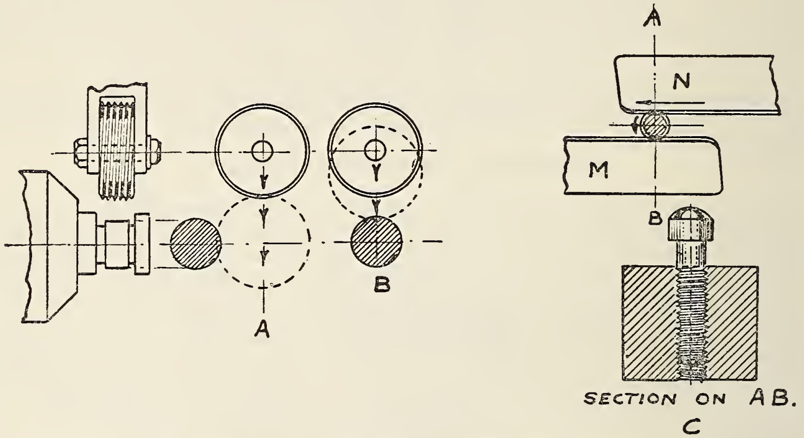

FIGURE 48.—*Methods of rolling screw threads.*

which are set at an angle to the line of motion of the blank equal to the helix angle of the thread to be produced. The angles of the grooves and ridges in a plane perpendicular to the direction of the grooves are given by the formula—

$$\text{Tan } a_1 = \tan a \cos s$$

in which

a_1 = half angle of ridge of die
a = half angle of thread to be rolled
s = helix angle of thread

The spacing of the ridges is determined by the formula—

$$p_1 = p \cos s$$

in which

p_1 = spacing of ridges of die
p = pitch of thread to be rolled
s = helix angle of thread

The blank is inserted at one end of the stationary die, and rolls between the die faces until it is ejected at the other, the thread being formed in one passage of the blank. When cylindrical dies are used, one of the dies, which is a complete cylinder, revolves continuously in one direction and the other is a stationary cylindrical segment. This method is used extensively for threading almost all forms of small and medium sizes of screws and bolts, when required in sufficiently large quantities to warrant the use of a thread-rolling machine.[8]

5. FINISHING OF SCREW THREADS

On account of the difficulty of producing an accurately finished thread by means of a cutting tool, in ordinary gage-making practice the thread is ground, lapped, or ground and lapped, in order to finish all elements of the thread to correct dimensions. The process of grinding is applied to hardened screws only, and is intended to correct any errors present as the result of distortion in the hardening process, as well as those resulting from the cutting operation. Lapping is usually applied to hardened screw threads, and may be either substituted for grinding, or performed after grinding to remove the marks left by the grinding wheel and to

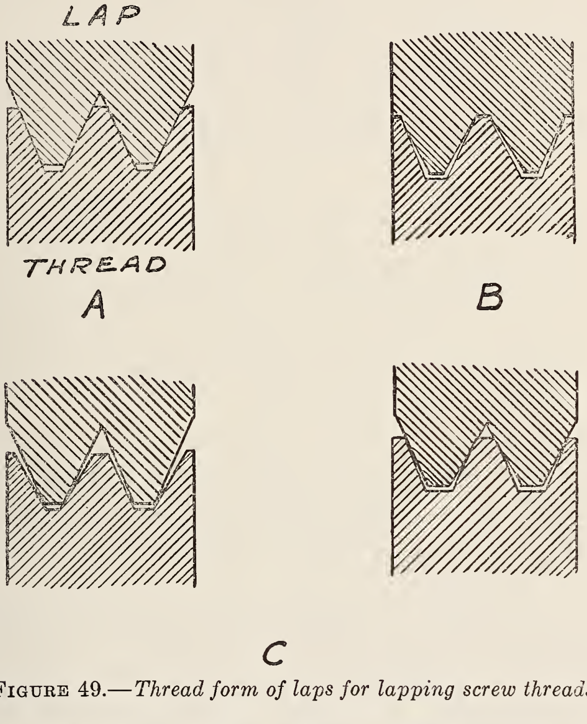

FIGURE 49.—*Thread form of laps for lapping screw threads.*

produce a smooth and highly finished surface. These processes are used largely in the production of screw-thread gages.

(*a*) GRINDING.—The grinding of a thread is similar to the process of milling a thread by the single-cutter method. The profile of the periphery of the grinding wheel is "dressed" by means of a diamond to conform to the shape of the thread groove in an axial plane, with the axis of the wheel set at an angle to the axis of the thread, in a plane parallel to the axis of the thread, equal to the helix angle. In order to produce a thread having straight sides and correct angle, the periphery of the wheel should be dressed to the required angle after the wheel has been set to the helix angle, in the plane containing the axis of the thread and the center of the wheel. The same considerations as to the exact profile of the periphery of the grinding wheel, to produce a thread of exactly correct form, apply as for the tooth profile of a single milling cutter set at the helix angle of the thread. The principal differences between the thread milling and grinding processes are that a large diameter of grinding wheel is desirable, and several light

[8] The principles involved in determining the spacing and angle of ridges of flat dies, and position of the dies, are considered in Principles of Thread Rolling and the Setting of Dies, by J. F. Springer, American Machinist, vol. 33, Apr. 21, 1910, pp. 739–741.

cuts are taken, whereas, a small diameter of milling cutter is desirable and a single cut is taken.

(b) Lapping.—The lapping of a screw thread may be defined as a process of abrasion by successively traversing the thread, as it revolves, with a so-called lap, which consists of an engaging screw thread of softer material, usually fine-grained cast iron, brass, or cold-rolled steel, in which very fine abrasive material is embedded in the thread surface. For removing considerable material, the laps are charged with coarser abrasive, and for imparting fine finish, a finer abrasive; in either case the abrasive used is very fine, and the lap is thoroughly lubricated. A number of laps may be necessary to finish either an internal or external thread to the required form and dimensions, as illustrated in figure 49.

6. GAGING PRACTICES AND TYPES OF GAGES

The production of accurate parts is primarily a matter of constant vigilance and of training of workmen. The smaller the tolerances which are to be maintained, the more complete the inspection or gaging system must be. In order to secure satisfactory results, the manufacturing tools provided must be sufficiently accurate, and the manufacturing methods must be sufficiently reliable, to produce the required results. After tools and methods of proved reliability are provided, it is necessary to watch the wear on the tools or changes in their set-up to insure that the required conditions are maintained. This is accomplished by periodical tests of the tools, by periodical gaging of the product, and sometimes by both.

The most difficult element of a screw thread to gage is the lead. Lead-testing devices for checking tools and gages are available, but, in general, their operation is too slow for use as production inspection equipment. In addition, the lead is the most important element of a screw thread as regards the nature of the contact between the surfaces of the mating parts. Furthermore, the result of an error in lead is almost double that of an equal error in diameter as regards interchangeability. For exacting threaded work, if the method of inspection of the product does not effectively detect lead errors, the tools used must be carefully inspected for lead. In order to reduce the possibilities of disagreement to a minimum, the manufacturer should strive to produce parts well within the specified limits rather than close to the limiting sizes.

(a) Thread Micrometers.—Thread micrometers are sometimes used to measure the pitch diameter of taps and screws. Thread micrometers should be calibrated periodically against a master gage, to avoid errors due to wear on the anvils of the instrument. As thread micrometers give no indication of lead and angle errors, the results of tests made with thread micrometers alone cannot be taken as conclusive, and a "go" gage should always be used as a supplementary test. Thread micrometers are very effective means of checking against the change in set-up due to wear on tools, etc.

(b) Thread Snap Gages.—Thread snap gages are generally adjustable and have contact points consisting of cone-pointed anvils, wedge-shaped prisms with rounded edges, serrated or grooved plates, or grooved or threaded cylinders adjustably mounted and suitably spaced in a U-shaped frame. These gages are used to some extent in gaging external threads and have the advantages that work may be inspected with great rapidity by the single motion of passing it between the anvils of the gage and given a visual examination for clearance as well as a tactile inspection. The positions of the anvils are set to a setting gage, and the anvils are then clamped in position and sealed. Thread snap gages are to be preferred as "not go" gages.

The cone-pointed snap gage usually has a single point on each side of the frame, and is an effective "not go" gage. It does not, however, fully meet the requirements for a "go" gage, as it does not check the lead, and, therefore, must be supplemented with some type of indicating gage to check the lead when used for checking pitch diameter, angle, and thread form. Also, as it checks only a single diameter at a time, the "go" snap gage must be tried at a series of points to determine whether the maximum diameter of an external thread is within the tolerance. When provided with three contact points, two on one side spaced an integral number of threads apart and one on the other, such a gage checks the lead for progressive, but not always for local or periodic lead errors, and, thus, it more nearly fulfills the requirements for a "go" thread gage. This type or other types of short engagement are suitable for product of classes 4 and 5, provided that an independent inspection of the lead is made.

Thread snap gages having multiple toothed contact points, that is, toothed blades, serrated or grooved plates, or grooved or threaded cylinders, are made in a variety of forms, either as separate or combined "go" and "not go" gages. The fit of a screw in such a gage is affected by variations in pitch diameter, lead, and angle of the screw, and the gage accordingly may be used as a "go" gage for the less accurate classes of work, such as classes 1 and 2, and, if well designed and accurately made, also for classes 3, 4, and 5.

(*c*) Thread Ring Gages.—Thread ring gages are extensively used to inspect the threads on screws. These are usually adjustable to suitable setting gages. When the product is to be within specified limits, "go" and "not go" gages are required. The use of such gages gives some information as to lead and angle errors as well as pitch diameter errors.

(*d*) Thread Comparators.—A development in the art of measuring threaded parts is the optical thread comparator, which embodies the principle of gaging in an optical projection system. In addition to giving a rapid indication of whether the elements of the screw thread lie within the limiting dimensions specified, such instruments furnish more detailed information as to the errors in screw threads than is usually obtained by means of mechanical gages, particularly as to irregularities in thread form, lead, and diameter. These instruments can be adapted to measure taps and other threading tools.

The available forms of projection comparators differ somewhat in design and principle, but each consists primarily of a source of parallel light, such as an electric arc or concentrated filament lamp with condensing lens system, a projection lens system, a screen upon which the magnified shadow image of the work is projected, and a device for holding the work in position in front of the projection lenses. The screen consists of a tolerance chart on which two outlines of the correct thread form at the magnification used are spaced one above the other a distance equal to the tolerance multiplied by the magnification. The chart and gage holder are adjusted to position by projecting the shadow image of a setting gage and adjusting to bring the outline of the shadow image and certain lines of the chart into coincidence, after which the system may be used as a gaging device.

The above types of optical thread comparators are applicable to external threads. Two types of optical thread comparators for internal threads have been developed by the Bureau of Standards, one know as an "optical coincidence thread gage", and the other as a "stereoscopic thread gage."[9]

(*e*) Indicating Gages.—An indicating thread gage has movable contact points, which are set to a setting gage, and is intended to give an exact indication of the variations of the dimensions of a screw thread within the specified limits, rather than to show merely that the thread is within, or outside of, the specified limits, as is the case with limit gages. In such gages the movable contact points actuate a multiplying lever system, or other means for magnifying their motion, and the amount of the motion is registered on a graduated dial or scale. Indicating gages are made according to a variety of designs, some to indicate progressive lead error only, some to indicate pitch diameter only, some to indicate both separately but on the same gage, others to indicate the major and minor diameters as well, and still others to indicate the apparent size. They have been applied almost exclusively to external threads. Those which indicate the apparent size may be considered as most nearly fulfilling the requirements of a gaging system. However, those indicating lead errors are very useful in controlling lead errors in threading tools and screw-thread products. Also certain types can be used to indicate the variation in roundness on pitch or major diameters.

(*f*) Thread Plug Gages.—At the present time the most practical means of gaging threaded holes or nuts is by the use of thread plug gages. When the product is to be within specified limits, "go" and "not go" gages are required. The use of such gages gives some information as to lead and angle errors as well as pitch diameter errors. A correct "go" plug gage will reject any parts which fall below the minimum dimensions specified.

One practice of inspecting tapped holes is first to inspect the tap, and then to test the tapped holes periodically with "go" and "not go" gages. The tap can be watched for wear by testing the tapped holes with a "go" thread gage. One widely used practice consists of using a "go" thread plug gage, and a "not go" plain plug gage for the minor diameter.

One practice of inspecting taps is to measure the several elements, such as pitch diameter, angle, and lead. Another practice consists of tapping a hole with

[9] Described in B.S. Jour. Research, vol. 6, pp. 229–237, February 1931.

each tap before it is issued from the tool crib and testing these tapped holes with "go" and "not go" thread plug gages.

Sometimes the tap is tested after it is returned to the tool crib. If it is correct, it is replaced in its proper compartment. If it has worn below the limits, it is discarded and work produced by it is checked and corrected when necessary.

(*g*) Plain Gages.—"Go" and "not go" plain cylindrical plug gages are used for inspecting the minor diameter of the tapped hole. Plain ring or snap gages are used for inspecting the major diameter of the screw. When used, it is recommended that the "go" inspection gage be a ring gage and the "not go" inspection gage be a snap gage. The working gages may be combined as a "go" and "not go" snap gage.

(*h*) Gear-Tooth Caliper for Thread Thickness.—A device which is particularly useful in the measurement of thread thickness of Acme screw threads, or of tools for producing them, is the gear-tooth caliper. With this device the depth at which the measurement is made is controlled by means of a scale and vernier or a micrometer and the thickness is determined by means of another.

(*i*) Testing of Gages.—Gages should be tested periodically for wear and to insure that the gages are properly distributed. When successive inspections in the same plant are involved, it is good practice to inspect all gages of the same nominal size against each other periodically, and to distribute these gages so that the earlier inspections are made with those which are the greatest amount inside of the component limits, while the later inspections are made with those gages closest in size to the component limits.

The original testing of a thread gage should include measurements of diameters, lead, and angle. If these elements test satisfactorily, the later inspection need be only measurements of pitch diameter.[10]

APPENDIX 4. CLASS 5, WRENCH FIT FOR THREADED STUDS (TENTATIVE SPECIFICATIONS)

The tentative specifications embodied herein for class 5, wrench fit for threaded studs, are based partly upon experimental data obtained in an investigation conducted by the Bureau of Standards and partly upon data obtained from manufacturers relative to existing practice. The specifications are complete only for studs set in hard materials (cast iron, steel, bronze, etc.), and are not complete for studs set in aluminum for which larger interference of metal is permissible. They are presented for the information of those who may have use for them but are in no way mandatory.

1. FORM OF THREAD

The American National form of thread profile, as specified in section III, shall be used. The thread form of the tapped hole is modified, however, by truncating the crest of the thread a greater amount than that specified for threads of strictly American National form. This truncation is such that the minimum depth of thread engagement is one half of the basic thread depth. The maximum depth of engagement is governed by the tolerances specified for the major diameter of the stud and the minor diameter of the tapped hole.

2. THREAD SERIES

The range of sizes from ¼ inch to 1½ inches, inclusive, of the American National coarse-thread series and the American National fine-thread series of sizes and pitches as given in section III, are recommended for general use for class 5, wrench fit for threaded studs.

3. CLASSIFICATION AND TOLERANCES

The accompanying specifications are intended for use in the production and assembly of threaded studs and tapped holes on an interchangeable basis.

(a) GENERAL SPECIFICATIONS

The following general specifications apply for all materials to class 5, wrench fit for threaded studs, American National coarse-thread series and American National fine-thread series.

[10] Methods of measuring pitch diameter of screw-thread gages are described in appendix 2, p. 129.

1. Definition.—The wrench fit class is intended to cover the manufacture of threaded studs and holes which are to be assembled permanently by the application of power.

2. Minimum Tapped Hole.—The pitch diameter of the minimum threaded hole corresponds to the basic size, the tolerances being applied above the basic size.

3. Maximum and Minimum Stud Above Basic.—The pitch diameter of both the maximum and minimum studs of a given size and pitch are above the basic dimensions, which are computed from the basic major diameter of the thread. The maximum major diameter of the stud is basic.

4. Length of Engagement.—A length of engagement equal to one and one half times the basic major diameter for studs set in hard materials, and two times the basic major diameter for studs set in soft materials, is the basis of the tolerances and allowances specified herein. The length of engagement of two diameters is especially desirable for studs set in soft materials when subject to alternating stresses or to vibration.

5. Minimum Interferences.—The minimum interferences specified are such that a wrench-tight fit will result in all cases. If the thread surfaces are smooth and thread form is maintained, these interferences will permit disassembly and reassembly of the same stud and hole as many as four times and still produce a satisfactory wrench-tight fit.

6. Maximum Interferences.—The maximum interferences specified are such that all conditions necessary for a good wrench fit are fulfilled. If threads are well lubricated with a suitable lute no galling or seizing of the threads will result. Also, mild-steel studs, even of the smaller sizes, will not break if the rate of assembly is not excessive.

When a mixture of white lead and oil is used as a lute it is important that it be of a thick fluid consistency in order to prevent galling or seizing, particularly when fine threads in hard materials are concerned, and that it be applied liberally. If a lute consisting of 40 percent zinc dust, which has passed through a 200-mesh sieve, and 60 percent petrolatum is used, the tendency for the threads to gall or seize with maximum interference is materially reduced.

7. Tolerances.—(*a*) The tolerances specified represent the extreme variations permitted on the product.

(*b*) The tolerance on the tapped hole is plus, and is applied from the basic size to above basic size.

(*c*) The tolerance on the screw is minus, and is applied from the maximum screw size to below the maximum screw size.

(*d*) The pitch diameter tolerances for the tapped hole are the same as for the class 4, close-fit nut, except on the ¼-inch size, as noted in table 69. These tolerances necessitate the use of ground-thread taps.

(*e*) The pitch diameter tolerances for the stud are as given in tables 69 and 70. They are the maximum variations permissible for each individual size of stud, as determined by the maximum and minimum interferences.

(*f*) Pitch diameter tolerances include angle variations but do not include lead variations.

(*g*) The tolerances on the major diameters of class 5, wrench-fit studs are the same as for class 2, free-fit finished screws.

(*h*) The minimum minor diameter of a stud of a given pitch is such as to result in a basic flat ($\frac{1}{8} \times p$) at the root. It is equal to the measured pitch diameter of the stud minus the basic thread depth.

(*i*) The maximum minor diameter of a screw of a given pitch may be such as results from the use of a worn or rounded threading tool, when the pitch diameter is at its maximum value. In no case, however, should the form of the thread, as results from tool wear, be such as to cause the screw to be rejected on the maximum minor diameter by a "go" ring gage, the minor diameter of which is equal to the minimum minor diameter of the class 2 nut.

(*j*) The maximum major diameter of the tapped hole of a given pitch is such as to result in a flat equal to one third of the basic flat ($\frac{1}{24} \times p$). When the minimum hole is basic, its maximum major diameter will be above the basic major diameter by the amount of the specified pitch diameter tolerance plus two ninths of the basic thread depth.

(*k*) The minimum major diameter of a tapped hole is the basic major diameter. In no case, however, should the minimum major diameter of the hole, as results from a worn tap or cutting tool, be such as to cause it to be rejected on the minimum major diameter by a "go" plug gage made to the standard form at the crest.

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(*l*) The tolerance on the minor diameter of a tapped hole of a given pitch is one sixth of the basic thread depth.

8. Illustration.—The relations of the maximum and minimum major, pitch, and minor diameters of stud and tapped hole specified herein are shown in figures 50, 51, and 52.

(b) CLASSIFICATION

1. Allowance and Tolerance Values.—Allowances and tolerances are specified in tables 69 and 70, inclusive, for coarse-threaded and fine-threaded

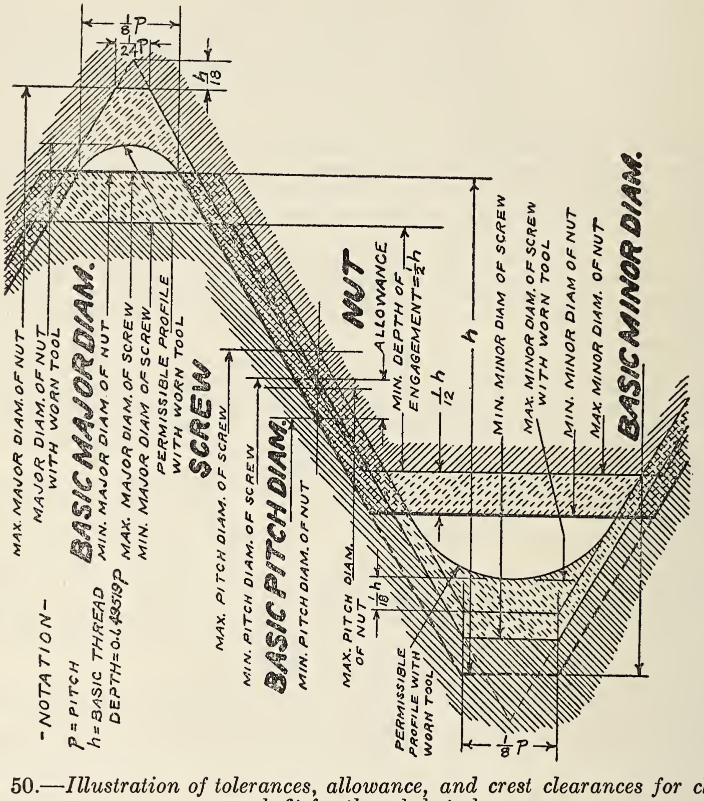

Figure 50.—*Illustration of tolerances, allowance, and crest clearances for class 5, wrench fit for threaded studs.*

studs set in hard materials—namely, cast iron, steel, and bronze. These are based upon data obtained in an experimental investigation and fulfill the conditions outlined in the above specifications.

4. TABLES OF DIMENSIONS

Tables 71 and 72 give recommended thread dimensions of studs and tapped holes which meet the above specifications for coarse-threaded and fine-threaded studs set in hard materials. Also the limiting values of the torques at full engagement (lever-arm times force) which may be expected in the assembly of studs and tapped holes made to these dimensions are given.

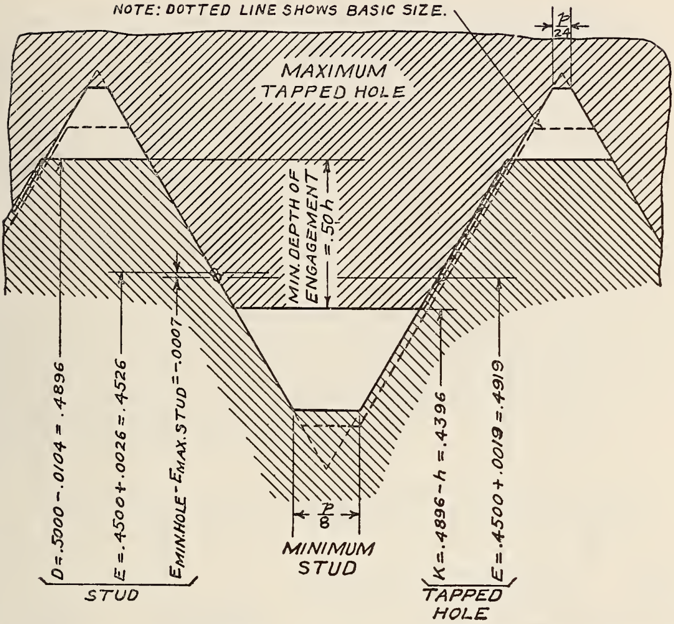

FIGURE 51.—*Illustration of loosest condition for class 5, wrench fit for threaded studs, one-half inch, 13 threads, set in hard materials.*

NOTATION

D = major diameter.
E = pitch diameter.
K = minor diameter.
h = 0.0500 = basic thread depth.

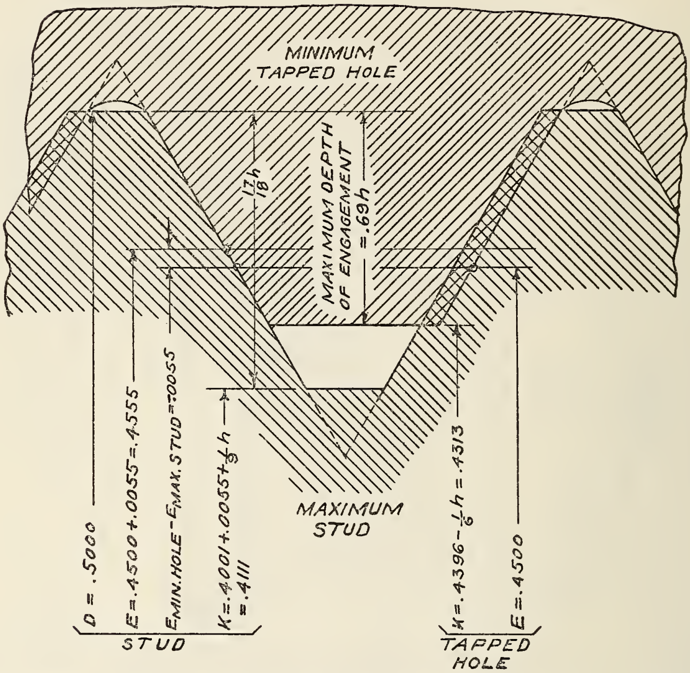

FIGURE 52.—*Illustration of tightest condition for class 5, wrench fit for threaded studs, one-half inch, 13 threads, set in hard materials.*

NOTATION

D=major diameter.
E=pitch diameter.
K=minor diameter.
h=0.0500=basic thread depth.

Table 69.—*Class 5, wrench fit for threaded studs, allowances and tolerances for studs and tapped holes, coarse threaded studs in hard materials*

Sizes	Threads per inch	Interference on pitch diameter		Pitch diameter tolerances [1]		Errors in half angle consuming one half of pitch diameter tolerances	
		Minimum	Maximum	Stud	Tapped hole [2]	Stud	Tapped hole
1	2	3	4	5	6	7	8
		Inch	*Inch*	*Inch*	*Inch*	*Deg. Min.*	*Deg. Min.*
¼	20	0.0003	0.0018	0.0007	0.0008	0 16	0 25
5/16	18	.0005	.0040	.0020	.0015	0 41	0 31
⅜	16	.0005	.0045	.0024	.0016	0 44	0 29
7/16	14	.0006	.0050	.0026	.0018	0 42	0 29
½	13	.0007	.0055	.0029	.0019	0 44	0 28
9/16	12	.0008	.0060	.0032	.0020	0 44	0 28
⅝	11	.0008	.0060	.0031	.0021	0 39	0 26
¾	10	.0009	.0065	.0033	.0023	0 38	0 26
⅞	9	.0010	.0065	.0031	.0024	0 32	0 25
1	8	.0011	.0065	.0027	.0027	0 25	0 25
1⅛	7	.0011	.0065	.0024	.0030	0 19	0 24
1¼	7	.0012	.0065	.0023	.0030	0 18	0 24
1⅜	6	.0012	.0065	.0017	.0036	0 12	0 25
1½	6	.0013	.0070	.0021	.0036	0 14	0 25

[1] Inasmuch as a moderate difference in lead between stud and tapped hole (about 0.005 inch per inch) has been shown to improve the quality of a stud fit having minimum pitch diameter interference, no lead tolerance is specified. Therefore, the tolerances specified for pitch diameter include all errors of pitch diameter and angle but not of lead. (See "5. Gages and gaging" herein.) Excessive lead errors, however, should be avoided, as they increase the tendency of the stud to loosen when subjected to load. Columns 7 and 8 give, for information, the errors in angle which can be compensated for by half the tolerances on pitch diameter given in columns 5 and 6.

[2] The tolerances on the tapped hole given in column 6 are the same as those specified for class 4, close-fit screws and nuts, with the exception of the ¼-inch size.

Table 70.—*Class 5, wrench fit for threaded studs, allowances and tolerances for studs and tapped holes, fine-threaded studs in hard materials*

Sizes	Threads per inch	Interference on pitch diameter		Pitch diameter tolerances [1]		Errors in half angle consuming one half of pitch diameter tolerances	
		Minimum	Maximum	Stud	Tapped hole [2]	Stud	Tapped hole
1	2	3	4	5	6	7	8
		Inch	*Inch*	*Inch*	*Inch*	*Deg. Min.*	*Deg. Min.*
¼	28	0.0005	0.0034	0.0018	0.0011	0 58	0 35
5/16	24	.0005	.0037	.0020	.0012	0 55	0 33
⅜	24	.0006	.0044	.0026	.0012	1 11	0 33
7/16	20	.0006	.0044	.0025	.0013	0 57	0 30
½	20	.0007	.0050	.0030	.0013	1 9	0 30
9/16	18	.0007	.0050	.0028	.0015	0 58	0 31
⅝	18	.0008	.0055	.0032	.0015	1 6	0 31
¾	16	.0008	.0059	.0035	.0016	1 4	0 29
⅞	14	.0008	.0061	.0035	.0018	0 56	0 29
1	14	.0009	.0069	.0042	.0018	1 7	0 29
1⅛	12	.0009	.0067	.0038	.0020	0 52	0 28
1¼	12	.0011	.0060	.0029	.0020	0 40	0 28
1⅜	12	.0011	.0055	.0024	.0020	0 33	0 28
1½	12	.0012	.0050	.0018	.0020	0 25	0 28

[1] Inasmuch as a moderate difference in lead between stud and tapped hole (about 0.005 inch per inch) has been shown to improve the quality of a stud fit having minimum pitch diameter interference, no lead tolerance is specified. Therefore, the tolerances specified for pitch diameter include all errors of pitch diameter and angle but not of lead. (See "5. Gages and gaging" herein.) Excessive lead errors, however, should be avoided, as they increase the tendency of the stud to loosen when subjected to load. Columns 7 and 8 give, for information, the errors in angle which can be compensated for by half the tolerances on pitch diameter given in columns 5 and 6.

[2] The tolerances on the tapped hole given in column 6 are the same as those specified for class 4, close-fit screws and nuts.

TABLE 71.—*Class 5, wrench fit, American National coarse-thread series, steel studs set in hard materials (cast iron, semisteel, bronze, etc.)*

Sizes	Threads per inch	Stud sizes: Major diameter		Stud sizes: Pitch diameter		Stud sizes: Minor diameter	Tapped-hole sizes: Minor diameter		Tapped-hole sizes: Pitch diameter		Tapped-hole sizes: Major diameter	Recommended tap drill size		Approximate torque at full engagement of 1½*D*	
		Maximum	Minimum	Maximum	Minimum	Maximum [1]	Minimum	Maximum	Minimum	Maximum	Minimum [2]	Nominal size	Diameter	Maximum	Minimum
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*		*Inches*	*In.-lbs.*	*In.-lbs.*
¼ [3]	20	0.2500	0.2428	0.2193	0.2186	0.1904	0.2049	0.2103	0.2175	0.2183	0.2500	No. 4	0.2090	105	35
5/16	18	.3125	.3043	.2804	.2784	.2483	.2622	.2682	.2764	.2779	.3125	H	.2660	265	80
⅜	16	.3750	.3660	.3389	.3365	.3028	.3186	.3254	.3344	.3360	.3750	P	.3230	420	120
7/16	14	.4375	.4277	.3961	.3935	.3549	.3736	.3813	.3911	.3929	.4375	V	.3770	610	180
½	13	.5000	.4896	.4555	.4526	.4111	.4313	.4396	.4500	.4519	.5000	7/16	.4375	850	265
9/16	12	.5625	.5513	.5144	.5112	.4663	.4882	.4972	.5084	.5104	.5625	12.5 mm	.4921	1,170	360
⅝	11	.6250	.6132	.5720	.5689	.5195	.5444	.5542	.5660	.5681	.6250	35/64	.5469	1,450	450
¾	10	.7500	.7372	.6915	.6882	.6338	.6614	.6722	.6850	.6873	.7500	43/64	.6719	2,300	730
⅞	9	.8750	.8610	.8093	.8062	.7452	.7768	.7888	.8028	.8052	.8750	25/32	.7812	3,200	1,080
1	8	1.0000	.9848	.9253	.9226	.8531	.8901	.9036	.9188	.9215	1.0000	57/64	.8906	4,250	1,500
1⅛	7	1.1250	1.1080	1.0387	1.0363	.9562	.9998	1.0152	1.0322	1.0352	1.1250	1	1.0000	5,300	1,875
1¼	7	1.2500	1.2330	1.1637	1.1614	1.0812	1.1248	1.1402	1.1572	1.1602	1.2500	1⅛	1.1250	6,950	2,535
1⅜	6	1.3750	1.3548	1.2732	1.2715	1.1770	1.2286	1.2466	1.2667	1.2703	1.3750	1 15/64	1.2344	8,150	2,970
1½	6	1.5000	1.4798	1.3987	1.3966	1.3025	1.3536	1.3716	1.3917	1.3953	1.5000	1 23/64	1.3594	10,400	3,900

[1] Dimensions given for the maximum minor diameter of the screw are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the screw shall be that corresponding to a flat at the minor diameter of the screw equal to $\frac{1}{8} \times p$, and may be determined by subtracting the basic thread depth, h, (or $0.6495p$) from the minimum pitch diameter of the screw.

[2] Dimensions for the minimum major diameter of the tapped hole correspond to the basic flat ($\frac{1}{8} \times p$), and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the tapped hole shall be that corresponding to a flat at the major diameter of the tapped hole equal to $\frac{1}{24} \times p$, and may be determined by adding $1\frac{2}{9} \times h$ (or $0.7939p$) to the maximum pitch diameter of the nut.

[3] Selective assembly in the case of the ¼-inch size may be required on account of the small tolerances necessary on pitch diameter. To avoid breaking a mild steel stud, the maximum interference on pitch diameter of 0.0018 inch must not be exceeded.

TABLE 72.—*Class 5, wrench fit, American National fine-thread series, steel studs set in hard materials (cast iron, semisteel, bronze, etc.)*

Sizes	Threads per inch	Stud sizes					Tapped-hole sizes					Recommended tap drill size		Approximate torque at full engagement of 1½*D*	
		Major diameter		Pitch diameter		Minor diameter	Minor diameter		Pitch diameter		Major diameter				
		Maximum	Minimum	Maximum	Minimum	Maximum [1]	Minimum	Maximum	Minimum	Maximum	Minimum [2]	Nominal size	Diameter	Maximum	Minimum
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*		*Inches*	*In.-lbs.*	*In.-lbs.*
¼	28	0.2500	0.2438	0.2302	0.2284	0.2096	0.2167	0.2206	0.2268	0.2279	0.2500	7/32	0.2188	140	45
5/16	24	.3125	.3059	.2891	.2871	.2650	.2743	.2788	.2854	.2866	.3125	J	.2770	230	70
⅜	24	.3750	.3684	.3523	.3497	.3282	.3368	.3413	.3479	.3491	.3750	R	.3390	410	125
7/16	20	.4375	.4303	.4094	.4069	.3805	.3924	.3978	.4050	.4063	.4375	X	.3970	540	170
½	20	.5000	.4928	.4725	.4695	.4436	.4549	.4603	.4675	.4688	.5000		.4576	810	260
9/16	18	.5625	.5543	.5314	.5286	.4993	.5122	.5182	.5264	.5279	.5625	33/64	.5156	1,040	330
⅝	18	.6250	.6168	.5944	.5912	.5623	.5747	.5807	.5889	.5904	.6250	37/64	.5781	1,430	460
¾	16	.7500	.7410	.7153	.7118	.6792	.6936	.7004	.7094	.7110	.7500		.6970	2,200	685
⅞	14	.8750	.8652	.8347	.8312	.7935	.8111	.8188	.8286	.8304	.8750	13/16	.8125	3,070	945
1	14	1.0000	.9902	.9605	.9563	.9193	.9361	.9438	.9536	.9554	1.0000	15/16	.9375	4,590	1,410
1⅛	12	1.1250	1.1138	1.0776	1.0738	1.0295	1.0507	1.0597	1.0709	1.0729	1.1250		1.0552	5,620	1,750
1¼	12	1.2500	1.2388	1.2019	1.1990	1.1538	1.1757	1.1847	1.1959	1.1979	1.2500	30.0 mm	1.1811	6,960	2,530
1⅜	12	1.3750	1.3638	1.3264	1.3240	1.2782	1.3007	1.3097	1.3209	1.3229	1.3750		1.3052	8,440	3,225
1½	12	1.5000	1.4888	1.4509	1.4491	1.4028	1.4257	1.4347	1.4459	1.4479	1.5000		1.4302	10,070	4,215

[1] Dimensions given for the maximum minor diameter of the screw are figured to the intersection of the worn tool arc with a center line through crest and root. The minimum minor diameter of the screw shall be that corresponding to a flat at the minor diameter of the screw equal to $\frac{1}{8} \times p$, and may be determined by subtracting the basic thread depth, h, (or $0.6495p$) from the minimum pitch diameter of the screw.

[2] Dimensions for the minimum major diameter of the tapped hole correspond to the basic flat ($\frac{1}{8} \times p$), and the profile at the major diameter produced by a worn tool must not fall below the basic outline. The maximum major diameter of the tapped hole shall be that corresponding to a flat at the major diameter of the tapped hole equal to $\frac{1}{24} \times p$, and may be determined by adding $1\frac{2}{9} \times h$ (or $0.7939p$) to the maximum pitch diameter of the nut.

5. GAGES AND GAGING

The fundamentals of this subject, as it relates to screw threads, are laid down in section III. The relatively close limits on pitch diameter specified for class 5, wrench fit for threaded studs, necessitate careful and accurate gaging of both the stud and tapped hole, particularly since the actual measurements obtained depend somewhat upon the methods of gaging used.

Considering first the case of minimum interference: The minimum stud and maximum hole are selected by means of "not go" gages. With the usual or recommended forms of "not go" gages, the presence of lead errors does not affect the gaging. It has been shown by the experimental data obtained that this is a desirable condition, as the presence of a slight difference in lead between stud and hole is an advantage, especially with minimum pitch diameter interference. It is important, however, as with the other classes of fit, that the "not go" gage should check the pitch diameter only, for upon this the minimum tightness of a stud fit depends, assuming that the correct thread form and smoothness of thread surface are maintained.

In the case of maximum interference the maximum stud and minimum hole are selected by means of "go" gages, and these may or may not be the usual types of threaded plugs and rings. Plug and ring gages control pitch diameter, lead, thread angle, maximum minor diameter of stud, and minimum major diameter of hole. The minimum minor diameter of the hole being considerably above basic, it is not controlled by the "go" threaded plug gage, and as it has been shown that a certain minimum clearance at minor diameter must be maintained, it is very important that the hole should be gaged further by means of a "go" plain plug gage. Gaging the tapped hole by means of a "not go" plain plug gage is also desirable, but not strictly necessary.

Gaging of the major diameter of the stud thread is not essential; this element may be controlled by the size of stock. Some means of controlling the minimum minor diameter of the stud is, however, very desirable, particularly on studs of the smaller sizes, because the shearing strength of the stud depends upon this element. For this purpose the projection comparator is very useful, but inspection of the cutting tool to assure a width of flat at the root of the thread not less than $\frac{1}{8} \times p$ is sufficient.

The use of thread micrometers or "go" thread snap gages of short engagement for checking the pitch diameter of the stud is good practice provided that the thread form is ascertained by optical inspection. Gaging for lead errors is not essential provided that the lead of the threading tools is maintained within the usual limits of good commercial practice.

If the tap (ground thread tap) is a close fit in the hole after tapping—that is, if the tap cannot be screwed easily (without the use of a wrench) through the hole after tapping—it may be assumed that the pitch diameter of the hole is very nearly the same as that of the tap.

APPENDIX 5. COMMON PRACTICE AS TO THREAD SERIES AND CLASS OF FIT FOR SCREWS, BOLTS, AND NUTS

The usual commercial practice as to application of thread series and class of fit to screws, bolts, and nuts is indicated in table 73.

TABLE 73.—*Common practice as to thread series and class of fit for screws, bolts, and nuts*

Product	Thread series	Class of fit
1	2	3
Rough machine bolts	Coarse	Class 1, loose fit.
Semifinished machine bolts:		
General applications	do	Class 2, free fit.
Automotive vehicles	Fine	Class 3, medium fit.
Finished machine bolts:		
General applications	Coarse	Do.
Automotive vehicles	Fine	Do.
Aircraft	do	Do.
Machine screws	Coarse or fine	Class 2, free fit.
Machine-screw nuts:		
Numbered sizes	do	Class 1, loose fit.
Fractional sizes	do	Class 2, free fit.
Cap screws	do	Do.
Stove bolts	Coarse	Class 1, loose fit.
Carriage bolts	do	Class 2, free fit.
Step bolts	do	Do.
Button-head machine bolts	do	Do.
Set screws	do	Class 3, medium fit.
Threaded studs:		
Nut end	do	Class 2, free fit.
	Fine	Class 3, medium fit.
Stud end	Coarse or fine	Class 5, wrench fit.
Tap bolts	Coarse	Class 2, free fit.
Tap rivets	do	Class 3, medium fit.

APPENDIX 6. AMERICAN NATIONAL ACME SCREW THREADS (TENTATIVE SPECIFICATIONS)

1. GENERAL AND HISTORICAL

When formulated, prior to 1895, Acme screw threads were intended to replace square threads and a variety of threads of other forms used chiefly for the purpose of producing traversing motions on machines, tools, etc. Acme screw threads are now extensively used for a variety of purposes. For ordinary use, where lateral looseness is not objectionable, clearances between the screw and nut are provided at the major and minor diameters and on the sides of the thread. These allow free movement of the screw in the nut without appreciable longitudinal looseness or end play. This quality of fit is provided for herein.

2. TERMINOLOGY

The terms and symbols relating to screw threads, which are used herein and not otherwise defined, are defined in section II.

3. AMERICAN NATIONAL ACME FORM OF THREAD

(a) SPECIFICATIONS

1. ANGLE OF THREAD.—The angle between the sides of the thread measured in an axial plane shall be 29°. The line bisecting this 29° angle shall be perpendicular to the axis of the screw thread.

2. DEPTH OF THREAD.—The basic depth of the thread shall be equal to one half of the pitch.

3. THICKNESS OF THREAD.—The basic thickness of the thread at a diameter smaller by one half the pitch than the basic major diameter shall be equal to one half of the pitch.[11]

[11] The diameter at which the thickness of thread is measured corresponds to the basic pitch diameter of 60° screw threads used for bolts, nuts, etc. On threads whose included angle is equal to 45° or more, the thickness of the thread is controlled and measured by the pitch diameter. On threads whose included angle is less than 45°, the thickness of the thread should be controlled directly. See p. 138.

4. Clearance at Minor Diameter.—A clearance shall be provided at the minor diameter by making the minor diameter of the screw 0.010 inch smaller than basic for 10 or less threads per inch and 0.005 inch smaller than basic for more than 10 threads per inch.

5. Clearance at Major Diameter.—A clearance shall be provided at the major diameter for all classes by making the major diameter of the nut or threaded hole at least 0.020 inch larger than basic.

6. Fillets at Minor Diameter.—Fillets at the juncture of sides and root of the thread of the screw will develop on account of the rounding of the corners of the threading tool and the side cutting action of milling cutters when these threads are milled. It will be necessary, therefore, on tapped holes for all classes of fits, to provide a fillet or bevel at the minor diameter of the tap to remove the corner of the crest of the thread of the tapped hole. This fillet, or bevel, should be at least 0.010 inch for pitches of 3 threads per inch and finer, and at least 0.020 inch for pitches coarser than 3 threads per inch.

(b) ILLUSTRATION

The basic form of this thread is shown in figure 53.

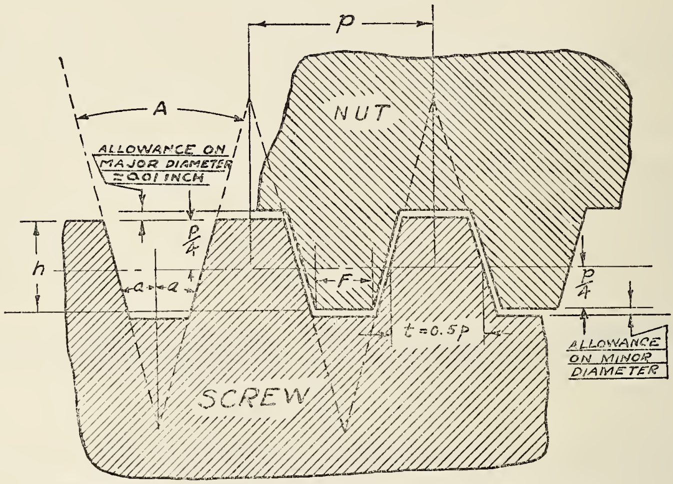

Figure 53.—*American National Acme form of thread.*

NOTATION

A=29° 00′
a=14° 30′
p=pitch
n=number of threads per inch
N=number of turns per inch
h=0.5p, basic depth of thread
t=thickness of thread
F=0.37069p=basic width of flat

4. THREAD SERIES

For general purposes there has been selected a series of diameters and pitches of Acme threads, listed in table 74, which are designated as standard. When it is not feasible to use one of these sizes, it is recommended that, as far as practicable, some one of the pitches shown in table 75 be used; also, that the diameter be within the range specified for each pitch. If a greater lead is required on a given diameter than that corresponding to the recommended maximum pitch, it is advisable to use a multiple thread of finer pitch rather than a single thread of coarser pitch.

TABLE 74.—*American National Acme general purpose thread series*

Identification		Basic diameters			Thread data					
Sizes	Threads per inch	Major diameter, D	Pitch diameter, E	Minor diameter, K	Pitch, p	Thread thickness at pitch line	Basic depth of thread, h=0.5 p	Depth of thread with clearance	Basic width of flat, F=0.37069p	Helix angle at basic pitch diameter, s
1	2	3	4	5	6	7	8	9	10	11
		Inches	*Inches*	*Inches*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Deg. Min.*
¼	16	0.2500	0.2187	0.1875	0.06250	0.03125	0.03125	0.03625	0.0232	5 12
5/16	14	.3125	.2768	.2411	.07143	.03571	.03571	.04071	.0265	4 42
⅜	12	.3750	.3333	.2816	.08333	.04167	.04167	.04667	.0309	4 33
7/16	12	.4375	.3958	.3541	.08333	.04167	.04167	.04667	.0309	3 50
½	10	.5000	.4500	.4000	.10000	.05000	.05000	.06000	.0371	4 3
⅝	8	.6250	.5625	.5000	.12500	.06250	.06250	.07250	.0463	4 3
¾	8	.7500	.6875	.6250	.12500	.06250	.06250	.07250	.0463	3 19
⅞	8	.8750	.8125	.7500	.12500	.06250	.06250	.07250	.0463	2 48
1	5	1.0000	.9000	.8000	.20000	.10000	.10000	.11000	.0741	4 3
1⅛	5	1.1250	1.0250	.9250	.20000	.10000	.10000	.11000	.0741	3 33
1¼	5	1.2500	1.1500	1.0500	.20000	.10000	.10000	.11000	.0741	3 10
1⅜	5	1.3750	1.2750	1.1750	.20000	.10000	.10000	.11000	.0741	2 52
1½	4	1.5000	1.3750	1.2500	.25000	.12500	.12500	.13500	.0927	3 19
1¾	4	1.7500	1.6250	1.5000	.25000	.12500	.12500	.13500	.0927	2 48
2	4	2.0000	1.8750	1.7500	.25000	.12500	.12500	.13500	.0927	2 26
2½	2	2.5000	2.2500	2.0000	.50000	.25000	.25000	.26000	.1853	4 3
3	2	3.0000	2.7500	2.5000	.50000	.25000	.25000	.26000	.1853	3 19
4	2	4.0000	3.7500	3.5000	.50000	.25000	.25000	.26000	.1853	2 26
5	2	5.0000	4.7500	4.5000	.50000	.25000	.25000	.26000	.1853	1 55

TABLE 75.—*Recommended pitches, corresponding range of major diameters, and basic thread data, American National Acme threads*

Number of threads per inch, n	Recommended range of major diameters [1]		Pitch, p	Basic depth of thread, h=0.5p	Basic width of flat, F=0.37069p
	Least	Greatest			
1	2	3	4	5	6
	Inches	*Inches*	*Inch*	*Inch*	*Inch*
1	4.5000	13.5000	1.00000	0.5000	0.3707
1⅓	3.5000	10.5000	.75000	.3750	.2780
1½	3.0000	9.0000	.66667	.3333	.2471
2	2.2500	6.7500	.50000	.2500	.1853
2½	1.7500	5.2500	.40000	.2000	.1483
3	1.5000	4.5000	.33333	.1667	.1236
4	1.1250	3.3750	.25000	.1250	.0927
5	.8750	2.6250	.20000	.1000	.0741
6	.7500	2.2500	.16667	.0833	.0618
8	.5625	1.6875	.12500	.0625	.0463
10	.4375	1.3125	.10000	.0500	.0371
12	.3750	1.1250	.08333	.0417	.0309
14	.3125	.9375	.07143	.0357	.0265
16	.2500	.7500	.06250	.0312	.0232

[1] These recommended least diameters correspond to a maximum helix angle (at the minor diameter) of approximately 5°. The recommended greatest diameters are 3 times the least.

5. CLASSIFICATION AND TOLERANCES

There is established herein for general use a single class of fit of American National Acme screw threads.

(a) GENERAL SPECIFICATIONS

The following general specifications apply to all standard Acme screw threads:

1. BASIC DIAMETERS.—The maximum major and pitch diameters of the screw, and the minimum minor diameter of the nut are basic.

2. TOLERANCES.—(*a*) The tolerances specified represent the extreme variations allowed on the product.

(*b*) The tolerances on diameters of the nuts or threaded holes are plus, and are applied from the minimum nut sizes to above the minimum nut sizes.

(*c*) The tolerances on diameters of the screws are minus, and are applied from the maximum screw sizes to below the maximum screw sizes.

(*d*) The tolerances on the thicknesses of threads are minus, and are applied from the maximum thread thickness to below the maximum thread thickness.

(*e*) The thread thickness tolerances for a screw and nut of the same diameter and pitch are equal.

(*f*) The thread thickness tolerances include lead and angle errors.

(*g*) The tolerances on the major diameters of the screws and minor diameters of the nuts are based upon the pitch of the thread.

(*h*) The minimum major diameter of the nut is at least 0.020 inch larger than the basic major diameter.

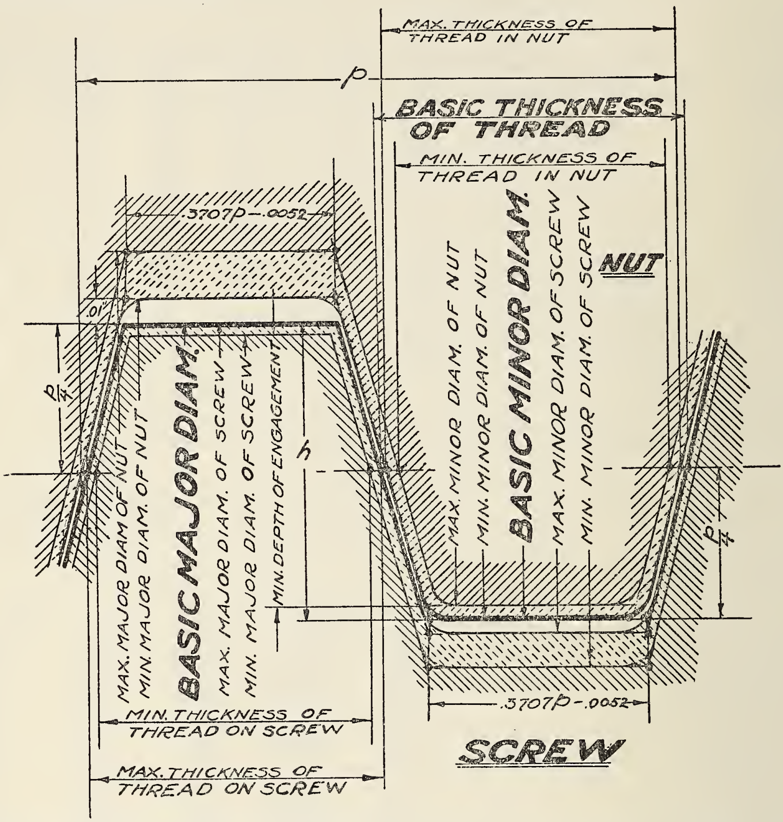

FIGURE 54.—*Illustration of allowances, tolerances, and crest clearances, Acme threads.*

NOTATION

p=pitch.
h=basic thread depth.
Heavy line shows basic size.

(*i*) The maximum major diameter of the nut of a given pitch is such as to result in a flat equal to $0.3707p-0.0052$ inch when the pitch diameter of the nut is at its maximum value.

(*j*) The maximum minor diameter of a screw of a given pitch is such as to result in a flat at the root equal to $0.3707p-0.0052$ inch when the pitch diameter of the screw is at its maximum value.[13]

(b) LIMITING DIMENSIONS AND TOLERANCES

Limiting dimensions for standard Acme threads are given in table 76. The application of these limits is illustrated in figures 54, 55, and 56.

[13] When the width of flat of the cutting tool is at this maximum value the entire thread thickness or pitch diameter tolerance cannot be used without falling below the minimum limit on minor diameter of the screw.

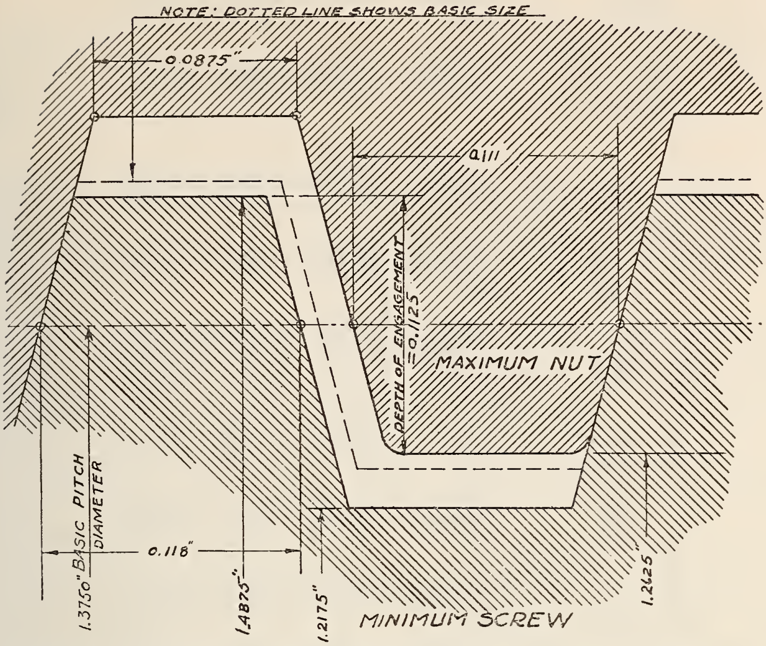

FIGURE 55.—*Illustration of loosest condition for 1½-inch 4 Acme threads.*

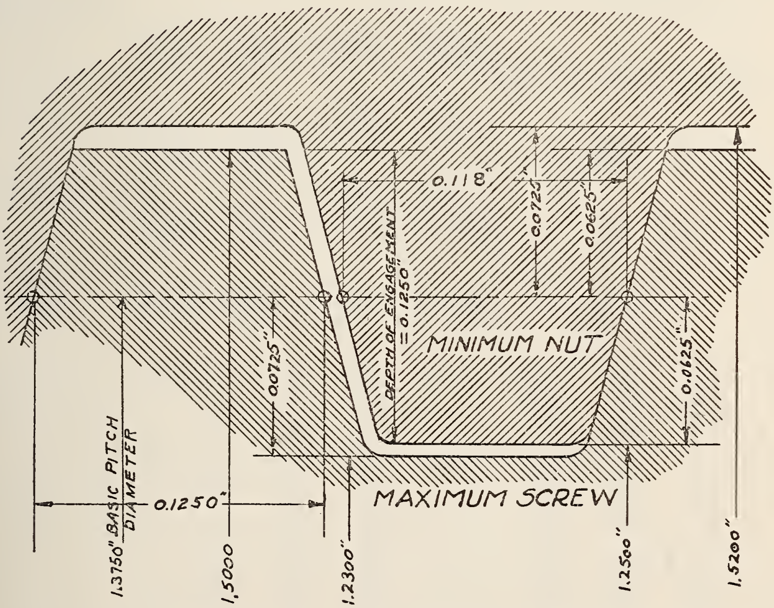

FIGURE 56.—*Illustration of tightest condition for 1½-inch 4 Acme threads.*

TABLE 76.—*American National Acme general purpose thread series, limiting dimensions and tolerances*

Sizes	Threads per inch	Screw sizes: Major diameter, Maximum (basic)	Screw sizes: Major diameter, Minimum	Screw sizes: Pitch diameter, Maximum (basic)	Screw sizes: Pitch diameter, Minimum	Screw sizes: Tolerance equivalent on thickness of threads	Screw sizes: Minor diameter, Maximum	Screw sizes: Minor diameter, Minimum	Nut sizes: Minor diameter, Minimum (basic)	Nut sizes: Minor diameter, Maximum	Nut sizes: Pitch diameter, Minimum	Nut sizes: Pitch diameter, Maximum	Nut sizes: Tolerance equivalent on thickness of threads	Nut sizes: Major diameter, minimum
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Inches	*Inches*	*Inches*	*Inches*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inch*	*Inches*
1/4	16	0.2500	0.2469	0.2187	0.2107	0.002	0.1775	0.1744	0.1875	0.1906	0.2267	0.2347	0.002	0.2600
5/16	14	.3125	.3089	.2768	.2688	.002	.2311	.2275	.2411	.2447	.2847	.2928	.002	.3225
3/8	12	.3750	.3708	.3333	.3213	.003	.2816	.2774	.2816	.2858	.3453	.3573	.003	.3850
7/16	12	.4375	.4333	.3958	.3838	.003	.3441	.3399	.3541	.3583	.4078	.4198	.003	.4475
1/2	10	.5000	.4950	.4500	.4380	.003	.3800	.3750	.4000	.4050	.4620	.4740	.003	.5200
5/8	8	.6250	.6187	.5625	.5465	.004	.4800	.4737	.5000	.5063	.5785	.5945	.004	.6450
3/4	8	.7500	.7437	.6875	.6715	.004	.6050	.5987	.6250	.6313	.7035	.7195	.004	.7700
7/8	8	.8750	.8687	.8125	.7965	.004	.7300	.7237	.7500	.7563	.8285	.8445	.004	.8950
1	5	1.0000	.9900	.9000	.8800	.005	.7800	.7700	.8000	.8100	.9200	.9400	.005	1.0200
1 1/8	5	1.1250	1.1150	1.0250	1.0050	.005	.9050	.8950	.9250	.9350	1.0450	1.0650	.005	1.1450
1 1/4	5	1.2500	1.2400	1.1500	1.1260	.006	1.0300	1.0200	1.0500	1.0600	1.1740	1.1980	.006	1.2700
1 3/8	5	1.3750	1.3650	1.2750	1.2510	.006	1.1550	1.1450	1.1750	1.1850	1.2990	1.3230	.006	1.3950
1 1/2	4	1.5000	1.4875	1.3750	1.3470	.007	1.2300	1.2175	1.2500	1.2625	1.4030	1.4310	.007	1.5200
1 3/4	4	1.7500	1.7375	1.6250	1.5980	.007	1.4800	1.4675	1.5000	1.5125	1.6530	1.6810	.007	1.7700
2	4	2.0000	1.9875	1.8750	1.8430	.008	1.7300	1.7175	1.7500	1.7625	1.9070	1.9390	.008	2.0200
2 1/2	2	2.5000	2.4800	2.2500	2.2060	.011	1.9800	1.9600	2.0000	2.0200	2.2940	2.3380	.011	2.5200
3	2	3.0000	2.9800	2.7500	2.7060	.011	2.4800	2.4600	2.5000	2.5200	2.7940	2.8380	.011	3.0200
4	2	4.0000	3.9800	3.7500	3.7060	.011	3.4800	3.4600	3.5000	3.5200	3.7940	3.8380	.011	4.0200
5	2	5.0000	4.9800	4.7500	4.7060	.011	4.4800	4.4600	4.5000	4.5200	4.7940	4.8380	.011	5.0200

6. GAGES

The inspection of threaded product by means of gages and measuring tools is necessary to maintain the product within the limits specified and to prevent the use of threading tools after they have worn beyond proper limits. With the application of suitable methods of gaging and with reasonably good workmanship, uniform and known thread sizes will result.

(a) FUNDAMENTALS

Both "go" and "not go" gages, representing the extreme product limits, are necessary for the proper inspection of American National Acme screw threads. This and other fundamentals of the subject of gaging screw threads, which are stated for fastening screws in division 5 of section III, are also applicable to Acme threads.

(b) GAGE TOLERANCES

Table 77 is given herein for the purpose of establishing definite limits for gages used in the inspection of Acme threads, rather than for the purpose of specifying the gages required for the various inspection operations. The dimensions of gages should be in accordance with the principles (*a*) that the "go" gage should check simultaneously as many elements as possible and a "not go" gage can effectively check but one element; and (*b*), that permissible variations in the gages be within the extreme product limits.

1. Tolerances on Lead.—The tolerances on lead given in table 77 are specified as an allowable variation between any two threads not farther apart than 12 inches.

2. Tolerances on Angle of Thread.—The tolerances on angle of thread, as specified in table 77 for the various pitches, are tolerances on one half of the included angle. This insures that the bisector of the included angle will be perpendicular to the axis of the thread within proper limits. The equivalent deviation from the true thread form caused by such irregularities as convex or concave sides of thread, or slight projections on the thread form, should not exceed the tolerances permitted on angle of thread.

3. Fillets at Minor Diameter.—"Go" threaded plug gages for nuts have fillets at the minor diameter, the radii of which are not less than 0.010 inch for pitches of three threads per inch and finer, and not less than 0.020 inch for pitches coarser than three threads per inch.

Table 77.—*Tolerances for "go" and "not go" thread gages, American National Acme threads*

Threads per inch	Tolerance on thread thickness at basic pitch line		Tolerance in lead	Tolerance on half angle of thread		Tolerance on major diameter		Tolerance on minor diameter	
	From—	To—				From—	To—	From—	To—
1	2	3	4	5		6	7	8	9
	In h	Inch	Inch ±	Deg. ±	Min.	Inch	Inch	Inch	Inch
1	0.0000	0.0008	0.0005	0	5	0.0000	0.0010	0.0000	0.0010
1⅓	.0000	.0007	.0005	0	5	.0000	.0010	.0000	.0010
1½	.0000	.0006	.0005	0	5	.0000	.0010	.0000	.0010
2	.0000	.0006	.0005	0	5	.0000	.0010	.0000	.0010
2½	.0000	.0005	.0005	0	5	.0000	.0010	.0000	.0010
3	.0000	.0005	.0005	0	5	.0000	.0010	.0000	.0010
4	.0000	.0004	.0005	0	5	.0000	.0010	.0000	.0010
5	.0000	.0004	.0005	0	5	.0000	.0010	.0000	.0010
6	.0000	.0003	.0005	0	5	.0000	.0008	.0000	.0008
8	.0000	.0003	.0005	0	5	.0000	.0006	.0000	.0006
10	.0000	.0002	.0005	0	10	.0000	.0005	.0000	.0005
12	.0000	.0002	.0005	0	10	.0000	.0004	.0000	.0004
14	.0000	.0002	.0005	0	10	.0000	.0004	.0000	.0004
16	.0000	.0002	.0005	0	10	.0000	.0003	.0000	.0003

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