U. S. DEPARTMENT OF COMMERCE

BUREAU OF STANDARDS

REPORT OF THE NATIONAL SCREW THREAD COMMISSION

(REVISED, 1928)

MISCELLANEOUS PUBLICATION, BUREAU OF STANDARDS, No. 89

NATIONAL SCREW THREAD COMMISSION
WASHINGTON, D. C.

Respectfully,

H. W. Bearce, Secretary.

U. S. DEPARTMENT OF COMMERCE
R. P. LAMONT, Secretary
BUREAU OF STANDARDS
George K. Burgess, Director

REPORT

OF THE

NATIONAL SCREW THREAD COMMISSION

(REVISED, 1928)

(AUTHORIZED BY CONGRESS, JULY 18, 1918, H. R. 10852)

AS APPROVED JUNE 22, 1928

MISCELLANEOUS PUBLICATIONS
OF THE
BUREAU OF STANDARDS

No. 89

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON: 1929

NATIONAL SCREW THREAD COMMISSION
WASHINGTON, D. C.

June 15, 1929.

To Holders of the
1928 Report of the
National Screw Thread Commission:

The following revisions have been recommended by the Bolt, Nut and Rivet Manufacturers Association and approved by the Sectional Committee on Bolt, Nut and Rivet Proportions: (See circular letter of April 30, 1929, by Prof. A. E. Norton, Chairman, to members of Sectional Committee).

Page 135, line 5 } change chamfer on square bolt
" 136 " 2 }, heads and nuts from 30° to 25°.
Page 142, Table 69, delete footnote and references thereto in column 1.
Also change values in tables as follows:

Page	Table	Size (column 1)	Change: In Column No.	Present value	New value
142	69	9/16	6 7 8	31/64 .505 .463	1/2 .521 .479
142	69	5/8	2 3	.9375 .906	1.000 .968
143	70	9/16	6 7 8	31/64 .495 .473	1/2 .511 .489
143 144 145	70 71 72	5/8 5/8 5/8	2 3	.9375 .922	1.000 .984

Also, in order to bring your copy up to date please make the following changes:

Page 220, Fig. 66, title, change "top" to "tap".
Page 251, Table 122, column 12, last line, change "2 7/8" to "3".

Page 221, Table 106, column 5, insert "12" opposite 2" size to agree with Simplified Practice Recommendation No. R51-28.

Respectfully,

H. W. Bearce, Secretary.

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PREFACE

This is the third report of the National Screw Thread Commission, being a revision of the 1924 report. The general arrangement of the previous report has been retained with the exception that specifications for threading tools have been removed from the body of the report, extensively revised, and included as an appendix. The designation of the screw-thread standards promulgated by the commission has been changed from "national" to "American National." Other important revisions are: The addition of sizes above 1½ inches to the fine thread series, but with coarser pitches than those originally published in the progress report of 1921; increase of the tolerances on minor diameter of nut, over the range of sizes smaller than 1⅛ inches, of the coarse and fine thread series; the insertion of the 3-inch—3½ threads per inch—size in the coarse-thread series; the substitution of tables of specific pitch diameter tolerances for threads of special diameters, pitches, and lengths of engagement in place of the method of determining such tolerances by adding together increments, thus establishing consistency with the pitch diameter tolerances specified for the regular thread series; and revision of head proportions of wood screws.

New material added to the body of the report includes the following specifications: Wrench head bolts and nuts and wrench openings; other screw, bolt, and nut proportions by reference to certain specifications of the American Engineering Standards Committee[1] and the Federal Specifications Board; an outline of standard practice for Acme screw threads; screw threads for oil well drilling equipment, including pipe, casing, line pipe, cable drilling tool joints, rotary drilling taper joints, cold drawn and machined working barrels, and sucker rods by reference to specifications published by the American Petroleum Institute; standard hose connections for welding and cutting torches; rolled threads for screw shells of electric sockets and lamp bases; and a 12-pitch thread series. The specifications for pipe threads are carried over in this report in their original form pending completion of the work of the new A. S. A. Sectional Committee on the Standardization of Pipe Threads.

New material added to the appendixes, besides that mentioned relative to threading tools, includes the following as useful information: Standard designs of plain and threaded plug and ring gages; specifications covering class 5, wrench fit for threaded studs; common practice as to thread series and class of fit for screws, bolts, and nuts; and wire methods of measurement of thread thickness of Acme threads.

Acknowledgment for cooperation and assistance essential to the progress of the work is again made to those mentioned in the preface to the 1924 report; namely, the manufacturers and users of screw-thread products, tools, and gages; the American Society of Mechanical Engineers; the Society of Automotive Engineers; the American Standards Association[1] and its Sectional Committees on Screw Threads and Plain Limit Gages; The Federal Specifications Board; the National Board of Fire Underwriters; the United States Army; the United States Navy; and the Bureau of Standards; and, in addition, to the A. S. A. Sectional Committee on Bolt, Nut, and Rivet Proportions, the standardization committees of the American Petroleum Institute, the International Acetylene Association, the Gas Products Association, the American Gage Design Committee, and the special N. S. T. C. Committee on Taps.

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[1] Reorganized as the American Standards Association, Oct. 11, 1928.

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

Hon. DWIGHT F. DAVIS,
Secretary of War
Hon. CURTIS D. WILBUR,
Secretary of the Navy
Hon. HERBERT HOOVER,
Secretary of Commerce

JUNE 22, 1928.

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, dated February 11, 1925, herewith submits its report revised 1928, for your acceptance and approval, in accordance with Public Act No. 201 (H. R. 10852, 65th Cong.), approved July 18, 1918; as amended by Public Act No. 324 (H. R. 15495, 65th Cong.), approved March 3, 1919; Public Resolution No. 34 (H. J. 299, 66th Cong.), approved March 23, 1920; Public Resolution No. 43 (H. J. 227, 67th Cong.), approved March 21, 1922; and Public Act No. 125 (H. R. 264, 69th Cong.), approved April 16, 1926.

GEORGE K. BURGESS,
Chairman.
E. C. PECK, *Lieut. Colonel, U. S. A.*,
J. O. JOHNSON, *Colonel, U. S. A.*,
Appointed by the Secretary of War.
H. B. HIRD, *Commander, U. S. N.*,
D. P. MOON, *Lieut. Commander, U. S. N.*,
Appointed by the Secretary of the Navy.
F. O. WELLS,
L. D. BURLINGAME,
Appointed by the Secretary of Commerce from nominations by the American Society of Mechanical Engineers.
EARLE BUCKINGHAM,
GEO. S. CASE,
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. 299, 66th Cong.), Public Resolution No. 43 (H. J. 227, 67th Cong.), and Public Act No. 125 (H. R. 264, 69th Cong.), is hereby accepted and approved.

(Signed September 5, 1928) Dwight F. Davis,
Secretary of War.

(Signed September 14, 1928) Curtis D. Wilbur,
Secretary of the Navy.

(Signed July 14, 1928) Herbert Hoover,
Secretary of Commerce.

1928 REPORT OF THE NATIONAL SCREW THREAD COMMISSION

(Authorized by Congress, July 18, 1918, H. R. 10852)

AS APPROVED JUNE 22, 1928

CONTENTS

[2] New material not included in report revised Aug. 19, 1924.

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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 ¼ 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.

In England the standardization of screw threads began with the efforts of Sir Joseph Whitworth in ascertaining shop practice in the manufacture of screw threads, resulting in the standardization and adoption of the Whitworth thread system, which found extensive use in England. This work has been carried forward by the British Engineering Standards Association, an organization formed in 1901.

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 OF 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 of 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 present-day quantity production of machine parts is standardization of form and dimensions of parts, which involves also the specification of standard 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 can not 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, rotundity, diameter, and length; whereas in a screw-thread fit it is necessary to consider rotundity, 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 Joint Public 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:

	Date appointed
Appointed by the Secretary of Commerce:	
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.
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.
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.

Appointed by the Secretary of the Navy—Continued.	Date appointed
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.

(*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.
Robt. Lacy, first lieutenant of Engineers, U. S. Army, assistant secretary.
A. W. Coombs, stenographic reporter.

(*d*) Committees.—The commission resolved itself into the following subcommittees, with authority to call to their aid one or more experts for counsel. These subcommittees were responsible for compiling and auditing data pertaining to the subject of each committee, and for compiling reports for presentation to the commission as a whole, for the action of the commission:

Pitches, systems, and form of thread	F. O. Wells, chairman. Commander S. M. Robinson. E. H. Ehrman. H. W. Bearce, secretary.
Classification and tolerances	Lieut. Col. E. C. Peck, chairman. James Hartness. E. H. Ehrman. H. L. Van Keuren, secretary.
Terminology	F. O. Wells, chairman. Commander E. J. Marquart. Maj. O. B. Zimmerman. Lieut. Robert Lacy, secretary.
Gages and methods of test	James Hartness, chairman. Lieut. Col. E. C. Peck. Commander E. J. Marquart. H. L. Van Keuren, secretary.

Order of business	James Hartness, chairman. Lieut. Col. E. C. Peck. F. O. Wells.
Research	E. H. Ehrman, chairman. Maj. O. B. Zimmerman. Commander S. M. Robinson.

(*e*) LATER COMMITTEES.—After the publication of the progress report of 1921, the following additional subcommittees were appointed:

Taps, dies, tap drills, and wire gages	Lieut. Col. E. C. Peck, chairman. Ralph E. Flanders. Earle Buckingham.
Boltheads, nuts, and wrenches	F. O. Wells, chairman. Commander L. N. McNair (replaced by Commander J. N. Ferguson). E. H. Ehrman (replaced by George S. Case).
Bar sizes	E. H. Ehrman, chairman (replaced by George S. Case). Maj. J. O. Johnson. Commander Joseph S. Evans (replaced by Commander M. A. Libbey).
Instrument threads and brass tubing	Commander L. N. McNair, chairman (replaced by Commander J. N. Ferguson). F. O. Wells. Dr. S. W. Stratton (replaced by Dr. George K. Burgess).
Acme and special threads	Maj. J. O. Johnson, chairman. Ralph E. Flanders. Commander Joseph S. Evans (replaced by Commander M. A. Libbey). Earle Buckingham.
Rearrangement of progress report	Lieut. Col. E. C. Peck, chairman. Ralph E. Flanders. George S. Case.
Revision of progress report	Ralph E. Flanders, chairman. Maj. J. O. Johnson. Commander J. N. Ferguson. Earle Buckingham.

After publication of the 1924 report, subcommittees were reorganized as follows:

Screw threads used in electrical industry	Prof. Earle Buckingham, chairman. Commander M. A. Libbey (replaced by Commander Harry B. Hird). F. O. Wells. Luther D. Burlingame.
Bolt heads, nuts, and wrenches	Commander John B. Rhodes, chairman (replaced by Commander T. C. Kinkaid, and Commander Kinkaid replaced by Lieut. Commander D. P. Moon). F. O. Wells. George S. Case. Luther D. Burlingame.

Oil well casing threads	Col. John O. Johnson, chairman. Lieut. Col. E. C. Peck. Commander M. A. Libbey (replaced by Commander Harry B. Hird). George S. Case.
Stud fits	Lieut. Col. E. C. Peck, chairman. Prof. Earle Buckingham. Col. John O. Johnson. Commander M. A. Libbey (replaced by Commander Harry B. Hird).
Taps	Lieut. Col. E. C. Peck, chairman. Luther D. Burlingame. Prof. Earle Buckingham.
Acme threads	Commander John B. Rhodes, chairman (replaced by Commander T. C. Kinkaid, and Commander Kinkaid replaced by Lieut Commander D. P. Moon). Prof. Earle Buckingham. Col. John O. Johnson.
Machine screw and stove bolt proportions	F. O. Wells, chairman. Commander John B. Rhodes (replaced by Commander T. C. Kinkaid, and Commander Kinkaid replaced by Lieut. Commander D. P. Moon). George S. Case. Luther D. Burlingame.
Revision of 1924 report	Luther D. Burlingame, chairman. Commander John B. Rhodes (replaced by Commander T. C. Kinkaid, and Commander Kinkaid replaced by Lieut. Commander D. P. Moon). Prof. Earle Buckingham. Col. John O. Johnson.
Special N. S. T. C. committee on taps	Lieut. Col. E. C. Peck; Prof. Earle Buckingham; George S. Case, alternate — representing the commission. Chas. Winter; H. C. Hungerford — representing organized manufacturers. J. Chester Bath, representing independent manufacturers A. C. Danekind; D. W. Ovaitt — representing users. H. W. Bearce, secretary.

(*f*) 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).

(*g*) Present Organization.—At the time of publication of this 1928 revised report the commission comprises the following:

Members:
- Dr. George K. Burgess, chairman.
- Lieut. Col. E. C. Peck, vice chairman.
- F. O. Wells.
- Col. John O. Johnson.
- Prof. Earle Buckingham.
- George S. Case.
- Luther D. Burlingame.
- Commander Harry B. Hird.
- Lieut. Commander Don P. Moon.
- H. W. Bearce, secretary.

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

(*h*) 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.*[3]—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

[3] 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."

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.

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. 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

Additional symbols for American National Pipe Threads are given in Section VI.

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 "L. H." shall follow the number of threads. 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 in. diameter, 8 threads per inch, class 1 fit	*1″—8—NC—1*
American National Fine Thread Series:	
Threaded part 1 in. diameter, 14 threads per inch, class 4 fit	*1″—14—NF—4*
American National Form, Special Pitch:	
Threaded part 1 in. diameter, 12 threads per inch, class 2 fit	*1″—12—NS—2*
American National Form, Left-Hand Thread:	
Threaded part 1 in. diameter, 12 threads per inch, class 4 fit	*1″—12 L. H.—NS—4*
American National Pipe Threads:	
American National taper pipe thread. Threaded part 1 in. diameter, 11½ threads per inch	*1″—11½—NPT*
American National straight pipe thread	*1″—11½—NPS*
American National Fire-Hose Coupling Threads and American National Hose-Coupling Threads:	
Threaded part 3 in. diameter, 6 threads per inch	*3″—6—NH*
Threaded part 1 in. diameter, 11½ threads per inch	*1″—11½—NH*

The number of threads per inch must 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

3. ILLUSTRATIONS SHOWING TERMINOLOGY

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

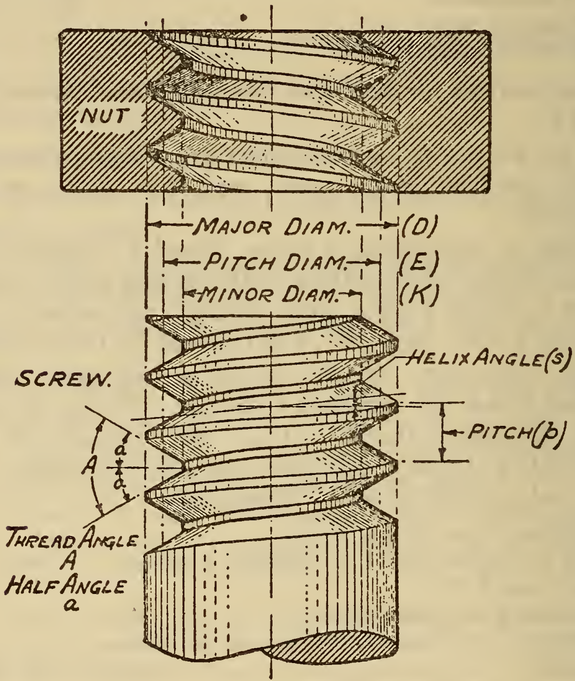

Fig. 1.—*Screw thread notation*

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

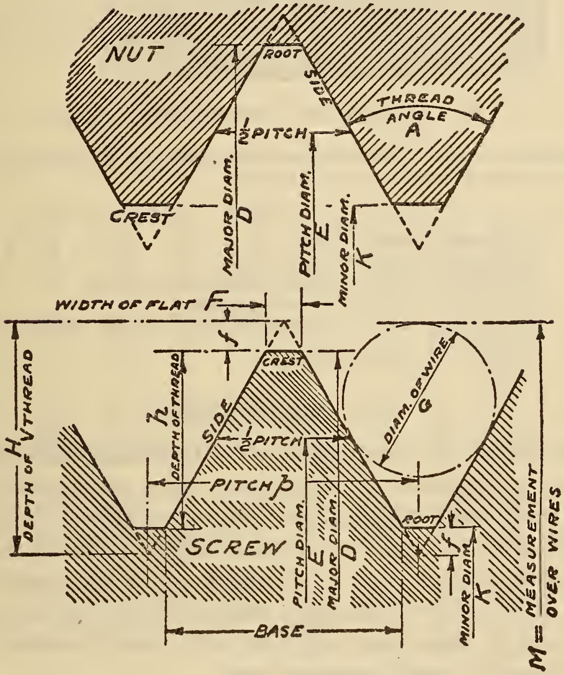

FIG. 2.—*Screw thread notation*

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 per cent (depending on the size), and not more than 83⅓ per cent of the basic thread depth. (See fig. 17.)

5. CLEARANCE AT MAJOR DIAMETER.—A clearance shall be provided at the major diameter of the nut by removing from 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.

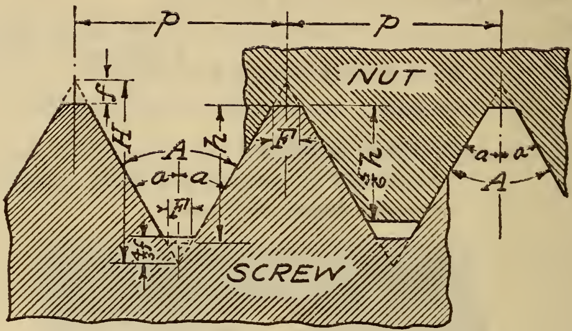

Fig. 3.—*American National form of thread*

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
F=0.125000 p width of flat at crest and root of American National form
f=0.108253 p }
=$\frac{1}{8}H$ } depth of truncation
=$\frac{1}{6}h$ }

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.).

(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
3/8	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
5/8	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
7/8	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
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 [1]	4	3.0000	2.8376	2.6752	76.200	.25000	.16238	.03125	.01042	1	36	5.6209
3	3½	3.0000	2.8144	2.6288	76.200	.28571	.18558	.03571	.01190	1	51	5.4276

[1] Optional. Standard for marine work.

(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
1/4	28	.2500	.2268	.2036	6.350	.03571	.02320	.00446	.00149	2 52	.0326
5/16	24	.3125	.2854	.2584	7.938	.04167	.02706	.02521	.00174	2 40	.0524
3/8	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
1/2	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
5/8	18	.6250	.5889	.5528	15.875	.05556	.03608	.00694	.00231	1 43	.2400
3/4	16	.7500	.7094	.6688	19.050	.06250	.04059	.00781	.00260	1 36	.3513
7/8	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
1 1/8	12	1.1250	1.0709	1.0167	28.575	.08333	.05413	.01042	.00347	1 25	.8118
1 1/4	12	1.2500	1.1959	1.1417	31.750	.08333	.05413	.01042	.00347	1 16	1.0238
1 1/2	12	1.5000	1.4459	1.3917	38.100	.08333	.05413	.01042	.00347	1 3	1.5212
1 3/4	10	1.7500	1.6850	1.6201	44.450	.10000	.06495	.01250	.00417	1 5	2.0615
2	10	2.0000	1.9350	1.8701	50.800	.10000	.06495	.01250	.00417	0 57	2.7468
2 1/4	8	2.2500	2.1688	2.0876	57.150	.12500	.08119	.01562	.00521	1 3	3.4228
2 1/2	8	2.5000	2.4188	2.3376	63.500	.12500	.08119	.01562	.00521	0 57	4.2917
2 3/4	8	2.7500	2.6688	2.5876	69.850	.12500	.08119	.01562	.00521	0 51	5.2588
3	8	3.0000	2.9188	2.8376	76.200	.12500	.08119	.01562	.00521	0 47	6.3240

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, somewhat 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 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.[4]—(*a*) The tolerances specified represent the extreme variations permitted 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 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 for the corresponding thread series, with the following exceptions: (1) Threads above 1½ inches diameter of the American National fine-thread series, class 1, loose fit and class 2, free fit, have major diameter tolerances equal to twice the pitch diameter tolerances of the corresponding pitches and fits of the American National coarse-thread series. (2) 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 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.

[4] Recommendations and explanations regarding the application of tolerances are given in Appendix 1.

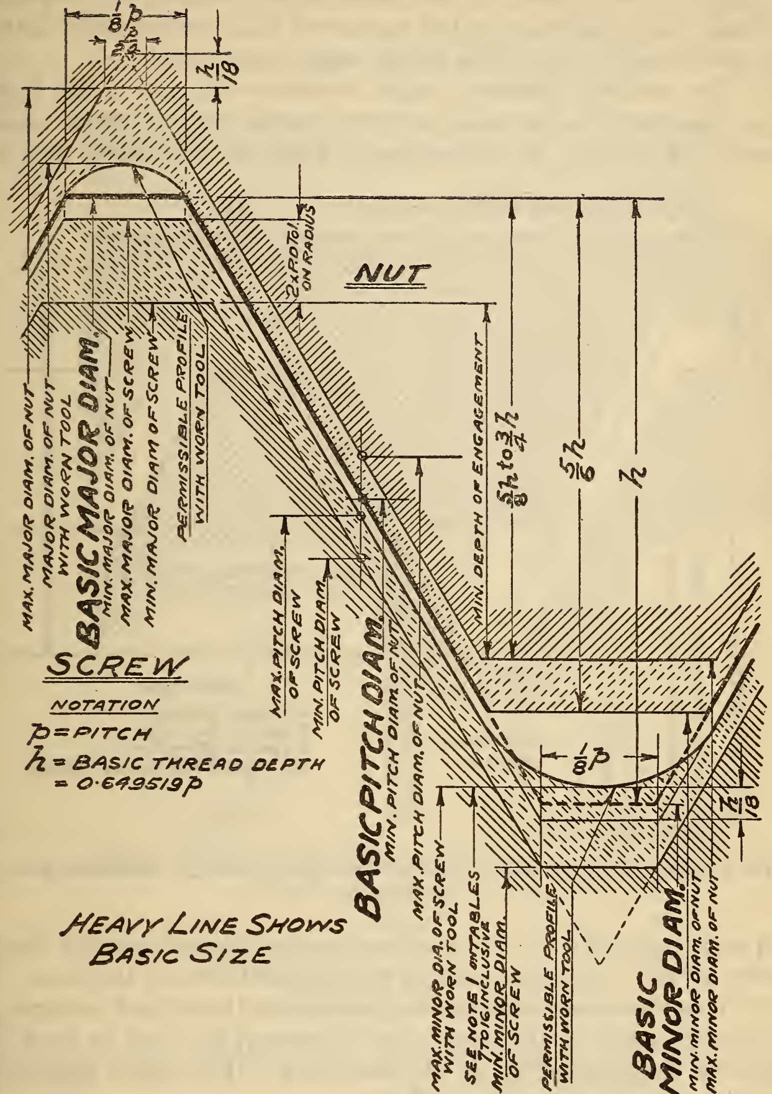

FIG. 4.—*Illustration of tolerances, allowance (neutral space), and crest clearances for class 1, loose fit*

(*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

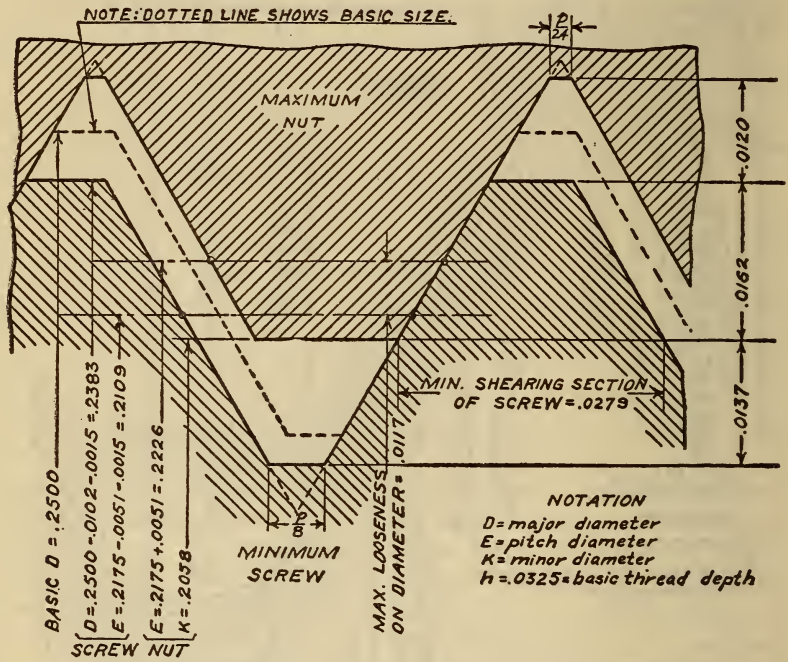

FIG. 5.—*Illustration of loosest condition for class 1, loose fit, one-fourth inch, 20 threads*

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.

(*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 IV, p. 78.)

(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.

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

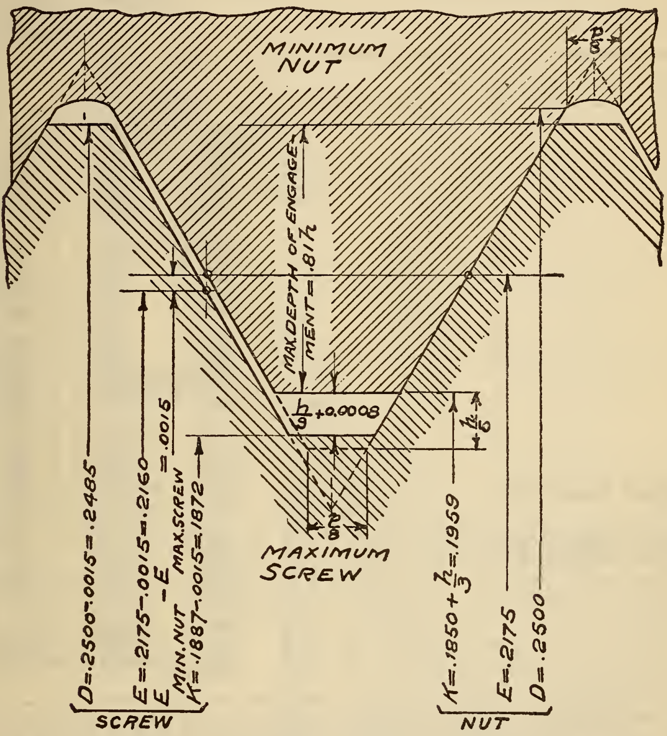

FIG. 6.—*Illustration of tightest condition for class 1, loose fit, one-fourth inch, 20 threads*

NOTATION

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

diameter of the minimum nut is the theoretical pitch diameter for that size.

(*c*) *Maximum screw below basic.*[5]—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.

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

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

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 (American National coarse)	.0028	.0092	.0027	1	45
10 (American National fine)	.0028	.0132	.0038	2	31
9	.0031	.0100	.0029	1	43
8 (American National coarse)	.0034	.0111	.0032	1	42
8 (American National fine)	.0034	.0145	.0042	2	13
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
3½	.0073	.0229	.0066	1	32

[1] *The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance can not, 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.

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

(*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.

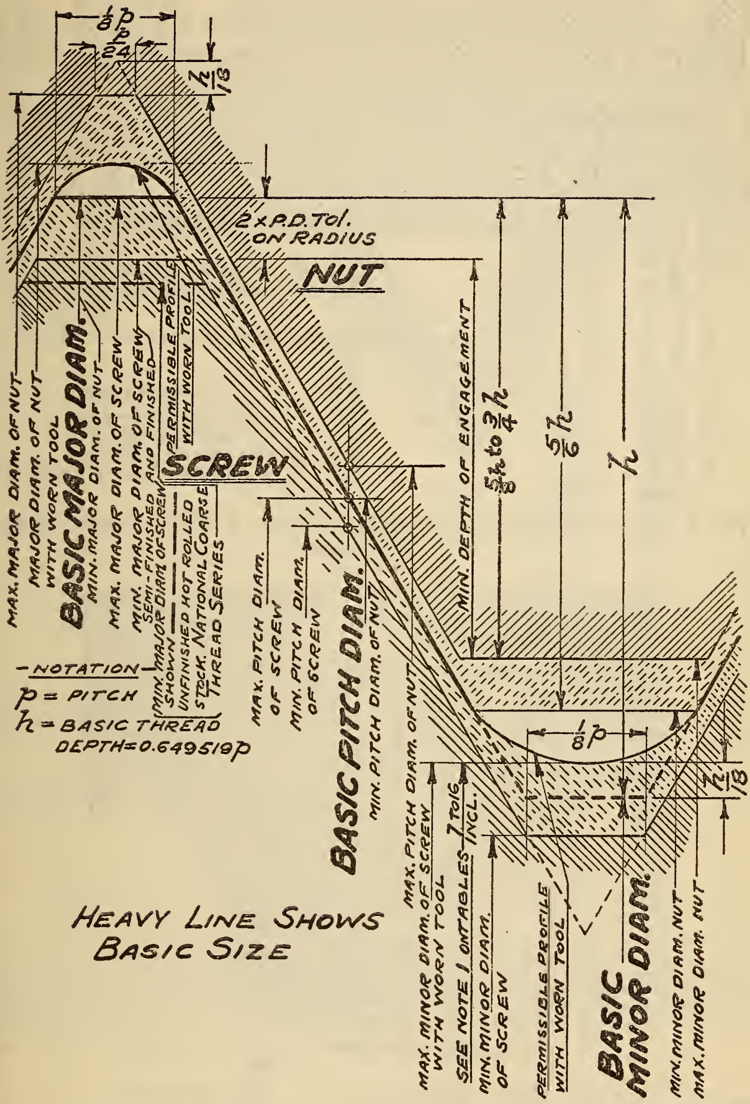

FIG. 7.—*Illustration of tolerances and crest clearances for class 2, free fit*

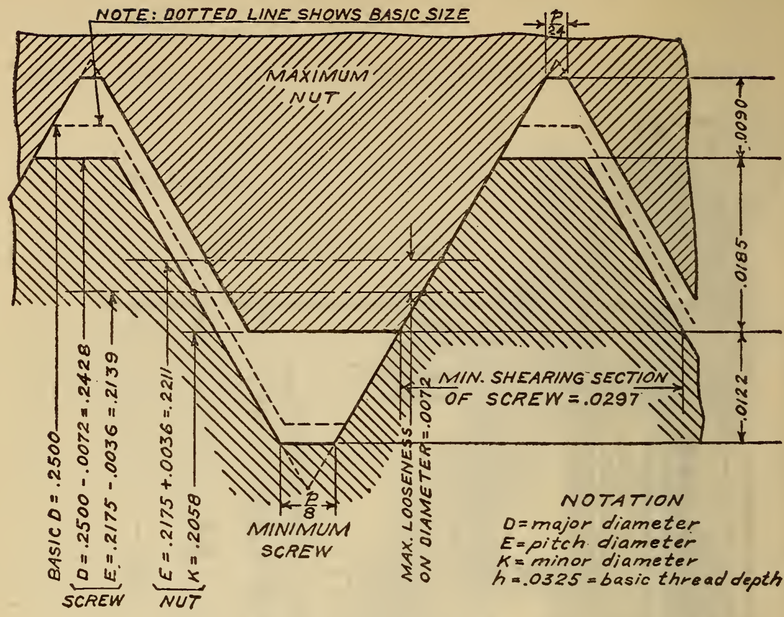

FIG. 8.—*Illustration of loosest condition for class 2, free fit, one-fourth inch, 20 threads*

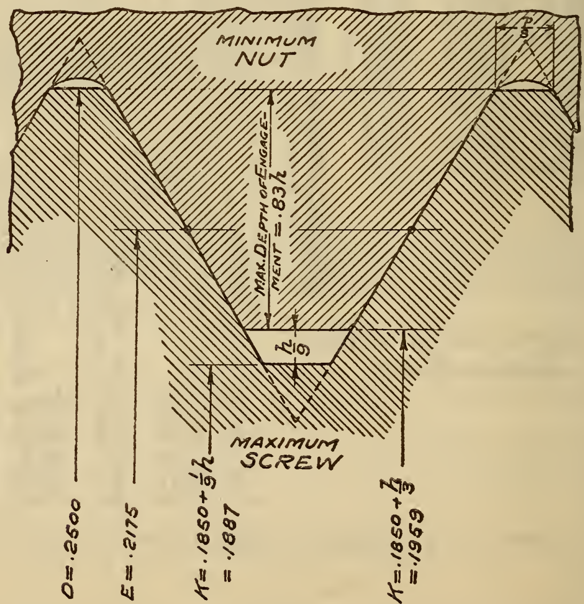

FIG. 9.—*Illustration of tightest condition for class 2, free fit, one-fourth inch, 20 threads*

(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 4.

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 (American National coarse)	.0000	.0064	.0018	1	13
10 (American National fine)	.0000	.0100	.0029	1	55
9	.0000	.0070	.0020	1	12
8 (American National coarse)	.0000	.0076	.0022	1	10
8 (American National fine)	.0000	.0110	.0032	1	41
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
3½	.0000	.0157	.0045	1	3

[1] *The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance can not, 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.

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

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

members. It is the same in every particular as class 2, free fit, except that the tolerances are smaller.

(*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 basic.*[7]—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.

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

Threads per inch	Allowances	Pitch-diameter tolerances [a]	Lead errors consuming one-half of pitch-diameter tolerances [b]	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 (American National coarse)	.0000	.0045	.0013	0	52
10 (American National fine)	.0000	.0084	.0024	1	36
9	.0000	.0049	.0014	0	51
8 (American National coarse)	.0000	.0054	.0016	0	50
8 (American National fine)	.0000	.0092	.0027	1	24
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
3½	.0000	.0107	.0031	0	43

[a] *The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance can not, 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.*

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

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

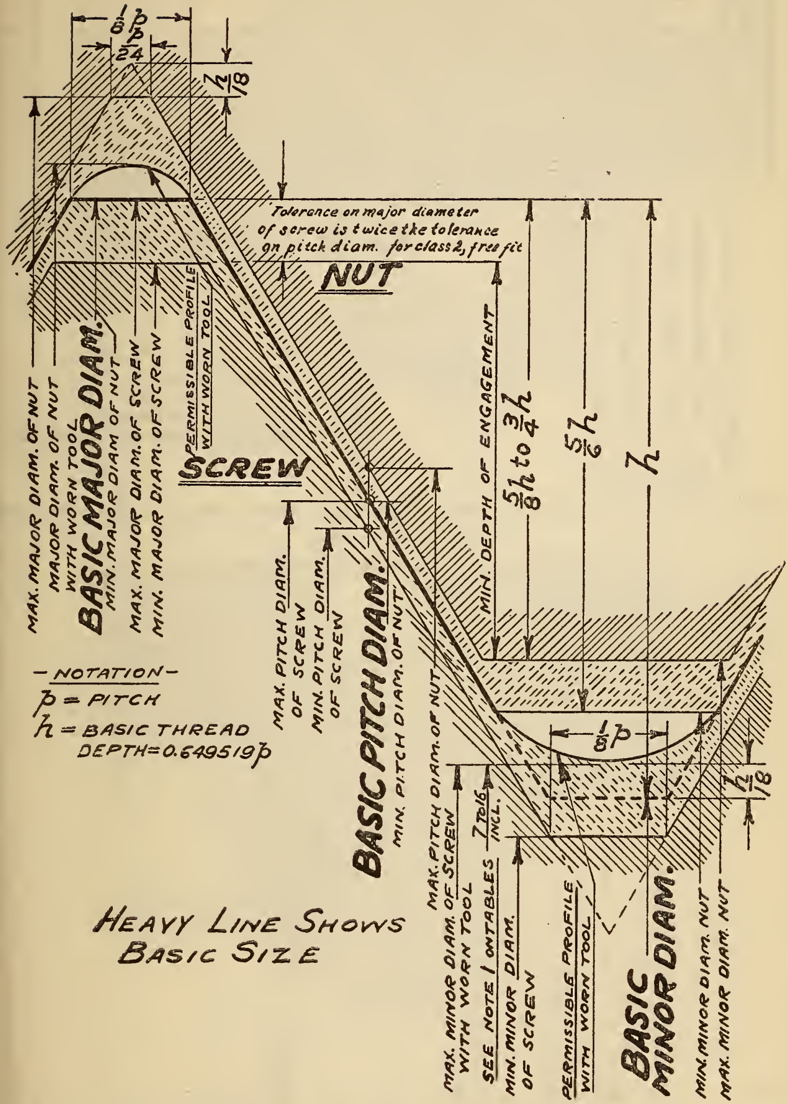

Fig. 10.—*Illustration of tolerances and crest clearances for class 3, medium fit*

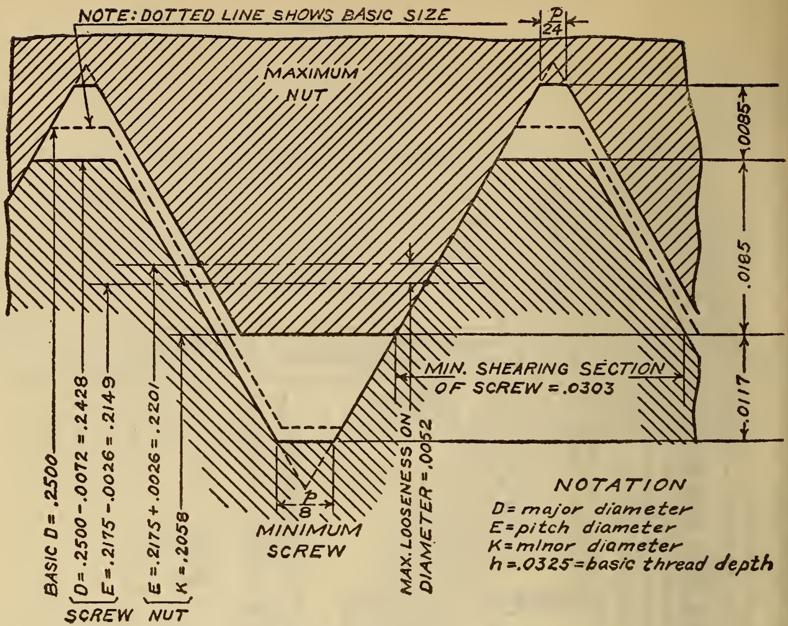

FIG. 11.—*Illustration of loosest condition for class 3, medium fit, one-fourth inch, 20 threads*

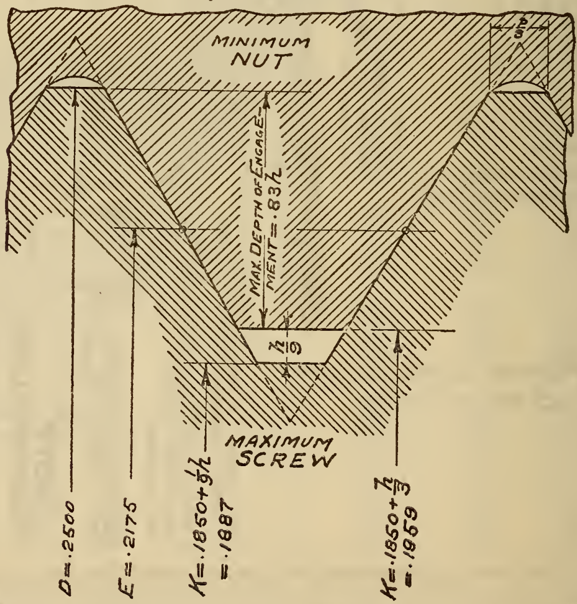

FIG. 12.—*Illustration of tightest condition for class 3, medium fit, one-fourth inch, 20 threads*

NOTATION

D = major diameter

E = pitch diameter

K = minor diameter

h = 0.0325 = basic thread depth

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 screw-thread

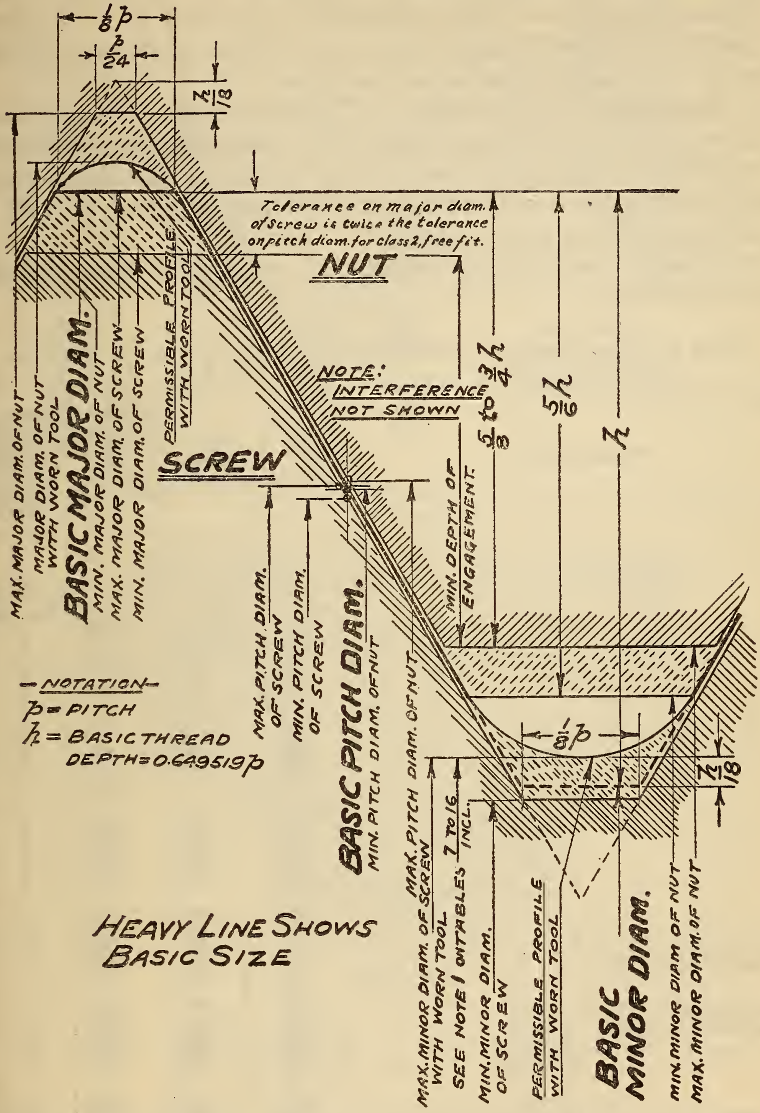

Fig. 13.—*Illustration of tolerances, allowance (interference), and crest clearances for class 4, close fit*

products belonging in this class it will be necessary to use precision tools, selected gages, 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.*
80	0.0001	0.0006	0.0002	0	55
72	.0001	.0007	.0002	0	58
64	.0001	.0007	.0002	0	51
56	.0002	.0007	.0002	0	45
48	.0002	.0008	.0002	0	44
44	.0002	.0008	.0002	0	40
40	.0002	.0009	.0003	0	41
36	.0002	.0009	.0003	0	37
32	.0002	.0010	.0003	0	37
28	.0002	.0011	.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 (American National coarse)	.0006	.0023	.0007	0	26
10 (American National fine)	.0006	.0042	.0012	0	48
9	.0006	.0024	.0007	0	25
8 (American National coarse)	.0007	.0027	.0008	0	25
8 (American National fine)	.0007	.0046	.0013	0	42
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
3½	.0016	.0053	.0015	0	21

[1] *The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance can not, 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.

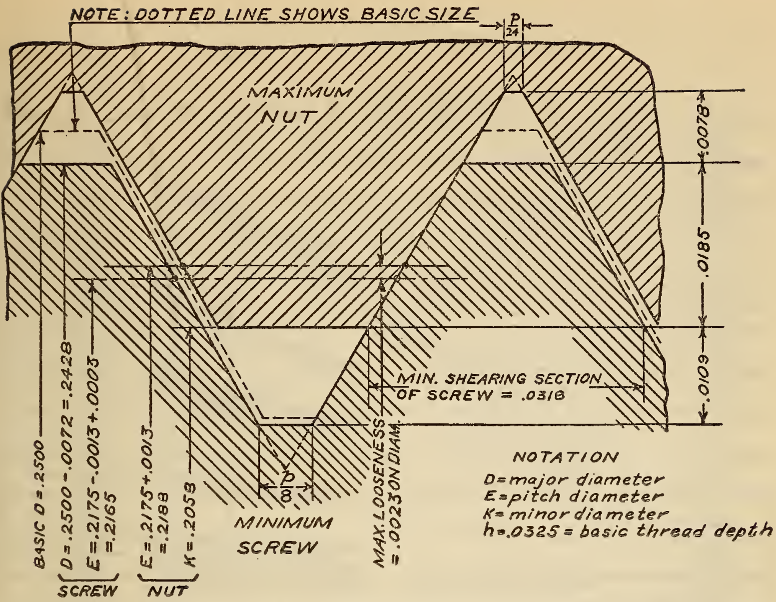

FIG. 14.—*Illustration of loosest condition for class 4, close fit, one-fourth inch, 20 threads*

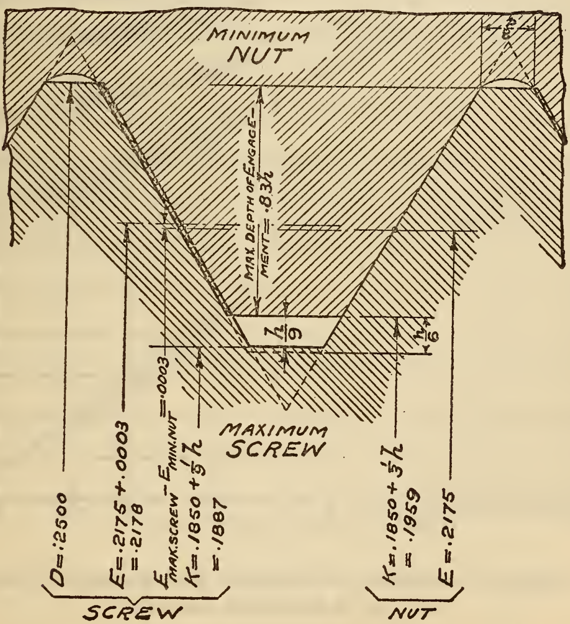

FIG. 15.—*Illustration of tightest condition for class 4, close fit, one-fourth inch, 20 threads*

NOTATION

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

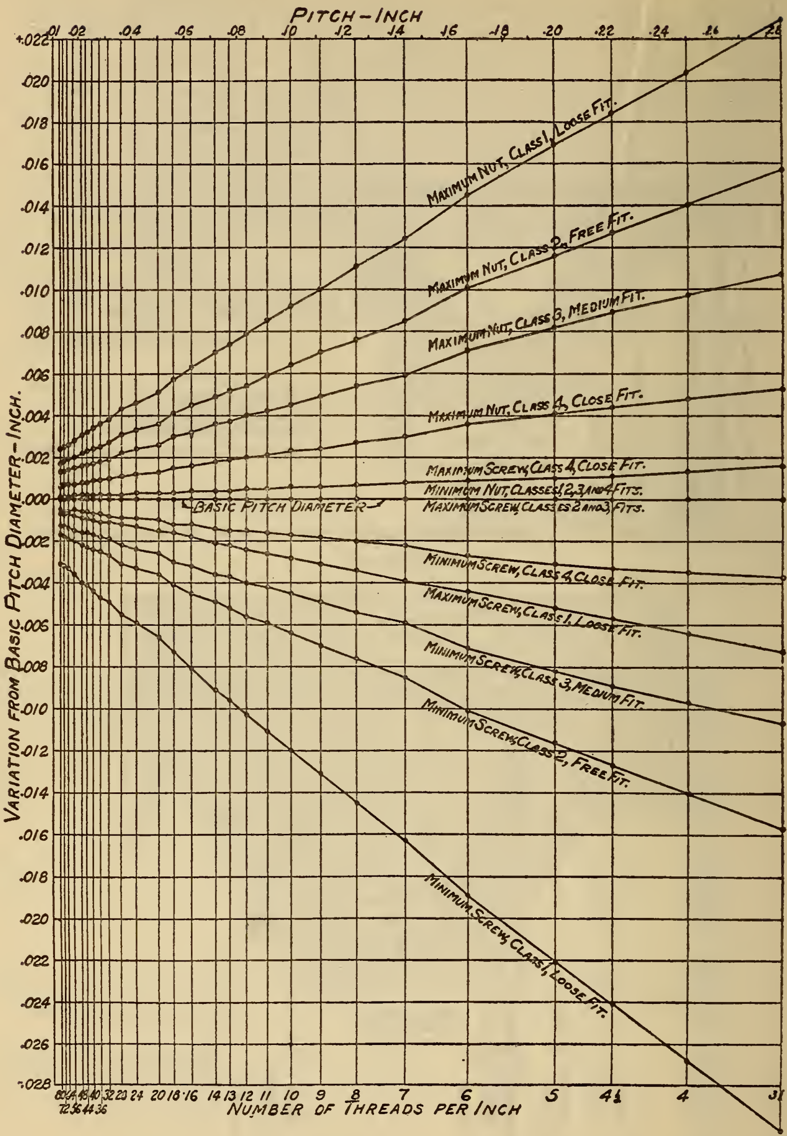

Fig. 16.—*Relation of maximum and minimum pitch diameters of classes 1, 2, 3, and 4 fits to basic pitch diameters*

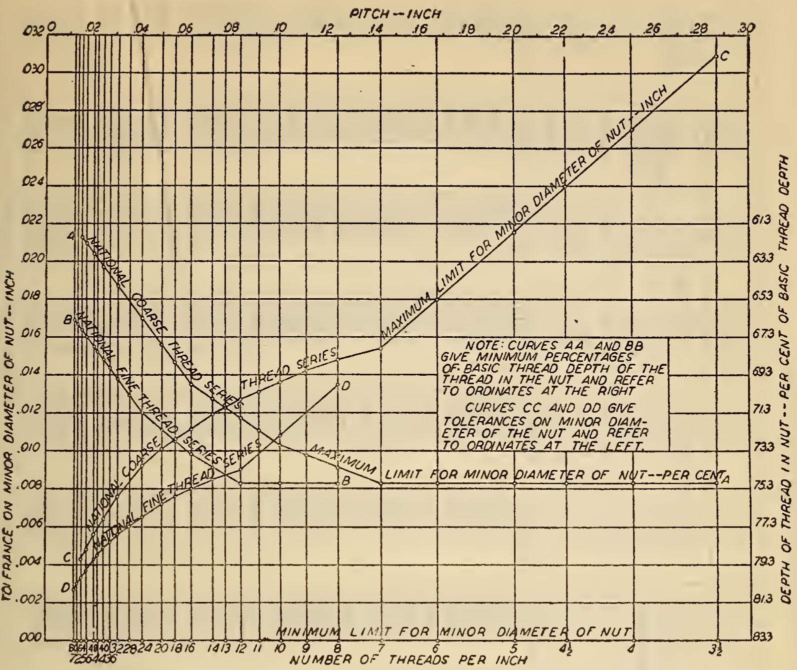

Fig. 17.—*Limits for minor diameter of nut, American National coarse and fine thread series*

4. TABLES OF 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: 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	0.0723	0.0671	0.0622	0.0596	0.0531	0.0561	0.0604	0.0629	0.0655	0.0730	0.073
2	56	.0852	.0796	.0736	.0708	.0633	.0667	.0715	.0744	.0772	.0860	.086
3	48	.0981	.0919	.0846	.0815	.0725	.0764	.0820	.0855	.0886	.0990	.099
4	40	.1110	.1042	.0948	.0914	.0803	.0849	.0913	.0958	.0992	.1120	.112
5	40	.1240	.1172	.1078	.1044	.0933	.0979	.1043	.1088	.1122	.1250	.125
6	32	.1369	.1293	.1166	.1128	.0986	.1042	.1118	.1177	.1215	.1380	.138
8	32	.1629	.1553	.1426	.1388	.1246	.1302	.1378	.1437	.1475	.1640	.164
10	24	.1887	.1795	.1616	.1570	.1376	.1449	.1541	.1629	.1675	.1900	.190
12	24	.2147	.2055	.1876	.1830	.1636	.1709	.1801	.1889	.1935	.2160	.216
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
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
3	3½	2.9927	2.9469	2.8071	2.7842	2.6421	2.6907	2.7216	2.8144	2.8373	3.0000	3.0000

[1] [2] See footnotes on p. 49.

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	0.073
2	56	.0860	.0820	.0804	.0744	.0724	.0641	.0667	.0715	.0744	.0764	.0860	.086
3	48	.0990	.0946	.0928	.0855	.0833	.0734	.0764	.0820	.0855	.0877	.0990	.099
4	40	.1120	.1072	.1052	.0958	.0934	.0813	.0849	.0913	.0958	.0982	.1120	.112
5	40	.1250	.1202	.1182	1088	.1064	.0943	.0979	.1043	.1088	.1112	.1250	.125
6	32	.1380	.1326	.1304	.1177	.1150	.0997	.1042	.1118	.1177	.1204	.1380	.138
8	32	.1640	.1586	.1564	.1437	.1410	.1257	.1302	.1378	.1437	.1464	.1640	.164
10	24	.1900	.1834	.1808	.1629	.1596	.1389	.1449	.1541	.1629	.1662	.1900	.190
12	24	.2160	.2094	.2068	.1889	.1856	.1649	.1709	.1801	.1889	.1922	.2160	.216
¼	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
⅜	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
½	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
⅝	11	.6250	.6132	.6080	.5660	.5601	.5135	.5266	.5397	.5660	.5719	.6250	.6250
¾	10	.7500	.7372	.7316	.6850	.6786	.6273	.6417	.6553	.6850	.6914	.7500	.7500
⅞	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
1⅛	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
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
3	3½	3.0000	2.9686	2.9542	2.8144	2.7987	2.6494	2.6907	2.7216	2.8144	2.8301	3.0000	3.0000

[1, 2] See footnotes on p. 49.

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	0.073
2	56	.0860	.0820	.0744	.0729	.0641	.0667	.0715	.0744	.0759	.0860	.086
3	48	.0990	.0946	.0855	.0839	.0734	.0764	.0820	.0855	.0871	.0990	.099
4	40	.1120	.1072	.0958	.0941	.0813	.0849	.0913	.0958	.0975	.1120	.112
5	40	.1250	.1202	.1088	.1071	.0943	.0979	.1043	.1088	.1105	.1250	.125
6	32	.1380	.1326	.1177	.1158	.0997	.1042	.1118	.1177	.1196	.1380	.138
8	32	.1640	.1586	.1437	.1418	.1257	.1302	.1378	.1437	.1456	.1640	.164
10	24	.1900	.1834	.1629	.1605	.1389	.1449	.1541	.1629	.1653	.1900	.190
12	24	.2160	.2094	.1889	.1865	.1649	.1709	.1801	.1889	.1913	.2160	.216
¼	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
⅜	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
½	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
⅝	11	.6250	.6132	.5660	.5618	.5135	.5266	.5397	.5660	.5702	.6250	.6250
¾	10	.7500	.7372	.6850	.6805	.6273	.6417	.6553	.6850	.6895	.7500	.7500
⅞	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
1⅛	7	1.1250	1.1080	1.0322	1.0263	.9497	.9704	.9858	1.0322	1.0381	1.1250	1.1250
1¼	7	1.2500	1.2330	1.1572	1.1513	1.0747	1.0954	1.1108	1.1572	1.1631	1.2500	1.2500
1½	6	1.5000	1.4798	1.3917	1.3846	1.2955	1.3196	1.3376	1.3917	1.3988	1.5000	1.5000
1¾	5	1.7500	1.7268	1.6201	1.6119	1.5046	1.5335	1.5551	1.6201	1.6283	1.7500	1.7500
2	4½	2.0000	1.9746	1.8557	1.8468	1.7274	1.7594	1.7835	1.8557	1.8646	2.0000	2.0000
2¼	4½	2.2500	2.2246	2.1057	2.0968	1.9774	2.0094	2.0335	2.1057	2.1146	2.2500	2.2500
2½	4	2.5000	2.4720	2.3376	2.3279	2.1933	2.2294	2.2564	2.3376	2.3473	2.5000	2.5000
2¾	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	3½	3.0000	2.9686	2.8144	2.8037	2.6494	2.6907	2.7216	2.8144	2.8251	3.0000	3.0000

[1] [2] See footnotes on p. 49.

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*
1	64	0.0730	0.0692	0.0630	0.0623	0.0538	0.0561	0.0604	0.0629	0.0636	0.0730	0.073
2	56	.0860	.0820	.0746	.0739	.0641	.0667	.0715	.0744	.0751	.0860	.086
3	48	.0990	.0946	.0857	.0849	.0734	.0764	.0820	.0855	.0863	.0990	.099
4	40	.1120	.1072	.0960	.0951	.0813	.0849	.0913	.0958	.0967	.1120	.112
5	40	.1250	.1202	.1090	.1081	.0943	.0979	.1043	.1088	.1097	.1250	.125
6	32	.1380	.1326	.1179	.1169	.0997	.1042	.1118	.1177	.1187	.1380	.138
8	32	.1640	.1586	.1439	.1429	.1257	.1302	.1378	.1437	.1447	.1640	.164
10	24	.1900	.1834	.1632	.1620	.1389	.1449	.1541	.1629	.1641	.1900	.190
12	24	.2160	.2094	.1892	.1880	.1649	.1709	.1801	.1889	.1901	.2160	.216
¼	20	.2500	.2428	.2178	.2165	.1887	.1959	.2060	.2175	.2188	.2500	.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
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
3	3½	3.0000	2.9686	2.8160	2.8107	2.6494	2.6907	2.7216	2.8144	2.8197	3.0000	3.0000

[1] [2] See footnotes on p. 49.

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	0.060
1	72	.0723	.0673	.0633	.0608	.0553	.0580	.0610	.0640	.0665	.0730	.073
2	64	.0853	.0801	.0752	.0726	.0661	.0691	.0724	.0759	.0785	.0860	.086
3	56	.0982	.0926	.0866	.0838	.0763	.0797	.0834	.0874	.0902	.0990	.099
4	48	.1111	.1049	.0976	.0945	.0855	.0894	.0937	.0985	.1016	.1120	.112
5	44	.1241	.1177	.1093	.1061	.0962	.1004	.1049	.1102	.1134	.1250	.125
6	40	.1370	.1302	.1208	.1174	.1063	.1109	.1158	.1218	.1252	.1380	.138
8	36	.1629	.1557	.1449	.1413	.1288	.1339	.1391	.1460	.1496	.1640	.164
10	32	.1889	.1813	.1686	.1648	.1506	.1562	.1618	.1697	.1735	.1900	.190
12	28	.2148	.2062	.1916	.1873	.1710	.1773	.1833	.1928	.1971	.2160	.216
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 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 3/4	10	1.7472	1.7288	1.6822	1.6690	1.6245	1.6417	1.6525	1.6850	1.6982	1.7500	1.7500
2	10	1.9972	1.9788	1.9322	1.9190	1.8745	1.8917	1.9025	1.9350	1.9482	2.0000	2.0000
2 1/4	8	2.2466	2.2244	2.1654	2.1509	2.0932	2.1147	2.1282	2.1688	2.1833	2.2500	2.2500
2 1/2	8	2.4966	2.4744	2.4154	2.4009	2.3432	2.3647	2.3782	2.4188	2.4333	2.5000	2.5000
2 3/4	8	2.7466	2.7244	2.6654	2.6509	2.5932	2.6147	2.6282	2.6688	2.6833	2.7500	2.7500
3	8	2.9966	2.9744	2.9154	2.9009	2.8432	2.8647	2.8782	2.9188	2.9333	3.0000	3.0000

[1][2] See footnotes on p. 49.

TABLE 12.—*Class 2, free 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	0.0502	0.0447	0.0465	0.0492	0.0519	0.0536	0.0600	0.060
1	72	.0730	.0694	.0640	.0622	.0560	.0580	.0610	.0640	.0658	.0730	.073
2	64	.0860	.0822	.0759	.0740	.0668	.0691	.0724	.0759	.0778	.0860	.086
3	56	.0990	.0950	.0874	.0854	.0771	.0797	.0834	.0874	.0894	.0990	.099
4	48	.1120	.1076	.0985	.0963	.0864	.0894	.0937	.0985	.1007	.1120	.112
5	44	.1250	.1204	.1102	.1079	.0971	.1004	.1049	.1102	.1125	.1250	.125
6	40	.1380	.1332	.1218	.1194	.1073	.1109	.1158	.1218	.1242	.1380	.138
8	36	.1640	.1590	.1460	.1435	.1299	.1339	.1391	.1460	.1485	.1640	.164
10	32	.1900	.1846	.1697	.1670	.1517	.1562	.1618	.1697	.1724	.1900	.190
12	28	.2160	.2098	.1928	.1897	.1722	.1773	.1833	.1928	.1959	.2160	.216
¼	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
⅜	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
½	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
⅝	18	.6250	.6168	.5889	.5848	.5568	.5649	.5725	.5889	.5930	.6250	.6250
¾	16	.7500	.7410	.7094	.7049	.6733	.6823	.6903	.7094	.7139	.7500	.7500
⅞	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
1⅛	12	1.1250	1.1138	1.0709	1.0653	1.0228	1.0348	1.0438	1.0709	1.0765	1.1250	1.1250
1¼	12	1.2500	1.2388	1.1959	1.1903	1.1478	1.1598	1.1688	1.1959	1.2015	1.2500	1.2500
1½	12	1.5000	1.4888	1.4459	1.4403	1.3978	1.4098	1.4188	1.4459	1.4515	1.5000	1.5000
1¾	10	1.7500	1.7372	1.6850	1.6750	1.6273	1.6417	1.6525	1.6850	1.6950	1.7500	1.7500
2	10	2.0000	1.9872	1.9350	1.9250	1.8773	1.8917	1.9025	1.9350	1.9450	2.0000	2.0000
2¼	8	2.2500	2.2348	2.1688	2.1578	2.0966	2.1147	2.1282	2.1688	2.1798	2.2500	2.2500
2½	8	2.5000	2.4848	2.4188	2.4078	2.3466	2.3647	2.3782	2.4188	2.4298	2.5000	2.5000
2¾	8	2.7500	2.7348	2.6688	2.6578	2.5966	2.6147	2.6282	2.6688	2.6798	2.7500	2.7500
3	8	3.0000	2.9848	2.9188	2.9078	2.8466	2.8647	2.8782	2.9188	2.9298	3.0000	3.0000

[1] [2] See footnotes on p. 49.

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	0.060
1	72	.0730	.0694	.0640	.0627	.0560	.0580	.0610	.0640	.0653	.0730	.073
2	64	.0860	.0822	.0759	.0745	.0668	.0691	.0724	.0759	.0773	.0860	.086
3	56	.0990	.0950	.0874	.0859	.0771	.0797	.0834	.0874	.0889	.0990	.099
4	48	.1120	.1076	.0985	.0969	.0864	.0894	.0937	.0985	.1001	.1120	.112
5	44	.1250	.1204	.1102	.1086	.0971	.1004	.1049	.1102	.1118	.1250	.125
6	40	.1380	.1332	.1218	.1201	.1073	.1109	.1158	.1218	.1235	.1380	.138
8	36	.1640	.1590	.1460	.1442	.1299	.1339	.1391	.1460	.1478	.1640	.164
10	32	.1900	.1846	.1697	.1678	.1517	.1562	.1618	.1697	.1716	.1900	.190
12	28	.2160	.2098	.1928	.1906	.1722	.1773	.1833	.1928	.1950	.2160	.216
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 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 3/4	10	1.7500	1.7372	1.6850	1.6766	1.6273	1.6417	1.6525	1.6850	1.6934	1.7500	1.7500
2	10	2.0000	1.9872	1.9350	1.9266	1.8773	1.8917	1.9025	1.9350	1.9434	2.0000	2.0000
2 1/4	8	2.2500	2.2348	2.1688	2.1596	2.0966	2.1147	2.1282	2.1688	2.1780	2.2500	2.2500
2 1/2	8	2.5000	2.4848	2.4188	2.4096	2.3466	2.3647	2.3782	2.4188	2.4280	2.5000	2.5000
2 3/4	8	2.7500	2.7348	2.6688	2.6596	2.5966	2.6147	2.6282	2.6688	2.6780	2.7500	2.7500
3	8	3.0000	2.9848	2.9188	2.9096	2.8466	2.8647	2.8782	2.9188	2.9280	3.0000	3.0000

[1,2] See footnotes on p. 49.

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*
0	80	0.0600	0.0566	0.0520	0.0514	0.0447	0.0465	0.0492	0.0519	0.0525	0.0600	0.060
1	72	.0730	.0694	.0641	.0634	.0560	.0580	.0610	.0640	.0647	.0730	.073
2	64	.0860	.0822	.0760	.0753	.0668	.0691	.0724	.0759	.0766	.0860	.086
3	56	.0990	.0950	.0876	.0869	.0771	.0797	.0834	.0874	.0881	.0990	.099
4	48	.1120	.1076	.0987	.0979	.0864	.0894	.0937	.0985	.0993	.1120	.112
5	44	.1250	.1204	.1104	.1096	.0971	.1004	.1049	.1102	.1110	.1250	.125
6	40	.1380	.1332	.1220	.1211	.1073	.1109	.1158	.1218	.1227	.1380	.138
8	36	.1640	.1590	.1462	.1453	.1299	.1339	.1391	.1460	.1469	.1640	.164
10	32	.1900	.1846	.1699	.1689	.1517	.1562	.1618	.1697	.1707	.1900	.190
12	28	.2160	.2098	.1930	.1919	.1722	.1773	.1833	.1928	.1939	.2160	.216
1/4	28	.2500	.2438	.2270	.2259	.2062	.2113	.2173	.2268	.2279	.2500	.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 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 3/4	10	1.7500	1.7372	1.6856	1.6814	1.6273	1.6417	1.6525	1.6850	1.6892	1.7500	1.7500
2	10	2.0000	1.9872	1.9356	1.9314	1.8773	1.8917	1.9025	1.9350	1.9392	2.0000	2.0000
2 1/4	8	2.2500	2.2348	2.1695	2.1649	2.0966	2.1147	2.1282	2.1688	2.1734	2.2500	2.2500
2 1/2	8	2.5000	2.4848	2.4195	2.4149	2.3466	2.3647	2.3782	2.4188	2.4234	2.5000	2.5000
2 3/4	8	2.7500	2.7348	2.6695	2.6649	2.5966	2.6147	2.6282	2.6688	2.6734	2.7500	2.7500
3	8	3.0000	2.9848	2.9195	2.9149	2.8466	2.8647	2.8782	2.9188	2.9234	3.0000	3.0000

[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 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
		Threads per inch													
		64	56	48	40	40	32	32	24	24	20	18	16	14	13
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15
BOLTS AND SCREWS		*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
	Min	.0671	.0796	.0919	.1042	.1172	.1293	.1553	.1795	.2055	.2383	.2995	.3606	.4214	.4830
	Tol	.0052	.0056	.0062	.0068	.0068	.0076	.0076	.0092	.0092	.0102	.0114	.0126	.0140	.0148
Classes 2, 3, and 4, major diameter	Max	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375	.5000
	Min	.0692	.0820	.0946	.1072	.1202	.1326	.1586	.1834	.2094	.2428	.3043	.3660	.4277	.4896
	Tol	.0038	.0040	.0044	.0048	.0048	.0054	.0054	.0066	.0066	.0072	.0082	.0090	.0098	.0104
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
	Min	.0678	.0804	.0928	.1052	.1182	.1304	.1564	.1808	.2068	.2398	.3011	.3624	.4235	.4852
	Tol	.0052	.0056	.0062	.0068	.0068	.0076	.0076	.0092	.0092	.0102	.0114	.0126	.0140	.0148
Class 1, minor diameter	Max.[1]	.0531	.0633	.0725	.0803	.0933	.0986	.1246	.1376	.1636	.1872	.2427	.2965	.3478	.4034
Classes 2, 3, and 4, minor diameter	Max.[1]	.0538	.0641	.0734	.0813	.0943	.0997	.1257	.1389	.1649	.1887	.2443	.2983	.3499	.4056
Class 1, loose fit, pitch diameter	Max	.0622	.0736	.0846	.0948	.1078	.1166	.1426	.1616	.1876	.2160	.2748	.3326	.3890	.4478
	Min	.0596	.0708	.0815	.0914	.1044	.1128	.1388	.1570	.1830	.2109	.2691	.3263	.3820	.4404
	Tol	.0026	.0028	.0031	.0034	.0034	.0038	.0038	.0046	.0046	.0051	.0057	.0063	.0070	.0074
Class 2, free fit, pitch diameter	Max	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500
	Min	.0610	.0724	0833	.0934	.1064	.1150	.1410	.1596	.1856	.2139	.2723	.3299	.3862	.4448
	Tol	.0019	.0020	.0022	.0024	.0024	.0027	0027	.0033	.0033	.0036	.0041	.0045	.0049	.0052
Class 3, medium fit, pitch diameter	Max	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500
	Min	.0615	.0729	.0839	.0941	.1071	.1158	.1418	.1605	.1865	.2149	.2734	.3312	.3875	.4463
	Tol	.0014	.0015	.0016	.0017	.0017	.0019	.0019	.0024	.0024	.0026	.0030	.0032	.0036	.0037
Class 4, close fit, pitch diameter	Max	.0630	.0746	.0857	.0960	.1090	.1179	.1439	.1632	.1892	.2178	.2767	.3348	.3915	.4504
	Min	.0623	.0739	.0849	.0951	.1081	.1169	.1429	.1620	.1880	.2165	.2752	.3332	.3897	.4485
	Tol	.0007	.0007	.0008	.0009	.0009	.0010	.0010	.0012	.0012	.0013	.0015	.0016	.0018	.0019

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Classes 1, 2, 3, and 4, major diameter	Min.[2]	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375	.5000
Classes 1, 2, 3, and 4, minor diameter	Max	.0604	.0715	.0820	.0913	.1043	.1118	.1378	.1541	.1801	.2060	.2630	.3184	.3721	.4290
	Min	.0561	.0667	.0764	.0849	.0979	.1042	.1302	.1449	.1709	.1959	.2524	.3073	.3602	.4167
	Tol	.0043	.0048	.0056	.0064	.0064	.0076	.0076	.0092	.0092	.0101	.0106	.0111	.0119	.0123
Classes 1, 2, 3, and 4, pitch diameter	Min	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500
Class 1, loose fit, pitch diameter	Max	.0655	.0772	.0886	.0992	.1122	.1215	.1475	.1675	.1935	.2226	.2821	.3407	.3981	.4574
	Tol	.0026	.0028	.0031	.0034	.0034	.0038	.0038	.0046	.0046	.0051	.0057	.0063	.0070	.0074
Class 2, free fit, pitch diameter	Max	.0648	.0764	.0877	.0982	.1112	.1204	.1464	.1662	.1922	.2211	.2805	.3389	.3960	.4552
	Tol	.0019	.0020	.0022	.0024	.0024	.0027	.0027	.0033	.0033	.0036	.0041	.0045	.0049	.0052
Class 3, medium fit, pitch diameter	Max	.0643	.0759	.0871	.0975	.1105	.1196	.1456	.1653	.1913	.2201	.2794	.3376	.3947	.4537
	Tol	.0014	.0015	.0016	.0017	.0017	.0019	.0019	.0024	.0024	.0026	.0030	.0032	.0036	.0037
Class 4, close fit, pitch diameter	Max	.0636	.0751	.0863	.0967	.1097	.1187	.1447	.1641	.1901	.2188	.2779	.3360	.3929	.4519
	Tol	.0007	.0007	.0008	.0009	.0009	.0010	.0010	.0012	.0012	.0013	.0015	.0016	.0018	.0019

[1] See footnote on p. 59.

[2] See footnote on p. 59.

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

		Sizes														
		9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3
		Threads per inch														
		12	11	10	9	8	7	7	6	5	4 1/2	4 1/2	4	4	4	3 1/2
1		**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
BOLTS AND SCREWS		*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Class 1, major diameter	Max	0.5601	0.6224	0.7472	0.8719	0.9966	1.1211	1.2461	1.4956	1.7448	1.9943	2.2443	2.4936	2.7436	2.9936	2.9927
	Min	.5443	.6054	.7288	.8519	.9744	1.0963	1.2213	1.4666	1.7110	1.9575	2.2075	2.4528	2.7028	2.9528	2.9469
	Tol	.0158	.0170	.0184	.0200	.0222	.0248	.0248	.0290	.0338	.0368	.0368	.0408	.0408	.0408	.0458
Classes 2, 3, and 4, major diameter	Max	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000	3.0000
	Min	.5513	.6132	.7372	.8610	.9848	1.1080	1.2330	1.4798	1.7268	1.9746	2.2246	2.4720	2.7220	2.9720	2.9686
	Tol	.0112	.0118	.0128	.0140	.0152	.0170	.0170	.0202	.0232	.0254	.0254	.0280	.0280	.0280	.0314
Class 2, major diameter (threaded parts of unfinished, hot-rolled material	Max	.5625	.6250	.7500	.8750	1.0000	1.2500	1.2500	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000	3.0000
	Min	.5467	.6080	.7316	.8550	.9778	1.1002	1.2252	1.4710	1.7162	1.9632	2.2132	2.4592	2.7092	2.9592	2.9542
	Tol	.0158	.0170	.0184	.0200	.0222	.0248	.0248	.0290	.0338	.0368	.0368	.0408	.0408	.0408	.0458
Class 1, minor diameter	Max.[1]	.4579	.5109	.6245	.7356	.8432	.9458	1.0708	1.2911	1.4994	1.7217	1.9717	2.1869	2.4369	2.6869	2.6421
Classes 2, 3, and 4, minor diameter	Max.[1]	.4603	.5135	.6273	.7387	.8466	.9497	1.0747	1.2955	1.5046	1.7274	1.9774	2.1933	2.4433	2.6933	2.6494
Class 1, loose fit, pitch diameter	Max	.5060	.5634	.6822	.7997	.9154	1.0283	1.1533	1.3873	1.6149	1.8500	2.1000	2.3312	2.5812	2.8312	2.8071
	Min	.4981	.5549	.6730	.7897	.9043	1.0159	1.1409	1.3728	1.5980	1.8316	2.0816	2.3108	2.5608	2.8108	2.7842
	Tol	.0079	.0085	.0092	.0100	.0111	.0124	.0124	.0145	.0169	.0184	.0184	.0204	.0204	.0204	.0229
Class 2, free fit, pitch diameter	Max	.5084	.5660	.6850	.8028	.9188	1.0322	1.1572	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	2.8144
	Min	.5028	.5601	.6786	.7958	.9112	1.0237	1.1487	1.3816	1.6085	1.8430	2.0930	2.3236	2.5736	2.8236	2.7987
	Tol	.0056	.0059	.0064	.0070	.0076	.0085	.0085	.0101	.0116	.0127	.0127	.0140	.0140	.0140	.0157
Class 3, medium fit, pitch diameter	Max	.5084	.5660	.6850	.8028	.9188	1.0322	1.1572	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	2.8144
	Min	.5044	.5618	.6805	.7979	.9134	1.0263	1.1513	1.3846	1.6119	1.8468	2.0968	2.3279	2.5779	2.8279	2.8037
	Tol	.0040	.0042	.0045	.0049	.0054	.0059	.0059	.0071	.0082	.0089	.0089	.0097	.0097	.0097	.0107
Class 4, close fit, pitch diameter	Max	.5089	.5665	.6856	.8034	.9195	1.0330	1.1580	1.3926	1.6211	1.8568	2.1068	2.3389	2.5889	2.8389	2.8160
	Min	.5069	.5644	.6833	.8010	.9168	1.0300	1.1550	1.3890	1.6170	1.8524	2.1024	2.3341	2.5841	2.8341	2.8107
	Tol	.0020	.0021	.0023	.0024	.0027	.0030	.0030	.0036	.0041	.0044	.0044	.0048	.0048	.0048	.0053

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Classes 1, 2, 3, and 4, major diameter	Min.[1]	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000	3.0000
Classes 1, 2, 3, and 4, minor diameter	Max	.4850	.5397	.6553	.7689	.8795	.9858	1.1108	1.3376	1.5551	1.7835	2.0335	2.2564	2.5064	2.7564	2.7216
	Min	.4723	.5266	.6417	.7547	.8647	.9704	1.0954	1.3196	1.5335	1.7594	2.0094	2.2294	2.4794	2.7294	2.6907
	Tol	.0127	.0131	.0136	.0142	.0148	.0154	.0154	.0180	.0216	.0241	.0241	.0270	.0270	.0270	.0309
Classes 1, 2, 3, and 4, pitch diameter	Min	.5084	.5660	.6850	.8028	.9188	1.0322	1.1572	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	2.8144
Class 1, loose fit, pitch diameter	Max	.5163	.5745	.6942	.8128	.9299	1.0446	1.1696	1.4062	1.6370	1.8741	2.1241	2.3580	2.6080	2.8580	2.8373
	Tol	.0079	.0085	.0092	.0100	.0111	.0124	.0124	.0145	.0169	.0184	.0184	.0204	.0204	.0204	.0229
Class 2, free fit, pitch diameter	Max	.5140	.5719	.6914	.8098	.9264	1.0407	1.1657	1.4018	1.6317	1.8684	2.1184	2.3516	2.6016	2.8516	2.8301
	Tol	.0056	.0059	.0064	.0070	.0076	.0085	.0085	.0101	.0116	.0127	.0127	.0140	.0140	.0140	.0157
Class 3, medium fit, pitch diameter	Max	.5124	.5702	.6895	.8077	.9242	1.0381	1.1631	1.3988	1.6283	1.8646	2.1146	2.3473	2.5973	2.8473	2.8251
	Tol	.0040	.0042	.0045	.0049	.0054	.0059	.0059	.0071	.0082	.0089	.0089	.0097	.0097	.0097	.0107
Class 4, close fit, pitch diameter	Max	.5104	.5681	.6873	.8052	.9215	1.0352	1.1602	1.3953	1.6242	1.8601	2.1101	2.3424	2.5924	2.8424	2.8197
	Tol	.0020	.0021	.0023	.0024	.0027	.0030	.0030	.0036	.0041	.0044	.0044	.0048	.0048	.0048	.0053

[1] See footnote on p. 59.

[1] See footnote on p. 59.

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	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
1		2	3	4	5	6	7	8	9	10	11	12	13
BOLTS AND SCREWS		*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
	Min	.0545	.0673	.0801	.0926	.1049	.1177	.1302	.1557	.1813	.2062	.2402	.3020
	Tol	.0048	.0050	.0052	.0056	.0062	.0064	.0068	.0072	.0076	.0086	.0086	.0092
Classes 2, 3, and 4, major diameter	Max	.0600	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125
	Min	.0566	.0694	.0822	.0950	.1076	.1204	.1332	.1590	.1846	.2098	.2438	.3059
	Tol	.0034	.0036	.0038	.0040	.0044	.0046	.0048	.0050	.0054	.0062	.0062	.0066
Class 1, minor diameter	Max [1]	.0440	.0553	.0661	.0763	.0855	.0962	.1063	.1288	.1506	.1710	.2050	.2601
Classes 2, 3, and 4, minor diameter	Max [1]	.0447	.0560	.0668	.0771	.0864	.0971	.1073	.1299	.1517	.1722	.2062	.2614
Class 1, pitch diameter	Max	.0512	.0633	.0752	.0866	.0976	.1093	.1208	.1449	.1686	.1916	.2256	.2841
	Min	.0488	.0608	.0726	.0838	.0945	.1061	.1174	.1413	.1648	.1873	.2213	.2795
	Tol	.0024	.0025	.0026	.0028	.0031	.0032	.0034	.0036	.0038	.0043	.0043	.0046
Class 2, pitch diameter	Max	.0519	.0640	.0759	.0874	.0985	.1102	.1218	.1460	.1697	.1928	.2268	.2854
	Min	.0502	.0622	.0740	.0854	.0963	.1079	.1194	.1435	.1670	.1897	.2237	.2821
	Tol	.0017	.0018	.0019	.0020	.0022	.0023	.0024	.0025	.0027	.0031	.0031	.0033
Class 3, pitch diameter	Max	.0519	.0640	.0759	.0874	.0985	.1102	.1218	.1460	.1697	.1928	.2268	.2854
	Min	.0506	.0627	.0745	.0859	.0969	.1086	.1201	.1442	.1678	.1906	.2246	.2830
	Tol	.0013	.0013	.0014	.0015	.0016	.0016	.0017	.0018	.0019	.0022	.0022	.0024
Class 4, pitch diameter	Max	.0520	.0641	.0760	.0876	.0987	.1104	.1220	.1462	.1699	.1930	.2270	.2857
	Min	.0514	.0634	.0753	.0869	.0979	.1096	.1211	.1453	.1689	.1919	.2259	.2845
	Tol	.0006	.0007	.0007	.0007	.0008	.0008	.0009	.0009	.0010	.0011	.0011	.0012

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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
Classes 1. 2. 3, and 4, minor diameter	Max	.0492	.0610	.0724	.0834	.0937	.1049	.1158	.1391	.1618	.1833	.2173	.2739
	Min	.0465	.0580	.0691	.0797	.0894	.1004	.1109	.1339	.1562	.1773	.2113	.2674
	Tol	.0027	.0030	.0033	.0037	.0043	.0045	.0049	.0052	.0056	.0060	.0060	.0065
Classes 1, 2, 3, and 4, pitch diameter	Min	.0519	.0640	.0759	.0874	.0985	.1102	.1218	.1460	.1697	.1928	.2268	.2854
Class 1, pitch diameter	Max	.0543	.0665	.0785	.0902	.1016	.1134	.1252	.1496	.1735	.1971	.2311	.2900
	Tol	.0024	.0025	.0026	.0028	.0031	.0032	.0034	.0036	.0038	.0043	.0043	.0046
Class 2, pitch diameter	Max	.0536	.0658	.0778	.0894	.1007	.1125	.1242	.1485	.1724	.1959	.2299	.2887
	Tol	.0017	.0018	.0019	.0020	.0022	.0023	.0024	.0025	.0027	.0031	.0031	.0033
Class 3, pitch diameter	Max	.0532	.0653	.0773	.0889	.1001	.1118	.1235	.1478	.1716	.1950	.2290	.2878
	Tol	.0013	.0013	.0014	.0015	.0016	.0016	.0017	.0018	.0019	.0022	.0022	.0024
Class 4, pitch diameter	Max	.0525	.0647	.0766	.0881	.0993	.1110	.1227	.1469	.1707	.1939	.2279	.2866
	Tol	.0006	.0007	.0007	.0007	.0008	.0008	.0009	.0009	.0010	.0011	.0011	.0012

[1] See footnote on p. 59.

[2] See footnote on p. 59.

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

		Sizes										
		3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2
		Threads per inch										
		24	20	20	18	18	16	14	14	12	12	12
1		**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
BOLTS AND SCREWS		*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*
Class 1, major diameter	Max	0.3737	0.4360	0.4985	0.5609	0.6234	0.7482	0.8729	0.9979	1.1226	1.2476	1.4976
	Min	.3645	.4258	.4883	.5495	.6120	.7356	.8589	.9839	1.1068	1.2318	1.4818
	Tol	.0092	.0102	.0102	.0114	.0114	.0126	.0140	.0140	.0158	.0158	.0158
Classes 2, 3, and 4, major diameter	Max	.3750	.4375	.5000	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.5000
	Min	.3684	.4303	.4928	.5543	.6168	.7410	.8652	.9902	1.1138	1.2388	1.4888
	Tol	.0066	.0072	.0072	.0082	.0082	.0090	.0098	.0098	.0112	.0112	.0112
Class 1, minor diameter	Max.[1]	.3226	.3747	.4372	.4927	.5552	.6715	.7853	.9103	1.0204	1.1454	1.3954
Classes 2, 3, and 4, minor diameter	Max.[1]	.3239	.3762	.4387	.4943	.5568	.6733	.7874	.9124	1.0228	1.1478	1.3978
Class 1, pitch diameter	Max	.3466	.4035	.4660	.5248	.5873	.7076	.8265	.9515	1.0685	1.1935	1.4435
	Min	.3420	.3984	.4609	.5191	.5816	.7013	.8195	.9445	1.0606	1.1856	1.4356
	Tol	.0046	.0051	.0051	.0057	.0057	.0063	.0070	.0070	.0079	.0079	.0079
Class 2, pitch diameter	Max	.3479	.4050	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.4459
	Min	.3446	.4014	.4639	.5223	.5848	.7049	.8237	.9487	1.0653	1.1903	1.4403
	Tol	.0033	.0036	.0036	.0041	.0041	.0045	.0049	.0049	.0056	.0056	.0056
Class 3, pitch diameter	Max	.3479	.4050	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.4459
	Min	.3455	.4024	.4649	.5234	.5859	.7062	.8250	.9500	1.0669	1.1919	1.4419
	Tol	.0024	.0026	.0026	.0030	.0030	.0032	.0036	.0036	.0040	.0040	.0040
Class 4, pitch diameter	Max	.3482	.4053	.4678	.5267	.5892	.7098	.8290	.9540	1.0714	1.1964	1.4464
	Min	.3470	.4040	.4665	.5252	.5877	.7082	.8272	.9522	1.0694	1.1944	1.4444
	Tol	.0012	.0013	.0013	.0015	.0015	.0016	.0018	.0018	.0020	.0020	.0020

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Classes 1, 2, 3, and 4, major diameter	Min.[2]	.3750	.4375	.5000	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.5000
Classes 1, 2, 3, and 4, minor diameter	Max.	.3364	.3906	.4531	.5100	.5725	.6903	.8062	.9312	1.0438	1.1688	1.4188
	Min.	.3299	.3834	.4459	.5024	.5649	.6823	.7977	.9227	1.0348	1.1598	1.4098
	Tol.	.0065	.0072	.0072	.0076	.0076	.0080	.0085	.0085	.0090	.0090	.0090
Classes 1, 2, 3, and 4, pitch diameter	Min.	.3479	.4050	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.4459
Class 1, pitch diameter	Max.	.3525	.4101	.4726	.5321	.5946	.7157	.8356	.9606	1.0788	1.2038	1.4538
	Tol.	.0046	.0051	.0051	.0057	.0057	.0063	.0070	.0070	.0079	.0079	.0079
Class 2, pitch diameter	Max.	.3512	.4086	.4711	.5305	.5930	.7139	.8335	.9585	1.0765	1.2015	1.4515
	Tol.	.0033	.0036	.0036	.0041	.0041	.0045	.0049	.0049	.0056	.0056	.0056
Class 3, pitch diameter	Max.	.3503	.4076	.4701	.5294	.5919	.7126	.8322	.9572	1.0749	1.1999	1.4499
	Tol.	.0024	.0026	.0026	.0030	.0030	.0032	.0036	.0036	.0040	.0040	.0040
Class 4, pitch diameter	Max.	.3491	.4063	.4688	.5279	.5904	.7110	.8304	.9554	1.0729	1.1979	1.4479
	Tol.	.0012	.0013	.0013	.0015	.0015	.0016	.0018	.0018	.0020	.0020	.0020

[1] See footnote on p. 59.

[2] See footnote on p. 59.

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

		Sizes					
		1¾	2	2¼	2½	2¾	3
		Threads per inch					
		10	10	8	8	8	8
1		25	26	27	28	29	30
BOLTS AND SCREWS		*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Class 1, major diameter	Max.	1.7472	1.9972	2.2466	2.4966	2.7466	2.9966
	Min.	1.7288	1.9788	2.2244	2.4744	2.7244	2.9744
	Tol.	.0184	.0184	.0222	.0222	.0222	.0222
Classes 2, 3, and 4, major diameter	Max.	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000
	Min.	1.7372	1.9872	2.2348	2.4848	2.7348	2.9848
	Tol.	.0128	.0128	.0152	.0152	.0152	.0152
Class 1, minor diameter	Max.[1]	1.6245	1.8745	2.0932	2.3432	2.5932	2.8432
Classes 2, 3, and 4, minor diameter	Max.[1]	1.6273	1.8773	2.0966	2.3466	2.5966	2.8466
Class 1, pitch diameter	Max.	1.6822	1.9322	2.1654	2.4154	2.6654	2.9154
	Min.	1.6690	1.9190	2.1509	2.4009	2.6509	2.9009
	Tol.	.0132	.0132	.0145	.0145	.0145	.0145
Class 2, pitch diameter	Max.	1.6850	1.9350	2.1688	2.4188	2.6688	2.9188
	Min.	1.6750	1.9250	2.1578	2.4078	2.6578	2.9078
	Tol.	.0100	.0100	.0110	.0110	.0110	.0110
Class 3, pitch diameter	Max.	1.6850	1.9350	2.1688	2.4188	2.6688	2.9188
	Min.	1.6766	1.9266	2.1596	2.4096	2.6596	2.9096
	Tol.	.0084	.0084	.0092	.0092	.0092	.0092
Class 4, pitch diameter	Max.	1.6856	1.9356	2.1695	2.4195	2.6695	2.9195
	Min.	1.6814	1.9314	2.1649	2.4149	2.6649	2.9149
	Tol.	.0042	.0042	.0046	.0046	.0046	.0046

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Classes 1, 2, 3, and 4, major diameter	Min.[2]	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000
Classes 1, 2, 3, and 4, minor diameter	Max.	1.6525	1.9025	2.1282	2.3782	2.6282	2.8782
	Min.	1.6417	1.8917	2.1147	2.3647	2.6147	2.8647
	Tol.	.0108	.0108	.0135	.0135	.0135	.0135
Classes 1, 2, 3, and 4, pitch diameter	Min.	1.6850	1.9350	2.1688	2.4188	2.6688	2.9188
Class 1, pitch diameter	Max.	1.6982	1.9482	2.1833	2.4333	2.6833	2.9333
	Tol.	.0132	.0132	.0145	.0145	.0145	.0145
Class 2, pitch diameter	Max.	1.6950	1.9450	2.1798	2.4298	2.6798	2.9298
	Tol.	.0100	.0100	.0110	.0110	.0110	.0110
Class 3, pitch diameter	Max.	1.6934	1.9434	2.1780	2.4280	2.6780	2.9280
	Tol.	.0084	.0084	.0092	.0092	.0092	.0092
Class 4, pitch diameter	Max.	1.6892	1.9392	2.1734	2.4234	2.6734	2.9234
	Tol.	.0042	.0042	.0046	.0046	.0046	.0046

[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.

5. GAGES

The art of measuring screw threads has developed very rapidly during the past few years. 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.

3. Gage Classification.—The limiting dimensions of the threaded parts to be produced must 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.*[8]—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.

(*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 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*

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[8] Recommendations as to the design and construction of mechanical gages are given in Appendix 7.

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 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. Thread Form of Thread Plug and Ring Gages.—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 minor diameter of the "not go" ring gage is the minimum minor diameter of the nut plus at least 0.0002 inch, with a plus gage tolerance. Also the maximum major diameter of the "not go" thread plug gage is at least 0.0002 inch less than the basic major diameter, with a minus gage tolerance. (See fig. 18.)

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.

8. 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.

9. 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 8 ounces is recommended for pitches finer than 20 threads per inch, and of not more than 3 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:

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[9] Methods of measuring pitch diameter of screw thread gages are described in Appendix 2 p. 184.

1. Classification of Gages, and Gage Tolerances.—Screw-thread gages are classified according to accuracy into classes X, Y, and Z, the class X being the most accurate. 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 4, close 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 all classes of fits. They may also be necessary for working gages for the class 4 fit. The tolerances on these 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.

(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) *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.

(*f*) *Tolerances on lead.*—The tolerances on lead given in Tables 18 to 20, 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.

(*g*) *Tolerances on angle of thread.*—The tolerances on angle of thread, as specified in Tables 18 to 20, 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. 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 21 may be used. This table contains recommended tolerances for classes X, Y, and Z gages, which have been tentatively adopted by the A. S. A. Sectional Committee on the Standardization of Plain Limit Gages for General Engineering Work.

3. Recommended Gage Practice.—There are given in Table 17 the recommended uses for the foregoing classes of gages. Tables 22, 23, 24, and 25 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 X, Y, and Z gages*

Class of fit	Setting gage	Inspection gage	Working gage
1	2	3	4
Class 1, loose fit	Class X	Class Y	Class Z.
Class 2, free fit	do	do	Class Y.
Class 3, medium fit	do	Class X	Do.
Class 4, close fit	do	do	Class X.

TABLE 18.—*Tolerances for class X "go" thread gages and all "not 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	0.0000	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
3½	.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 2 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 2, "Symbols."

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

A 1-inch, 14-pitch gage of the American National fine thread series, class 3, medium fit, shall be marked 1″—14—NF—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
3½	.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
3½	.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.

TABLE 21.—*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 22.—*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
			Threads per inch													
			64	56	48	40	40	32	32	24	24	20	18	16	14	13
1			**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
"GO" GAGES FOR SCREWS			*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
		Min	.0719	.0848	.0977	.1106	.1236	.1365	.1625	.1882	.2142	.2480	.3104	.3726	.4348	.4972
	Classes 2, 3, and 4	Max	.0730	.0860	.0990	.1120	.1250	.1380	.1640	.1900	.2160	.2500	.3125	.3750	.4375	.5000
		Min	.0726	.0856	.0986	.1116	.1246	.1376	.1636	.1895	.2155	.2495	.3120	.3744	.4369	.4994
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
		Min., class X	.0620	.0734	.0844	.0946	.1076	.1163	.1423	.1613	.1873	.2157	.2745	.3323	.3887	.4475
		Max., class Y	.0621	.0735	.0845	.0947	.1077	.1165	.1425	.1614	.1874	.2158	.2746	.3324	.3888	.4476
		Min., class Y	.0618	.0732	.0842	.0944	.1074	.1162	.1422	.1611	.1871	.2155	.2743	.3320	.3884	.4472
		Max., class Z	.0620	.0734	.0844	.0946	.1076	.1163	.1423	.1613	1873	.2157	.2744	.3322	.3886	.4474
		Min., class Z	.0616	.0729	.0839	.0941	.1071	.1158	.1418	.1607	.1867	.2151	.2738	.3316	.3880	.4467
	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
		Min., class X	.0627	.0742	.0853	.0956	.1086	.1174	.1434	.1626	.1886	.2172	.2761	.3341	.3908	.4497
		Max., class Y	.0628	.0743	.0854	.0957	.1087	.1176	.1436	.1627	.1887	.2173	.3762	.3342	.3909	.4498
		Min., class Y	.0625	.0740	.0851	.0954	.1084	.1173	.1433	.1624	.1884	.2170	.2759	.3338	.3905	.4494
	Class 4, close fit	Max., class X	.0630	.0746	.0857	.0960	.1090	.1179	.1439	.1632	.1892	.2178	.2767	.3348	.3915	.4504
		Min., class X	.0628	.0744	.0855	.0958	.1088	.1176	.1436	.1629	.1889	.2175	.2764	.3345	.3912	.4501
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
		Min	.0557	.0663	.0760	.0845	.0975	.1038	.1298	.1444	.1704	.1954	.2519	.3067	.3596	.4161
"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
		Max	.0675	.0800	.0923	.1046	.1176	.1297	.1557	.1800	.2060	.2388	.3000	.3612	.4220	.4836
	Classes 2, 3, and 4	Min	.0692	.0820	.0946	.1072	.1202	.1326	.1586	.1834	.2094	.2428	.3043	.3660	.4277	.4896
		Max	.0696	.0824	.0950	.1076	.1206	.1330	.1590	.1839	.2099	.2433	.3048	.3666	.4283	.4902
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
		Max	.0598	.0710	.0817	.0916	.1046	.1131	.1391	.1573	.1833	.2112	.2694	.3266	.3823	.4407
	Class 2, free fit	Min	.0610	.0724	.0833	.0934	.1064	.1150	.1410	.1596	.1856	.2139	.2723	.3299	.3862	.4448
		Max	.0612	.0726	.0835	.0936	.1066	.1153	.1413	.1599	.1859	.2142	.2726	.3302	.3865	.4451
	Class 3, medium fit.	Min	.0615	.0729	.0839	.0941	.1071	.1158	.1418	.1605	.1865	.2149	.2734	.3312	.3875	.4463
		Max	.0617	.0731	.0841	.0943	.1073	.1161	.1421	.1608	.1868	.2152	.2737	.3315	.3878	.4466
	Class 4, close fit	Min	.0623	.0739	.0849	.0951	.1081	.1169	.1429	.1620	.1880	.2165	.2752	.3332	.3897	.4485
		Max	.0625	.0741	.0851	.0953	.1083	.1172	.1432	.1623	.1883	.2168	.2755	.3335	.3900	.4488
Minor diameter of ring gage.	Classes 1, 2, 3, and 4.	Min.[2]	.0563	.0669	.0766	.0851	.0981	.1044	.1304	.1451	.1711	.1961	.2526	.3075	.3604	.4169
		Max.[2]	.0567	.0673	.0770	.0855	.0985	.1048	.1308	.1456	.1716	.1966	.2531	.3081	.3610	.4175

[1] [2] See footnotes on p. 72.

			Sizes														
			9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3
			Threads per inch														
			12	11	10	9	8	7	7	6	5	4 1/2	4 1/2	4	4	4	3 1/2
1			16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
"Go" Gages for Screws			*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Major diameter of setting plug.	Class 1	Max	0.5601	0.6224	0.7472	0.8719	0.9966	1.1211	1.2461	1.4956	1.7448	1.9943	2.2443	2.4936	2.7436	2.9936	2.9927
		Min	.5595	.6218	.7466	.8712	.9959	1.1204	1.2454	1.4948	1.7440	1.9935	2.2435	2.4927	2.7427	2.9927	2.9918
	Classes 2, 3, and 4.	Max	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000	3.0000
		Min	.5619	.6244	.7494	.8743	.9993	1.1243	1.2493	1.4992	1.7492	1.9992	2.2492	2.4991	2.7491	2.9991	2.9991
Pitch diameter of setting plug or ring gage.	Class 1, loose fit.	Max., class X	.5060	.5634	.6822	.7997	.9154	1.0283	1.1533	1.3873	1.6149	1.8500	2.1000	2.3312	2.5812	2.8312	2.8071
		Min., class X	.5057	.5631	.6819	.7994	.9150	1.0279	1.1529	1.3869	1.6145	1.8496	2.0996	2.3308	2.5808	2.8308	2.8067
		Max., class Y	.5058	.5632	.6820	.7995	.9152	1.0281	1.1531	1.3870	1.6146	1.8497	2.0997	2.3309	2.5809	2.8309	2.8068
		Min., class Y	.5054	.5628	.6816	.7990	.9147	1.0276	1.1526	1.3865	1.6141	1.8492	2.0992	2.3303	2.5803	2.8303	2.8062
		Max., class Z	.5056	.5630	.6817	.7992	.9148	1.0277	1.1527	1.3867	1.6142	1.8493	2.0993	2.3305	2.5805	2.8305	2.8064
		Min., class Z	.5049	.5623	.6810	.7985	.9141	1.0270	1.1520	1.3859	1.6134	1.8485	2.0985	2.3296	2.5796	2.8296	2.8055
	Class 2, free fit, and class 3, medium fit.	Max., class X	.5084	.5660	.6850	.8028	.9188	1.0322	1.1572	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	2.8144
		Min., class X	.5081	.5657	.6847	.8025	.9184	1.0318	1.1568	1.3913	1.6197	1.8553	2.1053	2.3372	2.5872	2.8372	2.8140
		Max., class Y	.5082	.5658	.6848	.8026	.9186	1.0320	1.1570	1.3914	1.6198	1.8554	2.1054	2.3373	2.5873	2.8373	2.8141
		Min , class Y	.5078	.5654	.6844	.8021	.9181	1.0315	1.1565	1.3909	1.6193	1.8549	2.1049	2.3367	2.5867	2.8367	2.8135
	Class 4, close fit.	Max., class X	.5089	.5665	.6856	.8034	.9195	1.0330	1.1580	1.3926	1.6211	1.8568	2.1068	2.3389	2.5889	2.8389	2.8160
		Min., class X	.5086	.5662	.6853	.8031	.9191	1.0326	1.1576	1.3922	1.6207	1.8564	2.1064	2.3385	2.5885	2.8385	2.8156
Minor diameter of ring gage.	Classes 1, 2, 3, and 4.	Max [1]	.4723	.5266	.6417	.7547	.8647	.9704	1.0954	1.3196	1.5335	1.7594	2.0094	2.2294	2.4794	2.7294	2.6907
		Min	.4717	.5260	.6411	.7540	.8640	.9697	1.0947	1.3188	1.5327	1.7586	2.0086	2.2285	2.4785	2.7285	2.6898
"Not Go" Gages for Screws																	
Major diameter of setting plug.	Class 1	Min	.5443	.6054	.7288	.8519	.9744	1.0963	1.2213	1.4666	1.7110	1.9575	2.2075	2.4528	2.7028	2.9528	2.9469
		Max	.5449	.6060	.7294	.8526	.9751	1.0970	1.2220	1.4674	1.7118	1.9583	2.2083	2.4537	2.7037	2.9537	2.9478
	Classes 2, 3, and 4.	Min	.5513	.6132	.7372	.8610	.9848	1.1080	1.2330	1.4798	1.7268	1.9746	2.2246	2.4720	2.7220	2.9720	2.9686
		Max	.5519	.6138	.7378	.8617	.9855	1.1087	1.2337	1.4806	1.7276	1.9754	2.2254	2.4729	2.7229	2.9729	2.9695
Pitch diameter of setting plug or ring gage.	Class, 1, loose fit.	Min	.4981	.5549	.6730	.7897	.9043	1.0159	1.1409	1.3728	1.5980	1.8316	2.0816	2.3108	2.5608	2.8108	2.7842
		Max	.4984	.5552	.6733	.7900	.9047	1.0163	1.1413	1.3732	1.5984	1.8320	2.0820	2.3112	2.5612	2.8112	2.7846
	Class 2, free fit.	Min	.5028	.5601	.6786	.7958	.9112	1.0237	1.1487	1.3816	1.6085	1.8430	2.0930	2.3236	2.5736	2.8236	2.7987
		Max	.5031	.5604	.6789	.7961	.9116	1.0241	1.1491	1.3820	1.6089	1.8434	2.0934	2.3240	2.5740	2.8240	2.7991
	Class 3, medium fit.	Min	.5044	.5618	.6805	.7979	.9134	1.0263	1.1513	1.3846	1.6119	1.8468	2.0968	2.3279	2.5779	2.8279	2.8037
		Max	.5047	.5621	.6808	.7982	.9138	1.0267	1.1517	1.3850	1.6123	1.8472	2.0972	2.3283	2.5783	2.8283	2.8041
	Class 4, close fit.	Min	.5069	.5644	.6833	.8010	.9168	1.0300	1.1550	1.3890	1.6170	1.8524	2.1024	2.3341	2.5841	2.8341	2.8107
		Max	.5072	.5647	.6836	.8013	.9172	1.0304	1.1554	1.3894	1.6174	1.8528	2.1028	2.3345	2.5845	2.8345	2.8111
Minor diameter of ring gage.	Classes 1, 2, 3, and 4.	Min [2]	.4725	.5268	.6419	.7549	.8649	.9706	1.0956	1.3198	1.5337	1.7596	2.0096	2.2296	2.4796	2.7296	2.6909
		Max [2]	.4731	.5274	.6425	.7556	.8656	.9713	1.0963	1.3206	1.5345	1.7604	2.0104	2.2305	2.4805	2.7305	2.6918

[1] [2] See footnotes on p. 72.

TABLE 23.—*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
1			2	3	4	5	6	7	8	9	10	11	12	13
"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 X	.0520	.0641	.0760	.0876	.0987	.1104	.1220	.1462	.1699	.1930	.2270	.2857
		Min., class X	.0518	.0639	.0758	.0874	.0985	.1102	.1218	.1460	.1696	.1927	.2267	.2854
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
	Classes 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	.0514	.0634	.0753	.0869	.0979	.1096	.1211	.1453	.1689	.1919	.2259	.2845
		Max	.0516	.0636	.0755	.0871	.0981	.1098	.1213	.1455	.1692	.1922	.2262	.2848
Minor diameter of ring gage	Classes 1, 2, 3, and 4.	Min.[2]	.0467	.0582	.0693	.0799	.0896	.1006	.1111	.1341	.1564	.1775	.2115	.2676
		Max.[2]	.0470	.0585	.0697	.0803	.0900	.1010	.1115	.1345	.1568	.1780	.2120	.2681

[1] [2] See footnotes on p. 72.

1			3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2
		Threads per inch	24	20	20	18	18	16	14	14	12	12	12
			14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
"GO" GAGES FOR SCREWS			*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*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	1.4976
		Min	.3732	.4355	.4980	.5604	.6229	7476	.8723	.9973	1.1220	1.2470	1.4970
	Classes 2, 3, and 4	Max	.3750	.4375	.5000	.5625	.6250	.7500	.8750	1.0000	1.1250	1.2500	1.5000
		Min	.3745	.4370	.4995	.5620	.6245	.7494	.8744	.9994	1.1244	1.2494	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	1.4435
		Min., class X	.3463	.4032	.4657	.5245	.5870	.7073	.8262	.9512	1.0682	1.1932	1.4432
		Max., class Y	.3464	.4033	.4658	.5246	.5871	.7074	.8263	.9513	1.0683	1.1933	1.4433
		Min., class Y	.3461	.4030	.4655	.5243	.5868	.7070	.8259	.9509	1.0679	1.1929	1.4429
		Max., class Z	.3463	.4032	.4657	.5244	.5869	.7072	.8261	.9511	1.0681	1.1931	1.4431
		Min., class Z	.3457	.4026	.4651	.5238	.5863	.7066	.8255	.9505	1.0674	1.1924	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	1.4459
		Min., class X	.3476	.4047	.4672	.5261	.5886	.7091	.8283	.9533	1.0706	1.1956	1.4456
		Max., class Y	.3477	.4048	.4673	.5262	.5887	.7092	.8284	.9534	1.0707	1.1957	1.4457
		Min., class Y	.3474	.4045	.4670	.5259	.5884	.7088	.8280	.9530	1.0703	1.1953	1.4453
	Class 4, close fit	Max, class X	.3482	.4053	.4678	.5267	.5892	.7098	.8290	.9540	1.0714	1.1964	1.4464
		Min., class X	.3479	.4050	.4675	.5264	.5889	.7095	.8287	.9537	1.0711	1.1961	1.4461
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	1.4098
		Min	.3294	.3829	.4454	.5019	.5644	.6817	.7971	.9221	1.0342	1.1592	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	1.4818
		Max	.3650	.4263	.4888	.5500	.6125	.7362	.8595	.9845	1.1074	1.2324	1.4824
	Classes 2, 3, and 4	Min	.3684	.4303	.4928	.5543	.6168	.7410	.8652	.9902	1.1138	1.2388	1.4888
		Max	.3689	.4308	.4933	.5548	.6173	.7416	.8658	.9908	1.1144	1.2394	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	1.4356
		Max	.3423	.3987	.4612	.5194	.5819	.7016	.8198	.9448	1.0609	1.1859	1.4359
	Class 2, free fit	Min	.3446	.4014	.4639	.5223	.5848	.7049	.8237	.9487	1.0653	1.1903	1.4403
		Max	.3449	.4017	.4642	.5226	.5851	.7052	.8240	.9490	1.0656	1.1906	1.4406
	Class 3, medium fit.	Min	.3455	.4024	.4649	.5234	.5859	.7062	.8250	.9500	1.0669	1.1919	1.4419
		Max	.3458	.4027	.4652	.5237	.5862	.7065	.8253	.9503	1.0672	1.1922	1.4422
	Class 4, close fit	Min	.3470	.4040	.4665	.5252	.5877	.7082	.8272	.9522	1.0694	1.1944	1.4444
		Max	.3473	.4043	.4668	.5255	.5880	.7085	.8275	.9525	1.0697	1.1947	1.4447
Minor diameter of ring gage	Classes 1, 2, 3, and 4.	Min.[2]	.3301	.3836	.4461	.5026	.5651	.6825	.7979	.9229	1.0350	1.1600	1.4100
		Max.[2]	.3306	.3841	.4466	.5031	.5656	.6831	.7985	.9235	1.0356	1.1606	1.4106

[1] [2] See footnotes on p. 72.

TABLE 23.—*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

			Size 1¾	2	2¼	2½	2¾	3
			Threads per inch 10	10	8	8	8	8
1			25	26	27	28	29	30
"GO" GAGES FOR SCREWS			Inches	Inches	Inches	Inches	Inches	Inches
Major diameter of setting plug	Class 1	Max	1.7472	1.9972	2.2466	2.4966	2.7466	2.9966
		Min	1.7466	1.9966	2.2459	2.4959	2.7459	2.9959
	Classes 2, 3, and 4	Max	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000
		Min	1.7494	1.9994	2.2493	2.4993	2.7493	2.9993
Pitch diameter of setting plug or ring gage	Class 1, loose fit	Max., class X	1.6822	1.9322	2.1654	2.4154	2.6654	2.9154
		Min., class X	1.6819	1.9319	2.1650	2.4150	2.6650	2.9150
		Max., class Y	1.6820	1.9320	2.1652	2.4152	2.6652	2.9152
		Min., class Y	1.6816	1.9316	2.1647	2.4147	2.6647	2.9147
		Max., class Z	1.6817	1.9317	2.1648	2.4148	2.6648	2.9148
		Min., class Z	1.6810	1.9310	2.1641	2.4141	2.6641	2.9141
	Class 2, free fit, and class 3, medium fit.	Max., class X	1.6850	1.9350	2.1688	2.4188	2.6688	2.9188
		Min., class X	1.6847	1.9347	2.1684	2.4184	2.6684	2.9184
		Max., class Y	1.6848	1.9348	2.1686	2.4186	2.6686	2.9186
		Min., class Y	1.6844	1.9344	2.1681	2.4181	2.6681	2.9181
	Class 4, close fit	Max., class X	1.6856	1.9356	2.1695	2.4195	2.6695	2.9195
		Min., class X	1.6853	1.9353	2.1691	2.4191	2.6691	2.9191
Minor diameter of ring gage	Classes 1, 2, 3, and 4.	Max.[1]	1.6417	1.8917	2.1147	2.3647	2.6147	2.8647
		Min	1.6411	1.8911	2.1140	2.3640	2.6140	2.8640
"NOT GO" GAGES FOR SCREWS								
Major diameter of setting plug	Class 1	Min	1.7288	1.9788	2.2244	2.4744	2.7244	2.9744
		Max	1.7294	1.9794	2.2251	2.4751	2.7251	2.9751
	Classes 2, 3, and 4	Min	1.7372	1.9872	2.2348	2.4848	2.7348	2.9848
		Max	1.7378	1.9878	2.2355	2.4855	2.7355	2.9855
Pitch diameter of setting plug or ring gage	Class 1, loose fit	Min	1.6690	1.9190	2.1509	2.4009	2.6509	2.9009
		Max	1.6693	1.9193	2.1513	2.4013	2.6513	2.9013
	Class 2, free fit	Min	1.6750	1.9250	2.1578	2.4078	2.6578	2.9078
		Max	1.6753	1.9253	2.1582	2.4082	2.6582	2.9082
	Class 3, medium fit.	Min	1.6766	1.9266	2.1596	2.4096	2.6596	2.9096
		Max	1.6769	1.9269	2.1600	2 4100	2.6600	2.9100
	Class 4, close fit	Min	1.6814	1.9314	2.1649	2.4149	2.6649	2.9149
		Max	1.6817	1.9317	2.1653	2.4153	2.6653	2.9153
Minor diameter of ring gage	Classes 1, 2, 3, and 4.	Min.[2]	1.6419	1.8919	2.1149	2.3649	2.6149	2.8649
		Max.[2]	1.6425	1.8925	2.1156	2.3656	2.6156	2.8656

[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 check pitch diameter only, it is necessary that the minor diameter of the "not go" ring gage be never less than that specified for the "go" ring gage. The limiting dimensions given in this table for the minor diameter of the "not go" ring gage represent this condition.

TABLE 24.—*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
	Threads per inch													
	64	56	48	40	40	32	32	24	24	20	18	16	14	13
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
"GO" GAGES FOR NUTS	*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
Major diameter of plug gage, classes 1, 2, 3, and 4. Max.	.0734	.0864	.0994	.1124	.1254	.1384	.1644	.1905	.2165	.2505	.3130	.3756	.4381	.5006
Pitch diameter of plug gage. Classes 1, 2, 3, and 4. Min., class X	.0629	.0744	.0855	.0958	.1088	.1177	.1437	.1629	.1889	.2175	.2764	.3344	.3911	.4500
Pitch diameter of plug gage. Classes 1, 2, 3, and 4. Max., class X	.0631	.0746	.0857	.0960	.1090	.1180	.1440	.1632	.1892	.2178	.2767	.3347	.3914	.4503
Pitch diameter of plug gage. Classes 1, 2, and 3. Min., class Y	.0630	.0745	.0856	.0959	.1089	.1178	.1438	.1631	.1891	.2177	.2766	.3346	.3913	.4502
Pitch diameter of plug gage. Classes 1, 2, and 3. Max., class Y	.0633	.0748	.0859	.0962	.1092	.1181	.1441	.1634	.1894	.2180	.2769	.3350	.3917	.4506
Pitch diameter of plug gage. Class 1. Min., class Z	.0631	.0746	.0857	.0960	.1090	.1180	.1440	.1632	.1892	.2178	.2768	.3348	.3915	.4504
Pitch diameter of plug gage. Class 1. Max., class Z	.0635	.0751	.0862	.0965	.1095	.1185	.1445	.1638	.1898	.2184	.2774	.3354	.3921	.4511
"NOT GO" GAGES FOR NUTS														
Major diameter of plug gage, classes 1, 2, 3, and 4. Max.[1]	.0728	.0858	.0988	.1118	.1248	.1378	.1638	.1898	.2158	.2498	.3123	.3748	.4373	.4998
Major diameter of plug gage, classes 1, 2, 3, and 4. Min.[1]	.0696	.0821	.0945	.1066	.1196	.1312	.1572	.1810	.2070	.2392	.3005	.3615	.4220	.4833
Pitch diameter of plug gage. Class 1, loose fit. Max.	.0655	.0772	.0886	.0992	.1122	.1215	.1475	.1675	.1935	.2226	.2821	.3407	.3981	.4574
Pitch diameter of plug gage. Class 1, loose fit. Min.	.0653	.0770	.0884	.0990	.1120	.1212	.1472	.1672	.1932	.2223	.2818	.3404	.3978	.4571
Pitch diameter of plug gage. Class 2, free fit. Max.	.0648	.0764	.0877	.0982	.1112	1204	.1464	.1662	.1922	.2211	.2805	.3389	.3960	.4552
Pitch diameter of plug gage. Class 2, free fit. Min.	.0646	.0762	.0875	.0980	.1110	.1201	.1461	.1659	.1919	.2208	.2802	.3386	.3957	.4549
Pitch diameter of plug gage. Class 3, medium fit. Max.	.0643	.0759	.0871	.0975	.1105	.1196	.1456	.1653	.1913	.2201	.2794	.3376	.3947	.4537
Pitch diameter of plug gage. Class 3, medium fit. Min.	.0641	.0757	.0869	.0973	.1103	.1193	.1453	.1650	.1910	.2198	.2791	.3373	.3944	.4534
Pitch diameter of plug gage. Class 4, close fit. Max.	.0636	.0751	.0863	.0967	.1097	.1187	.1447	.1641	.1901	.2188	.2779	.3360	.3929	.4519
Pitch diameter of plug gage. Class 4, close fit. Min.	.0634	.0749	.0861	.0965	.1095	.1184	.1444	.1638	.1898	.2185	.2776	.3357	.3926	.4516

[1] See footnote on p. 77.

TABLE 24.—*Limiting dimensions of thread plug gages for nuts of classes 1, 2, 3, and 4 fits, American National coarse-thread series*—Contd.

	Sizes														
	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3
	Threads per inch														
	12	11	10	9	8	7	7	6	5	4 1/2	4 1/2	4	4	4	3 1/2
1	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
"GO" GAGES FOR NUTS	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Major diameter of plug gage, classes 1, 2, 3, and 4. Min	0.5625	0.6250	0.7500	0.8750	1.0000	1.1250	1.2500	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000	3.0000
Major diameter of plug gage, classes 1, 2, 3, and 4. Max	.5631	.6256	.7506	.8757	1.0007	1.1257	1.2507	1.5008	1.7508	2.0008	2.2508	2.5009	2.7509	3.0009	3.0009
Pitch diameter of plug gage. Classes 1, 2, 3, and 4. Min., class X	.5084	.5660	.6850	.8028	.9188	1.0322	1.1572	1.3917	1.6201	1.8557	2.1057	2.3376	2.5876	2.8376	2.8144
Pitch diameter of plug gage. Classes 1, 2, 3, and 4. Max., class X	.5087	.5663	.6853	.8031	.9192	1.0326	1.1576	1.3921	1.6205	1.8561	2.1061	2.3380	2.5880	2.8380	2.8148
Pitch diameter of plug gage. Classes 1, 2, and 3. Min., class Y	.5086	.5662	.6852	.8030	.9190	1.0324	1.1574	1.3920	1.6204	1.8560	2.1060	2.3379	2.5879	2.8379	2.8147
Pitch diameter of plug gage. Classes 1, 2, and 3. Max., class Y	.5090	.5666	.6856	.8035	.9195	1.0329	1.1579	1.3925	1.6209	1.8565	2.1065	2.3385	2.5885	2.8385	2.8153
Pitch diameter of plug gage. Class 1. Min., class Z	.5088	.5664	.6855	.8033	.9194	1.0328	1.1578	1.3923	1.6208	1.8564	2.1064	2.3383	2.5883	2.8383	2.8151
Pitch diameter of plug gage. Class 1. Max., class Z	.5095	.5671	.6862	.8040	.9201	1.0335	1.1585	1.3931	1.6216	1.8572	2.1072	2.3392	2.5892	2.8392	2.8160
"NOT GO" GAGES FOR NUTS															
Major diameter of plug gage, classes 1, 2, 3, and 4. Max.[1]	.5623	.6248	.7498	.8748	.9998	1.1248	1.2498	1.4998	1.7498	1.9998	2.2498	2.4998	2.7498	2.9998	2.9998
Major diameter of plug gage, classes 1, 2, 3, and 4. Min.[1]	.5445	.6053	.7283	.8509	.9729	1.0941	1.2191	1.4639	1.7067	1.9519	2.2019	2.4459	2.6959	2.9459	2.9381
Pitch diameter of plug gage. Class 1, loose fit. Max	.5163	.5745	.6942	.8128	.9299	1.0446	1.1696	1.4062	1.6370	1.8741	2.1241	2.3580	2.6080	2.8580	2.8373
Pitch diameter of plug gage. Class 1, loose fit. Min	.5160	.5742	.6939	.8125	.9295	1.0442	1.1692	1.4058	1.6366	1.8737	2.1237	2.3576	2.6076	2.8576	2.8369
Pitch diameter of plug gage. Class 2, free fit. Max	.5140	.5719	.6914	.8098	.9264	1.0407	1.1657	1.4018	1.6317	1.8684	2.1184	2.3516	2.6016	2.8516	2.8301
Pitch diameter of plug gage. Class 2, free fit. Min	.5137	.5716	.6911	.8095	.9260	1.0403	1.1653	1.4014	1.6313	1.8680	2.1180	2.3512	2.6012	2.8512	2.8297
Pitch diameter of plug gage. Class 3, medium fit. Max	.5124	.5702	.6895	.8077	.9242	1.0381	1.1631	1.3988	1.6283	1.8646	2.1146	2.3473	2.5973	2.8473	2.8251
Pitch diameter of plug gage. Class 3, medium fit. Min	.5121	.5699	.6892	.8074	.9238	1.0377	1.1627	1.3984	1.6279	1.8642	2.1142	2.3469	2.5969	2.8469	2.8247
Pitch diameter of plug gage. Class 4, close fit. Max	.5104	.5681	.6873	.8052	.9215	1.0352	1.1602	1.3953	1.6242	1.8601	2.1101	2.3424	2.5924	2.8424	2.8197
Pitch diameter of plug gage. Class 4, close fit. Min	.5101	.5678	.6870	.8049	.9211	1.0348	1.1598	1.3949	1.6238	1.8597	2.1097	2.3420	2.5920	2.8420	2.8193

[1] See footnote on p. 77.

TABLE 25.—*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
1			2	3	4	5	6	7	8	9	10	11	12	13
"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	Classes 1, 2, 3, and 4	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]	.0598	.0728	.0858	.0988	.1118	.1248	.1378	.1638	.1898	.2158	.2498	.3123
		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.	.0525	.0647	.0766	.0881	.0993	.1110	.1227	.1469	.1707	.1939	.2279	.2866
		Min.	.0523	.0645	.0764	.0879	.0991	.1108	.1225	.1467	.1704	.1936	.2276	.2863

[1] See footnote on p. 77.

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

	Sizes										
	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2
	Threads per inch										
	24	20	20	18	18	16	14	14	12	12	12
1	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
"GO" GAGES FOR NUTS	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*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	1.5000
Major diameter, classes 1, 2, 3, and 4 — Max	.3755	.4380	.5005	.5630	.6255	.7506	.8756	1.0006	1.1256	1.2506	1.5006
Pitch diameter of plug gage: Classes 1, 2, 3, and 4 — Min., class X	.3479	.4050	.4675	.5264	.5889	.7094	.8286	.9536	1.0709	1.1959	1.4459
Pitch diameter of plug gage: Classes 1, 2, 3, and 4 — Max., class X	.3482	.4053	.4678	.5267	.5892	.7097	.8289	.9539	1.0712	1.1962	1.4462
Pitch diameter of plug gage: Classes 1, 2, and 3 — Min., class Y	.3481	.4052	.4677	.5266	.5891	.7096	.8288	.9538	1.0711	1.1961	1.4461
Pitch diameter of plug gage: Classes 1, 2, and 3 — Max., class Y	.3484	.4055	.4680	.5269	.5894	.7100	.8292	.9542	1.0715	1.1965	1.4465
Pitch diameter of plug gage: Class 1 — Min., class Z	.3482	.4053	.4678	.5268	.5893	.7098	.8290	.9540	1.0713	1.1963	1.4463
Pitch diameter of plug gage: Class 1 — Max., class Z	.3488	.4059	.4684	.5274	.5899	.7104	.8296	.9546	1.0720	1.1970	1.4470
"NOT GO" GAGES FOR NUTS											
Major diameter of plug gage, classes 1, 2, 3, and 4 — Max.[1]	.3748	.4373	.4998	.5623	.6248	.7498	.8748	.9998	1.1248	1.2498	1.4998
Major diameter of plug gage, classes 1, 2, 3, and 4 — Min.[1]	.3660	.4267	.4892	.5505	.6130	.7365	.8595	.9845	1.1070	1.2320	1.4820
Pitch diameter of plug gage: Class 1, loose fit — Max	.3525	.4101	.4726	.5321	.5946	.7157	.8356	.9606	1.0788	1.2038	1.4538
Pitch diameter of plug gage: Class 1, loose fit — Min	.3522	.4098	.4723	.5318	.5943	.7154	.8353	.9603	1.0785	1.2035	1.4535
Pitch diameter of plug gage: Class 2, free fit — Max	.3512	.4086	.4711	.5305	.5930	.7139	.8335	.9585	1.0765	1.2015	1.4515
Pitch diameter of plug gage: Class 2, free fit — Min	.3509	.4083	.4708	.5302	.5927	.7136	.8332	.9582	1.0762	1.2012	1.4512
Pitch diameter of plug gage: Class 3, medium fit — Max	.3503	.4076	.4701	.5294	.5919	.7126	.8322	.9572	1.0749	1.1999	1.4499
Pitch diameter of plug gage: Class 3, medium fit — Min	.3500	.4073	.4698	.5291	.5916	.7123	.8319	.9569	1.0746	1.1996	1.4496
Pitch diameter of plug gage: Class 4, close fit — Max	.3491	.4063	.4688	.5279	.5904	.7110	.8304	.9554	1.0729	1.1979	1.4479
Pitch diameter of plug gage: Class 4, close fit — Min	.3488	.4060	.4685	.5276	.5901	.7107	.8301	.9551	1.0726	1.1976	1.4476

[1] See footnote on p. 77.

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

			Sizes					
			1¾	2	2¼	2½	2¾	3
			Threads per inch					
			10	10	8	8	8	8
1			25	26	27	28	29	30
"GO" GAGES FOR NUTS			*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Major diameter, classes 1, 2, 3, and 4		Min	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000
		Max	1.7506	2.0006	2.2507	2.5007	2.7507	3.0007
Pitch diameter of plug gage	Classes 1, 2, 3, and 4	Min., class X	1.6850	1.9350	2.1688	2.4188	2.6688	2.9188
		Max., class X	1.6853	1.9353	2.1692	2.4192	2.6692	2.9192
	Classes 1, 2, and 3	Min., class Y	1.6852	1.9352	2.1690	2.4190	2.6690	2.9190
		Max., class Y	1.6856	1.9356	2.1695	2.4195	2.6695	2.9195
	Class 1	Min., class Z	1.6855	1.9355	2.1694	2.4194	2.6694	2.9194
		Max., class Z	1.6862	1.9362	2.1701	2.4201	2.6701	2.9201
"NOT GO" GAGES FOR NUTS								
Major diameter of plug gage, classes 1, 2, 3, and 4		Max.[1]	1.7498	1.9998	2.2498	2.4998	2.7498	2.9998
		Min.[1]	1.7283	1.9783	2.2229	2.4729	2.7229	2.9729
Pitch diameter of plug gage	Class 1, loose fit	Max	1.6982	1.9482	2.1833	2.4333	2.6833	2.9333
		Min	1.6979	1.9479	2.1829	2.4329	2.6829	2.9329
	Class 2, free fit	Max	1.6950	1.9450	2.1798	2.4298	2.6798	2.9298
		Min	1.6947	1.9447	2.1794	2.4294	2.6794	2.9294
	Class 3, medium fit	Max	1.6934	1.9434	2.1780	2.4280	2.6780	2.9280
		Min	1.6931	1.9431	2.1776	2.4276	2.6776	2.9276
	Class 4, close fit	Max	1.6892	1.9392	2.1734	2.4234	2.6734	2.9234
		Min	1.6889	1.9389	2.1730	2.4230	2.6730	2.9230

[1] The difference between these dimensions is not a manufacturing tolerance in the usual sense, but these dimensions represent the limits between which the dimensions may fall. In order that the "not go" gage 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 be never greater than that specified for the "go" plug gage. The limiting dimensions given in this table for the major diameter of the "not go" plug gage represent this condition. On the other hand, it is desirable that the crest of the "not go" gage be truncated a considerable amount, as shown in Figure 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, and this condition is represented by the limiting dimensions given in this table as the minimum minor diameter of the plug gage. "Not go" plug gages may be made to any dimension between the limits given, but the manufacturing tolerances should preferably be applied from these latter limits as starting points.

SECTION IV. 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.

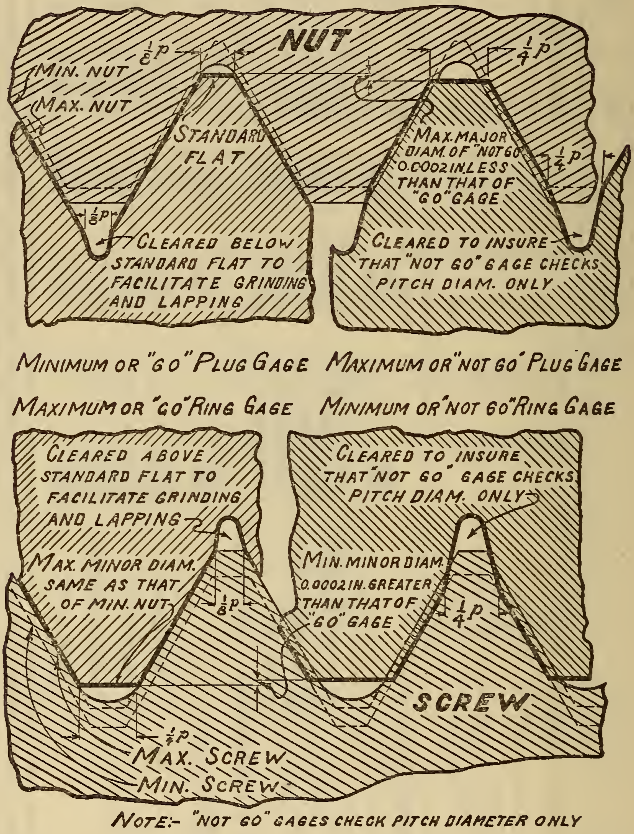

FIG. 18.—*Thread form of "go" and "not go" thread plug and ring gages*

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

It is recommended that one of the following pitches be selected whenever it is necessary to use a screw thread of special diameter and pitch: 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 26. The use of 12 threads per inch, wherever possible, is recommended for all applications requiring special threads. This pitch is very convenient for a variety of miscellaneous work in machine construction, as for thin nuts on shafts and sleeves, on threaded studs, etc. It is the coarsest pitch, for a thread of basic depth, 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.

In Section XD there are given the limiting dimensions for 12 pitch threads of the following sizes: ½, 9/16, ⅝, 11/16, ¾, 13/16, ⅞, 15/16, 1, 1 1/16, 1⅛, 1 3/16, 1¼, 1 5/16, 1⅜, 1½, 1¾, 2, 2¼, 2½, 2¾, and 3 inches. Sizes up to an including 1¾ inches are widely used in railroad practice and die-head chasers for these sizes are stocked by manufacturers.

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.

TABLE 26.—*Thread data for recommended pitches for special threads*

Threads per inch *n*	Pitch *p*	Depth of thread *h*	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.[10]

2. Tolerances.[11]—(*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 can not, 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. 83.)

(*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.

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[10] 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.

[11] Recommendations and explanations regarding the application of tolerances are given in Appendix 1, page 181.

(*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 mininum 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.

(*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.[12]

(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.[13]

Tables 27 and 28 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.

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[12] 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.

[13] See footnote 10, p. 80.

Tables 27 and 29 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 27 and 30 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, selected gages, 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.

The maximum pitch diameters of the screws are slightly larger than the minimum pitch diameters of the nuts determined from Table 27.

Tables 27 and 31 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 27, 28, 29, 30, and 31 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 27.

Pitch diameter tolerances are taken from Tables 28, 29, 30, and 31, depending upon the class of fit required. These pitch diameter tolerances were obtained by adding increments 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 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.

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 27.

(*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 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 28:

Pitch diameter tolerance................=0.0095

Also from Table 27, 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 29:

Pitch diameter tolerance................=0.0066

In this instance the pitch diameter tolerance is printed in italics. In accordance with the footnote under Table 29 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 30:

Pitch diameter tolerance................=0.0065

From Table 27 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

TABLE 27.—*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 28, 29, 30, and 31 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 28, 29, 30, and 31 for pitch diameter tolerances.

Threads per inch	Screw sizes: Major diameter, Maximum, Class 1	Major diameter, Maximum, Classes 2, 3, 4	Major diameter, Tolerance, Class 1	Major diameter, Tolerance, Classes 2, 3, 4	Pitch diameter, maximum, Class 1	Pitch diameter, maximum, Classes 2, 3	Pitch diameter, maximum, Class 4	Minor diameter,[1] maximum, Class 1	Minor diameter,[1] maximum, Classes 2, 3, 4	Nut sizes: Minor diameter, Minimum, Classes 1, 2, 3, and 4	Minor diameter, Tolerance, Classes 1, 2, 3, and 4	Pitch diameter, minimum, Classes 1, 2, 3, and 4	Major diameter,[2] minimum, 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 28.—*Pitch diameter tolerances for special screw threads, class 1, loose 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
	Ins.	*Ins.*	*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		½				.0057	.0057	.0057	.0057	.0070	.0077	.0080	.0087	.0092	.0101	0.0109	0.0114						
	½	1½				.0057	.0057	.0057	.0057	.0070	.0079	.0095	.0102	.0107	.0114	*.0114*	*.0114*						
	1½	3				.0102	.0104	.0106	.0109	.0112	.0114	*.0114*	*.0114*	*.0114*	*.0114*	*.0114*	*.0114*						
16		½				.0063	[1].0063	.0063	.0063	.0070	.0079	.0083	.0090	.0095	.0104	.0112	.0118	0.0124					
	½	1½				.0063	.0063	.0063	[2].0063	.0070	.0079	.0098	.0105	.0110	.0119	.0126	*.0126*	*.0126*					
	1½	3				.0105	.0107	.0109	.0112	.0115	.0120	.0123	.0126	*.0126*	*.0126*	*.0126*	*.0126*	*.0126*					

14	-------	½	-------	-------	-------	-------	.0070	.0070	.0070	.0070	.0079	.0087	.0093	.0099	.0108	.0115	.0122	.0128	0.0133	0.0138	-------	-------	-------
	½	1½	-------	-------	-------	-------	.0070	.0070	.0070	[2].0070	.0079	.0102	.0108	.0114	.0123	.0130	.0137	.0140	*.0140*	*.0140*	-------	-------	-------
	1½	3	-------	-------	-------	-------	.0111	.0113	.0116	.0119	.0123	.0127	.0133	.0139	.0140	*.0140*	*.0140*	*.0140*	*.0140*	*.0140*	-------	-------	-------
12	-------	½	-------	-------	-------	-------	.0075	.0077	.0079	.0079	.0079	.0091	.0097	.0103	.0112	.0119	.0126	.0132	.0138	.0143	0.0148	0.0152	-------
	½	1½	-------	-------	-------	-------	.0079	.0079	.0079	.0079	[2].0079	.0106	.0112	.0118	.0127	.0134	.0141	.0147	.0153	.0158	*.0158*	*.0158*	-------
	1½	3	-------	-------	-------	-------	.0115	.0117	.0120	.0123	.0127	.0131	.0137	.0143	.0152	.0158	*.0158*	*.0158*	*.0158*	*.0158*	*.0158*	*.0158*	-------
10	-------	1	-------	-------	-------	-------	-------	.0087	[1].0092	.0093	.0098	.0102	.0108	.0113	.0122	.0130	.0136	.0142	.0148	.0153	.0158	.0163	0.0171
	1	3	-------	-------	-------	-------	-------	.0117	.0120	.0123	.0128	[2].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	[2].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 29.—*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
	Ins.	*Ins.*	*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	.0064	.0066	.0070	.0076	.0082	.0091	.0098	.0105	.0111	.0116	.0122	0.0126	0.0128	------
	1	3	------	------	------	------	------	.0088	.0091	.0094	.0098	[2].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	.0076	.0080	.0085	.0094	.0102	.0109	.0115	.0120	.0125	.0130	.0135	0.0143
	1	3	------	------	------	------	------	.0090	.0093	.0095	.0100	.0104	[2].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	[2].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 30.—*Pitch diameter tolerances for special screw threads, class 3, medium 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	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
	Ins.	*Ins.*	*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	.0024	.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	.0046	.0050	.0054	.0060	.0066	.0075	.0082	.0089	.0095	.0101	.0106	.0111	.0115	0.0124
	1	3	-	-	-	-	-	.0071	.0071	.0071	.0071	[2].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	.0054	.0056	.0062	.0068	.0077	.0084	.0091	.0097	.0102	.0108	.0113	.0117	.0126
	1	3	-	-	-	-	-	.0071	.0071	.0071	.0071	.0086	[2].0092	.0099	.0108	.0114	.0121	.0127	.0132	.0138	.0143	.0147	.0152
	3	6	-	-	-	-	-	.0122	.0125	.0128	.0132	.0136	.0142	.0148	.0152	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*	*.0152*
6	-	1	-	-	-	-	-	-	.0048	.0054	.0055	.0059	.0065	.0070	.0079	.0087	.0094	.0100	.0105	.0110	.0115	.0120	.0128
	1	3	-	-	-	-	-	-	.0071	.0071	[1].0071	.0089	.0095	.0100	.0109	.0117	.0124	.0130	.0135	.0140	.0145	.0150	.0158
	3	6	-	-	-	-	-	-	.0128	.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.

18415°—29——7

TABLE 31.—*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—	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
	Ins.	*Ins.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
64	------	½	0.0007	0.0007	0.0009	0.0010	0.0012	0.0013	0.0014	0.0016	0.0018	0.0020	0.0023	0.0026	0.0030	0.0034	0.0037	------	------	------	------	------	------
	½	1½	.0015	.0015	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0027	.0030	.0033	.0038	*.0038*	*.0038*	------	------	------	------	------	------
	1½	3	.0028	.0029	.0030	.0031	.0032	.0033	.0034	.0036	.0036	*.0038*	*.0038*	*.0038*	*.0038*	*.0038*	*.0038*	------	------	------	------	------	------
56	------	½	.0007	.0007	.0009	.0010	.0012	.0013	.0014	.0016	.0018	.0020	.0023	.0026	.0030	.0034	.0037	0.0040	------	------	------	------	------
	½	1½	.0015	.0015	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0027	.0031	.0033	.0038	.0040	*.0040*	*.0040*	------	------	------	------	------
	1½	3	.0028	.0029	.0030	.0031	.0032	.0033	.0034	.0036	.0036	.0040	*.0040*	*.0040*	*.0040*	*.0040*	*.0040*	*.0040*	------	------	------	------	------
48	------	½	.0008	.0008	.0009	.0010	.0012	.0013	.0015	.0016	.0018	.0020	.0023	.0026	.0031	.0034	.0038	.0041	0.0044	------	------	------	------
	½	1½	.0015	.0015	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0028	.0031	.0034	.0038	.0042	.0044	*.0044*	*.0044*	------	------	------	------
	1½	3	.0029	.0030	.0030	.0031	.0032	.0033	.0035	.0036	.0036	.0040	.0043	.0044	*.0044*	*.0044*	*.0044*	*.0044*	*.0044*	------	------	------	------
40	------	½	.0009	[1].0009	.0009	.0010	.0012	.0013	.0015	.0016	.0018	.0021	.0024	.0027	.0031	.0035	.0038	.0041	.0044	0.0046	------	------	------
	½	1½	.0015	.0015	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0028	.0031	.0034	.0038	.0042	.0046	.0048	*.0048*	*.0048*	------	------	------
	1½	3	.0029	.0030	.0031	.0032	.0033	.0034	.0035	.0036	.0036	.0041	.0044	.0047	.0048	*.0048*	*.0048*	*.0048*	*.0048*	*.0048*	------	------	------
36	------	½	------	.0009	.0009	.0010	.0012	.0013	.0015	.0017	.0019	.0021	.0024	.0027	.0031	.0035	.0038	.0041	.0044	.0047	0.0049	------	------
	½	1½	------	.0015	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0028	.0031	.0034	.0039	.0042	.0046	.0049	.0050	*.0050*	*.0050*	------	------
	1½	3	------	.0030	.0031	.0032	.0033	.0034	.0035	.0036	.0036	.0041	.0044	.0047	.0050	*.0050*	*.0050*	*.0050*	*.0050*	*.0050*	*.0050*	------	------
32	------	½	------	.0010	.0010	.0010	.0012	.0013	.0015	.0017	.0019	.0021	.0024	.0027	.0031	.0035	.0038	.0041	.0044	.0047	.0049	0.0052	------
	½	1½	------	.0015	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0029	.0032	.0034	.0039	.0043	.0046	.0049	.0052	.0054	*.0054*	*.0054*	------
	1½	3	------	.0030	.0031	.0032	.0033	.0034	.0036	.0036	.0036	.0041	.0044	.0047	.0051	.0054	*.0054*	*.0054*	*.0054*	*.0054*	*.0054*	*.0054*	------
28	------	½	------	------	.0011	[2].0011	.0012	.0013	.0015	.0017	.0019	.0021	.0024	.0027	.0032	.0036	.0039	.0042	.0045	.0047	.0050	.0052	0.0056
	½	1½	------	------	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0029	.0032	.0035	.0039	.0043	.0046	.0049	.0052	.0055	.0057	.0059	.0062
	1½	3	------	------	.0032	.0032	.0033	.0034	.0036	.0036	.0036	.0041	.0044	.0047	.0052	.0056	.0059	.0062	*.0062*	*.0062*	*.0062*	*.0062*	*.0062*
24	------	½	------	------	.0012	.0012	[2].0012	.0013	.0015	.0018	.0020	.0022	.0025	.0028	.0032	.0036	.0039	.0042	.0045	.0048	.0050	.0052	.0057
	½	1½	------	------	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0029	.0032	.0035	.0040	.0043	.0047	.0050	.0052	.0055	.0057	.0060	.0064
	1½	3	------	------	.0032	.0033	.0034	.0035	.0036	.0036	.0036	.0042	.0045	.0048	.0052	.0056	.0059	.0062	.0065	.0066	*.0066*	*.0066*	*.0066*
20	------	½	------	------	.0012	[1].0013	.0013	[2].0013	.0015	.0018	.0020	.0022	.0025	.0028	.0033	.0036	.0040	.0043	.0046	.0048	.0050	.0053	.0057
	½	1½	------	------	.0015	.0015	.0015	.0015	.0015	.0018	.0020	.0030	.0033	.0036	.0040	.0044	.0047	.0050	.0053	.0056	.0058	.0060	.0065
	1½	3	------	------	.0032	.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	[1].0016	.0016	.0016	.0018	.0020	.0023	.0026	.0029	.0033	.0037	.0040	.0043	.0046	.0049	.0051	.0053	.0058
	½	1½	-------	-------	-------	.0016	.0016	.0016	[2].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	[2].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	[2].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	[1].0023	.0023	.0023	.0027	.0030	.0033	.0037	.0041	.0044	.0048	.0050	.0053	.0055	.0058	.0062
	1	3	-------	-------	-------	-------	-------	.0036	.0036	.0036	.0036	[2].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	[1].0027	.0027	.0028	.0031	.0034	.0038	.0042	.0045	.0048	.0051	.0054	.0056	.0059	.0063
	1	3	-------	-------	-------	-------	-------	.0036	.0036	.0036	.0036	.0043	[2].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	.0029	.0032	.0035	.0040	.0043	.0047	.0050	.0053	.0055	.0058	.0060	.0064
	1	3	-------	-------	-------	-------	-------	-------	.0036	.0036	[1].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	[1].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 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 shorter length of engagement, coarser pitch, or smaller diameter.

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

From Table 29:

Pitch diameter tolerance = 0.0060

From Table 27 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 − .0060 = 2.9669

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 + .0060 = 2.9789

5. SPECIFICATIONS FOR GAGES[14]

(See also Section III, division 5, "Gages")

(*a*) CLASSIFICATION OF GAGES AND GAGE TOLERANCES.—Screw-thread gages are classified according to accuracy into classes X, Y, and Z, the class X being the most accurate. 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. Also, only one set of tolerances, namely, class X, is specified for "not go" gages. The selection of "go" 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 4 specifications, class X gages may be required for all purposes. On the other hand, for parts made to class 1 specifications, class Z gages may be sufficiently accurate for all purposes. The recommended uses for the various classes of gages are given in Table 32. In Tables 33, 34, and 35 are specified tolerances on diameter, lead, and angle for each class of gage.

"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.

[14] In ordering gages for special threads the length of engagement of the component thread (as distinct from the length of the gage), as well as the diameter, pitch, and class of fit, should be stated.

(*b*) Thread Form of Plug and Ring Thread Gages.—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 minor diameter of the "not go" ring gage is the minimum minor diameter of the nut plus at least 0.0002 inch, with a plus gage tolerance. Also the maximum major diameter of the "not go" thread plug gage is at least 0.0002 inch less than the basic major diameter, with a minus gage tolerance.

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" 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.

(*c*) 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 2, "Symbols." For example, a 1-inch, 16-pitch gage of American National form of thread, class 3, medium fit, shall be marked: 1″—16—NS—3.

Table 32.—*Recommended uses for classes X, Y, and Z gages*

Class of fit	Setting gage	Inspection gage	Working gage
1	2	3	4
Class 1	Class X	Class Y	Class Z.
Class 2	do	do	Class Y.
Class 3	do	Class X	Do.
Class 4	do	do	Class X.

Table 33.—*Tolerances for class X "go" thread gages and all "not 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*
64	0.0000	0.0002	0.0002	0	30	0.0000	0.0004
56	.0000	.0002	.0002	0	30	.0000	.0004
48	.0000	.0002	.0002	0	30	.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
12	.0000	.0003	.0003	0	10	.0000	.0006
10	.0000	.0003	.0003	0	10	.0000	.0006
8	.0000	.0004	.0004	0	5	.0000	.0007
6	.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 length of engagement.

Table 34.—*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*
64	0.0001	0.0004	0.0002	0	45	0.0000	0.0004
56	.0001	.0004	.0002	0	45	.0000	.0004
48	.0001	.0004	.0002	0	45	.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
12	.0002	.0006	.0003	0	10	.0000	.0006
10	.0002	.0006	.0003	0	10	.0000	.0006
8	.0002	.0007	.0004	0	5	.0000	.0007
6	.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 length of engagement.

Table 35.—*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*
64	0.0002	0.0006	0.0002	0	45	0.0000	0.0004
56	.0002	.0007	.0002	0	45	.0000	.0004
48	.0002	.0007	.0002	0	45	.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
12	.0004	.0011	.0004	0	10	.0000	.0006
10	.0005	.0012	.0004	0	10	.0000	.0006
8	.0006	.0013	.0005	0	5	.0000	.0007
6	.0006	.0014	.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 length of engagement.

SECTION V. 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.

From the best information available when fire-hose coupling threads were under discussion, the commission concluded that they should be placed in the loose-fit class and that the allowance provided in the original specifications should be interpreted as the minimum difference in pitch diameter of the couplings and nipples; that is, that a looser fit could be tolerated than that represented by the nominal dimensions, but that a tighter fit would be objectionable. The nominal size of the coupling was, therefore, taken as the minimum coupling, and the nominal size of the nipple as the maximum nipple; the loose-fit tolerances being applied in such a direction as to make the maximum coupling larger and the minimum nipple smaller than the nominal size by the amount of the tolerance. The dimensions for American National fire-hose coupling threads appearing in the 1921 Progress Report of the commission were calculated on that basis.

It later appeared from evidence presented by the National Board of Fire Underwriters that the fits resulting from the limiting dimensions specified in the 1921 Progress Report may in extreme cases be looser than good practice warrants. The commission was, therefore, requested to revise its specifications for fire-hose coupling threads in such a manner that the resulting fits would be somewhat closer than those originally permitted. The revision requested was accomplished by reducing the allowance between the minimum coupling and the maximum nipple; the minimum coupling dimension being retained as published in the 1921 Progress Report. However, from evidence presented by certain manufacturers, it appeared desirable to provide a larger wear limit for gages and also permit the use of field inspection gages which were outside of the limits set for the manufacturers' gages, in order to insure the approval, by the purchaser, of threaded couplings which had passed the manufacturers' gages. To permit this, the tolerances on both the coupling and nipple were increased slightly.

Furthermore, since the publication of the 1921 Progress Report, it has been found desirable, in order to facilitate production and simplify the manufacture of threading tools and gages, to adopt the American National form of thread for American National fire-hose coupling threads. This, however, is a very minor change and only slightly affects the thread form at crest and root.

The specifications have been further supplemented by recommended limiting dimensions of gages such that every coupling and nipple accepted by the gages will be known to be within the limiting dimensions specified. Only such a system can insure that the finished product will assemble and function properly.

Comparison of the resulting dimensions with those contained in the original specifications of the National Board of Fire Underwriters and in Bureau of Standards Circular No. 50, shows that the two are not in conflict. The nominal dimensions originally specified for couplings and nipples are not inconsistent with the above limiting dimensions, and the revised dimensions should not be considered as changing in any way the original specifications for American National fire-hose coupling threads, but as supplementing those specifications, and as expressing them in definite and measurable terms. It should be understood that these dimensions for American National fire-hose coupling threads are the limiting dimensions for the finished product and not for the threading tools.

With regard to the American National hose-coupling threads, which range in size from three-fourths to 2 inches, the series of sizes and pitches originally adopted by the commission are essentially the same as the corresponding sizes of the American National straight pipe threads, with the exception of the three-fourths-inch size. In this case 11 and $11\frac{1}{2}$ threads, with a diameter of $1\frac{1}{16}$ inches, were already in very extensive use. The adoption of the so-called "straight iron pipe thread" was indorsed by the National Association of Brass Manufacturers, and at the time of its adoption was recommended by the committee on Small Hose Couplings of the National Fire Protection Association and tentatively adopted by that association.

In ordering threading tools 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 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 36 a thread series and basic dimensions for hose-coupling threads from ¾ to 2 inches in diameter, which will be known as the "American National hose-coupling threads."

The American National hose-coupling thread is recommended for use on all couplings and connections where sizes between ¾ and 2 inches in diameter are required.

Table 36.—*American National hose-coupling threads*

BASIC MINIMUM COUPLING DIMENSIONS

Nominal size	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*
¾ [1]	11½	0.08696	0.05648	1.0725	1.0160	0.9595	
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

Nominal size	Number of threads per inch	Pitch	Depth of thread	Major diameter	Pitch diameter	Minor diameter	Allowance
¾ [1]	11½	0.08696	0.05648	1.0625	1.0060	0.9495	0.01
1	11½	.08696	.05648	1.2951	1.2386	1.1821	.01
1¼	11½	.08696	.05648	1.6399	1.5834	1.5269	.01
1½	11½	.08696	.05648	1.8788	1.8223	1.7658	.01
2	11½	.08696	.05648	2.3528	2.2963	2.2398	.01

[1] The ¾-inch hose coupling is used on ½-inch and ⅝-inch, as well as on ¾-inch, hose.

(*b*) American National Fire-Hose Coupling Threads.—There are specified in Table 37 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 37.—*American National fire-hose coupling threads*

BASIC MINIMUM COUPLING DIMENSIONS

Nominal size	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*
2.5000	7.5	0.13333	0.08660	3.0836	2.9970	2.9104	
3.0000	6.0	.16667	.10825	3.6389	3.5306	3.4223	
3.5000	6.0	.16667	.10825	4.2639	4.1556	4.0473	
4.5000	4.0	.25000	.16238	5.7859	5.6235	5.4611	

BASIC MAXIMUM NIPPLE DIMENSIONS

Nominal size	Number of threads per inch	Pitch	Depth of thread	Major diameter	Pitch diameter	Minor diameter	Allowance
2.5000	7.5	0.13333	0.08660	3.0686	2.9820	2.8954	0.0150
3.0000	6.0	.16667	.10825	3.6239	3.5156	3.4073	.0150
3.5000	6.0	.16667	.10825	4.2439	4.1356	4.0273	.0200
4.5000	4.0	.25000	.16238	5.7609	5.5985	5.4361	.0250

3. ALLOWANCES AND TOLERANCES

(*a*) Specified allowances and tolerances, given in Table 38, 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 38).

(*f*) The tolerance on the major diameter of the nipple 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.

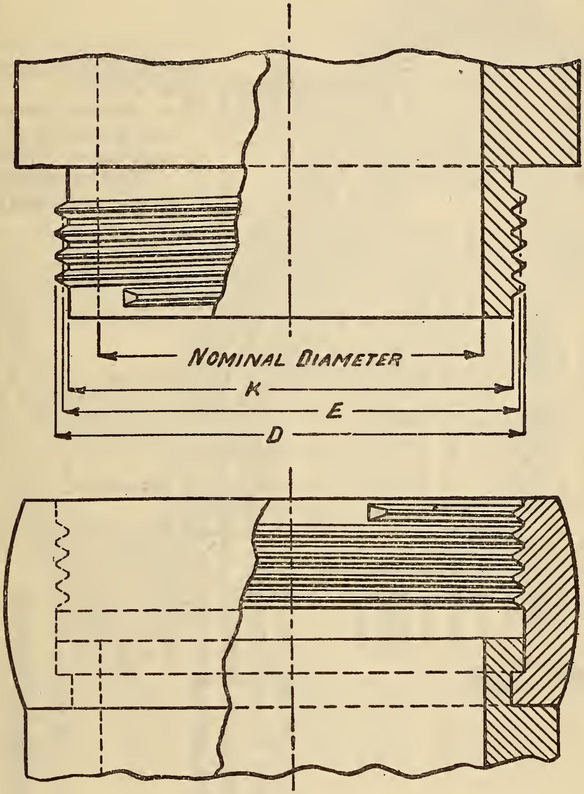

FIG. 19.—*American National hose-coupling and American National fire-hose coupling threads*

See Tables 38, 39, and 40 for dimensions and tolerances.

(*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 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

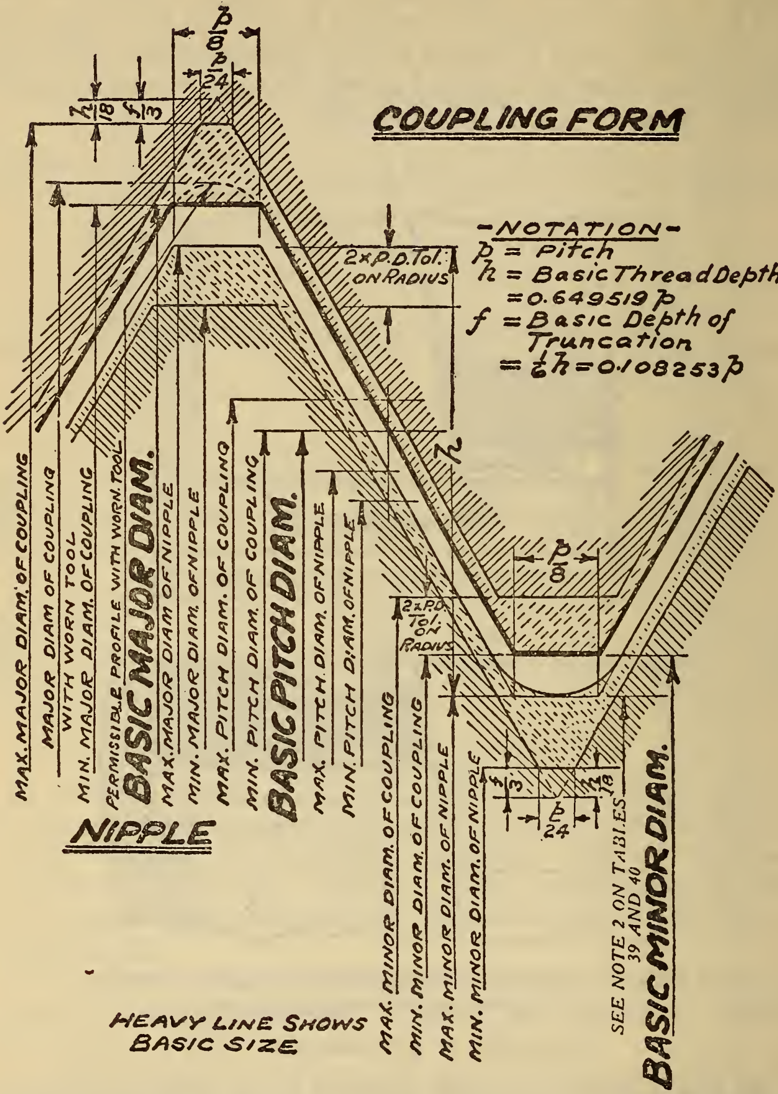

Fig. 20.—*American National hose-coupling and American National fire-hose coupling threads*

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

Nominal size	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	
		Inch	*Inch*	*Inch*	*Deg.*	*Min.*
¾	11½	0.010	0.0085	0.0025	1	52
1	11½	.010	.0085	.0025	1	52
1¼	11½	.010	.0085	.0025	1	52
1½	11½	.010	.0085	.0025	1	52
2	11½	.010	.0085	.0025	1	52
2½	7½	.015	.0160	.0046	2	17
3	6	.015	.0180	.0052	2	4
3½	6	.020	.0180	.0052	2	4
4½	4	.025	.0250	.0072	1	55

[1] The tolerances specified for pitch diameter include all errors of pitch diameter, lead, and angle. The full tolerance can not, therefore, be used on pitch diameter unless the lead and angle of the thread are perfect. Columns 5 and 6 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 4. 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.

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

4. TABLES OF DIMENSIONS

TABLE 39.—*American National hose couplings, thread dimensions*

COUPLING THREAD

Nominal size	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*
¾	11½	0.08696	0.05648	-------	-------	[1] 1.0725	1.0245	0.0085	1.0160	0.9765	0.0170	0.9595
1	11½	.08696	.05648	-------	-------	[1] 1.3051	1.2571	.0085	1.2486	1.2091	.0170	1.1921
1¼	11½	.08696	.05648	-------	-------	[1] 1.6499	1.6019	.0085	1.5934	1.5539	.0170	1.5369
1½	11½	.08696	.05648	-------	-------	[1] 1.8888	1.8408	.0085	1.8323	1.7928	.0170	1.7758
2	11½	.08696	.05648	-------	-------	[1] 2.3628	2.3148	.0085	2.3063	2.2668	.0170	2.2498

NIPPLE THREAD

¾	11½	0.08696	0.05648	1.0625	0.0170	1.0455	1.0060	0.0085	0.9975	[2] 0.9495	-------	-------
1	11½	.08696	.05648	1.2951	.0170	1.2781	1.2386	.0085	1.2301	[2] 1.1821	-------	-------
1¼	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	-------	-------

[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.

[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 the basic thread depth, h (or $0.6495p$), from the minimum pitch diameter of the nipple.

TABLE 40.—*American National fire-hose couplings, thread dimensions*

COUPLING THREAD

Nominal size	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	7.5	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

Nominal size	Threads per inch	Pitch	Depth of thread	Major diameter Maximum	Major diameter Tolerance	Major diameter Minimum	Pitch diameter Maximum	Pitch diameter Tolerance	Pitch diameter Minimum	Minor diameter Maximum	Minor diameter Tolerance	Minor diameter Minimum
2½	7.5	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 $1\frac{2}{9}\times h$ (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 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 the basic thread depth, h (or $0.6495p$), from the minimum pitch diameter of the nipple.

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 41. Limiting dimensions for these gages are given in Tables 42 and 43.

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 42 and 43, 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 41.—*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 42.—*Limiting dimensions of field inspection thread plug gages for couplings (internal threads)* [1]

Nominal size	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	7.5	3.0846	3.0836	2.9980	2.9970	3.0836	3.0826	3.0130	3.0120
3.000	6.0	3.6399	3.6389	3.5316	3.5306	3.6389	3.6379	3.5486	3.5476
3.500	6.0	4.2649	4.2639	4.1566	4.1556	4.2639	4.2629	4.1736	4.1726
4.500	4.0	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 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 43.—*Limiting dimensions of field inspection thread ring gages for coupling nipples (external threads)* [1]

Nominal size	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	7.5	2.9820	2.9810	2.9104	2.9094	2.9670	2.9660	2.9114	2.9104
3.000	6.0	3.5156	3.5146	3.4223	3.4213	3.4986	3.4976	3.4233	3.4223
3.500	6.0	4.1356	4.1346	4.0473	4.0463	4.1186	4.1176	4.0483	4.0473
4.500	4.0	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 VI. AMERICAN NATIONAL PIPE THREADS

[NOTE.—*See* Preface]

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 indorsed 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 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.[15]—The crest and root of the thread form are truncated an amount equal to 0.0330 p; the depth of thread is, therefore, equal to 0.8 p.

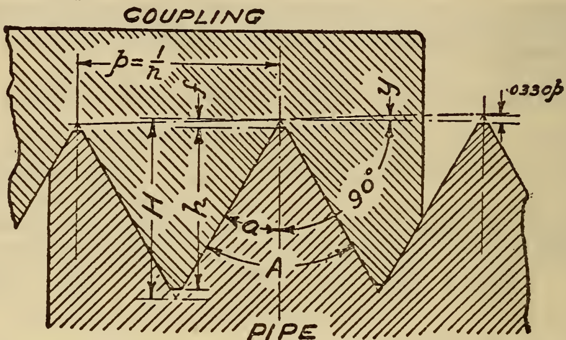

FIG. 21.—*American National taper pipe thread form and notation*

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=0.866025 p depth of 60° sharp V thread [16]
h {=0.800000 p, =0.923761 H} depth of thread on work
f {=0.033012 p, =0.038120 H, =0.041266 h} depth of truncation
$p=1/n$ pitch
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.

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

[16] For a symmetrical straight screw thread, $H=p \cot a$. For a symmetrical taper screw thread $H=\frac{p}{2}(\cot^2 a-\tan^2 y \tan a)$, so that the exact value for an American National taper pipe thread is H=0.865743 p as against H=0.866025 p, 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=0.866025 p continues in use for threads of three-fourths inch, or less, taper per foot.

2. SYMBOLS

The list of symbols given in Section II–2, 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

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 44.

1. Outside diameter of pipe.—The outside diameters of pipe are given in column 5 of Table 44.

2. Diameters of taper threads.—The pitch diameters of the taper threads are determined by formulas based on the outside diameter of pipe and the pitch of thread. These are as follows [17] (see Symbols above):

$$E_0=D-(0.05\,D+1.1)\,p$$
$$E_1=E_0+0.0625\,L_1$$

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 [17] (see Symbols above):

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

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 44. 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.[18]

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[17] 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.

[18] On account of the gage tolerance of one-half turn on working gages, this is equivalent to one turn plus or one turn minus from the gaging notch when using working gages. (See figs. 29 and 30.)

18415°—29——8

TABLE 44.—*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, $E_0=D-\frac{0.05D+1.1}{n}$	Pitch diameters: At length L_1 on pipe, or at end of coupling, $E_1=E_0+\frac{L_1}{16}$		
								Basic	Maximum	Basic	Minimum
1	2	3	4	5	6	7	8	9	10	11	12
		Inch	*Inch*	*Inches*	*Inches*	*Inches*	*Inch*	*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
¼	18	.05556	.04444	.540	.200	.40178	.00347	.47739	.49510	.48989	.48468
⅜	18	.05556	.04444	.675	.240	.40778	.00347	.61201	.63222	.62701	.62181
½	14	.07143	.05714	.840	.320	.53371	.00446	.75843	.78513	.77843	.77173
¾	14	.07143	.05714	1.050	.339	.54571	.00446	.96768	.99557	.98887	.98217
1	11½	.08696	.06957	1.315	.400	.68278	.00543	1.21363	1.24678	1.23863	1.23048
1¼	11½	.08696	.06957	1.660	.420	.70678	.00543	1.55713	1.59153	1.58338	1.57523
1½	11½	.08696	.06957	1.900	.420	.72348	.00543	1.79609	1.83049	1.82234	1.81418
2	11½	.08696	.06957	2.375	.436	.75652	.00543	2.26902	2.30442	2.29627	2.28812
2½	8	.12500	.10000	2.875	.682	1.13750	.00781	2.71953	2.77388	2.76216	2.75044
3	8	.12500	.10000	3.500	.766	1.20000	.00781	3.34062	3.40022	3.38850	3.37678
3½	8	.12500	.10000	4.000	.821	1.25000	.00781	3.83750	3.90053	3.88881	3.87709
4	8	.12500	.10000	4.500	.844	1.30000	.00781	4.33438	4.39884	4.38712	4.37541
4½	8	.12500	.10000	5.000	.875	1.35000	.00781	4.83125	4.89766	4.88594	4.87422
5	8	.12500	.10000	5.563	.937	1.40630	.00781	5.39073	5.46101	5.44929	5.43757
6	8	.12500	.10000	6.625	.958	1.51250	.00781	6.44609	6.51769	6.50597	6.49425
7	8	.12500	.10000	7.625	1.000	1.61250	.00781	7.43984	7.51406	7.50234	7.49062
8	8	.12500	.10000	8.625	1.063	1.71250	.00781	8.43359	8.51175	8.50003	8.48831
9	8	.12500	.10000	9.625	1.130	1.81250	.00781	9.42734	9.50969	9.49797	9.48625
10	8	.12500	.10000	10.750	1.210	1.92500	.00781	10.54531	10.63266	10.62094	10.60922
11	8	.12500	.10000	11.750	1.285	2.02500	.00781	11.53906	11.63109	11.61938	11.60766
12	8	.12500	.10000	12.750	1.360	2.12500	.00781	12.53281	12.62953	12.61781	12.60609
14 O. D.	8	.12500	.10000	14.000	1.562	2.25000	.00781	13.77500	13.88434	13.87262	13.86091
15 O. D.	8	.12500	.10000	15.000	1.687	2.35000	.00781	14.76875	14.88591	14.87419	14.86247
16 O. D.	8	.12500	.10000	16.000	1.812	2.45000	.00781	15.76250	15.88747	15.87575	15.86403

17 O. D	8	.12500	.10000	17.000	1.900	2.55000	.00781	16.75625	16.88672	16.87500	16.86328
18 O. D	8	.12500	.10000	18.000	2.000	2.65000	.00781	17.75000	17.88672	17.87500	17.86328
20 O. D	8	.12500	.10000	20.000	2.125	2.85000	.00781	19.73750	19.88203	19.87031	19.85859
22 O. D	8	.12500	.10000	22.000	2.250	3.05000	.00781	21.72500	21.87734	21.86562	21.85391
24 O. D	8	.12500	.10000	24.000	2.375	3.25000	.00781	23.71250	23.87266	23.86094	23.84922
26 O. D	8	.12500	.10000	26.000	2.500	3.45000	.00781	25.70000	25.86797	25.85625	25.84453
28 O. D	8	.12500	.10000	28.000	2.625	3.65000	.00781	27.68750	27.86328	27.85156	27.83984
30 O. D	8	.12500	.10000	30.000	2.750	3.85000	.00781	29.67500	29.85859	29.84688	29.83516

(*b*) American National Straight Pipe Threads.—The specified sizes and basic dimensions on the "American National straight pipe threads" are given in Table 45.

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):

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

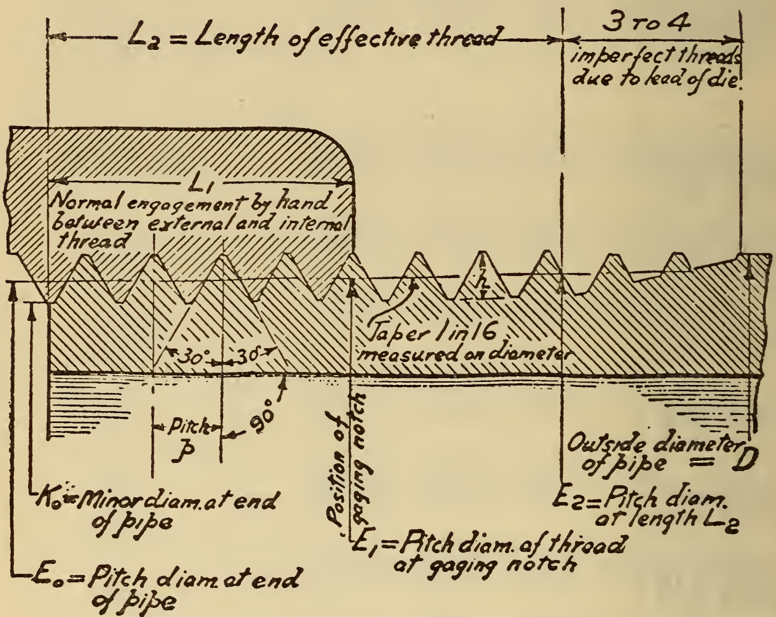


Fig. 22.—*American National taper pipe thread notation*

NOTATION

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

$E_1 = E_0 + 0.0625\,L_1$

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

$h = 0.8\,p$

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.[19] (See columns 4 and 6 of Table 45.)

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

[19] 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 and not at the end of the coupling when the thread is chamfered.

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.

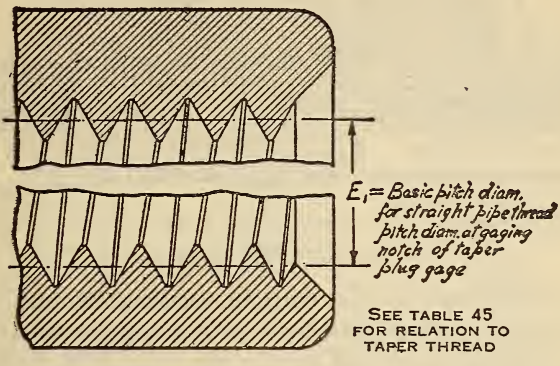


FIG. 23.—*American National straight pipe thread notation (internal)*

NOTE.—This thread is gaged with the taper threaded plug gage and should gage flush at the face with the gaging notch, allowing a maximum variation of one turn plus or minus from the notch.

TABLE 45.—*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			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	.99557	.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	3.48850	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 by hand, the joint being made by a packing material between the locknut and the coupling. (See fig. 24.)

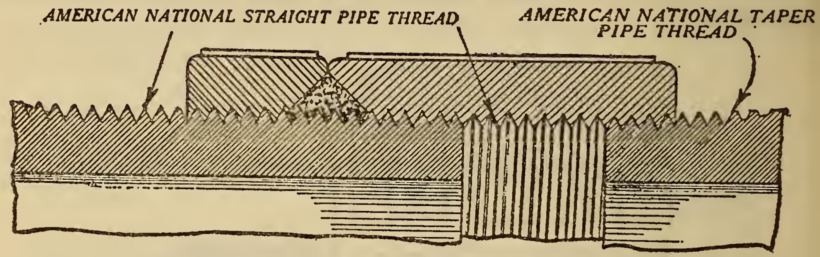


Fig. 24.—*Illustration of "long screw" joint between straight threaded coupling and taper threaded pipe*

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 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.

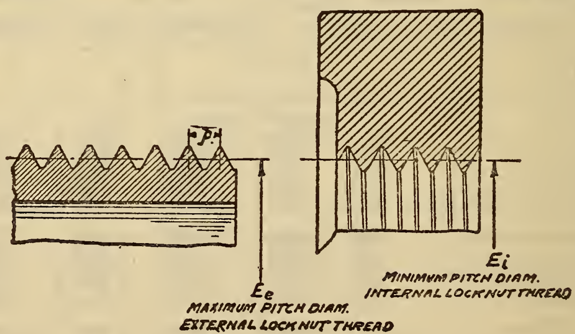


Fig. 25.—*American National locknut thread notation*

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 46 for relation to taper pipe thread.

(*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 46. 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."

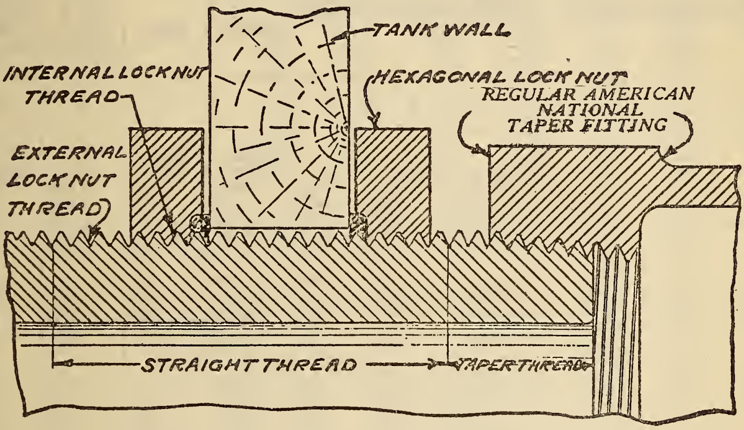


Fig. 26.—*Illustration of "tank nipple" thread*

Table 46.—*Dimensions of American National locknut threads*

[For notation, see fig. 25]

Nominal size in inches	Threads per inch	E_e (Maximum) [1]	E_i (Minimum) [1]	Depth of thread
1	2	3	4	5
		Inches	*Inches*	*Inch*
⅛	27	0. 38402	0. 38633	0. 02963
¼	18	. 50378	. 50725	. 04444
⅜	18	. 64090	. 64437	. 04444
½	14	. 79629	. 80075	. 05714
¾	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_e and plus on E_i.

4. TABLES OF PIPE DIMENSIONS

Tables 47, 48, 49, and 50, which follow, are not a part of the thread standard, but are reprinted as part of the Manual on American Standard Pipe Threads.

TABLE 47.—*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*
1/8	0.269	0.405	0.068	0.057	0.072	9.431	0.245
1/4	.364	.540	.088	.104	.125	7.073	.425
3/8	.493	.675	.091	.191	.167	5.658	.568
1/2	.622	.840	.109	.304	.250	4.547	.852
3/4	.824	1.050	.113	.533	.333	3.637	1.134
1	1.049	1.315	.133	.864	.494	2.904	1.684
1 1/4	1.380	1.660	.140	1.495	.669	2.301	2.281
1 1/2	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
2 1/2	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
3 1/2	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
4 1/2 [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 No. 57.

TABLE 48.—*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	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 No. 57.

TABLE 49.—*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	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 No. 57.

TABLE 50.—*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	26⅞	26¾	26½	--------
30	30	--------	--------	--------	29⅛	29	28⅞	28¾	28½	--------

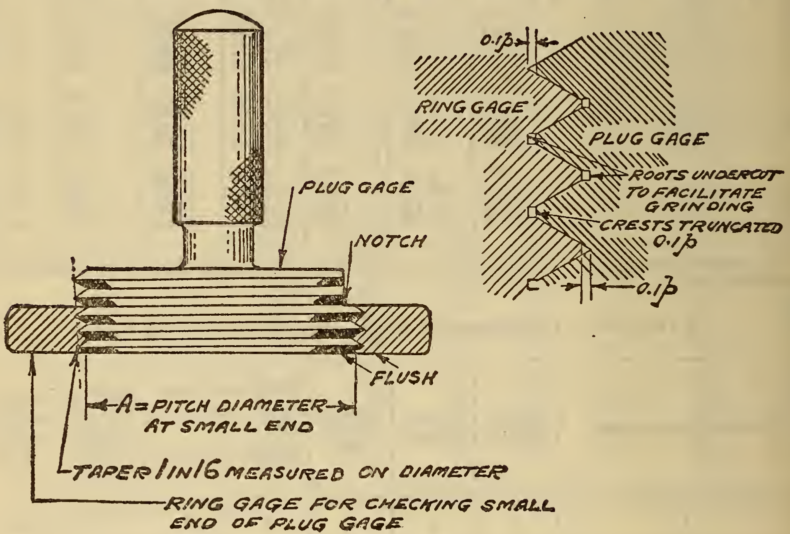


FIG. 27.—*Master gages or check gages for checking working gages*

5. GAGES

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

(*a*) CLASSIFICATION OF GAGES.—*1. Master gage.*—The master gage is a taper threaded plug gage. The roots of the threads are cut to a sharp V or may be undercut to facilitate the making of the thread. The crests are truncated an amount equal to 0.1 *p*. (See fig. 27.)[20] Basic dimensions of taper pipe thread gages are given in Table 55. This gage is provided with the gaging notch as illustrated in Figure 27. The master gage is the gage to which all other gages are ultimately referred, either by transfer of measurements or direct comparison by engagement. It is intended primarily for the use of gage and thread tool manufacturers.

2. *Check (or reference) gages.*—The check gages consist of a plug gage, similar in all respects to the master gage, and one ring gage. The ring gage has a thickness equal to dimension L_1, is the same diameter at the small end as the small end of the plug gage, and is flush with the plug gage at the small end and at the gaging notch when screwed on tight by hand. (See fig. 27.) The check plug gage is used to inspect inspection and working taper threaded ring gages.

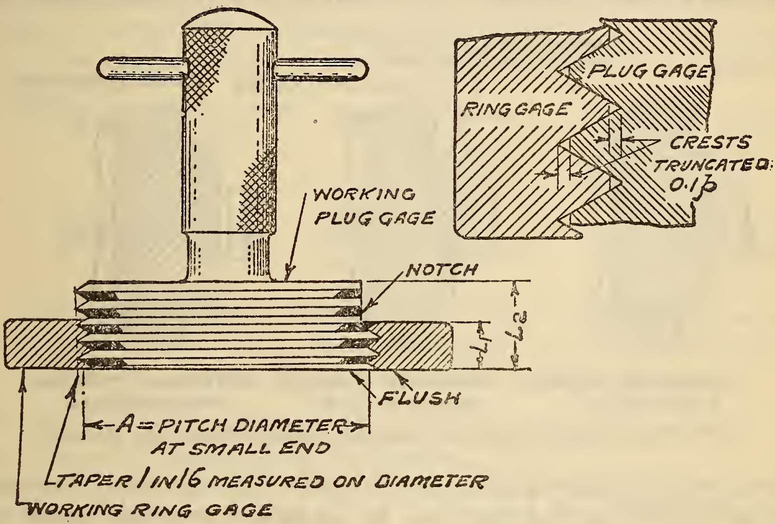


FIG. 28.—*Inspection or working gages for checking product*

The check ring gage is used to compare the check plug with the master plug, or the inspection and working plug gages with the check plug gage.

3. *Inspection gages.*—Inspection gages consist of one taper threaded plug gage and one taper threaded ring gage. The roots of the threads are cut to sharp V or may be undercut to facilitate making the thread. The crests are truncated an amount equal to 0.1 p, but otherwise the gages are made to the dimensions given in Table 44.[20] The ring gage has a thickness equal to dimension L_1, and the same diameter at the small end as the small end of the plug gage. (See fig. 28.)

[20] The object of truncating the crests on gages (truncation 0.1 p) 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.

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 against the check gages, and in use their errors should be taken into account.

4. 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

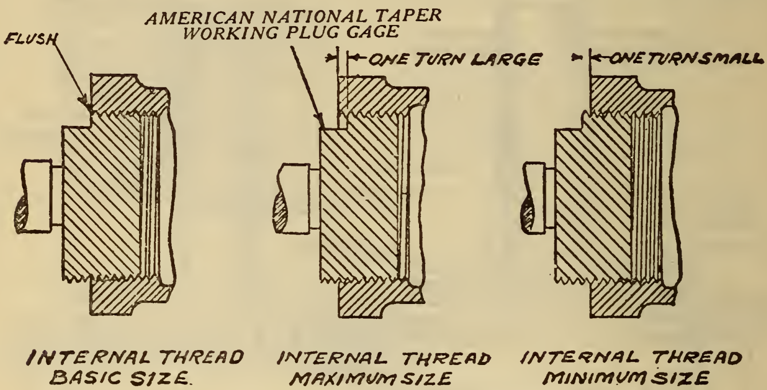


FIG. 29.—*Gaging of internal American National taper pipe threads*

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.

(*b*) GAGING PRACTICES.—*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. The fitting or coupling is within the working or net tolerance if the working gage notch is within one turn of the 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 when screwed on tight by hand.

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 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.

(*c*) Specifications for Gages.—*1. Master gages.*—Master gages shall be made within the closest possible limits of error. In no case shall the accumulative error exceed the total accumulative tolerance on diameter given in Table 51. Each master gage shall 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

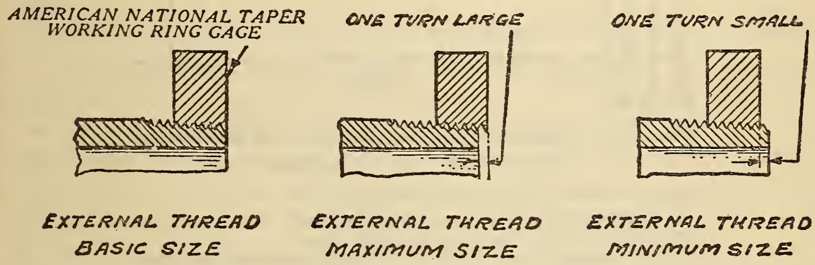


Fig. 30.—*Gaging of external American National taper pipe threads*

deviations of this gage from the basic size shall be ascertained by the Bureau of Standards at Washington, D. C.

2. Check (or reference) gages.—Column 2 of Table 51 gives the maximum allowable accumulation of all errors in the thread surface of a check gage, expressed in terms of diameter, as illustrated in Figure 31. No point on the thread surface of the gage should be outside the zone of tolerance indicated by the shaded portion of the illustration. This column is used when checking gages by measurement. If the errors in the gage are reported in terms of pitch, angle of thread, and diameter, Tables 53 and 54 may be used to determine the accumulation of these errors for comparison with column 2. In Table 53 the results of errors in angle are expressed in terms of diameter. In Table 54 the results of errors in pitch are expressed in terms of diameter.

For example: A three-fourths inch, 14 thread, pipe thread plug gage is reported as follows:

Pitch diameter, large end, 0.98881 inch.
Pitch diameter, small end, 0.96775 inch.
One-half included angle of thread, 29° 58′.
Maximum error in lead, 0.00007 inch.

The correct pitch diameter at large end is 0.98886 inch. The error is 0.00005 inch. The correct pitch diameter at small end is 0.96768 inch. (See Table 44.)

Error of 2′ in angle is equivalent to 0.00005 inch; 0.00007 inch error in lead is equivalent to 0.00012 inch. (See Table 44.) The accumulative error at large end in terms of diameter = 0.00023 inch. The accumulative error at small end equals 0.00025 inch.

The gage falls within the limits of the check gage (0.00028 inch as given in Table 51).

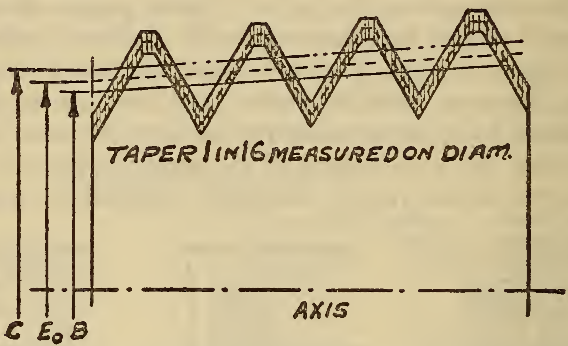


FIG. 31.—*Relation of tolerance to basic dimensions of a correct taper pipe thread gage*

E_0 = basic pitch diameter at small end of gage
B = minimum pitch diameter at small end of gage
C = maximum pitch diameter at small end of gage
$B = E_0 -$ column 2 from Table 51 for check gages, or column 2 from Table 52 for new working gages
$C = E_0 +$ column 2 from Table 51 for check gages, or column 2 from Table 52 for new working gages

NOTE.—No point of the thread surface of the gage should be outside of the zone of tolerance indicated by the shaded portion of the illustration. The dotted line indicates the outline of a correct gage made exactly to the basic dimensions.

Column 3 of Table 51 gives the equivalent of column 2, expressed in terms of distance parallel to the axis, and represents the maximum distance which a check ring gage of correct thickness, or a check plug gage of correct length from small end to gaging notch, may vary from being flush at the gaging notch, or at the small end, when referred to basic dimensions. It is equal to sixteen times column 2 because of the basic taper of 1 in 16, measured on the diameter. This column is used when checking check gages by comparison with a master gage. The necessary allowance must be made for the error in the master gage.

Column 4 of Table 51 gives the equivalent of column 3, expressed in terms of the decimal part of a turn. This column is also used when checking check gages by comparison with a master gage. The necessary allowance must be made for the error in the master gage.

A tolerance of plus or minus 0.0002 inch is allowed on the distance between the gaging notch and the small end of the check plug gage, or on the thickness of the check ring gage.

It is possible for check plug and ring gages, which come within all of the above tolerances, to vary from being flush with each other at the small end, or at the gaging notch, when screwed together tight by hand. The maximum variation which might occur, expressed in terms of distance, is given in column 5 of Table 51.

3. Inspection gages.—The tolerances on new inspection gages are the same as on working gages. (See Table 52.)

4. New working gages.—Column 2 of Table 52 gives the maximum allowable accumulation of all errors in the thread surface of new working gages, expressed in terms of diameter, as illustrated in Figure 31. No point in the thread surface of the gage should be outside of the zone of tolerance indicated by the shaded portion of the illustration. This column is used when checking gages by measurement.

Column 3 of Table 52 gives the equivalent of column 2, expressed in terms of distance parallel to the axis, and represents the maximum distance which a new working ring gage of correct thickness, or a new working plug gage of correct length from small end to gaging notch, may vary from being flush at the gaging notch, or at the small end, when referred to basic dimensions. It is equal to sixteen times column 2, because of the basic taper of 1 in 16, measured on the diameter. This column is used when checking working gages by comparison with a gage the error of which is known. The necessary allowance must be made for this error.

Column 4 of Table 52 gives the equivalent of column 3, expressed in terms of the decimal part of a turn. This column is also used when checking working gages by comparison with a gage the error of which is known. The necessary allowance must be made for this error.

A tolerance of plus or minus 0.0005 inch is allowed on the distance between the gaging notch and the small end of the working plug gage, or on the thickness of the working ring gage.

It is possible for working plug and ring gages which come within all of the above tolerances to vary from being flush with each other at the small end or at the gaging notch, when screwed together tight by hand. The maximum variation which might occur, expressed in terms of distance, is given in column 5 of Table 52.

It is also possible for working plug and ring gages which come within all of the above tolerances to vary from being flush at the small end or at the gaging notch, when screwed tight by hand on a reference gage which comes within the tolerances specified for reference gages. The maximum variation which might occur, expressed in terms of distance, is given in column 6 of Table 52.

5. *Worn working gages.*—The maximum wear on working gages must not be more than the equivalent of one-half turn from the basic dimensions.

In order that no work passed by the working gage shall be rejected by the inspection gage, it will be necessary to discontinue the use of the working gage when it has worn one-half turn; that is, the working gage should always be kept within the tolerance equivalent of one turn from the basic dimensions.

TABLE 51.—*Tolerances for check (or reference) gages, American National taper pipe threads*

Nominal sizes in inches	Total accumulative tolerance on diameter (see fig. 31)	Equivalent longitudinal variation (16× column 2)	Equivalent angular variation expressed as decimal part of one turn	(1)
1	2	3	4	5
	Inch	*Inch*		*Inch*
1/8	0.00020	0.0032	0.086	0.0068
1/4	.00022	.0035	.063	.0074
3/8	.00024	.0038	.068	.0080
1/2	.00026	.0042	.059	.0088
3/4	.00028	.0045	.063	.0094
1	.00030	.0048	.055	.0100
1 1/4	.00032	.0051	.059	.0106
1 1/2	.00034	.0054	.062	.0112
2	.00036	.0058	.067	.0120
2 1/2	.00038	.0061	.050	.0126
3	.00038	.0061	.050	.0126
3 1/2	.00041	.0066	.053	.0136
4	.00043	.0069	.055	.0142
4 1/2	.00045	.0072	.058	.0148
5	.00047	.0075	.060	.0154
6	.00051	.0082	.065	.0168
7	.00055	.0088	.070	.0180
8	.00059	.0094	.075	.0192
9	.00063	.0101	.080	.0206
10	.00066	.0106	.085	.0216
11	.00070	.0112	.090	.0228
12	.00074	.0118	.095	.0240
14	.00082	.0131	.105	.0266
15	.00086	.0138	.110	.0279
16	.00090	.0144	.115	.0292
17	.00094	.0150	.120	.0305
18	.00098	.0157	.125	.0318
20	.00106	.0170	.135	.0344
22	.00113	.0181	.145	.0366
24	.00121	.0194	.155	.0392
26	.00129	.0206	.165	.0416
28	.00137	.0219	.175	.0442
30	.00144	.0230	.185	.0464

[1] Maximum amount it is possible for plug and ring gages to vary from being flush at small end or at gaging notch when screwed together tight by hand (2 times column 3+0.0004 inch).

TABLE 52.—*Tolerances for inspection and working gages, American National taper pipe threads*

Nominal sizes in inches	Total accumulative tolerance on diameter (see fig. 31)	Equivalent longitudinal variation (16 × column 2)	(1)	(2)	(3)
1	2	3	4	5	6
	Inch	*Inch*		*Inch*	*Inch*
1/8	0.00040	0.0064	0.172	0.0138	0.0103
1/4	.00044	.0070	.126	.0150	.0112
3/8	.00048	.0077	.136	.0164	.0122
1/2	.00052	.0083	.118	.0176	.0132
3/4	.00056	.0090	.126	.0190	.0142
1	.00060	.0096	.110	.0202	.0151
1 1/4	.00064	.0102	.118	.0214	.0160
1 1/2	.00068	.0109	.124	.0228	.0170
2	.00072	.0115	.134	.0240	.0180
2 1/2	.00076	.0122	.100	.0254	.0190
3	.00076	.0122	.100	.0254	.0190
3 1/2	.00082	.0131	.105	.0272	.0204
4	.00086	.0138	.110	.0286	.0214
4 1/2	.00090	.0144	.115	.0298	.0223
5	.00094	.0150	.120	.0310	.0232
6	.00102	.0163	.130	.0336	.0252
7	.00110	.0176	.140	.0362	.0271
8	.00118	.0189	.150	.0388	.0290
9	.00126	.0202	.160	.0414	.0310
10	.00132	.0211	.170	.0432	.0324
11	.00140	.0224	.180	.0458	.0343
12	.00148	.0237	.190	.0484	.0362
14	.00164	.0262	.210	.0534	.0400
15	.00172	.0275	.220	.0560	.0420
16	.00180	.0288	.230	.0586	.0439
17	.00188	.0301	.240	.0611	.0458
18	.00196	.0314	.250	.0638	.0478
20	.00212	.0339	.270	.0688	.0516
22	.00226	.0362	.290	.0734	.0550
24	.00242	.0387	.310	.0784	.0588
26	.00258	.0413	.330	.0836	.0626
28	.00274	.0438	.350	.0886	.0664
30	.00288	.0461	.370	.0932	.0698

[1] Equivalent angular variation expressed as a decimal part of one turn.
[2] Maximum amount it is possible for new working plug and ring gages which come within the specified tolerances to vary from being flush at the small end or at the gaging notch when screwed together tight by hand (2 times column 3+0.0010 inch).
[3] Maximum amount it is possible for new working plug or ring gages which come within specified tolerances to vary from being flush at the small end or at the gaging notch when screwed on reference gage tight by hand. $\left\{\frac{\text{Column 5, Table 51+column 5, Table 52.}}{2}\right\}$

TABLE 53.—*Corrections in diameter for errors in half angle, American National taper pipe thread gages*

Error in half angle of thread in minutes, a'	Correction in diameter, E''				
	8 threads per inch	11 1/2 threads per inch	14 threads per inch	18 threads per inch	27 threads per inch
1	2	3	4	5	6
	Inch	*Inch*	*Inch*	*Inch*	*Inch*
1	0.00006	0.00004	0.00003	0.00002	0.00002
2	.00011	.00008	.00006	.00005	.00003
3	.00017	.00012	.00010	.00007	.00005
4	.00022	.00016	.00013	.00010	.00007
5	.00028	.00019	.00016	.00012	.00008
6	.00034	.00023	.00019	.00015	.00010
7	.00039	.00027	.00022	.00017	.00012
8	.00045	.00031	.00026	.00020	.00013
9	.00050	.00035	.00029	.00022	.00015
10	.00056	.00039	.00032	.00025	.00017

TABLE 53.—*Corrections in diameter for errors in half angle, American National taper pipe thread gages*—Continued

Error in half angle of thread in minutes, a'	Correction in diameter, E''				
	8 threads per inch	11½ threads per inch	14 threads per inch	18 threads per inch	27 threads per inch
1	2	3	4	5	6
	Inch	*Inch*	*Inch*	*Inch*	*Inch*
11	0.00062	0.00043	0.00035	0.00027	0.00018
12	.00067	.00047	.00038	.00030	.00020
13	.00073	.00051	.00042	.00032	.00022
14	.00078	.00054	.00045	.00035	.00023
15	.00084	.00058	.00048	.00037	.00025
16	.00089	.00062	.00051	.00040	.00027
17	.00095	.00066	.00054	.00042	.00028
18	.00101	.00070	.00058	.00045	.00030
19	.00106	.00074	.00061	.00047	.00031
20	.00112	.00078	.00064	.00050	.00033
21	.00117	.00082	.00067	.00052	.00035
22	.00123	.00086	.00070	.00055	.00036
23	.00129	.00089	.00074	.00057	.00038
24	.00134	.00093	.00077	.00060	.00040
25	.00140	.00097	.00080	.00062	.00041
26	.00145	.00101	.00083	.00065	.00043
27	.00151	.00105	.00086	.00067	.00045
28	.00157	.00109	.00089	.00070	.00046
29	.00162	.00113	.00093	.00072	.00048
30	.00168	.00117	.00096	.00075	.00050
45	.00252	.00175	.00144	.00112	.00075
60	.00336	.00233	.00192	.00149	.00099

a' = error in half included angle of thread.
E'' = correction in diameter.
$E''=\frac{1.53812}{n}\times\tan a'$.

TABLE 54.—*Corrections in diameter for errors in lead, 60° threads*

Error in lead in inches, p'	Correction in diameter, E'									
	0.00000	0.00001	0.00002	0.00003	0.00004	0.00005	0.00006	0.00007	0.00008	0.00009
1	2	3	4	5	6	7	8	9	10	11
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
0.00000	0.00000	0.00002	0.00003	0.00005	0.00007	0.00009	0.00010	0.00012	0.00014	0.00016
.00010	.00017	.00019	.00021	.00023	.00024	.00026	.00028	.00029	.00031	.00033
.00020	.00035	.00036	.00038	.00040	.00042	.00043	.00045	.00047	.00048	.00050
.00030	.00052	.00054	.00055	.00057	.00059	.00061	.00062	.00064	.00066	.00068
.00040	.00069	.00071	.00073	.00074	.00076	.00078	.00080	.00081	.00083	.00085
.00050	.00087	.00088	.00090	.00092	.00094	.00095	.00097	.00099	.00100	.00102
.00060	.00104	.00106	.00107	.00109	.00111	.00113	.00114	.00116	.00118	.00120
.00070	.00121	.00123	.00125	.00126	.00128	.00130	.00132	.00133	.00135	.00137
.00080	.00139	.00140	.00142	.00144	.00145	.00147	.00149	.00151	.00152	.00154
.00090	.00156	.00158	.00159	.00161	.00163	.00165	.00166	.00168	.00170	.00171
.00100	.00173	.00175	.00177	.00178	.00180	.00182	.00184	.00185	.00187	.00189
.00110	.00191	.00192	.00194	.00196	.00197	.00199	.00201	.00203	.00204	.00206
.00120	.00208	.00210	.00211	.00213	.00215	.00217	.00218	.00220	.00222	.00223
.00130	.00225	.00227	.00229	.00230	.00232	.00234	.00236	.00237	.00239	.00241
.00140	.00242	.00244	.00246	.00248	.00249	.00251	.00253	.00255	.00256	.00258
.00150	.00260	.00262	.00263	.00265	.00267	.00268	.00270	.00272	.00274	.00275
.00160	.00277	.00279	.00281	.00282	.00284	.00286	.00288	.00289	.00291	.00293
.00170	.00294	.00296	.00298	.00300	.00301	.00303	.00305	.00307	.00308	.00310
.00180	.00312	.00313	.00315	.00317	.00319	.00320	.00322	.00324	.00326	.00327
.00190	.00329	.00331	.00333	.00334	.00336	.00338	.00339	.00341	.00343	.00345
.00200	.00346	.00348	.00350	.00352	.00353	.00355	.00357	.00359	.00360	.00362

p' = error in lead.
E' = correction in diameter.
$E'=1.732\,p'$.

TABLE 55.—*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 diameter 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

[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.

TABLE 55.—*Basic dimensions of threaded plug and ring gages for Amcrican National taper pipe threads*—Continued

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 diameter 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*
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 VII. WOOD SCREWS

This specification summarizes the results of the standardization of wood screws by the manufacturers in cooperation with the Bureau of Standards and the technical committee on builders' hardware of the Federal Specifications Board. It has been officially adopted by the Federal Specifications Board for the use of all departments and independent establishments of the Government in the purchase of wood screws, and published as Circular No. 140 of the Bureau of Standards, second edition, issued October 8, 1927.

The former difference of 0.013165 inch in diameter, used as a basis for the arithmetical progression of the numbering system, has been discarded in favor of a difference of 0.013 inch (even) as established by the commission for machine screws. This provides interchangeability for the numbered sizes of machine screws and wood screws in connection with articles that may be fastened either to metal or wood.

Flat, round, and oval head types are covered in the specification.

The numbered sizes of wood screws run consecutively from No. 0 (0.060 inch) to No. 24 (0.372 inch), omitting Nos. 13, 15, 17, 19, 21, 22, and 23.

1. GENERAL SPECIFICATIONS

(*a*) Types.—Wood screws shall be furnished in three types; namely, flat, round, or oval head, as specified.

(*b*) Material and Workmanship.—Wood screws shall be made of steel or brass, as specified, and shall be free from any defects which would affect their serviceability.

(*c*) Measurement of Lengths.—The length of all screws shall be measured from the largest diameter of bearing surface of the head to the extreme end of the point measured parallel to the axis of the screw.

(*d*) Measurement of Diameters.—The diameter shall be measured on the body of the screw under the head.

(*e*) Tolerance on Diameter.—The maximum variation on diameter permitted is from +0.004 to −0.007 inch.

(*f*) Tolerance on Number of Threads per Inch.—The maximum variations in the number of threads per inch permitted are plus or minus 10 per cent.

(*g*) Points.—Standard screws shall be furnished with gimlet points. Cone and diamond pointed screws are special.

(*h*) Finish.—Wood screws shall be furnished plain, uncoated, unless blued, nickel plated, or other special finish is specified.

(*i*) Head Proportions and Length of Thread.—The proportions of the head and length of thread shall be as indicated in Figure 32 and Tables 56, 57, and 58.

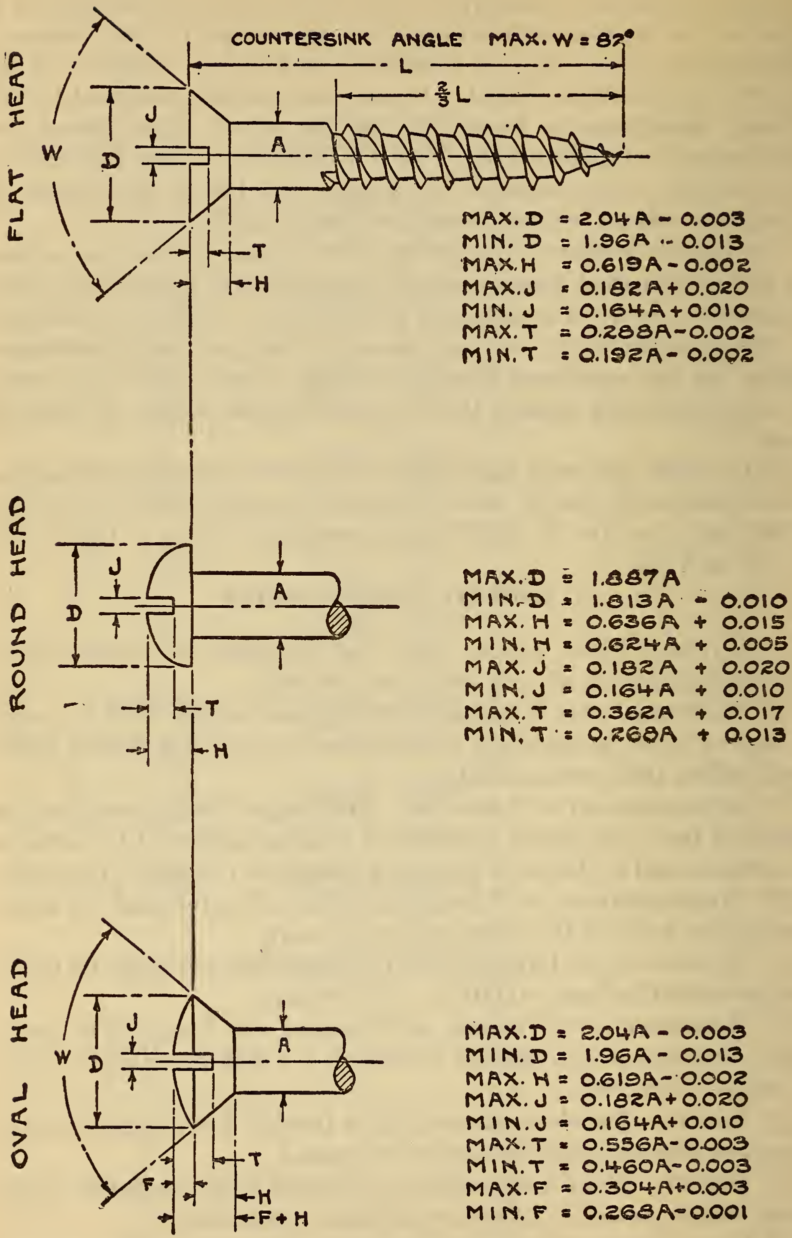


FIG. 32.—*Wood screws*

TABLE 56.—*Head proportions of flat-head wood screws*

Nominal size	A	D		H	J		T	
	Diameter	Head diameter		Height of head, maximum	Width of slot		Depth of slot	
		Maximum	Minimum		Maximum	Minimum	Maximum	Minimum
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
0	0.060	0.119	0.105	0.035	0.031	0.020	0.015	0.010
1	.073	.146	.130	.043	.033	.022	.019	.012
2	.086	.172	.156	.051	.036	.024	.023	.015
3	.099	.199	.181	.059	.038	.026	.027	.017
4	.112	.225	.207	.067	.040	.028	.030	.020
5	.125	.252	.232	.075	.043	.031	.034	.022
6	.138	.279	.257	.083	.045	.033	.038	.024
7	.151	.305	.283	.091	.047	.035	.041	.027
8	.164	.332	.308	.100	.050	.037	.045	.029
9	.177	.358	.334	.108	.052	.039	.049	.032
10	.190	.385	.359	.116	.055	.041	.053	.034
11	.203	.411	.385	.124	.057	.043	.056	.037
12	.216	.438	.410	.132	.059	.045	.060	.039
14	.242	.491	.461	.148	.064	.050	.068	.044
16	.268	.544	.512	.164	.069	.054	.075	.049
18	.294	.597	.563	.180	.074	.058	.083	.054
20	.320	.650	.614	.196	.078	.062	.090	.059
24	.372	.756	.716	.228	.088	.071	.105	.069

TABLE 57.—*Head proportions of round-head wood screws*

Nominal size	A	D		H		J		T	
	Diameter	Head diameter		Height of head		Width of slot		Depth of slot	
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
0	0.060	0.113	0.099	0.053	0.042	0.031	0.020	0.039	0.029
1	.073	.138	.122	.061	.051	.033	.022	.043	.033
2	.086	.162	.146	.070	.059	.036	.024	.048	.036
3	.099	.187	.169	.078	.067	.038	.026	.053	.040
4	.112	.211	.193	.086	.075	.040	.028	.058	.043
5	.125	.236	.217	.095	.083	.043	.031	.062	.047
6	.138	.260	.240	.103	.091	.045	.033	.067	.050
7	.151	.285	.264	.111	.099	.047	.035	.072	.053
8	.164	.309	.287	.119	.107	.050	.037	.076	.057
9	.177	.334	.311	.128	.115	.052	.039	.081	.060
10	.190	.359	.334	.136	.124	.055	.041	.086	.064
11	.203	.383	.358	.144	.132	.057	.043	.090	.067
12	.216	.408	.382	.152	.140	.059	.045	.095	.071
14	.242	.457	.429	.169	.156	.064	.050	.105	.078
16	.268	.506	.476	.185	.172	.069	.054	.114	.085
18	.294	.555	.523	.202	.188	.074	.058	.123	.092
20	.320	.604	.570	.219	.205	.078	.062	.133	.099
24	.372	.702	.664	.252	.237	.088	.071	.152	.113

TABLE 58.—*Head proportions of oval-head wood screws*

Nominal size	A	D		H	J		T		F		F+H	
	Diameter	Head diameter		Height of head	Width of slot		Depth of slot		Height of oval		Maximum	Minimum
		Maximum	Minimum	Maximum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum		
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
0	0.060	0.119	0.105	0.035	0.031	0.020	0.030	0.025	0.021	0.015	0.056	0.041
1	.073	.146	.130	.043	.033	.022	.038	.031	.025	.019	.068	.052
2	.086	.172	.156	.051	.036	.024	.045	.037	.029	.022	.080	.062
3	.099	.199	.181	.059	.038	.026	.052	.043	.033	.026	.092	.074
4	.112	.225	.207	.067	.040	.028	.059	.049	.037	.029	.104	.084
5	.125	.252	.232	.075	.043	.031	.067	.055	.041	.033	.116	.095
6	.138	.279	.257	.083	.045	.033	.074	.060	.045	.036	.128	.105
7	.151	.305	.283	.091	.047	.035	.081	.066	.049	.039	.140	.115
8	.164	.332	.308	.100	.050	.037	.088	.072	.053	.043	.153	.127
9	.177	.358	.334	.108	.052	.039	.095	.078	.057	.046	.165	.137
10	.190	.385	.359	.116	.055	.041	.103	.084	.061	.050	.177	.148
11	.203	.411	.385	.124	.057	.043	.110	.090	.065	.053	.189	.158
12	.216	.438	.410	.132	.059	.045	.117	.096	.069	.057	.201	.169
14	.242	.491	.461	.148	.064	.050	.132	.108	.077	.064	.225	.191
16	.268	.544	.512	.164	.069	.054	.146	.120	.084	.071	.248	.212
18	.294	.597	.563	.180	.074	.058	.160	.132	.092	.078	.272	.233
20	.320	.650	.614	.196	.078	.062	.175	.144	.100	.085	.296	.254
24	.372	.756	.716	.228	.088	.071	.204	.168	.116	.099	.344	.297

(*j*) INCLUDED ANGLE.—The included angle of the head on flat and oval head screws shall be 82°, with permissible variations of +0° and −2°.

2. THREAD SERIES

The numbered screw sizes, basic and limiting diameters, and threads per inch given in Table 59 are standard.

TABLE 59.—*American National wood screw standard size numbers, diameters, and pitches*

Number of screw	Threads per inch	Diameter			Number of screw	Threads per inch	Diameter		
		Basic	Maximum	Minimum			Basic	Maximum	Minimum
		Inch	*Inch*	*Inch*			*Inch*	*Inch*	*Inch*
0	32	0.060	0.064	0.053	10	13	0.190	0.194	0.185
1	28	.073	.077	.066	11	12	.203	.207	.196
2	26	.086	.090	.079	12	11	.216	.220	.209
3	24	.099	.103	.092	14	10	.242	.246	.235
4	22	.112	.116	.105	16	9	.268	.272	.261
5	20	.125	.129	.118	18	8	.294	.298	.287
6	18	.138	.142	.131	20	8	.320	.324	.313
7	16	.151	.155	.144	24	7	.372	.376	.365
8	15	.164	.168	.157					
9	14	.177	.181	.170					

3. TOLERANCES ON LENGTH

(*a*) FLAT AND OVAL HEAD SCREWS.—The maximum variations permitted in the length of flat and oval head screws are given in Table 60.

(*b*) ROUND-HEAD SCREWS.—The maximum variations permitted in the length of round-head screws are given in Table 61.

TABLE 60.—*Tolerances on length of flat and oval head screws* [1]

Nominal length in inches	Minus tolerance	Nominal length in inches	Minus tolerance
	Inch		*Inch*
1/4	0.031	2	0.060
3/8	.033	2 1/4	.064
1/2	.035	2 1/2	.068
5/8	.037	2 3/4	.072
3/4	.039	3	.076
7/8	.041	3 1/2	.084
1	.043	4	.092
1 1/4	.048	4 1/2	.101
1 1/2	.052	5	.109
1 3/4	.056		

[1] Plus tolerance=0.

TABLE 61.—*Tolerances on length of round-head screws* [1]

Nominal length in inches	Screw numbers								
	0	1	2	3	4	5	6	7	8
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1/4	0.064	0.071	0.077	0.084	0.090	------	------	------	------
3/8	.065	.073	.079	.086	.092	0.099	0.105	0.112	0.118
1/2	------	.075	.081	.088	.094	.101	.107	.114	.120
5/8	------	------	.083	.090	.096	.103	.109	.116	.122
3/4	------	------	.085	.092	.098	.105	.111	.118	.124
7/8	------	------	------	.094	.100	.107	.113	.120	.126
1	------	------	------	.096	.102	.109	.115	.122	.128
1 1/4	------	------	------	------	.106	.113	.119	.126	.132
1 1/2	------	------	------	------	.110	.117	.123	.130	.136
1 3/4	------	------	------	------	------	------	.127	.134	.140
2	------	------	------	------	------	------	.131	.138	.144
2 1/4	------	------	------	------	------	------	.135	.142	.148
2 1/2	------	------	------	------	------	------	.139	.146	.152
2 3/4	------	------	------	------	------	------	------	------	.156

Nominal length in inches	Screw numbers								
	9	10	11	12	14	16	18	20	24
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1/2	0.127	0.133	------	------	------	------	------	------	------
5/8	.129	.135	0.142	0.148	------	------	------	------	------
3/4	.131	.137	.144	.150	0.163	------	------	------	------
7/8	.133	.139	.146	.152	.165	------	------	------	------
1	.135	.141	.148	.154	.167	0.180	------	------	------
1 1/4	.139	.145	.152	.158	.171	.184	0.198	------	------
1 1/2	.143	.149	.156	.162	.175	.188	.202	0.215	------
1 3/4	.147	.153	.160	.166	.179	.192	.206	.219	------
2	.151	.157	.164	.170	.183	.196	.210	.223	------
2 1/4	.155	.161	.168	.174	.187	.200	.214	.227	------
2 1/2	.159	.165	.172	.178	.191	.204	.218	.231	------
2 3/4	.163	.169	.176	.182	.195	.208	.222	.235	------
3	.167	.173	.180	.186	.199	.212	.226	.239	0.265
3 1/2	------	.181	.188	.194	.207	.220	.234	.247	.273
4	------	------	------	.202	.215	.228	.242	.255	.281
4 1/2	------	------	------	------	.223	.236	.250	.263	.289
5	------	------	------	------	.231	.244	.258	.271	.297

[1] Plus tolerance=0. Minus tolerances as given in body of table.

4. AMERICAN NATIONAL STANDARD SIZES OF WOOD SCREWS

(*a*) Steel Screws.—The standard sizes of steel screws are given in Table 62.

(*b*) Brass Screws.—The standard sizes of brass screws are given in Table 63.

Table 62.—*Standard sizes of steel screws*

[F, flat head; R, round head; O, oval head]

Lengths (inches)	No. 0 diameter, 0.060 inch	No. 1 diameter, 0.073 inch	No. 2 diameter, 0.086 inch	No. 3 diameter, 0.099 inch	No. 4 diameter, 0.112 inch	No. 5 diameter, 0.125 inch	No. 6 diameter, 0.138 inch	No. 7 diameter, 0.151 inch	No. 8 diameter, 0.164 inch
1/4	FR	FR	FR	FR	FR	--------	--------	--------	--------
3/8	FR	FR	FR	FRO	FRO	FR	FR	FR	FR
1/2	--------	FR	FR	FR	FRO	FRO	FRO	FRO	FRO
5/8	--------	--------	FR	FR	FRO	FRO	FRO	FRO	FRO
3/4	--------	--------	FR	FR	FRO	FRO	FRO	FRO	FRO
7/8	--------	--------	--------	FR	FR	FR	FR	FRO	FRO
1	--------	--------	--------	FR	FR	FRO	FRO	FRO	FRO
1 1/4	--------	--------	--------	--------	FR	FR	FRO	FRO	FRO
1 1/2	--------	--------	--------	--------	FR	FR	FRO	FRO	FRO
1 3/4	--------	--------	--------	--------	--------	--------	FRO	FRO	FRO
2	--------	--------	--------	--------	--------	--------	FR	FR	FR
2 1/4	--------	--------	--------	--------	--------	--------	FR	FR	FR
2 1/2	--------	--------	--------	--------	--------	--------	FR	FR	FR
2 3/4	--------	--------	--------	--------	--------	--------	--------	--------	FR

Lengths (inches)	No. 9 diameter, 0.177 inch	No. 10 diameter, 0.190 inch	No. 11 diameter, 0.203 inch	No. 12 diameter, 0.216 inch	No. 14 diameter, 0.242 inch	No. 16 diameter, 0.268 inch	No. 18 diameter, 0.294 inch	No. 20 diameter, 0.320 inch	No. 24 diameter, 0.372 inch
1/2	FR	FR	--------	--------	--------	--------	--------	--------	--------
5/8	FR	FR	FR	FR	--------	--------	--------	--------	--------
3/4	FRO	FRO	FR	FR	--------	--------	--------	--------	--------
7/8	FRO	FRO	FR	FRO	FR	--------	--------	--------	--------
1	FRO	FRO	FRO	FRO	FRO	FR	--------	--------	--------
1 1/4	FRO	FRO	FRO	FRO	FRO	FR	FR	--------	--------
1 1/2	FRO	FRO	FRO	FRO	FRO	FRO	FRO	FRO	--------
1 3/4	FRO	FRO	FRO	FRO	FRO	FRO	FRO	FRO	--------
2	FR	FRO	FRO	FRO	FRO	FRO	FRO	FRO	--------
2 1/4	FR	FR	FR	FRO	FRO	FR	F	F	--------
2 1/2	FR	FR	FR	FRO	FRO	FR	FR	FR	--------
2 3/4	FR	FR	F	FR	FR	F	F	F	--------
3	FR	FR	F	FR	FR	FR	FR	F	F
3 1/2	--------	FR	F	FR	FR	FR	F	F	F
4	--------	--------	--------	FR	FR	FR	F	F	F
4 1/2	--------	--------	--------	--------	F	F	F	F	F
5	--------	--------	--------	--------	F	F	F	F	F

TABLE 63.—*Standard sizes of brass screws*

[F, flat head; R, round head; O, oval head]

Lengths (inches)	No. 0 diameter, 0.060 inch	No. 1 diameter, 0.073 inch	No. 2 diameter, 0.086 inch	No. 3 diameter, 0.099 inch	No. 4 diameter, 0.112 inch	No. 5 diameter, 0.125 inch	No. 6 diameter, 0.138 inch	No. 7 diameter, 0.151 inch
¼	FRO	FRO	FRO	FRO	FRO	--------	--------	--------
⅜	FRO	FRO	FRO	FRO	FRO	FRO	FRO	--------
½	--------	FRO	FRO	FRO	FRO	FRO	FRO	FRO
⅝	--------	--------	FRO	FRO	FRO	FRO	FRO	FRO
¾	--------	--------	FRO	FRO	FRO	FRO	FRO	FRO
⅞	--------	--------	--------	--------	FRO	FRO	FRO	FRO
1	--------	--------	--------	--------	FRO	FRO	FRO	FRO
1¼	--------	--------	--------	--------	--------	--------	FRO	FRO
1½	--------	--------	--------	--------	--------	--------	FRO	FRO

Lengths (inches)	No. 8 diameter, 0.164 inch	No. 9 diameter, 0.177 inch	No. 10 diameter, 0.190 inch	No. 11 diameter, 0.203 inch	No. 12 diameter, 0.216 inch	No. 14 diameter, 0.242 inch	No. 16 diameter, 0.268 inch	No. 18 diameter, 0.294 inch
½	FRO	--------	--------	--------	--------	--------	--------	--------
⅝	FRO	FRO	FRO	--------	--------	--------	--------	--------
¾	FRO	FRO	FRO	FR	FRO	--------	--------	--------
⅞	FRO	FRO	FRO	FR	FR	--------	--------	--------
1	FRO	FRO	FRO	FR	FRO	FRO	--------	--------
1¼	FRO	FRO	FRO	FR	FRO	FRO	--------	--------
1½	FRO	FRO	FRO	FR	FRO	FRO	--------	--------
1¾	FRO	FRO	FRO	FR	FRO	FRO	--------	--------
2	FRO	FRO	FRO	FR	FRO	FRO	F	F
2¼	--------	--------	FR	FR	FR	FR	F	F
2½	--------	--------	FR	FR	FR	FR	F	F
3	--------	--------	--------	--------	FR	FR	F	F
3½	--------	--------	--------	--------	F	F	F	F

SECTION VIII. AMERICAN NATIONAL SCREW, BOLT, AND NUT PROPORTIONS

Section VIII A. Wrench Head Bolts and Nuts, and Wrench Openings

A project to which the commission gave early attention was the standardization of bolt and nut proportions, particularly as to the widths across flats, because of the desirability of reducing the number of sizes of bar stock, dies, and wrenches necessary. 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 the standards for wrench-head bolts and nuts which are given below. This standard, in substantially the same form, is published as report No. B 18b–1926 of the American Standards Association.

These sizes of bolt heads and nuts are intended to supersede all existing standards which have grown up for commercial standard bolt heads and nuts. Through simplification of outside dimensions of bolt heads and nuts by eliminating thirty-second-inch sizes, and elimination of sizes little used, it has been possible to reduce the number of wrench openings required.

In all cases the basic widths across flats of bolt heads and nuts are taken as maximum sizes and the tolerances on bolt heads and nuts are minus only. The minimum wrench openings are made to provide a positive clearance between maximum nut and minimum wrench, and the tolerances on wrench openings are plus only. This insures a fit of the wrench to the bolt head and nut, whereas the tolerances allowed are as great as possible without causing the deformation of the corners of bolt heads or nuts by the wrenches.

1. GENERAL REQUIREMENTS

(*a*) Workmanship.—It is recommended that workmanship be compatible with the type and grade of product, and class of fit and of finish specified; and that the product be free from abnormal scale, fins, seams, or other defects.

(*b*) Screw Threads.—The form of thread profile is the American National form and the diameters and threads per inch are those specified as the American National coarse-thread series, or the American National fine-thread series, as given in Section III.[21]

(*c*) Body Diameters.—The dimensions and tolerances for body diameter of bolts and screws are given in Tables 64 and 65.

(*d*) Tolerance on Length.—The length of all bolts and screws up to and including 6 inches in length does not vary from the nominal length by more than ± 1/32 inch; and the length of all bolts and screws more than 6 inches in length does not vary from the nominal length by more than ± 1/16 inch.

(*e*) Bolt and Screw Lengths.—Bolts and screws, except for special requirements, should be ordered in the following increments of length:

Length	Increment
Inches	*Inches*
1/16 to 1/2	1/16
Over 1/2 to 1 1/4	1/8
Over 1 1/4 to 3 1/2	1/4
Over 3 1/2 to 6	1/2
Over 6 to 10	1
Over 10	2

2. MACHINE BOLTS

Machine bolts are regularly furnished one-fourth inch and over in diameter and with hexagon or square heads. They are furnished with square or hexagon nuts. They are threaded for a length dependent upon the diameter and length.

[21] See Appendix 6, p. 241, for common practice as to thread series and class of fit.

The length of a machine bolt is the measurement from the extreme point to the bearing surface of the head. The length of thread is measured from the extreme point to the last perfect thread.

The tops of bolt heads are flat and chamfered; the maximum angle of chamfer with the top surface is 30°, and the diameter of the top flat circle is from 85 to 100 per cent of the width across flats.

The width across flats of bolt heads is measured at the widest point. The taper of the sides of bolt heads does not exceed 4°.

Bolt heads are concentric with the body within a tolerance of 3 per cent of the width across flats.

The minimum lengths of thread, unless otherwise specified, are given in Table 66.

The thickness of the head is the distance from the top to the bearing surface.

(*a*) Rough and Semifinished Bolts.—Rough bolts are made by cold or hot pressing, punching, or forging. They are threaded but not machined.

Semifinished bolts are those which meet the tolerances prescribed without regard to the amount of machining needed to meet such tolerances, except that the bearing surfaces are finished smooth.

The dimensions of rough and semifinished bolts are given in Table 67.

Rough and semifinished bolt heads are at right angles to the body within 3°.

(*b*) Finished Bolts.—Finished bolts and nuts are machined all over, and threaded.

The dimensions of finished bolts are given in Table 68.

Finished bolt heads are at right angles to the body within 2°.

All finished bolts are washer faced. The thickness of the washer face is about one sixty-fourth inch. The diameter of the bearing surface of the washer face is equal to the width across flats within plus or minus 5 per cent.

3. TAP BOLTS

Tap bolts are the same as machine bolts, except that they are threaded to the head, and they may be used interchangeably. Tap bolts are regularly furnished in the coarse thread series one-fourth inch and over in diameter, without nuts, and with square or hexagon heads. The length of bolt is measured from the extreme point to the bearing surface of the head.

4. NUTS

Nuts are commonly either hot forged, cold punched, or machined from bar stock.

The tops of regular square and hexagon nuts when not castellated, of jam nuts, square and hexagon machine screw nuts, and of hexagon light nuts when not castellated, are flat and chamfered; the maximum angle of chamfer with the top surface is 30°; and the diameter of the top flat circle is from 85 to 100 per cent of the width across flats.

The width across flats of nuts is measured at the widest point. The taper of sides of nuts does not exceed 4°.

All finished hexagon and square regular nuts, castellated nuts, and hexagon light nuts are washer faced. The thickness of the washer face, including that of jam nuts having a washer face, is about one sixty-fourth inch. The diameter of the bearing surface of the washer face is equal to the width across flats within plus or minus 5 per cent. The thickness of the nut is the distance from the top to the bearing surface.

(*a*) Rough and Semifinished Regular Nuts.—Rough nuts are made by cold or hot pressing, punching, or forging. They are threaded but not machined.

Semifinished nuts are those which meet the tolerances prescribed without regard to the amount of machining needed to meet such tolerances, except that the bearing surfaces are finished smooth.

The dimensions of rough and semifinished square and hexagon regular nuts are given in Table 69.

Semifinished nuts are faced on the bearing surface and are at right angles to the axis of the threaded hole within 3°.

(*b*) Finished Regular Nuts.—The dimensions of finished square and hexagon regular nuts are given in Table 70.

The axis of the threaded hole is at right angles to the washer face within a tolerance of 2°.

(*c*) Castellated Nuts.—The dimensions of castellated nuts are given in Table 71.

The axis of the threaded hole is at right angles to the washer face within a tolerance of 2°.

(*d*) Finished and Semifinished Jam Nuts.—The dimensions of finished and semifinished jam nuts are given in Table 72. Jam nuts are either single or double chamfered as specified. If a single chamfer is specified, the opposite side is washer faced.

The axis of the threaded hole is at right angles to the washer or finished face within a tolerance of 2°.

(*e*) Hexagon Light Nuts.—The dimensions of hexagon light nuts are given in Table 73.

(*f*) Hexagon and Square Machine Screw Nuts and Square Stove Bolt Nuts.—The dimensions of hexagon and square machine screw nuts and square stove bolt nuts are given in Table 74.

Machine screw nuts, when made from hexagon bar stock, are faced on the bearing surface and this surface is at right angles to the axis of the threaded hole within 5°.

5. HEXAGON-HEAD CAP SCREWS

Cap screws are usually manufactured by upsetting or by machining. They are usually threaded definite lengths for each diameter irrespective of length of screw. They are furnished without nuts. The smallest diameter regularly furnished is one-fourth inch.

The length of cap screws is measured from the bearing surface of the head to the extreme point. The length of thread is measured from the extreme point to the last perfect thread.

The head is at right angles to the body within 2°, and concentric with the body within a tolerance of 3 per cent of the width across flats.

Cap screws 1 inch in length and under are threaded from the extreme point to the head. For cap screws longer than 1 inch, the minimum length of thread is one and one-half times the diameter plus one-fourth inch.

The dimensions of finished hexagon-head cap screws are given in Table 75.

The tops are smooth, flat, and chamfered; the maximum angle of chamfer with the top surface is 30°; and the diameter of the top flat circle is from 85 to 100 per cent of the width across flats.

All finished hexagon cap screw heads are washer faced. The thickness of the washer face is about one sixty-fourth inch. The diameter of the bearing surface of the washer face is equal to the width across flats within plus or minus 5 per cent. The thickness of the head is the distance from the top to the bearing surface.

6. WRENCH OPENINGS

Wrench openings for open-end wrenches are given in Table 76. The sizes given in the table for the maximum and minimum columns are sizes of "go" and "not go" gage blocks used for inspecting wrenches and are not product sizes.

Wrenches should be marked with the basic width across flats (maximum width of nut), as shown in column 1.

Table 64.—*Body diameters of bolts and screws, American National coarse-thread series*

Sizes	Class 1, loose fit		Class 2, free fit[1]; class 3, medium fit; class 4, close fit		Class 2, free fit, threaded parts of unfinished, hot-rolled material
	Maximum	Minimum	Maximum	Minimum	Minimum
1	2	3	4	5	6
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
1	0.0723	0.0671	0.0730	0.0692	0.0678
2	.0852	.0796	.0860	.0820	.0804
3	.0981	.0919	.0990	.0946	.0928
4	.1110	.1042	.1120	.1072	.1052
5	.1240	.1172	.1250	.1202	.1182
6	.1369	.1293	.1380	.1326	.1304
8	.1629	.1553	.1640	.1586	.1564
10	.1887	.1795	.1900	.1834	.1808
12	.2147	.2055	.2160	.2094	.2068
¼	.2485	.2383	.2500	.2428	.2398
5/16	.3109	.2995	.3125	.3043	.3011
⅜	.3732	.3606	.3750	.3660	.3624
7/16	.4354	.4214	.4375	.4277	.4235
½	.4978	.4830	.5000	.4896	.4852
9/16	.5601	.5443	.5625	.5513	.5467
⅝	.6224	.6054	.6250	.6132	.6080
¾	.7472	.7288	.7500	.7372	.7316
⅞	.8719	.8519	.8750	.8610	.8550
1	.9966	.9744	1.0000	.9848	.9778
1⅛	1.1211	1.0963	1.1250	1.1080	1.1002
1¼	1.2461	1.2213	1.2500	1.2330	1.2252
1½	1.4956	1.4666	1.5000	1.4798	1.4710
1¾	1.7448	1.7110	1.7500	1.7268	1.7162
2	1.9943	1.9575	2.0000	1.9746	1.9632
2¼	2.2443	2.2075	2.2500	2.2246	2.2132
2½	2.4936	2.4528	2.5000	2.4720	2.4592
2¾	2.7436	2.7028	2.7500	2.7220	2.7092
3	2.9936	2.9528	3.0000	2.9720	2.9592

[1] For class 2, free fit, these minimum values apply only to semifinished and finished bolts and screws.

Table 65.—*Body diameters of bolts and screws, American National fine-thread series*

Sizes	Class 1, loose fit		Class 2, free fit; class 3, medium fit; class 4, close fit		Sizes	Class 1, loose fit		Class 2, free fit; class 3, medium fit; class 4, close fit	
	Maximum	Minimum	Maximum	Minimum		Maximum	Minimum	Maximum	Minimum
1	2	3	4	5	1	2	3	4	5
	Inch	*Inch*	*Inch*	*Inch*		*Inches*	*Inches*	*Inches*	*Inches*
0	0.0593	0.0545	0.0600	0.0566	9/16	0.5609	0.5495	0.5625	0.5543
1	.0723	.0673	.0730	.0694	⅝	.6234	.6120	.6250	.6168
2	.0853	.0801	.0860	.0822	¾	.7482	.7356	.7500	.7410
3	.0982	.0926	.0990	.0950	⅞	.8729	.8589	.8750	.8652
4	.1111	.1049	.1120	.1076	1	.9979	.9839	1.0000	.9902
5	.1241	.1177	.1250	.1204	1⅛	1.1226	1.1068	1.1250	1.1138
6	.1370	.1302	.1380	.1332	1¼	1.2476	1.2318	1.2500	1.2388
8	.1629	.1557	.1640	.1590	1½	1.4976	1.4818	1.5000	1.4888
10	.1889	.1813	.1900	.1846	1¾	1.7472	1.7288	1.7500	1.7372
12	.2148	.2062	.2160	.2098	2	1.9972	1.9788	2.0000	1.9872
¼	.2488	.2402	.2500	.2438	2¼	2.2466	2.2244	2.2500	2.2348
5/16	.3112	.3020	.3125	.3059	2½	2.4966	2.4744	2.5000	2.4848
⅜	.3737	.3645	.3750	.3684	2¾	2.7466	2.7244	2.7500	2.7348
7/16	.4360	.4258	.4375	.4303	3	2.9966	2.9744	3.0000	2.9848
½	.4985	.4883	.5000	.4928					

TABLE 66.—*Minimum length of threaded portion of machine and tap bolts*

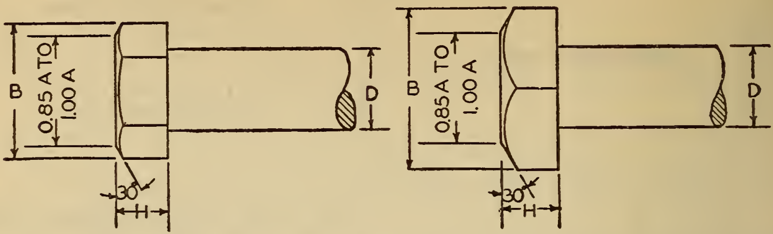
Length of bolt, L (inches)	Diameter of bolt, D (inches)					
	¼	5/16	⅜	7/16	½	9/16
	Length of threaded part, l					
1	2	3	4	5	6	7
	Inch	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*
1 to 1½	¾	¾	⅞	⅞	1	1
1⅝ to 2	⅞	⅞	1	1	1	1
2⅛ to 2½	1	1	1	1	1	1
2⅝ to 3	1	1	1	1	1	1
3⅛ to 4	1	1	1¼	1¼	1¼	1¼
4⅛ to 8	1	1	1¼	1¼	1¼	1¼
8⅛ to 12	1	1	1¼	1¼	1½	1½
12⅛ to 20	1	1	1½	1½	2	2

Length of bolt, L (inches)	Diameter of bolt, D (inches)					
	⅝	¾	⅞	1	1⅛	1¼
	Length of threaded part, l					
1	8	9	10	11	12	13
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1 to 1½	1¼	--------	--------	--------	--------	--------
1⅝ to 2	1¼	1½	1¾	--------	--------	--------
2⅛ to 2½	1¼	1½	1¾	1¾	--------	--------
2⅝ to 3	1¼	1½	1¾	2	2¼	--------
3⅛ to 4	1½	1½	1¾	2	2½	2½
4⅛ to 8	1½	1¾	2	2¼	2¾	3
8⅛ to 12	1¾	2	2¼	2½	3	3¼
12⅛ to 20	2	2	2½	3	3¼	3½

NOTE.—Machine bolts under 1 inch in length are threaded to the head. Machine bolts of any diameter, over 20 inches in length, and bolts over 1¼ inches in diameter, if length permits, are threaded a length equal to three times the diameter unless otherwise specified.

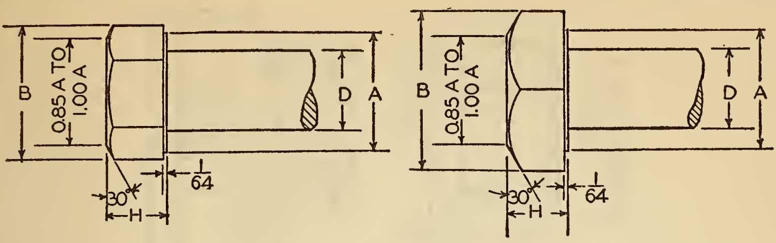
18415°—29——10

Table 67.—*Dimensions of rough and semifinished square and hexagon machine and tap bolt heads*



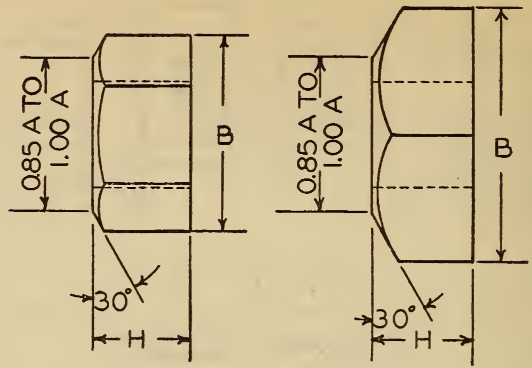
D	A		B		H		
Sizes	Width across flats		Minimum width across corners		Height		
	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
1	2	3	4	5	6	7	8
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1/4	0.3750	0.363	0.414	0.498	11/64	0.188	0.156
5/16	.5000	.484	.552	.665	13/64	.220	.186
3/8	.5625	.544	.620	.747	1/4	.268	.232
7/16	.6250	.603	.687	.828	19/64	.316	.278
1/2	.7500	.725	.827	.995	21/64	.348	.308
9/16	.8750	.847	.966	1.163	3/8	.396	.354
5/8	.9375	.906	1.033	1.244	27/64	.444	.400
3/4	1.1250	1.088	1.240	1.494	1/2	.524	.476
7/8	1.3125	1.269	1.447	1.742	19/32	.620	.568
1	1.5000	1.450	1.653	1.991	21/32	.684	.628
1 1/8	1.6875	1.631	1.859	2.239	3/4	.780	.720
1 1/4	1.8750	1.813	2.067	2.489	27/32	.876	.812
1 1/2	2.2500	2.175	2.480	2.986	1	1.036	.964
1 3/4	2.6250	2.538	2.893	3.485	1 5/32	1.196	1.116
2	3.0000	2.900	3.306	3.982	1 11/32	1.388	1.300
2 1/4	3.3750	3.263	3.720	4.480	1 1/2	1.548	1.452
2 1/2	3.7500	3.625	4.133	4.977	1 21/32	1.708	1.604
2 3/4	4.1250	3.988	4.546	5.476	1 53/64	1.885	1.773
3	4.5000	4.350	4.959	5.973	2	2.060	1.940

TABLE 68.—*Dimensions of finished square and hexagon machine and tap bolt heads*



D	A		B		H		
Sizes	Width across flats		Minimum width across corners		Height		
	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
1	2	3	4	5	6	7	8
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
¼	0.4375	0.428	0.488	0.588	3/16	0.194	0.180
5/16	.5625	.552	.629	.758	15/64	.242	.227
⅜	.6250	.613	.699	.842	9/32	.289	.273
7/16	.7500	.737	.840	1.012	21/64	.337	.319
½	.8125	.799	.911	1.097	⅜	.385	.365
9/16	.8750	.861	.982	1.182	27/64	.433	.411
⅝	.9375	.922	1.051	1.266	15/32	.481	.457
¾	1.1250	1.108	1.263	1.521	9/16	.576	.549
⅞	1.3125	1.293	1.474	1.775	21/32	.672	.641
1	1.5000	1.479	1.686	2.031	¾	.768	.733
1⅛	1.6875	1.665	1.898	2.286	27/32	.863	.824
1¼	1.8750	1.850	2.109	2.540	15/16	.959	.916
1½	2.2500	2.222	2.533	3.051	1⅛	1.150	1.100
1¾	2.6250	2.593	2.956	3.560	1 5/16	1.341	1.284
2	3.0000	2.964	3.379	4.070	1½	1.533	1.468
2¼	3.3750	3.335	3.802	4.579	1 11/16	1.724	1.651
2½	3.7500	3.707	4.226	5.090	1⅞	1.915	1.835
2¾	4.1250	4.078	4.649	5.599	2 1/16	2.106	2.019
3	4.5000	4.449	5.072	6.108	2¼	2.298	2.203

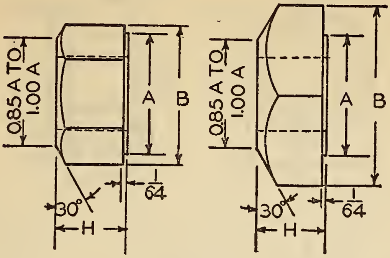
TABLE 69.—*Dimensions of rough and semifinished square and hexagon regular nuts*



D	A		B		H		
Sizes	Width across flats		Minimum width across corners		Thickness		
	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
1	2	3	4	5	6	7	8
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
¼	0.4375	0.425	0.485	0.584	7/32	0.235	0.203
5/16	.5625	.547	.624	.751	17/64	.283	.249
⅜	.6250	.606	.691	.832	21/64	.346	.310
7/16	.7500	.728	.830	1.000	⅜	.394	.356
½ [1]	.8125	.788	.898	1.082	7/16	.458	.418
9/16 [1]	.8750	.847	.966	1.163	31/64	.505	.463
⅝ [1]	.9375	.906	1.033	1.244	35/64	.569	.525
¾	1.1250	1.088	1.240	1.494	21/32	.680	.632
⅞	1.3125	1.269	1.447	1.742	49/64	.792	.740
1	1.5000	1.450	1.653	1.991	⅞	.903	.847
1⅛	1.6875	1.631	1.859	2.239	1	1.030	.970
1¼	1.8750	1.813	2.067	2.489	1 3/32	1.126	1.062
1½	2.2500	2.175	2.480	2.986	1 5/16	1.349	1.277
1¾	2.6250	2.538	2.893	3.485	1 17/32	1.571	1.491
2	3.0000	2.900	3.306	3.982	1¾	1.794	1.706
2¼	3.3750	3.263	3.720	4.480	1 31/32	2.017	1.921
2½	3.7500	3.625	4.133	4.977	2 3/16	2.240	2.136
2¾	4.1250	3.988	4.546	5.476	2 13/32	2.350	2.462
3	4.5000	4.350	4.959	5.973	2⅝	2.685	2.565

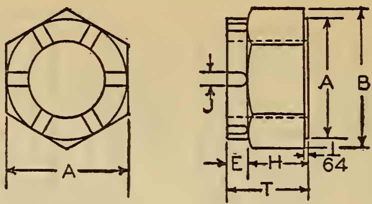
[1] Manufacturers' standard adopted by the Bolt, Nut, and Rivet Manufacturers Association Oct. 4, 1927, deviates from the above on the 9/16, ⅝, and ¾ inch sizes as follows: 9/16-inch size, nominal thickness = ½ inch, maximum thickness = 0.520 inch; ⅝-inch size, width across flats, maximum = 1.0000 inch, minimum = 0.969 inch; ¾-inch size, width across flats, maximum = 1.1875 inch, minimum = 1.150 inch.

TABLE 70.—*Dimensions of finished square and hexagon regular nuts*



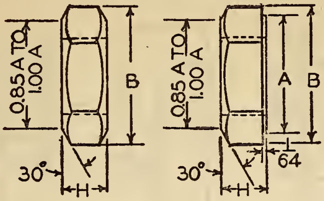
D	A		B		H		
Sizes	Width across flats		Minimum width across corners		Thickness		
	Maximum	Minimum	Hexagon	Square	Nominal	Maximum	Minimum
1	2	3	4	5	6	7	8
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
¼	0.4375	0.428	0.488	0.588	7/32	0.225	0.212
5/16	.5625	.552	.629	.758	17/64	.273	.258
⅜	.6250	.613	.699	.842	21/64	.336	.320
7/16	.7500	.737	.840	1.012	⅜	.384	.366
½	.8125	.799	.911	1.097	7/16	.448	.428
9/16	.8750	.861	.982	1.182	31/64	.495	.473
⅝	.9375	.922	1.051	1.266	35/64	.559	.535
¾	1.1250	1.108	1.263	1.521	21/32	.670	.642
⅞	1.3125	1.293	1.474	1.775	49/64	.781	.750
1	1.5000	1.479	1.686	2.031	⅞	.893	.858
1⅛	1.6875	1.665	1.898	2.286	1	1.019	.981
1¼	1.8750	1.850	2.109	2.540	1 3/32	1.115	1.072
1½	2.2500	2.222	2.533	3.051	1 5/16	1.338	1.288
1¾	2.6250	2.593	2.956	3.560	1 17/32	1.560	1.503
2	3.0000	2.964	3.379	4.070	1¾	1.783	1.718
2¼	3.3750	3.335	3.802	4.579	1 31/32	2.005	1.932
2½	3.7500	3.707	4.226	5.090	2 3/16	2.228	2.148
2¾	4.1250	4.078	4.649	5.599	2 13/32	2.450	2.363
3	4.5000	4.449	5.072	6.108	2⅝	2.673	2.578

TABLE 71.—*Dimensions of castellated nuts*



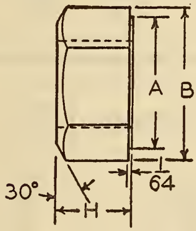
D	A		B	T			H	J	
Sizes	Width across flats		Minimum width across corners	Over-all thickness			Thickness, nominal	Slot	
	Maximum	Minimum		Nominal	Maximum	Minimum		Width	Depth
1	2	3	4	5	6	7	8	9	10
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inch*	*Inch*
1/4	0.4375	0.428	0.488	9/32	0.288	0.275	3/16	5/64	3/32
5/16	.5000	.489	.557	21/64	.335	.321	15/64	5/64	3/32
3/8	.5625	.551	.628	13/32	.414	.398	9/32	1/8	1/8
7/16	.6250	.612	.699	29/64	.462	.444	21/64	1/8	1/8
1/2	.7500	.737	.840	9/16	.573	.553	3/8	1/8	3/16
9/16	.8750	.860	.980	39/64	.620	.598	27/64	5/32	3/16
5/8	.9375	.922	1.051	23/32	.731	.707	15/32	5/32	1/4
3/4	1.1250	1.108	1.263	13/16	.826	.799	9/16	5/32	1/4
7/8	1.3125	1.293	1.474	29/32	.921	.891	21/32	5/32	1/4
1	1.5000	1.479	1.686	1	1.017	.983	3/4	5/32	1/4
1 1/8	1.6875	1.665	1.898	1 5/32	1.173	1.139	27/32	7/32	5/16
1 1/4	1.8750	1.850	2.109	1 1/4	1.272	1.229	15/16	7/32	5/16
1 1/2	2.2500	2.222	2.533	1 1/2	1.525	1.475	1 1/8	1/4	3/8

TABLE 72.—*Dimensions of finished and semifinished jam nuts*



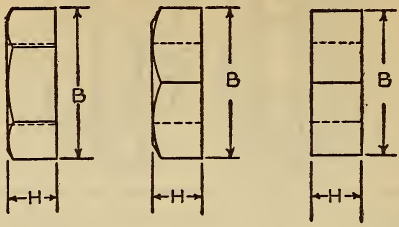
D	A		B	H		
Sizes	Width across flats		Width across corners of hexagon, minimum	Thickness		
	Maximum	Minimum		Nominal	Maximum	Minimum
1	2	3	4	5	6	7
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
¼	0.4375	0.428	0.488	5/32	0.163	0.150
5/16	.5625	.552	.629	3/16	.195	.180
⅜	.6250	.613	.699	7/32	.227	.211
7/16	.7500	.737	.840	¼	.259	.241
½	.8125	.799	.911	5/16	.323	.303
9/16	.8750	.861	.980	11/32	.355	.333
⅝	.9375	.922	1.051	⅜	.387	.363
¾	1.1250	1.108	1.263	7/16	.451	.424
⅞	1.3125	1.293	1.474	½	.516	.484
1	1.5000	1.479	1.686	9/16	.580	.545
1⅛	1.6875	1.665	1.898	⅝	.644	.606
1¼	1.8750	1.850	2.109	¾	.771	.729
1½	2.2500	2.222	2.533	⅞	.900	.850
1¾	2.6250	2.593	2.956	1	1.029	.971
2	3.0000	2.964	3.379	1⅛	1.158	1.093
2¼	3.3750	3.335	3.802	1¼	1.286	1.214
2½	3.7500	3.707	4.226	1½	1.540	1.460
2¾	4.1250	4.078	4.649	1⅝	1.669	1.581
3	4.5000	4.449	5.072	1¾	1.798	1.703

TABLE 73.—*Dimensions of hexagon light nuts*



D	A		B	H		
Sizes	Width across flats		Minimum width across corners	Thickness		
	Maximum	Minimum	Hexagon	Nominal	Maximum	Minimum
1	2	3	4	5	6	7
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
¼	0.4375	0.428	0.488	7/32	0.225	0.212
5/16	.5000	.489	.557	17/64	.273	.259
⅜	.5625	.551	.628	21/64	.336	.320
7/16	.6250	.612	.698	⅜	.384	.366
½	.7500	.737	.840	7/16	.448	.428

TABLE 74.—*Dimensions of hexagon and square machine screw nuts and square stove bolt nuts*

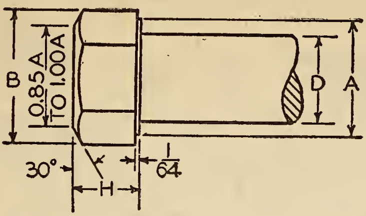


D	A		B	H		
Sizes	Width across flats		Width across corners of hexagon	Thickness		
	Maximum	Minimum	Minimum	Nominal	Maximum	Minimum
1	2	3	4	5	6	7
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
No. 0—0.0600	0.1562	0.150	0.171	3/64	0.050	0.043
No. 1—0.0730	.1562	.150	.171	3/64	.050	.043
No. 2—0.0860	.1875	.180	.205	1/16	.066	.057
No. 3—0.0990	.1875	.180	.205	1/16	.066	.057
No. 4—0.1120	.2500	.241	.275	3/32	.098	.087
No. 5 [1]—0.1250	.3125	.302	.344	7/64	.114	.102
No. 6—0.1380	.3125	.302	.344	7/64	.114	.102
No. 8 [1]—0.1640	.3437	.332	.378	1/8	.130	.117
No. 10 [1]—0.1900	.3750	.362	.413	1/8	.130	.117
No. 12 [1]—0.2160	.4375	.423	.482	5/32	.161	.148
1/4 [1]—0.2500	.4375	.423	.482	3/16	.193	.178
5/16 [1]—0.3125	.5625	.545	.621	7/32	.225	.208
3/8 [1]—0.3750	.6250	.607	.692	1/4	.257	.239
7/16—0.4375	.7500	.729	.831	9/32	.289	.269
1/2—0.5000	.8125	.790	.901	5/16	.321	.299

[1] These sizes in the coarse-thread series are interchangeable with the following sizes of American National standard stove-bolt nuts:

Machine screw	Stove bolt
	Inch
No. 5	1/8
No. 8	5/32
No. 10	3/16
No. 12	7/32
1/4-inch	1/4
5/16-inch	5/16
3/8-inch	3/8

TABLE 75.—*Dimensions of finished hexagon cap screw heads*



D	A		B	H		
Sizes	Width across flats		Width across corners	Height		
	Maximum	Minimum	Minimum	Nominal	Maximum	Minimum
1	2	3	4	5	6	7
	Inches	*Inches*	*Inches*	*Inch*	*Inch*	*Inch*
1/4	0.4375	0.428	0.488	3/16	0.194	0.181
5/16	.5000	.489	.557	15/64	.242	.227
3/8	.5625	.551	.628	9/32	.289	.273
7/16	.6250	.612	.698	21/64	.337	.319
1/2	.7500	.737	.840	3/8	.385	.365
9/16	.8125	.798	.910	27/64	.433	.411
5/8	.8750	.860	.980	15/32	.481	.457
3/4	1.0000	.983	1.121	9/16	.576	.549
7/8	1.1250	1.106	1.261	21/32	.672	.641
1	1.3125	1.292	1.473	3/4	.768	.733
1 1/8	1.5000	1.477	1.684	27/32	.863	.824
1 1/4	1.6875	1.663	1.896	15/16	.959	.916

NOTE.—Cap screws with hexagon heads are similar to machine bolts with hexagon heads, Table 68, and they may be used interchangeably.

TABLE 76.—*Open-end wrench openings*

Basic width across flats, bolt heads and nuts	Clearance	Tolerance	Dimensions of measuring blocks for wrench openings	
			Maximum	Minimum
1	2	3	4	5
Inches	*Inch*	*Inch*	*Inches*	*Inches*
5/32—0.1562	0.0014	0.005	0.163	0.158
3/16—0.1875	.0016	.005	.194	.189
1/4—0.2500	.0018	.005	.257	.252
5/16—0.3125	.0019	.007	.321	.314
11/32—0.3437	.0022	.007	.353	.346
3/8—0.3750	.0024	.007	.384	.377
7/16—0.4375	.0025	.007	.447	.440
1/2—0.5000	.0030	.007	.510	.503
9/16—0.5625	.0035	.007	.573	.566
5/8—0.6250	.0040	.007	.636	.629
3/4—0.7500	.0050	.008	.763	.755
13/16—0.8125	.0050	.008	.826	.818
7/8—0.8750	.0050	.008	.888	.880
15/16—0.9375	.0055	.009	.952	.943
1—1.0000	.0060	.009	1.015	1.006
1 1/8—1.1250	.0070	.010	1.142	1.132
1 1/4—1.2500	.0070	.010	1.267	1.257
1 5/16—1.3125	.0075	.011	1.331	1.320
1 1/2—1.5000	.0090	.012	1.521	1.509
1 11/16—1.6875	.0095	.013	1.710	1.697
1 7/8—1.8750	.0100	.013	1.898	1.885
2 1/4—2.2500	.0120	.015	2.277	2.262
2 5/8—2.6250	.0140	.017	2.656	2.639
3—3.0000	.0160	.019	3.035	3.016
3 3/8—3.3750	.0180	.021	3.414	3.393
3 3/4—3.7500	.0200	.023	3.793	3.770
4 1/8—4.1250	.0220	.024	4.171	4.147
4 1/2—4.5000	.0230	.026	4.549	4.523

Section VIII B. Standards for Proportions of Threaded Products Indorsed by the Commission [22]

1. REFERENCES

The commission further indorses the standards for proportions of the following threaded products as listed in the references below:

	Reference
1. Round unslotted-head bolts	1, 2
(*a*) Square-neck carriage bolts	1, 2
(*b*) Fin-neck carriage bolts	1, 2
(*c*) Ribbed carriage bolts	1, 2
(*d*) Step bolts	1, 2
(*e*) Button-head machine bolts	1, 2
(*f*) Countersunk carriage bolts	1, 2
2. Set screws	1
(*a*) Headed set screws	1
(*b*) Headless slotted set screws	1
3. Tap rivets	1
4. Plow bolts	3

[22] See also Appendix 6, p. 241.

1. "United States Government Master Specification for Bolts, Nuts, and Screws," Federal Specifications Board specification No. 548, promulgated March 5, 1928.[23] Issued in mimeographed form by the Federal Specifications Board, Bureau of Standards, Washington, D. C.

2. "Tentative American Standard Round Unslotted Head Bolts—Carriage, Step, and Machine Bolts." Report No. B 18e–1927, issued and sold by the American Standards Association, 29 West Thirty-ninth Street, New York, N. Y. Price 35 cents.

3. "Plow Bolts." United States Department of Commerce Simplified Practice Recommendation No. 23, February 19, 1924. Issued by the Bureau of Standards and sold by the Superintendent of Documents, Government Printing Office, Washington, D. C. Price 5 cents. Also published as Report No. B 18f—1928, "Tentative 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. AMERICAN NATIONAL ACME SCREW THREADS (STANDARD PRACTICE)

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 in class 1 herein.

There are cases in which lateral tightness is desirable, as, for example where the nut acts as the support of a long screw which otherwise would sag or spring out of position, or where the screw operates in a vertical or inclined position, or on precision lead screws. In classes 2, 3, and 4 herein, the Acme thread is modified to have a bearing on the minor diameter and such modification is recommended for accurate lead screws of any appreciable length, and for other adjusting screws where excessive side play is objectionable, as on valve stems.

For such applications the so-called square thread, actually a thread having an included angle of 3° to 10°, because of the impracticability of producing a truly square thread, has continued in use to some extent

[23] This specification also includes specifications for machine screws, cap screws, and stove bolts which are based on a tentative report of subcommittee No. 3 of the A. S. A. Sectional Committee on Bolt, Nut, and Rivet Proportions, but not approved by that committee.

because bearing on the top or bottom of the thread is readily obtained. Also, the wearing surface of the square thread at the minor diameter is somewhat greater than for an Acme thread of the same pitch, but this is counterbalanced by longer wearing life of the Acme thread in the nut on the sides of the threads, and the greater strength of the base section of the Acme thread, as well as the greater ease of production. The advantage may lie with the square thread only when minimum frictional resistance is an important factor, as, the line of thrust being parallel with the screw, the friction in a square thread is less than in a thread having sloping sides. It is believed, however, that applications in which an Acme thread of corresponding dimensions would not function equally as well as a square thread would be very exceptional. When the so-called square thread is considered necessary, the specifications given herein for thread series, classification, and tolerances for Acme threads can be applied with equal facility to square threads.

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.[24]

4. Clearance at Minor Diameter.—A clearance shall be provided at the minor diameter for class 1 Acme by making the minor diameter of the screw 0.020 $\sqrt{p}$ smaller than basic, and for classes 2, 3, and 4 Acme by making the minor diameter 0.005 $\sqrt{p}$ smaller than basic.

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 round ing of the corners of the threading tool and the side cutting action of milling cutters when these threads are milled. It will be necessary,

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[24] 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.

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 33.

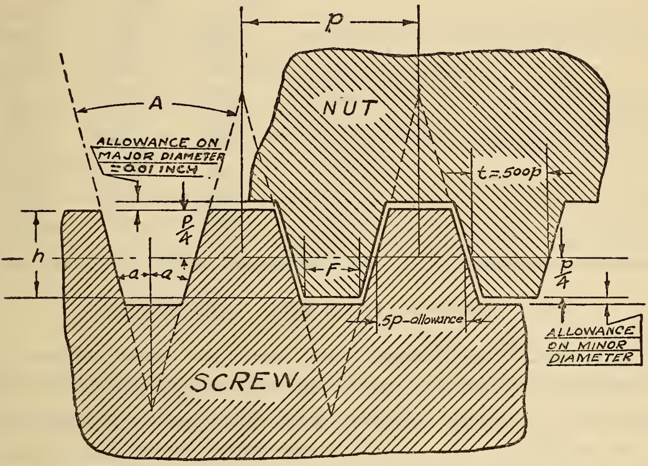


FIG. 33.—*American National Acme form of thread*

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

As these threads are used for such a wide variety of purposes, it is not feasible arbitrarily to select and designate any given combinations of diameters and pitches as standard. It is recommended, however, that as far as practicable, some one of the pitches shown in Table 77 be used; also, that the diameter be not less than the minimum diameter 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 77.—*Recommended pitches and corresponding minimum major diameters for American National Acme threads*

Number of threads per inch, n	Pitch, p	Basic depth of thread, $h=0.5p$	Recommended minimum major diameter [1]	Basic width of flat, $F=0.37069p$
1	2	3	4	5
	Inch	*Inch*	*Inches*	*Inch*
1	1.00000	0.5000	4.5000	0.3707
1⅓	.75000	.3750	3.5000	.2780
1½	.66667	.3333	3.0000	.2471
2	.50000	.2500	2.2500	.1853
2½	.40000	.2000	1.7500	.1483
3	.33333	.1667	1.5000	.1236
4	.25000	.1250	1.1250	.0927
5	.20000	.1000	.8750	.0741
6	.16667	.0833	.7500	.0618
8	.12500	.0625	.5625	.0463
10	.10000	.0500	.4375	.0371
12	.08333	.0417	.3750	.0309

[1] These recommended diameters correspond to a maximum helix angle (at the minor diameter) of approximately 5°.

5. CLASSIFICATION AND TOLERANCES

There are established herein for general use four distinct classes of fit of American National Acme screw threads, the first two covering adjusting or traversing screws, and the last two covering lead screws on which it is usually necessary that the lead of the thread be far more accurate than on adjusting screws. These four classes, together with the accompanying specifications, are for the purpose of insuring a uniform practice on screw-thread production throughout the country. They are designated as follows:

Class 1. For general use.
Class 2. Adjusting screws with limited side play.
Class 3. Commercial lead screws.
Class 4. Precision lead screws.

In designating the various classes of fit in these specifications the class number is followed by the word "Acme" in order to distinguish this classification from that applied to the various fits of fastening screws as given in Section III.

(a) GENERAL SPECIFICATIONS

The following general specifications apply to all classes of fit specified for Acme screw threads:

1. UNIFORM MINIMUM NUT.—The minor diameter and the thickness of thread in the minimum threaded hole or nut correspond to the basic size, while the minimum major diameter gives the basic clearance, the tolerances on diameters being applied above the basic size.

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, pitch, and class of fit are equal.

(*f*) The thread thickness tolerances include lead and angle errors. On classes 3 Acme and 4 Acme, the maximum permissible lead variations are specified.

(*g*) The thread thickness tolerances are obtained by adding together 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.

(*h*) The tolerances on the major diameters of the screws and minor diameters of the nuts are based upon the pitch of the thread.

(*i*) The maximum major diameter of a screw is the basic diameter.

(*j*) The minimum major diameter of the nut is at least 0.020 inch larger than the basic major diameter.

(*k*) 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. 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 0.02 inch.

(*l*) The minimum minor diameter of a screw of a given pitch is such as to result in a flat at the root equal to $0.3707p$ when the pitch diameter of the screw is at its minimum value.

(b) CLASSIFICATION OF FITS

1. CLASS 1 ACME.—(*a*) *Definition.*—This class is intended to cover the manufacture of threaded adjusting screws for general purposes where a considerable amount of shake or play, both side play and end play, is not objectionable.

This class is made with large allowances to permit ready assembly even when the threads are rough or dirty.

(*b*) *Allowances.*—An allowance is provided at the minor diameter which is obtained by making the maximum minor diameter of the screw $0.020\sqrt{p}$ smaller than the basic minor diameter. Also, there is an allowance between the sides of the thread on the screw and nut obtained by making the thickness of the thread on the screw $0.005\sqrt{p}$ less than the basic thread thickness.[25] (See fig. 34.)

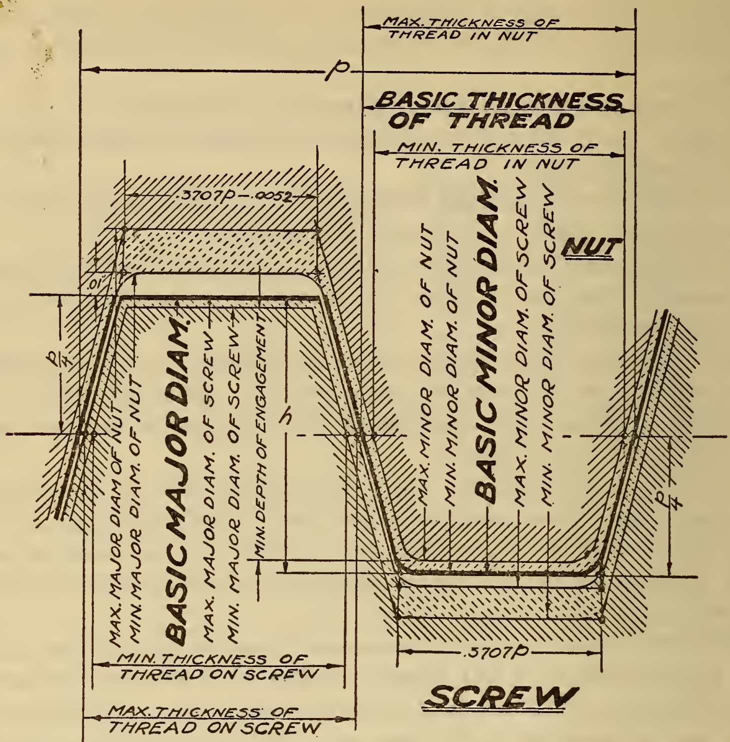


FIG. 34.—*Illustration of allowances, tolerances, and crest clearances, class 1 Acme*

NOTATION

p=pitch
h=basic thread depth
Heavy line shows basic size.

(*c*) *Tolerances.*—The tolerance on the thickness of the thread in both screw and nut is obtained by adding three values, or increments, as follows:

Diameter increment	=	$0.0010\sqrt{D}$
Length of engagement increment	=	$.0010\ Q$
Pitch increment	=	$.0050\sqrt{p}$

where

D=basic major diameter in inches
Q=length of engagement in inches
p=pitch of thread in inches

[25] Both allowances are obtained when cutting a screw by setting the threading tool having a flat of basic width to cut a thread depth $0.010\sqrt{p}$ deeper than basic.

(*d*) *Allowance and tolerance values.*—Tables 78 and 79 give the allowances and tolerances for major and minor diameters. They also give tolerance increments for thread thickness based upon the above formulas. Inasmuch as the diameter corresponding to a given pitch will ordinarily have a value not less than the recommended minimum given in column 4, Table 77, and not greater than three times that value, the diameter increment for all diameters corresponding to a given pitch may be taken as the mean of the increments obtained for the above limiting values without appreciably

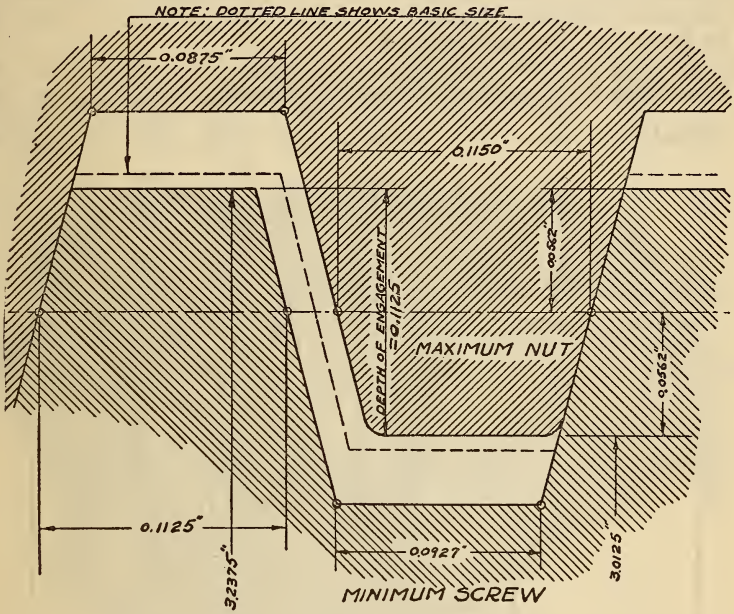


FIG. 35.—*Illustration of loosest condition for class 1 Acme, 4 threads per inch, 3¼ inches diameter, 6 inches length of engagement*

affecting the value of the thread thickness tolerance obtained by adding the respective increments. Thus, in column 4, Table 78, the diameter and pitch increments are combined according to the following formula:

$$\text{Column 4, Table 78} = 0.0050\sqrt{p} + \frac{0.0010\ (1+\sqrt{3})}{2}\sqrt{\text{column 4, Table 77}}$$

The total thread thickness tolerance is obtained by adding together the increments obtained from column 4, Table 78, and column 2, Table 79. The resulting tightest and loosest conditions of fit are illustrated in Figures 35 and 36.

(*e*) *Example.*—Three and one-fourth inches diameter, 4 threads per inch, 6 inches length of engagement, class 1 Acme:

From Table 78 we get for the screw:

Maximum major diameter	=3. 2500
Minimum major diameter	=3. 2500−0. 0125=3. 2375
Maximum minor diameter	=3. 2500− . 2600=2. 9900
Maximum thickness of thread	= . 1225

And for the nut:

Minimum major diameter	=3. 2500+0. 0200=3. 2700
Minimum minor diameter	=3. 2500− . 2500=3. 0000
Maximum minor diameter	=3. 0000+ . 0125=3. 0125
Maximum thickness of thread	= . 1250

And for the thread thickness tolerance:

From Table 78, pitch and diameter increments	= . 00395
From Table 79, engagement increment (6 inches)	= . 00600
Total	= . 00995

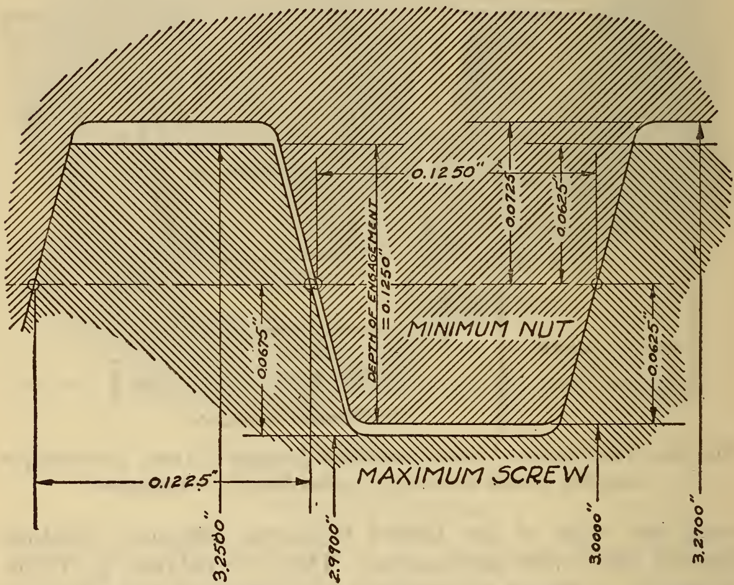


FIG. 36.—*Illustration of tightest condition for class 1 Acme, 4 threads per inch, 3¼ inches diameter*

Increment values are given to five decimal places for purposes of calculation. The final result should be rounded off to the nearest third decimal place. The thread thickness tolerance for both screw and nut in this example would be, therefore, 0.010 inch.

TABLE 78.—*Class 1 Acme, allowances, thread proportions, and pitch and diameter increments*

Number of threads per inch	Pitch	Allowance on thread thickness	Combined pitch and diameter increments of thread thickness tolerance	Screw: Tolerance on major diameters, minus	Screw: Maximum minor diameter=basic major diameter minus	Screw: Maximum thread thickness	Nut: Tolerance on minor diameter, plus	Nut: Minimum minor diameter=basic major diameter minus	Nut: Maximum thread thickness	Nut: Minimum major diameter=basic major diameter plus
1	2	3	4	5	6	7	8	9	10	11
	Inch	*Inch*	*Inch*	*Inch*	*Inches*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1	1.00000	0.0050	0.00790	0.0500	1.0200	0.4950	0.0500	1.0000	0.5000	0.0200
1⅓	.75000	.0043	.00689	.0375	.7673	.3707	.0375	.7500	.3750	.0200
1½	.66667	.0041	.00645	.0333	.6830	.3293	.0333	.6667	.3333	.0200
2	.50000	.0035	.00559	.0250	.5141	.2465	.0250	.5000	.2500	.0200
2½	.40000	.0032	.00497	.0200	.4126	.1968	.0200	.4000	.2000	.0200
3	.33333	.0029	.00456	.0167	.3449	.1638	.0167	.3333	.1667	.0200
4	.25000	.0025	.00395	.0125	.2600	.1225	.0125	.2500	.1250	.0200
5	.20000	.0022	.00351	.0100	.2089	.0978	.0100	.2000	.1000	.0200
6	.16667	.0020	.00322	.0083	.1748	.0813	.0083	.1667	.0833	.0200
8	.12500	.0018	.00279	.0063	.1321	.0607	.0063	.1250	.0625	.0200
10	.10000	.0016	.00248	.0050	.1063	.0484	.0050	.1000	.0500	.0200
12	.08333	.0014	.00228	.0042	.0891	.0402	.0042	.0833	.0417	.0200

TABLE 79.—*Class 1 Acme, length of engagement increments of thread thickness tolerances*

Length of engagement	Length of engagement increment	Length of engagement	Length of engagement increment
1	2	1	2
Inches	*Inch*	*Inches*	*Inch*
0.250	0.00025	4.000	0.00400
.375	.00038	4.500	.00450
.500	.00050	5.000	.00500
.625	.00063	5.500	.00550
.750	.00075	6.000	.00600
1.000	.00100	6.500	.00650
1.250	.00125	7.000	.00700
1.500	.00150	7.500	.00750
1.750	.00175	8.000	.00800
2.000	.00200	9.000	.00900
2.500	.00250	10.000	.01000
3.000	.00300	11.000	.01100
3.500	.00350	12.000	.01200

2. CLASS 2 ACME.—(*a*) *Definition.*—This class is intended to cover the manufacture of threaded adjusting screws for general purposes, where the amount of side play must be kept to a minimum, such as valve stems, etc.

This class is made with allowances to permit ready assembly and lubrication.

(*b*) *Allowances.*—A small allowance is provided at the minor diameter which is obtained by making the maximum minor diameter of the screw $0.005\sqrt{p}$ smaller than the basic minor diameter. Also there is an allowance between the sides of the thread on the screw and nut obtained by making the thickness of the thread on the screw $0.00125\sqrt{p}$ less than the basic thread thickness.[26] (See fig. 37.)

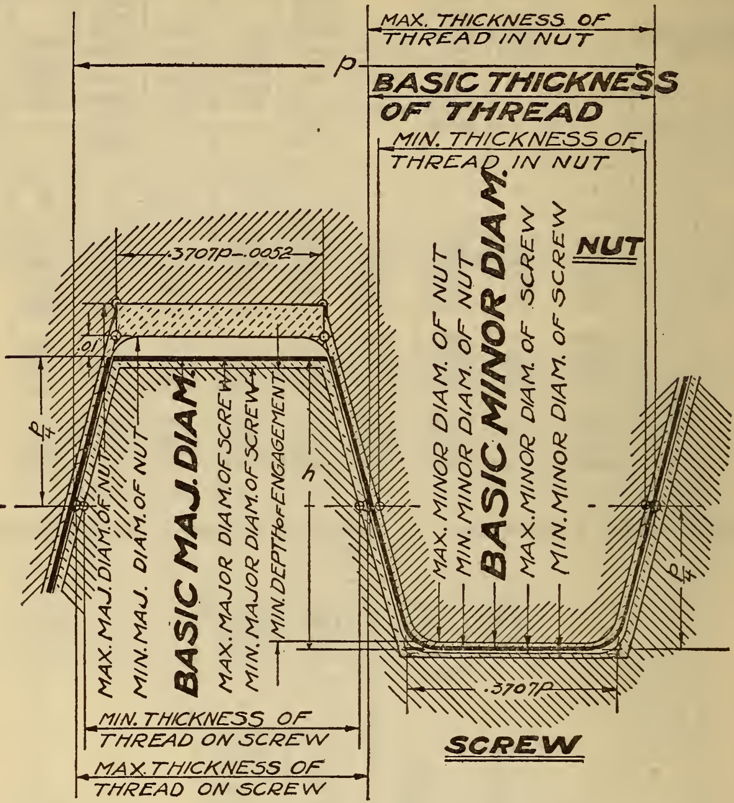


FIG. 37.—*Illustration of allowances, tolerances, and crest clearances, classes 2, 3, and 4 Acme*

NOTATION

p=pitch

h=basic thread depth

Heavy line shows basic size

(c) *Tolerances.*—The tolerance on the thickness of the thread in both screw and nut is obtained by adding three values, or increments, as follows:

Diameter increment $=0.0010\sqrt{D}$

Length of engagement increment $= .0005\ Q$

Pitch increment $= .0050\sqrt{p}$

where

D=basic major diameter in inches

Q=length of engagement in inches

p=pitch of thread in inches

[26] Both allowances are obtained when cutting a screw by setting the threading tool having a flat of basic width to cut a thread depth $0.0025\sqrt{p}$ deeper than basic.

(*d*) *Allowance and tolerance values.*—Tables 80 and 81 give the allowances and tolerances for major and minor diameters. They also give tolerance increments for thread thickness based upon the above formulas. Inasmuch as the diameter corresponding to a given pitch will ordinarily have a value not less than the recommended minimum given in column 4, Table 77, and not greater than three times that value, the diameter increment for all diameters corresponding to a given pitch may be taken as the mean of the increments obtained for the above limiting values without appreciably

NOTE.—Dotted line shows basic size.

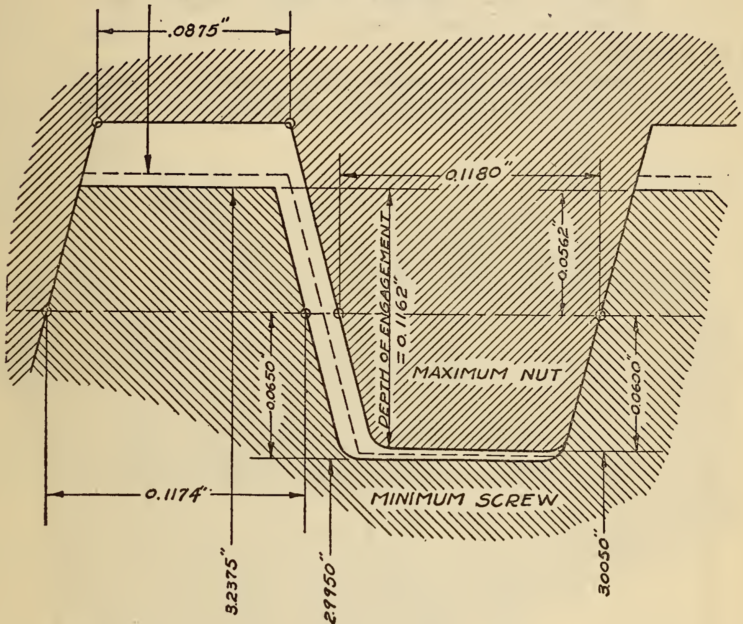


FIG. 38.—*Illustration of loosest condition for classes 2, 3, and 4 Acme, 4 threads per inch, 3¼ inches diameter, 6 inches length of engagement*

affecting the value of the thread thickness tolerance obtained by adding the respective increments. Thus, in column 4, Table 80, the diameter and pitch increments are combined according to the following formula:

$$\text{Column 4, Table 80} = 0.0050\sqrt{p} + \frac{0.0010\,(1+\sqrt{3})}{2}\sqrt{\text{column 4, Table 77}}$$

The total thread thickness tolerances are obtained by adding together the increments obtained from column 4, Table 80, and column 2, Table 81. The resulting tightest and loosest conditions of fit are illustrated in Figures 38 and 39.

(*e*) *Example*.—¾-inch diameter, 6 threads per inch, 2 inches length of engagement, class 2 Acme:

From Table 80 we get for the screw:

Maximum major diameter................=0.7500
Minimum major diameter =0.7500−0.0083= .7417
Maximum minor diameter = .7500− .1687= .5813
Minimum minor diameter = .5812− .0041= .5771
Maximum thickness of thread.............= .0828

And for the nut:

Minimum major diameter =0.7500+0.0200= .7700
Minimum minor diameter = .7500− .1667= .6833
Maximum minor diameter = .6833+ .0041= .6874
Maximum thickness of thread.............= .0833

And for the thread thickness tolerance:

From Table 80, pitch and diameter increments= .00322
From Table 81, engagement increment.....= .00100

Total..................................= .00422

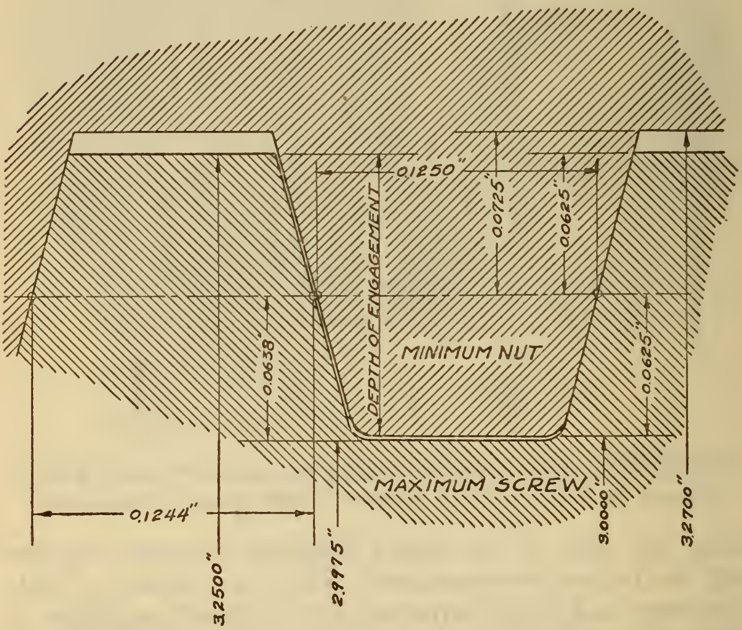


Fig. 39.—*Illustration of tightest condition for classes 2, 3, and 4 Acme, 4 threads per inch, 3¼ inches diameter*

Increment values are given to five decimal places for purposes of calculation. The final result should be rounded off to the nearest third decimal place. The thread thickness tolerance for both screw and nut in this example would be, therefore, 0.004 inch.

TABLE 80.—*Classes 2, 3, and 4 Acme, allowances, thread proportions, and pitch and diameter increments*

Number of threads per inch	Pitch	Allowance on thread thickness	Combined pitch and diameter increments of thread thickness tolerance	Radius of fillet at minor diameter, screw and nut	Screw				Nut			
					Tolerance on major diameter, minus	Maximum minor diameter = basic major diameter minus	Tolerance on minor diameter, minus	Maximum thread thickness	Tolerance on minor diameter, plus	Minimum minor diameter = basic major diameter minus	Maximum thread thickness	Minimum major diameter = basic major diameter plus
1	2	3	4	5	6	7	8	9	10	11	12	13
	Inch	*Inch*	*Inch*		*Inch*	*Inches*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1	1.00000	0.0013	0.00790	0.02	0.0500	1.0050	0.0100	0.4987	0.0100	1.0000	0.5000	0.0200
1⅓	.75000	.0011	.00689	.02	.0375	.7543	.0087	.3739	.0087	.7500	.3750	.0200
1½	.66667	.0010	.00645	.02	.0333	.6708	.0082	.3323	.0082	.6667	.3333	.0200
2	.50000	.0009	.00559	.02	.0250	.5035	.0071	.2491	.0071	.5000	.2500	.0200
2½	.40000	.0008	.00497	.02	.0200	.4032	.0063	.1992	.0063	.4000	.2000	.0200
3	.33333	.0007	.00456	.01	.0167	.3362	.0058	.1660	.0058	.3333	.1667	.0200
4	.25000	.0006	.00395	.01	.0125	.2525	.0050	.1244	.0050	.2500	.1250	.0200
5	.20000	.0006	.00351	.01	.0100	.2022	.0045	.0994	.0045	.2000	.1000	.0200
6	.16667	.0005	.00322	.01	.0083	.1687	.0041	.0828	.0041	.1667	.0833	.0200
8	.12500	.0004	.00279	.01	.0063	.1268	.0035	.0621	.0035	.1250	.0625	.0200
10	.10000	.0004	.00248	.01	.0050	.1016	.0032	.0496	.0032	.1000	.0500	.0200
12	.08333	.0004	.00228	.01	.0042	.0848	.0029	.0413	.0029	.0833	.0417	.0200

TABLE 81.—*Classes 2, 3, and 4 Acme, length of engagement increments of thread thickness tolerances*

Length of engagement	Length of engagement increment	Length of engagement	Length of engagement increment
1	2	1	2
Inches	*Inch*	*Inches*	*Inch*
0.250	0.00013	4.500	0.00225
.375	.00019	5.000	.00250
.500	.00025	5.500	.00275
.625	.00031	6.000	.00300
.750	.00038	6.500	.00325
1.000	.00050	7.000	.00350
1.250	.00063	7.500	.00375
1.500	.00075	8.000	.00400
1.750	.00088	9.000	.00450
2.000	.00100	10.000	.00500
2.500	.00125	11.000	.005500
3.000	.00150	12.000	.006000
3.500	.00175		
4.000	.00200		

3. CLASS 3 ACME (COMMERCIAL LEAD SCREW).—(*a*) *Definition.*—This class is intended to cover the manufacture of threaded lead screws used on machine tools, etc.

This class is made with allowances to permit ready assembly and lubrication.

(*b*) *Allowances.*—The allowances for this class are the same as for class 2 Acme, as given in Table 80.

(*c*) *Tolerances.*—The tolerances are also the same as for class 2 Acme as given in Tables 80 and 81, with the addition of a definite tolerance on lead. The tolerance on lead is plus or minus 0.002 inch per 12 inches of length; this to be measured by the advance of a nut of approximately the same length as the one to be used. The specified tolerance on lead applies to the whole or any part of the distance of 12 inches.

(*d*) *Example.*—2¼ inches diameter, 5 threads per inch, 4 inches length of engagement, class 3 Acme:

From Table 80, we get for the screw:	
Maximum major diameter	=2. 2500
Minimum major diameter	=2. 2500−0. 0100=2. 2400
Maximum minor diameter	=2. 2500− . 2022=2. 0478
Minimum minor diameter	=2. 0478− . 0045=2. 0432
Maximum thickness of thread	= . 0994
And for the nut:	
Minimum major diameter	=2. 2500+ . 0200=2. 2700
Minimum minor diameter	=2. 2500− . 2000=2. 0500
Maximum minor diameter	=2. 0500+ . 0045=2. 0545
Maximum thickness of thread	= . 1000
And for the thread thickness tolerance:	
From Table 80, pitch and diameter increments	=. 00351
From Table 81, engagement increment	=. 00200
Total	=. 00551

Increment values are given to five decimal places for purposes of calculation. The final result should be rounded off to the nearest third decimal place. The thread thickness tolerances for both screw and nut in this example would be, therefore, 0.006 inch.

4. Class 4 Acme (Precision Lead Screw).—(*a*) *Definition.*—This class is intended to cover the manufacture of precision threaded lead screws used in machine tools for tool room use, etc.

This class is made with allowances to permit ready assembly and lubrication.

(*b*) *Allowances.*—The allowances for this class are the same as for Class 2 Acme, as given in Table 80.

(*c*) *Tolerances.*—The tolerances are also the same as for class 2 Acme, as given in Tables 80 and 81, with the addition of a definite tolerance on lead. The tolerance on lead is plus or minus 0.0010 inch per 12 inches of length; this to be measured by the advance of a nut of approximately the same length as the one to be used. The specified tolerance on lead applies to the whole or any part of the distance of 12 inches.

(*d*) *Example.*—1¼ inches diameter, 8 threads per inch, 2½ inches length of engagement, class 4 Acme:

From Table 80 we get for the screw:

Maximum major diameter		=1.2500
Minimum major diameter	=1.2500−0.0063	=1.2437
Maximum minor diameter	=1.2500− .1268	=1.1232
Minimum minor diameter	=1.1232− .0035	=1.1197
Maximum thickness of thread		= .0621

And for the nut:

Maximum major diameter	=1.2500+ .0200	=1.2700
Minimum minor diameter	=1.2500− .1250	=1.1250
Maximum minor diameter	=1.1250+ .0035	=1.1285
Maximum thickness of thread		= .0625

And for the thread thickness tolerance:

From Table 80, pitch and diameter increments	= .00279
From Table 81, engagement increment	= .00125
Total	= .00404

Increment values are given to five decimal places for purposes of calculation. The final result should be rounded off to the nearest third decimal place. The thread thickness tolerance for both screw and nut in this example would be, therefore, 0.004 inch.

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) SPECIFICATIONS FOR GAGES

1. Limiting Dimensions.—Tables 82, 83, and 84 given herein are 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 as given are 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.

2. Tolerances on Lead.—The tolerances on lead given in Table 82 are specified as an allowable variation between any two threads not farther apart than 12 inches.

3. Tolerances on Angle of Thread.—The tolerances on angle of thread, as specified in Table 82 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.

4. 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 82.—*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			
								Class 1		Classes 2, 3, and 4	
	From—	To—	Classes 1 and 2	Classes 3 and 4		From—	To—	From—	To—	From—	To—
1	2	3	4	5	6	7	8	9	10	11	12
	Inch	*Inch*	*Inch* ±	*Inch* ±	*Deg. Min.* ±	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1	0.0000	0.0008	0.0005	0.0002	0 5	0.0000	0.0010	0.0000	0.0010	0.0000	0.0010
1⅓	.0000	.0007	.0005	.0002	0 5	.0000	.0010	.0000	.0010	.0000	.0009
1½	.0000	.0006	.0005	.0002	0 5	.0000	.0010	.0000	.0010	.0000	.0008
2	.0000	.0006	.0005	.0002	0 5	.0000	.0010	.0000	.0010	.0000	.0007
2½	.0000	.0005	.0005	.0002	0 5	.0000	.0010	.0000	.0010	.0000	.0006
3	.0000	.0005	.0005	.0002	0 5	.0000	.0010	.0000	.0010	.0000	.0006
4	.0000	.0004	.0005	.0002	0 5	.0000	.0010	.0000	.0010	.0000	.0005
5	.0000	.0004	.0005	.0002	0 5	.0000	.0010	.0000	.0010	.0000	.0005
6	.0000	.0003	.0005	.0002	0 5	.0000	.0008	.0000	.0008	.0000	.0004
8	.0000	.0003	.0005	.0002	0 5	.0000	.0006	.0000	.0006	.0000	.0004
10	.0000	.0002	.0005	.0002	0 10	.0000	.0005	.0000	.0005	.0000	.0003
12	.0000	.0002	.0005	.0002	0 10	.0000	.0004	.0000	.0004	.0000	.0003

TABLE 83.—*Limiting dimensions of gages for screws, classes 1, 2, 3, and 4 Acme*

	Threads per inch											
	1	1⅓	1½	2	2½	3	4	5	6	8	10	12
1	2	3	4	5	6	7	8	9	10	11	12	13
"GO" GAGES FOR SCREWS	*Inches*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Major diameter—All fits—Max.=basic major diameter minus	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Major diameter—All fits—Min.=basic major diameter minus	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0010	.0008	.0006	.0005	.0004
Thickness of thread at basic pitch line—Class 1—Max.	.5058	.3800	.3380	.2541	.2037	.1701	.1279	.1026	.0856	.0646	.0518	.0433
Thickness of thread at basic pitch line—Class 1—Min.	.5050	.3793	.3374	.2535	.2032	.1696	.1275	.1022	.0853	.0643	.0516	.0431
Thickness of thread at basic pitch line—Classes 2, 3, and 4—Max.	.5021	.3768	.3349	.2515	.2013	.1679	.1260	.1010	.0841	.0632	.0506	.0423
Thickness of thread at basic pitch line—Classes 2, 3, and 4—Min.	.5013	.3761	.3343	.2509	.2008	.1674	.1256	.1006	.0838	.0629	.0504	.0421
Minor diameter—Class 1—Max.=basic major diameter minus	1.0200	.7673	.6830	.5141	.4126	.3449	.2600	.2089	.1748	.1321	.1063	.0891
Minor diameter—Class 1—Min.=basic major diameter minus	1.0210	.7683	.6840	.5151	.4136	.3459	.2610	.2099	.1756	.1327	.1068	.0895
Minor diameter—Classes 2, 3, and 4—Max.=basic major diameter minus	1.0050	.7543	.6708	.5035	.4032	.3362	.2525	.2022	.1687	.1268	.1016	.0848
Minor diameter—Classes 2, 3, and 4—Min.=basic major diameter minus	1.0060	.7552	.6716	.5042	.4038	.3368	.2530	.2027	.1691	.1272	.1019	.0851
"NOT GO" GAGES FOR SCREWS												
Threaded ring or snap gages for thread thickness only:												
Major diameter—All fits—Min.=basic major diameter plus	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200
Thickness of thread at basic pitch line—All fits—Max.=pitch minus			Minimum thickness of thread of the screw at the basic pitch line									
Thickness of thread at basic pitch line—All fits—Min.=Max. minus	.0008	.0007	.0006	.0006	.0005	.0005	.0004	.0004	.0003	.0003	.0002	.0002
Minor diameter—All fits—Min.=basic major diameter minus	1.0000	.7500	.6667	5000	.4000	.3333	.2500	.2000	.1667	.1250	.1000	.0833
Gages for major diameter only:												
Diameter (major)—All fits—Min.=basic major diameter minus	.0500	.0375	.0333	.0250	.0200	.0167	.0125	.0100	.0083	.0063	.0050	.0042
Diameter (major)—All fits—Max.=basic major diameter minus	.0490	.0365	.0323	.0240	.0190	.0157	.0115	.0990	.0075	.0057	.0045	.0038
Gages for minor diameter only:												
Major diameter—Classes 2, 3, and 4—Min.=basic major diameter plus	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200	.0200
Thickness of thread at basic pitch line—Classes 2, 3, and 4—Max.	.5000	.3750	.3333	.2500	.2000	.1667	.1250	.1000	.0833	.0625	.0500	.0417
Minor diameter—Classes 2, 3, and 4—Min.=basic major diameter minus	1.0150	.7630	.6790	.5106	.4095	.3420	.2575	.2067	.1728	.1303	.1048	.0877
Minor diameter—Classes 2, 3, and 4—Max.=basic major diameter minus	1.0140	.7621	.6782	.5099	.4089	.3414	.2570	.2062	.1724	.1299	.1045	.0974

TABLE 84.—*Limiting dimensions of gages for nuts, classes 1, 2, 3, and 4 Acme*

	Threads per inch											
	1	1⅓	1½	2	2½	3	4	5	6	8	10	12
1	2	3	4	5	6	7	8	9	10	11	12	13
"Go" Gages for Nuts												
	Inches	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
Major diameter, All fits: Min. = basic major diameter plus	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
Major diameter, All fits: Max. = basic major diameter plus	.0210	.0210	.0210	.0210	.0210	.0210	.0210	.0210	.0208	.0206	.0205	.0204
Thickness of thread at basic pitch line, All fits: Min.	.5000	.3750	.3333	.2500	.2000	.1667	.1250	.1000	.0833	.0625	.0500	.0417
Thickness of thread at basic pitch line, All fits: Max.	.5008	.3757	.3339	.2506	.2005	.1672	.1254	.1004	.0836	.0628	.0502	.0419
Minor diameter, Class 1: Min. = basic major diameter minus	1.0000	.7500	.6667	.5000	.4000	.3333	.2500	.2000	.1667	.1250	.1000	.0833
Minor diameter, Class 1: Max. = basic major diameter minus	.9990	.7490	.6657	.4990	.3990	.3323	.2490	.1990	.1659	.1244	.0995	.0829
Minor diameter, Classes 2, 3, and 4: Min. = basic major diameter minus	1.0000	.7500	.6667	.5000	.4000	.3333	.2500	.2000	.1667	.1250	.1000	.0833
Minor diameter, Classes 2, 3, and 4: Max. = basic major diameter minus	.9990	.7491	.6659	.4993	.3994	.3327	.2495	.1995	.1663	.1246	.9997	.0830
"Not Go" Gages for Nuts												
Threaded plug gages for thread thickness only: Major diameter, All fits: Min. = basic major diameter plus	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Thickness of thread at basic pitch line, All fits: Max. = ½ pitch plus	Tolerance on the thickness of the nut thread at the basic pitch line											
Thickness of thread at basic pitch line, All fits: Min. = Max. minus	.0008	.0007	.0006	.0006	.0005	.0005	.0004	.0004	.0003	.0003	.0002	.0002
Minor diameter, All fits: Max. = basic major diameter minus	1.0050	.7543	.6708	.5035	.4032	.3362	.2525	.2022	.1687	.1268	.1016	.0848
Plain plug gages for minor diameter only:												
Diameter (minor), Class 1: Max. = basic major diameter minus	.9500	.7125	.6334	.4750	.3800	.3166	.2375	.1900	.1584	.1188	.0950	.0791
Diameter (minor), Class 1: Min. = basic major diameter minus	.9510	.7135	.6344	.4760	.3810	.3176	.2385	.1910	.1592	.1194	.0955	.0795
Diameter (minor), Classes 2, 3, and 4: Max. = basic major diameter minus	.9900	.7413	.6585	.4929	.3937	.3275	.2450	.1955	.1626	.1215	.0968	.0804
Diameter (minor), Classes 2, 3, and 4: Min. = basic major diameter minus	.9910	.7422	.6593	.4936	.3943	.3281	.2455	.1960	.1630	.1219	.0971	.0807

SECTION X. MISCELLANEOUS SPECIAL THREADS

Section XA. 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. Standards No. 5–A, "Pipe Specifications," issued by the division of standardization, American Petroleum Institute, 1508 Kirby Building, Dallas, Tex.

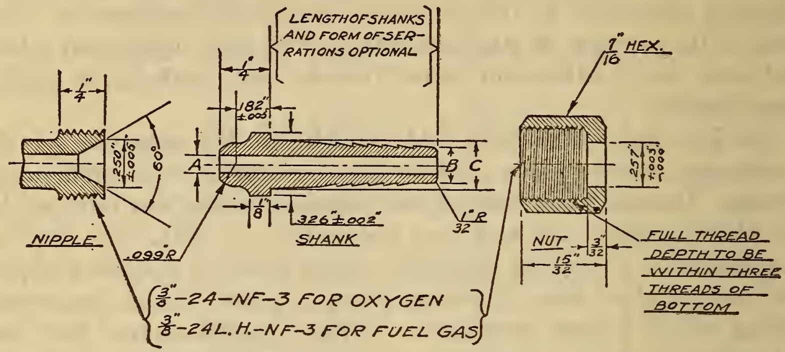
The commission indorses the screw thread and screw-thread gage specifications included in the following American Petroleum Institute standards:

No. 3.–A. P. I. dimensional standards for cable drilling tool joints.
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 cold-drawn and machined working barrels.
No. 11–B. A. P. I. sucker rod specifications.

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

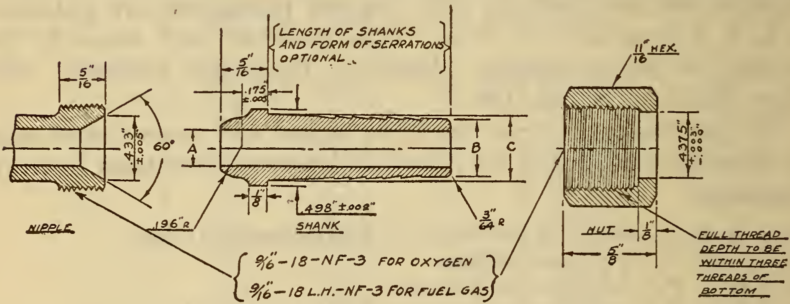
The specifications given herein, covering hose connections for welding and cutting torches, were finally approved and adopted by the commission June 28, 1926. These specifications were formulated and adopted in 1925, in essentially the same form, by the International Acetylene Association and the Gas Products Association, and have been adopted by the National Board of Fire Underwriters and 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 40 and 41.



HOSE	A	B	C
3/16 inch	3/32 inch	3/16 inch	0.248 +.000 −.005 inch
1/8	1/16	1/8	.187 +.000 −.005

FIG. 40.—"*A*" *size of standard hose connections for welding and cutting torches*



HOSE	A	B	C
3/8 inch	1/4 inch	3/8 inch	0.430 +.000 −.005 inch
5/16	3/16	5/16	.375 +.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

FIG. 41.—"*B*" *size of standard hose connections for welding and cutting torches*

1. STANDARD DIMENSIONS

1. Screw threads corresponding to the American National fine thread series, and class 3, medium fit, are specified in Figures 40 and 41, 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. Diameter 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 40 and 41.
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 42.
   - B size hose connection, as shown in Figure 47.
2. "Go" adjustable thread-ring gage for right-hand nipple thread—
   - A size, 3/8–24–NF–3
     - Minor diameter, maximum, 0.3299; minimum, 0.3294 inch.
     - Pitch diameter, maximum, 0.3477; minimum, 0.3474 inch.
   - B size, 9/16–18–NF–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, 3/8–24 L. H.–NF–3
     - Minor diameter, maximum, 0.3299; minimum, 0.3294 inch.
     - Pitch diameter, maximum, 0.3477; minimum, 0.3474 inch.
   - B size, 9/16–18 L. H.–NF–3
     - 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, 3/8–24–NF–3
     - Minor diameter, maximum, 0.3304; minimum, 0.3299 inch.
     - Pitch diameter, maximum, 0.3458; minimum, 0.3455 inch.
   - B size, 9/16–18–NF–3
     - Minor diameter, maximum, 0.5029; minimum, 0.5024 inch.
     - Pitch diameter, maximum, 0.5237; minimum, 0.5234 inch.

Gage No.

5. "Not go" adjustable thread-ring gage for left-hand nipple thread—
   - A size, 3/8–24 L. H.–NF–3
     - Minor diameter, maximum, 0.3304; minimum, 0.3299 inch.
     - Pitch diameter, maximum, 0.3458; minimum, 0.3455 inch.
   - B size, 9/16–18 L. H.–NF–3
     - 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, 3/8–24–NF–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, 9/16–18–NF–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, 3/8–24L. H.–NF–3
     - "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, 9/16–18 L. H.–NF–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.
8. "Go" and "not go" double-end thread plug gage for right-hand nut thread—
   - A size, 3/8–24–NF–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 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, 9/16–18–NF–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 from back.
     - "Not go" end—
       - Major diameter, maximum, 0.5510; minimum, 0.5505 inch.
       - Pitch diameter, maximum, 0.5294; minimum, 0.5291 inch.

Gage No.

9. "Go" and "not go" double-end thread plug gage for left-hand nut thread—
   - A size, 3/8–24 L. H.–NF–3
     - "Go" end—
       - Major diameter, maximum, 0.3755; minimum, 0.3750 inch.
       - Pitch diameter, maximum, 0.3784; minimum, 0.3481 inch.
       - Gaging notch, 0.125 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, 9/16–18 L. H.–NF–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 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 43.
    - B size, as shown in Figure 48.
11. "Go" ring gage for diameter of shank shoulder and concentricity of serrated portion—
    - A size, as shown in Figure 44.
    - B size, as shown in Figure 49.
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 45.
    - B size, as shown in Figure 50.
19. Template gage for nose of shank—
    - A size, as shown in Figure 46.
    - B size, as shown in Figure 51.

18415°—29——12

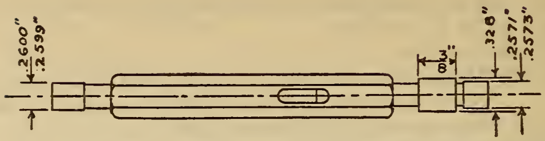


FIG. 42.—"Go" and "not go" gage for depth of threaded recess, and shank bore, A size

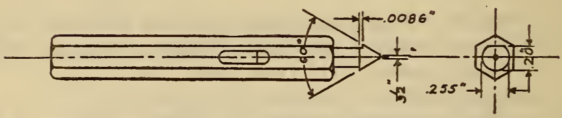


FIG. 43.—*Taper gage for nipple seat, A size*

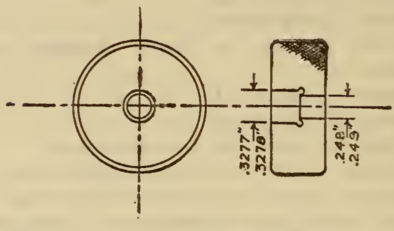


FIG. 44.—"Go" ring gage for diameter of shank shoulder and concentricity of serrated portion, A size

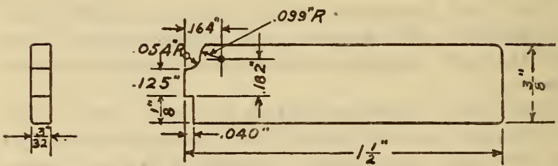


FIG. 45.—*Master template for nose of shank, A size*

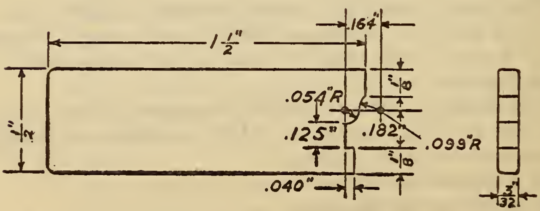


FIG. 46.—*Template gage for nose of shank, A size*

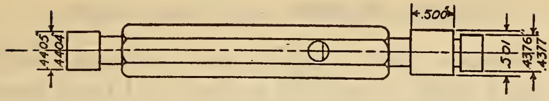


FIG. 47.—"*Go" and "not go" gage for depth of threaded recess, and shank bore, B size*

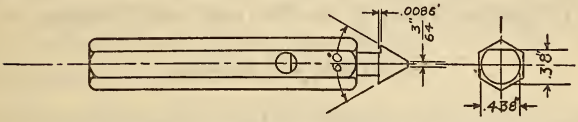


FIG. 48.—*Taper gage for nipple seat, B size*

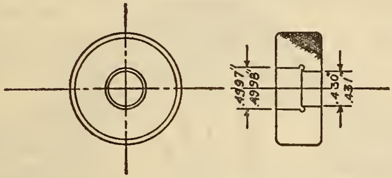


FIG. 49.—"*Go" ring gage for diameter of shank shoulder and concentricity of serrated portion, B size*

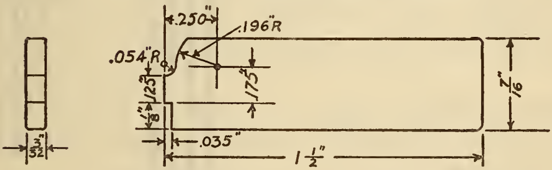


FIG. 50.—*Master template for nose of shank, B size*

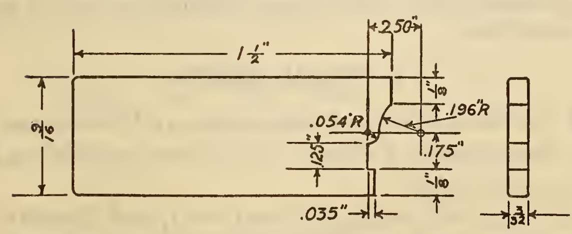


FIG. 51.—*Template gage for nose of shank, B size*

Section XC. 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 52.

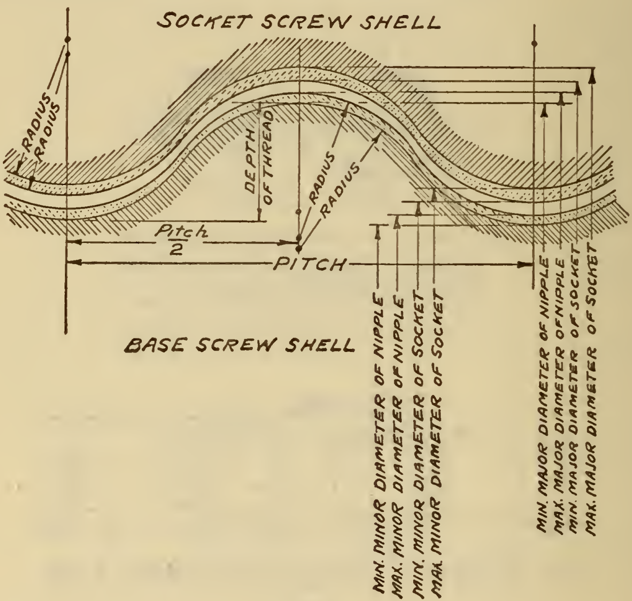


FIG. 52.—*Illustration of allowance and tolerances, American National rolled threads for screw shells of electric sockets and lamp bases*

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 85.

The corresponding dimensions and limits for socket screw shells, which are used in electric sockets, receptacles, and similar devices, are given in Table 86.

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 gage 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 gage 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 per cent of the tolerance on the product, and should be applied in such a 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 85 and 86, and should not be more than 10 per cent 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 per cent greater.

Table 85.—*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*	*Inches*	*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 86.—*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

Section XD. Screw Threads of Special Diameters, 12 Threads per Inch (Including Railway Sizes)

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 the 12 pitch is widely used, particularly for two distinct purposes as given below, but for different reasons.

Sizes of 12 pitch threads from one-half inch to and including 1¾ 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.[27]

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, for a thread of basic depth, 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.

There are, therefore, presented herein, supplementary to Section IV, "Screw threads of special diameters, pitches, and lengths of engagement," specifications and data covering a range of sizes of screw threads from one-half to 3 inches, inclusive, having 12 threads per inch, and based on a length of engagement of 1 inch.

1. FORM OF THREAD

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

[27] See U. S. Department of Commerce Simplified Practice Recommendation No. 51, "Die Head Chasers."

2. THREAD SERIES

The nominal sizes and basic dimensions of the "American National 12-pitch thread series" are specified in Table 87.

3. CLASSIFICATION AND TOLERANCES

The general specifications and classification of fits given in Section IV, herein, are applicable to the American National 12-pitch thread series. The dimensions and tolerances for four classes of fit, based on a length of engagement of 1 inch, and derived from Tables 27 to 31, are given in Table 88.

TABLE 87.—*American National 12-pitch thread series*

Identification		Basic diameters			Metric equivalent of major diameter
Sizes	Threads per inch	Major diameter *D*	Pitch diameter *E*	Minor diameter *K*	
1	2	3	4	5	6
		Inches	*Inches*	*Inches*	*mm*
1/2	12	0.5000	0.4459	0.3917	12.700
9/16 [1]	12	.5625	.5084	.4542	14.288
5/8	12	.6250	.5709	.5167	15.875
11/16	12	.6875	.6334	.5792	17.463
3/4	12	.7500	.6959	.6417	19.050
13/16	12	.8125	.7584	.7042	20.638
7/8	12	.8750	.8209	.7667	22.225
15/16	12	.9375	.8834	.8292	23.813
1	12	1.0000	.9459	.8917	25.400
1 1/16	12	1.0625	1.0084	.9542	26.988
1 1/8 [2]	12	1.1250	1.0709	1.0167	28.575
1 3/16	12	1.1875	1.1334	1.0792	30.163
1 1/4 [2]	12	1.2500	1.1959	1.1417	31.750
1 5/16	12	1.3125	1.2584	1.2042	33.338
1 3/8	12	1.3750	1.3209	1.2667	34.925
1 1/2 [2]	12	1.5000	1.4459	1.3917	38.100
1 3/4	12	1.7500	1.6959	1.6417	44.450
2	12	2.0000	1.9459	1.8917	50.800
2 1/4	12	2.2500	2.1959	2.1417	57.150
2 1/2	12	2.5000	2.4459	2.3917	63.500
2 3/4	12	2.7500	2.6959	2.6417	69.850
3	12	3.0000	2.9459	2.8917	76.200

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

TABLE 88.—*Limiting dimensions and tolerances, classes 1, 2, 3, and 4 fits, American National 12-pitch thread series*

Dimensions and tolerances	Size (inches)																					
	½	9/16 [1]	5/8	11/16	3/4	13/16	7/8	15/16	1	1 1/16	1 1/8 [2]	1 3/16	1 1/4 [2]	1 5/16	1 3/8	1 1/2 [2]	1 3/4	2	2 1/4	2 1/2	2 3/4	3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BOLTS AND SCREWS	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Class 1, major diameter Max.	0.4976	0.5601	0.6226	0.6851	0.7476	0.8101	0.8726	0.9351	0.9976	1.0601	1.1226	1.1851	1.2476	1.3101	1.3726	1.4976	1.7476	1.9976	2.2476	2.4976	2.7476	2.9976
Min.	.4818	.5443	.6068	.6693	.7318	.7943	.8568	.9193	.9818	1.0443	1.1068	1.1693	1.2318	1.2943	1.3568	1.4818	1.7318	1.9818	2.2318	2.4818	2.7318	2.9818
Tol.	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158	.0158
Classes 2, 3, and 4, major diameter Max.	.5000	.5625	.6250	.6875	.7500	.8125	.8750	.9375	1.0000	1.0625	1.1250	1.1875	1.2500	1.3125	1.3750	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000
Min.	.4888	.5513	.6138	.6763	.7388	.8013	.8638	.9263	.9888	1.0513	1.1138	1.1763	1.2388	1.3013	1.3638	1.4888	1.7388	1.9888	2.2388	2.4888	2.7388	2.9888
Tol.	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112	.0112
Class 1, minor diameter Max.[3]	.3954	.4579	.5204	.5829	.6454	.7079	.7704	.8329	.8954	.9579	1.0204	1.0829	1.1454	1.2079	1.2704	1.3954	1.6454	1.8954	2.1454	2.3954	2.6454	2.8954
Classes 2, 3, and 4, minor diameter Max.[3]	.3978	.4603	.5228	.5853	.6478	.7103	.7728	.8353	.8978	.9603	1.0228	1.0853	1.1478	1.2103	1.2728	1.3978	1.6478	1.8978	2.1478	2.3978	2.6478	2.8978
Class 1, loose fit, pitch diameter Max.	.4435	.5060	.5685	.6310	.6935	.7560	.8185	.8810	.9435	1.0060	1.0685	1.1310	1.1935	1.2560	1.3185	1.4435	1.6935	1.9435	2.1935	2.4435	2.6935	2.9435
Min.	.4356	.4981	.5606	.6231	.6856	.7481	.8106	.8731	.9356	.9981	1.0606	1.1231	1.1856	1.2481	1.3106	1.4356	1.6829	1.9329	2.1823	2.4323	2.6823	2.9323
Tol.	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0106	.0106	.0112	.0112	.0112	.0112
Class 2, free fit, pitch diameter Max.	.4459	.5084	.5709	.6334	.6959	.7584	.8209	.8834	.9459	1.0084	1.0709	1.1334	1.1959	1.2584	1.3209	1.4459	1.6959	1.9459	2.1959	2.4459	2.6959	2.9459
Min.	.4403	.5028	.5653	.6278	.6903	.7528	.8153	.8778	.9403	1.0028	1.0653	1.1278	1.1903	1.2528	1.3153	1.4403	1.6882	1.9382	2.1876	2.4376	2.6876	2.9376
Tol.	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0077	.0077	.0083	.0083	.0083	.0083
Class 3, medium fit, pitch diameter Max.	.4459	.5084	.5709	.6334	.6959	.7584	.8209	.8834	.9459	1.0084	1.0709	1.1334	1.1959	1.2584	1.3209	1.4459	1.6959	1.9459	2.1959	2.4459	2.6959	2.9459
Min.	.4419	.5044	.5669	.6294	.6919	.7544	.8169	.8794	.9419	1.0044	1.0669	1.1294	1.1919	1.2544	1.3169	1.4419	1.6896	1.9396	2.1890	2.4390	2.6890	2.9390
Tol.	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0063	.0063	.0069	.0069	.0069	.0069
Class 4, close fit, pitch diameter Max.	.4464	.5089	.5714	.6339	.6964	.7589	.8214	.8839	.9464	1.0089	1.0714	1.1339	1.1964	1.2589	1.3214	1.4464	1.6964	1.9464	2.1964	2.4464	2.6964	2.9464
Min.	.4444	.5069	.5694	.6319	.6944	.7569	.8194	.8819	.9444	1.0069	1.0694	1.1319	1.1944	1.2569	1.3194	1.4444	1.6933	1.9433	2.1930	2.4430	2.6930	2.9430
Tol.	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0031	.0031	.0034	.0034	.0034	.0034
NUTS AND TAPPED HOLES																						
Classes 1, 2, 3, and 4, major diameter Min.[4]	.5000	.5625	.6250	.6875	.7500	.8125	.8750	.9375	1.0000	1.0625	1.1250	1.1875	1.2500	1.3125	1.3750	1.5000	1.7500	2.0000	2.2500	2.5000	2.7500	3.0000
Classes 1, 2, 3, and 4, minor diameter Max.	.4225	.4850	.5438	.6063	.6688	.7313	.7938	.8563	.9188	.9813	1.0438	1.1063	1.1688	1.2313	1.2938	1.4188	1.6688	1.9188	2.1688	2.4188	2.6688	2.9188
Min.	.4098	.4723	.5348	.5973	.6598	.7223	.7848	.8473	.9098	.9723	1.0348	1.0973	1.1598	1.2223	1.2848	1.4098	1.6598	1.9098	2.1598	2.4098	2.6598	2.9098
Tol.	.0127	.0127	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090	.0090

Classes 1, 2, 3, and 4, pitch diameter Min	.4459	.5084	.5709	.6334	.6959	.7584	.8209	.8834	.9459	1.0084	1.0709	1.1334	1.1959	1.2584	1.3209	1.4459	1.6959	1.9459	2.1959	2.4459	2.6959	2.9459
Class 1, pitch diameter Max	.4538	.5163	.5788	.6413	.7038	.7663	.8288	.8913	.9538	1.0163	1.0788	1.1413	1.2038	1.2663	1.3288	1.4538	1.7065	1.9565	2.2071	2.4571	2.7071	2.9571
Class 1, pitch diameter Tol	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0079	.0106	.0106	.0112	.0112	.0112	.0112
Class 2, pitch diameter Max	.4515	.5140	.5765	.6390	.7015	.7640	.8265	.8890	.9515	1.0140	1.0765	1.1390	1.2015	1.2640	1.3265	1.4515	1.7036	1.9536	2.2042	2.4542	2.7042	2.9542
Class 2, pitch diameter Tol	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0056	.0077	.0077	.0083	.0083	.0083	.0083
Class 3, pitch diameter Max	.4499	.5124	.5749	.6374	.6999	.7624	.8249	.8874	.9499	1.0124	1.0749	1.1374	1.1999	1.2624	1.3249	1.4499	1.7022	1.9522	2.2028	2.4528	2.7028	2.9528
Class 3, pitch diameter Tol	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0040	.0063	.0063	.0069	.0069	.0069	.0069
Class 4, pitch diameter Max	.4479	.5104	.5729	.6354	.6979	.7604	.8229	.8854	.9479	1.0104	1.0729	1.1354	1.1979	1.2604	1.3229	1.4479	1.6990	1.9490	2.1993	2.4493	2.6993	2.9493
Class 4, pitch diameter Tol	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0020	.0031	.0031	.0034	.0034	.0034	.0034

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

[4] Dimensions for the minmium 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.

4. GAGES

The specifications for gages given in Section IV are applicable. Tolerances on diameter, lead, and angle for classes X, Y, and Z gages are given in Table 89.

TABLE 89.—*Tolerances for thread gages, American National 12-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—
1	2	3	4	5		6	7
	Inch	*Inch*	*Inch* ±	*Deg.* ±	*Min.*	*Inch*	*Inch*
Class X and all "not go"	0.0000	0.0003	0.0003	0	10	0.0000	0.0006
Class Y	.0002	.0006	.0003	0	10	.0000	.0006
Class Z	.0004	.0011	.0004	0	10	.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 length of engagement.

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 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 1/20 inch are to each other and to the tolerance for 1/20 inch as the 0.6th power of their respective pitches.

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

The exponent 0.6 was chosen for pitches finer than 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.

3. *Tolerances for extension of American National fine-thread series.*—For greater consistency among the tolerances specified in Sections III and IV it was found necessary to depart from the above basis for the extension of the American National fine-thread series above 1½ inches, and to specify tolerances obtained by adding increments as given in Table 90 according to the method given below under "(*b*)."

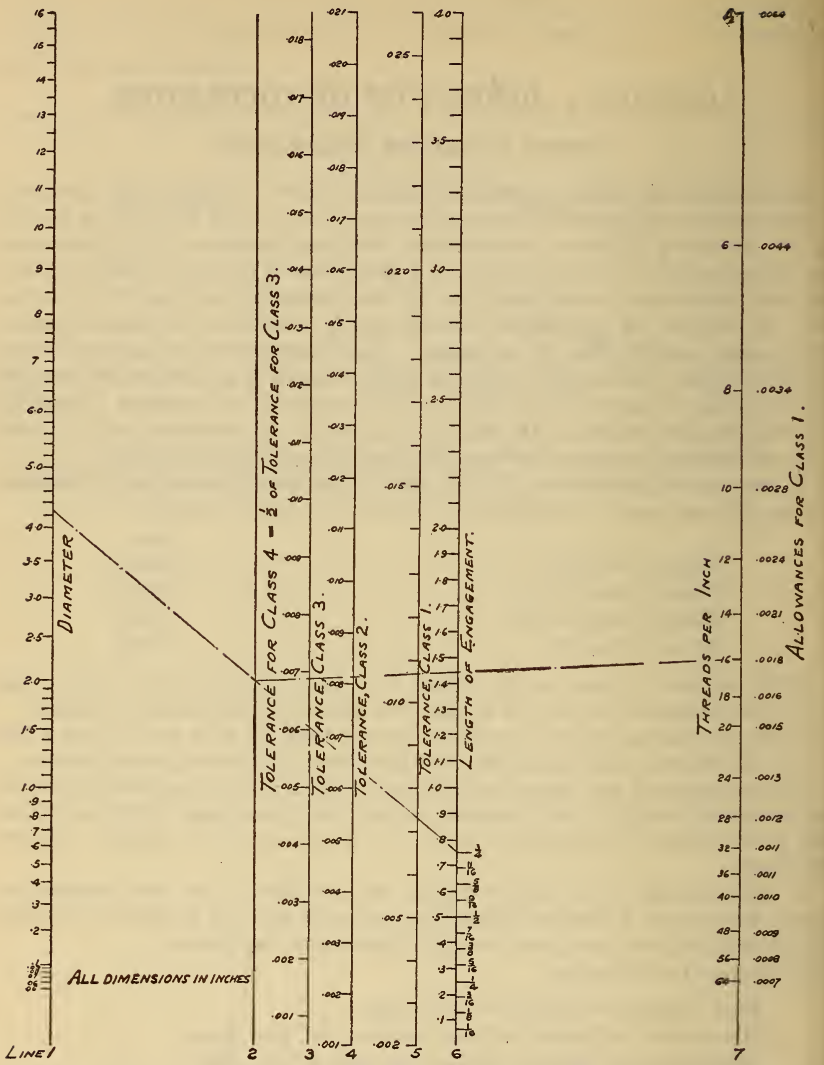


FIG. 53.—*Chart for determining tolerances for various classes of fit of special threads*

DIRECTIONS FOR USING CHART.—To determine the tolerance for a special screw or nut, given the diameter, threads per inch, and length of engagement: Lay a straightedge across lines Nos. 1 and 6, intersecting line 1 at the point corresponding to the diameter and line 6 at the point corresponding to the length of engagement, and note the point at which it intersects line 2. Then lay the straightedge across lines 2 and 7, intersecting line 2 at the point previously noted and line 7 at the point corresponding to the number of threads per inch. If the tolerance for a class 1 fit is desired, note the point of intersection of the straightedge on line 5; a class 2 fit, on line 4; and a class 3 or 4 fit, on line 3. The scale readings on these lines give the tolerances, but to determine the tolerance for a class 4 fit divide the scale reading on line 3 by 2.

The allowance for a class 1 fit is given opposite the threads per inch, line 7.

(*b*) TOLERANCES FOR SCREW THREADS OF SPECIAL DIAMETERS, PITCHES, AND LENGTHS OF ENGAGEMENT.—As stated in Section IV, the pitch diameter tolerances for special sizes of threads of American National form as given in Tables 28, 29, 30, and 31 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 90. Also tolerances corresponding to the sum of the increments may be obtained directly from the chart, Figure 53.

TABLE 90.—*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

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 ± 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

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

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 54. 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 equal to or 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

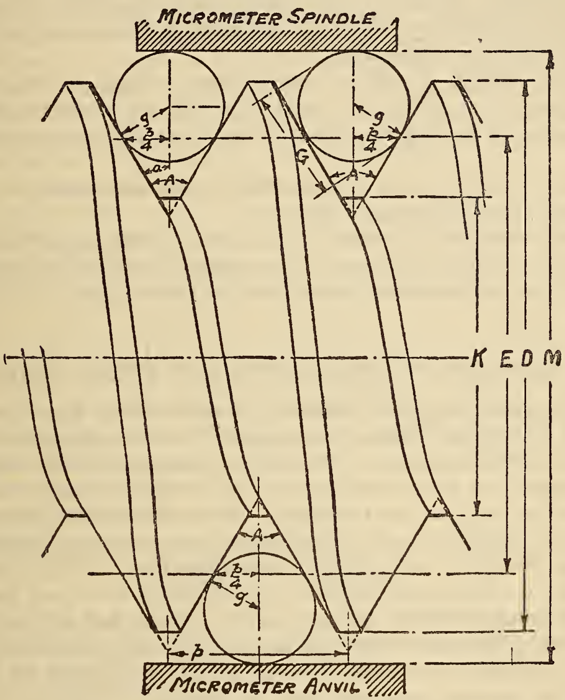


FIG. 54.—*Three-wire method of measuring pitch diameter of thread plug gages*

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:

$G=0.57735\times p$, for 60° 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 crest of the thread. The diameters of the best size, maximum, and minimum wires for American National coarse and fine threads are given in Tables 91 and 92.

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 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.

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 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 8 ounces is recommended. For pitches of 20 threads per inch and coarser a pressure not exceeding 3 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 can not 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]

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

---

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

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

in which S=tangent of the helix angle.

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

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

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. This 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.

18415°—29——13

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 given in most 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 91.

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 shown in Figure 55 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. 55.) 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 threads of which are symmetrical with respect to a line perpendicular to the axis, then has the form:[2]

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

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

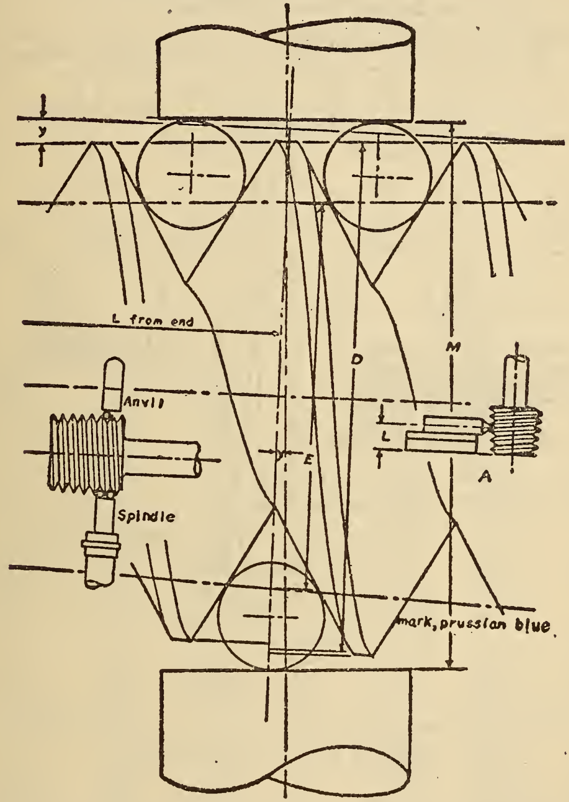


FIG. 55.—*Measurement of pitch diameter of taper thread gages by the three-wire method*

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:

$$E=1.00048\ M+0.86603\ p-3G$$

[2] See footnotes 16 and 1, pp. 106, 187. 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.

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.

The following method, illustrated in Figure 56, 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

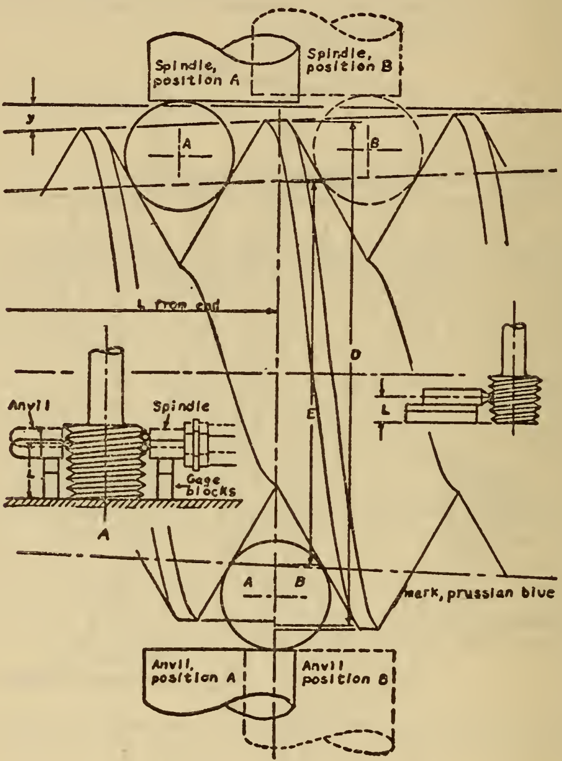


Fig. 56.—*Measurement of pitch diameter of taper thread gages by the two-wire method*

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 56 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 1.00048 M.

6. MEASUREMENT OF PITCH DIAMETER OF THREAD RING GAGES

The application of direct methods of measurement to determining 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.

TABLE 91.—*Wire sizes and constants, American National coarse, fine, and pipe threads*

Wire sizes [1]			Threads per inch	Pitch	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	11.5	.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
.08248	.14434	.07217	7	.14286	.07143	.12372
.09623	.16839	.08420	6	.16667	.08333	.14434
.11547	.20207	.10104	5	.20000	.10000	.17321
.12830	.22453	.11226	4.5	.22222	.11111	.19245
.14434	.25259	.12630	4	.25000	.12500	.21651
.16496	.28868	.14434	3.5	.28571	.14286	.24744

[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 92.—*Relation of best wire diameters and pitches* [1]*—wires for American National coarse, fine, 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	11.5	11	10	9	8	7	6	5	4.5	4	3.5
0.00722	⊗	X																											
.00802	X	⊗	X																										
.00902	X	X	⊗																										
.01031	X	X	X	⊗																									
.01203	X	X	X	X	⊗	X																							
.01312		X	X	X	X	⊗	X																						
.01443			X	X	X	X	⊗	X																					
.01604				X	X	X	X	⊗	X																				
.01804					X	X	X	X	⊗																				
.02062					X	X	X	X	X	⊗	X																		
.02138						X	X	X	X	X	⊗	X																	
.02406							X	X	X	X	X	⊗																	
.02887									X	X	X	X	⊗	X															
.03208										X	X	X	X	⊗	X														
.03608											X	X	X	X	⊗														
.04124												X	X	X	X	⊗	X												
.04441													X	X	X	X	⊗	X	X										
.04811													X	X	X	X	X	⊗	X	X									
.05020													X	X	X	X	X	X	⊗	X									
.05249														X	X	X	X	X	X	⊗	X								
.05773															X	X	X	X	X	X	⊗	X							
.06415																X	X	X	X	X	X	⊗	X						
.07217																	X	X	X	X	X	X	⊗						
.08248																		X	X	X	X	X	X	⊗					
.09623																					X	X	X	X	⊗				
.11547																							X	X	X	⊗	X		
.12830																								X	X	X	⊗	X	
.14434																									X	X	X	⊗	X
.16496																									X	X	X	X	⊗

[1] The crosses (X) 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.

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 three-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 three-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 93. 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 94, 95, 96, and 97.

TABLE 93.—*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

[1] Based on zero helix angle.

TABLE 94.—*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 95.—*Values of 1.12931p and 1.29152+0.48407S² 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	-------	-------	-------	-------	-------	-------	-------	-------	-------
3/8	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	-------	-------	-------	-------	-------	-------
5/8	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 96.—*Values of 1.12931p and 1.29152+0.48407S² 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 97.—*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

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.

1. 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.

Inspection of the angle and profile of the thread-forming tool is essential to control the accuracy of the thread produced. The same means and methods can be applied to such inspection as are applied in the measurement of screw-thread gages and threaded product. Attention is directed to the optical projection apparatus for measuring angle and lead, and examining profile; the microscope, which may be readily adapted to shop requirements; and indicating gages, which may be designed to check the dimensions of threading tools.

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.

(*a*) 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.

(*b*) 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.

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.

2. 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 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 57 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

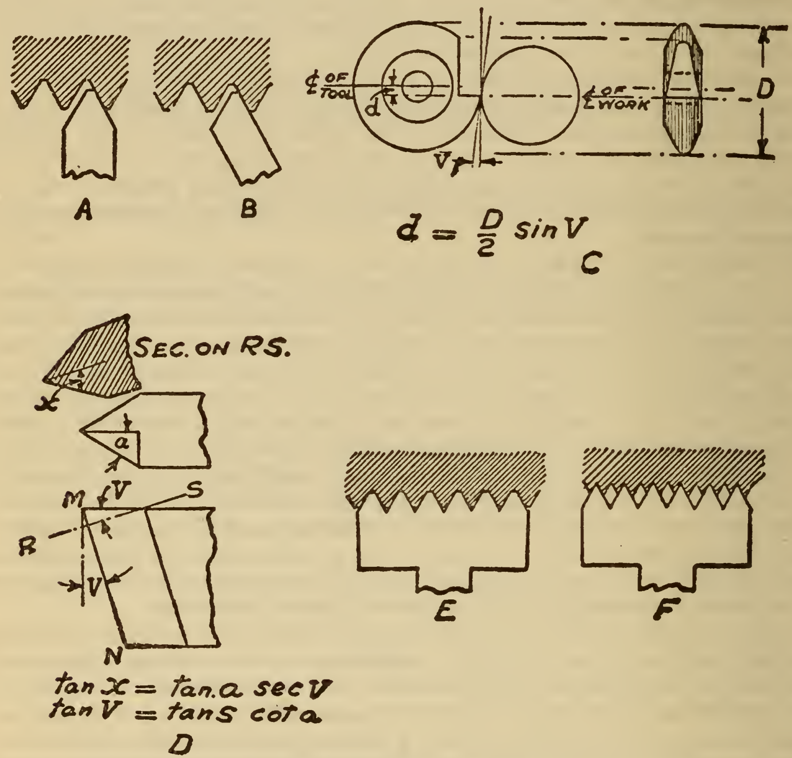


Fig. 57.—*Single point and multiple point thread cutting tools*

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 57 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 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 sometimes made to secure greater accuracy. Dies 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 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.[3]

(*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.[4]

3. 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

[3] 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), **113,** Apr. 7, 1922, pp. 441–442, and discussion pp. 412–414.

[4] 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, **42,** 1920, pp. 569–593; also the reference cited in footnote 3, p. 201, for thread milling cutter profile.

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 per cent of the single depth of thread for small screws to 85 per cent 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.[5]

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 the work with the necessary rigidity to withstand the heavy pressure, and to provide a bearing for the roll which will withstand the strain.

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 58, 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 58 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 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

[5] This formula is derived in Size of Stock for Bolts Having Rolled Threads, by F. Webster. American Machinist, 30, Oct. 31, 1907, p. 630.

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.[6]

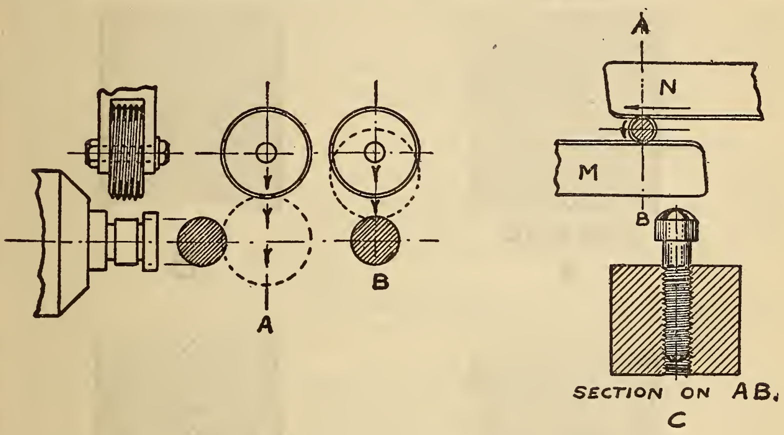


Fig. 58.—*Methods of rolling screw threads*

4. 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 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

[6] 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, 33, Apr. 21, 1910, pp. 739–741.

18415°—29——14

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 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-

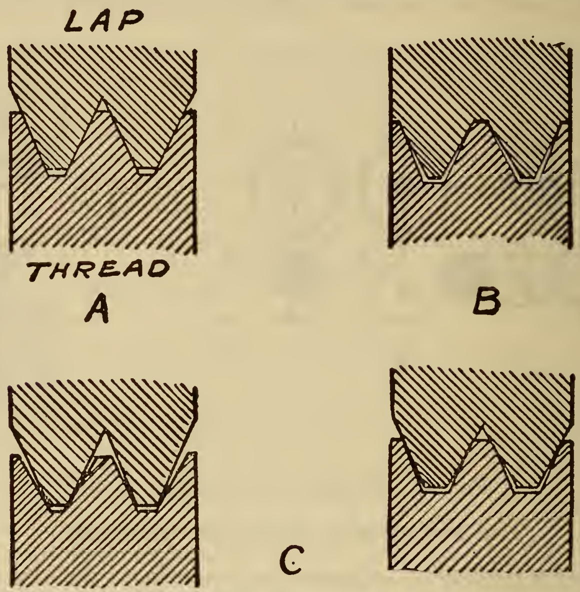


Fig. 59.—*Thread form of laps for lapping screw threads*

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 59.

APPENDIX 4. SPECIFICATIONS FOR THREADING TOOLS (RECOMMENDED PRACTICE)

The limiting sizes of the threaded product are always the essential requirements of the manufacturer and user of threaded parts. To maintain these sizes, not only the tools but also the processes employed must be suitable. So many varying factors are involved that it is not always possible to predetermine the exact sizes of the tools necessary to accomplish the required results. Variations in the nature of the material, the lubrication, the method of holding the product and tool, the sharpness of the tool, etc., all have an effect on the final results.

The effort has been made, in the following specifications, to establish sizes for various commonly used tools such that, when the tools are used with reasonable care under normal conditions, a threaded product will be produced in conformity with the product specifications.[7] The commission is concerned primarily with screw-thread products—that is, bolts, screws, and tapped holes—rather than with threading tools or with methods of use. It should be understood, therefore, that any recommendations with reference to threading tools, or methods of use, are intended only as useful information and are in no way mandatory.

1. TOOLS FOR AMERICAN NATIONAL FORM OF THREAD (60°)

(a) FORM OF TOOLS FOR PRODUCING SCREWS

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.

The tables and charts given in this section apply only to the tool used to produce the finished standard thread, and such a tool must be used on an axial section of the work.

1. Inspection of Tooth Outlines.—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. In Figure 60, for instance, the lathe threading tool is shown tipped up to the helix angle of the thread to be cut. This is sometimes done for the sake of a better cutting action, but necessitates a change in the tool shape, which must show an included angle of less than 60°, when projected on line y—y of the illustration, if the resulting thread as measured on the axial section x—x is to be exactly 60°. The ordinary thread milling cutter, set at the helix angle, and roller dies must have the same correction, if accurate results are desired. In brief, 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 to a magnification of one hundred or two hundred 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

[7] An analysis of the various factors which determine the accuracy of a screw thread in production is given in Appendix 3, p. 198.

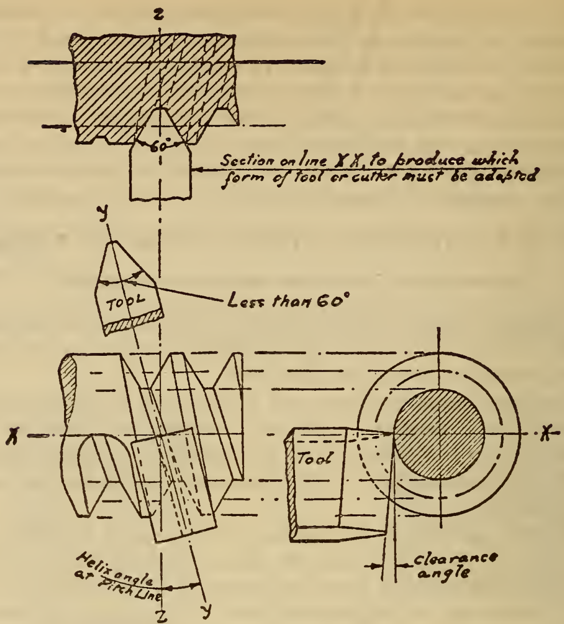


Fig. 60.—*Effect on shape of tool or cutter of setting it at the helix angle*

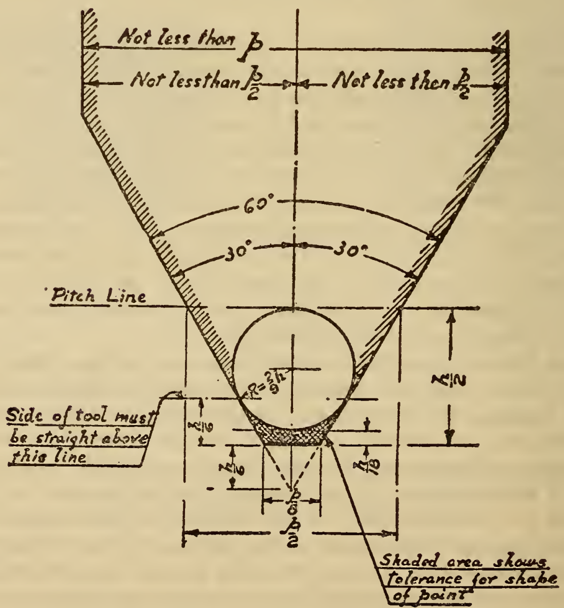


Fig. 61.—*Shape for cutter or single point lathe tool not intended to trim crest of thread*

system free from distortion. Optical projection machines and comparators are available for this work in commercial designs.

2. Outline for Single-Point Tool or Cutter.—In Figure 61 is shown the form of outline, measured on an axial section of the work, required for a single-point lathe tool or a milling cutter to produce directly a standard thread. Such a diagram, if drawn to a magnification of one hundred or two hundred times, will serve as a chart for projection testing. Note the shaded area at the point of the tool, within which a tool point of any shape is permissible. While sharp-cornered tools are easier to make, one with a permissible round might be more durable.

3. Outline for Multiple-Tooth Chasers and Hobs.—In Figure 62 are given similar instructions for determining the outline of multiple-toothed chasers and hobs. The tolerance at the point or crest of the tool is the same as in Figure 61. At the roots of the teeth, however, the depth of the thread space is carried

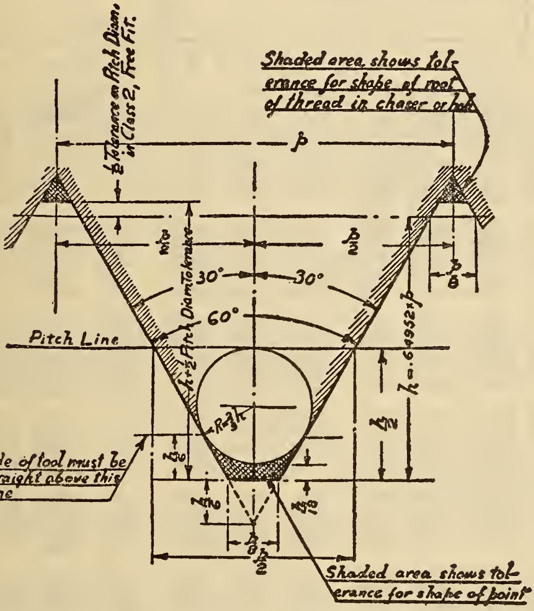


Fig. 62.—*Shape for teeth of chaser or hob not intended to trim crest of thread*

far enough to clear the crests of the screw thread being cut. This is in accordance with modern practice in threading alloy steels, which tend to tear at the crests. Relieving the chasers as shown minimizes this trouble.

It should be noted that this clearance at the crest of the screw is certain only on classes 2, 3, and 4 fits. If a class 1 screw is being cut to a minimum pitch diameter from stock of maximum major diameter size, the crests will be trimmed by the chaser. It is not possible to avoid this without carrying the grooves in the chasers nearer to a sharp bottom than is desirable.

When it is desired to follow the older practice which permits trimming of the crests, the outline shown in Figure 63 may be used. It is somewhat easier to make than the one shown in Figure 62.

Note that the tolerance allowed on the shape of the points or crests is the same as in Figures 61 and 62. In both Figures 62 and 63 the shape of the bottom of the thread spaces may be given any curved form which can be contained within the shaded tolerance area and still produce screw threads which will agree with the standards set up in this report.

In Table 98 are given the required dimensions for drawing the charts of Figures 61, 62, and 63 correctly for any standard pitch.

TABLE 98.—*Dimensions for determining shape of cutter, chaser, hob, or tap teeth, American National coarse and fine 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
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
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	.00508	.13498
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
3½	.28571	.14286	.03571	.01190	.18558	.09279	.06186	.04124	.03093	.01031	.00785	.19343

(b) TAPS

1. TAP DIMENSIONS AND TOLERANCES.—The dimensions and tolerances for cut and ground thread machine screw, hand, tapper, nut, and pulley taps given in Tables 99 to 103, inclusive, were prepared with the cooperation of a committee [8] of representative tap manufacturers and users, and represent present practice for the production of tapped holes of the classes indicated below. These standards may, therefore, be regarded as representing the best present commercial practice. They should be regarded as suggestive only and in no way mandatory.

[8] This committee, appointed in June, 1926, consisted of two members of the commission, two representatives of the Tap and Die Institute, one representative of the independent manufacturers of taps and dies, and two representatives of large users. The committee's report, as reprinted herewith, was approved June 30, 1927.

The use, however, of taps that are in conformity with these tables should not be taken as a guarantee that the tapped holes produced thereby will necessarily fall within any given class of fit. Figures 64 and 65 show the relations among the maximum pitch diameters of the standard taps and the maximum pitch diameters of the tapped holes for the four standard classes of fit. Taps may cut oversize an amount depending on the cutting speed, condition of the tapping machine, lubrication or cooling agent, relief and chamfer of tap, and other factors. In general, cut thread taps made to these specifications, when used under normal conditions, should in the majority of cases produce holes within class 2, free-fit tolerances; ground thread taps, within class 3, medium-fit tolerances.

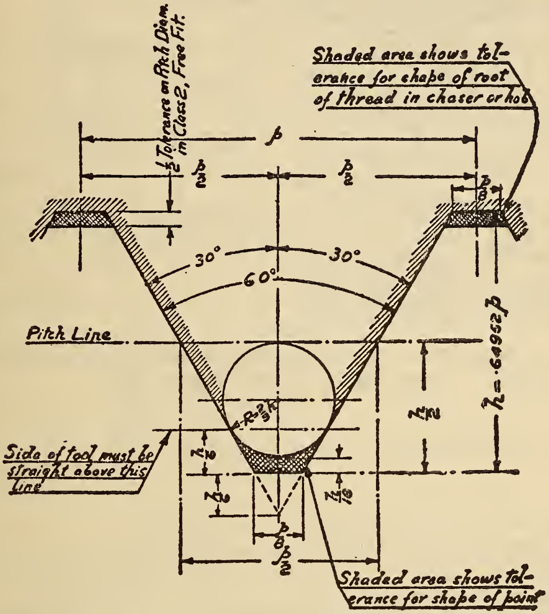


Fig. 63.—*Shape for teeth of chaser or hob intended to trim crest of thread*

The general dimensions contained in these tables do not pertain to screw threads, but are essential to the complete standardization of taps, and they have for that reason been included.

The point of measurement for the pitch diameter for all taps shall be at the first full thread.

The form of thread at the minor diameter is the American National form of thread, as specified in Section III, or sharper.

The maximum lead errors permitted are ±0.0030 inch in 1 inch of thread for cut thread taps, and ±0.0005 inch in 1 inch of thread for ground thread taps.

All taps have center holes at both ends, with the exception that cut thread taps up to and including five-sixteenths inch are pointed on the thread end.

Clearance on a ground thread tap may be provided by a slight radial relief or a back taper of 0.0005 to 0.0010 inch per inch.

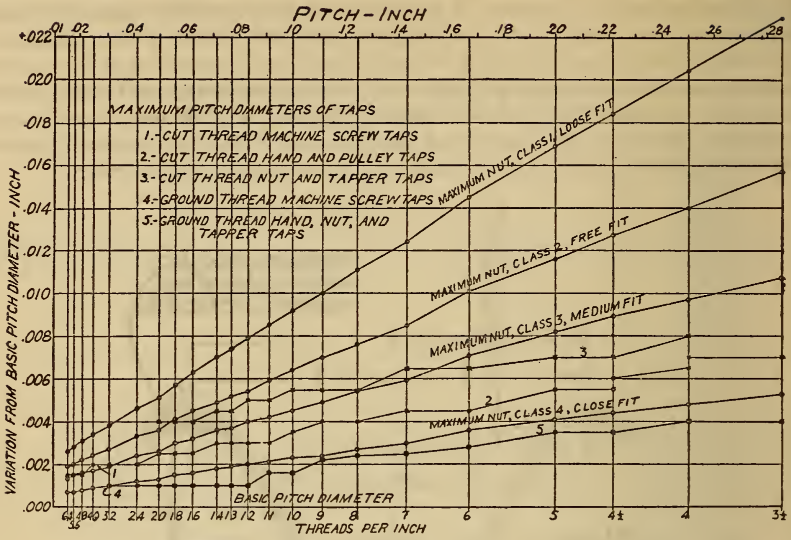


FIG. 64.—*Comparison of maximum pitch diameters of taps and nuts, American National coarse thread series*

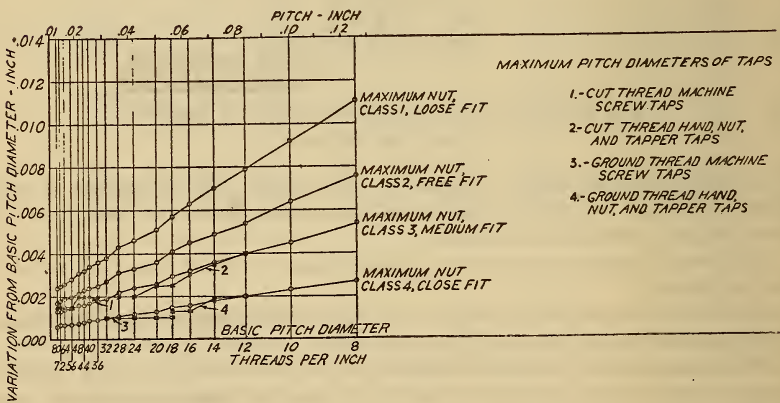
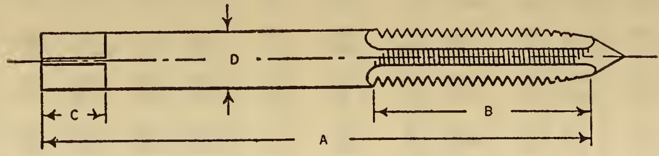


FIG. 65.—*Comparison of maximum pitch diameters of taps and nuts, American National fine thread series*

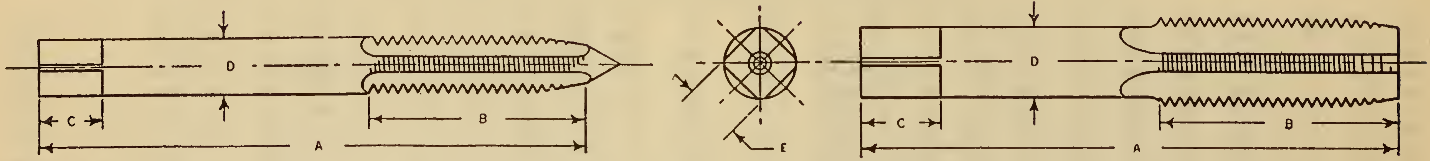
TABLE 99.—*Dimensions of machine screw taps, cut and ground threads,*[1] *American National coarse and fine thread series*



Sizes and threads per inch	Thread dimensions: Pitch diameter, Basic	Pitch diameter, Cut thread, Minimum	Pitch diameter, Cut thread, Maximum	Pitch diameter, Ground thread, Minimum	Pitch diameter, Ground thread, Maximum	Major diameter, Basic	Major diameter, Cut thread, Minimum	Major diameter, Cut thread, Maximum	Major diameter, Ground thread, Minimum	Major diameter, Ground thread, Maximum	Tolerance on half angle of thread, Cut thread	Tolerance on half angle of thread, Ground thread	Tolerance on full angle of thread, cut thread	General dimensions: Over-all length, Basic A	Over-all length, Tolerance	Length of thread, Basic B	Length of thread, Tolerance	Length of square, Basic C	Length of square, Tolerance	Diameter of shank, Maximum D	Diameter of shank, Tolerance, cut thread	Diameter of shank, Tolerance, ground thread	Size of square, Maximum E	Size of square, Tolerance
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Minutes ±	Minutes ±	Minutes ±	Inch	Inch ±	Inch	Inch ±	Inch	Inch ±	Inch	Inch —	Inch —	Inch	Inch —
0-80	0.0519	0.0524	0.0534			0.0600	0.0610	0.0625			60		90	1 5/8	1/32	5/16	3/64	3/16	1/32	0.141	0.004		0.110	0.004
1-64	.0629	.0634	.0644			.0730	.0740	.0755			60		90	1 11/16	1/32	3/8	3/64	3/16	1/32	.141	.004		.110	.004
1-72	.0640	.0645	.0655			.0730	.0740	.0755			60		90	1 11/16	1/32	3/8	3/64	3/16	1/32	.141	.004		.110	.004
2-56	.0744	.0749	.0759			.0860	.0875	.0890			60		90	1 3/4	1/32	7/16	3/64	3/16	1/32	.141	.004		.110	.004
2-64	.0759	.0764	.0774			.0860	.0875	.0890			60		90	1 3/4	1/32	7/16	3/64	3/16	1/32	.141	.004		.110	.004
3-48	.0855	.0860	.0870			.0990	.1005	.1020			60		90	1 13/16	1/32	1/2	3/64	3/16	1/32	.141	.004		.110	.004
3-56	.0874	.0879	.0889			.0990	.1005	.1020			60		90	1 13/16	1/32	1/2	3/64	3/16	1/32	.141	.004		.110	.004
4-40	.0958	.0963	.0978			.1120	.1135	.1155			60		90	1 7/8	1/32	9/16	3/64	3/16	1/32	.141	.004		.110	.004
4-48	.0985	.0990	.1005			.1120	.1135	.1155			60		90	1 7/8	1/32	9/16	3/64	3/16	1/32	.141	.004		.110	.004
5-40	.1088	.1093	.1108			.1250	.1265	.1285			60		90	1 15/16	1/32	5/8	3/64	3/16	1/32	.141	.004		.110	.004
5-44	.1102	.1107	.1122			.1250	.1265	.1285			60		90	1 15/16	1/32	5/8	3/64	3/16	1/32	.141	.004		.110	.004
6-32	.1177	.1182	.1197	0.1182	0.1187	.1380	.1395	.1415	0.1395	0.1410	60	30	90	2	1/32	1 1/16	3/64	3/16	1/32	.141	.004	0.0015	.110	.004
6-40	.1218	.1223	.1238			.1380	.1395	.1415			60		90	2	1/32	1 1/16	3/64	3/16	1/32	.141	.004		.110	.004
8-32	.1437	.1442	.1457	.1442	.1447	.1640	.1660	.1680	.1655	.1670	60	30	90	2 1/8	1/32	3/4	3/64	1/4	1/32	.168	.004	.0015	.131	.004
8-36	.1460	.1465	.1480			.1640	.1660	.1680			60		90	2 1/8	1/32	3/4	3/64	1/4	1/32	.168	.004		.131	.004
10-24	.1629	.1634	.1649	.1634	.1639	.1900	.1925	.1945	.1925	.1940	45	30	68	2 3/8	1/32	7/8	3/64	1/4	1/32	.194	.004	.0015	.152	.004
10-32	.1697	.1702	.1717	.1702	.1707	.1900	.1925	.1945	.1915	.1930	60	30	90	2 3/8	1/32	7/8	3/64	1/4	1/32	.194	.004	.0015	.152	.004
12-24	.1889	.1894	.1909	.1894	.1899	.2160	.2185	.2205	.2185	.2200	45	30	68	2 3/8	1/32	1 5/16	3/64	9/32	1/32	.220	.004	.0015	.165	.004
12-28	.1928	.1933	.1948	.1933	.1938	.2160	.2185	.2205	.2180	.2195	45	30	68	2 3/8	1/32	1 5/16	3/64	9/32	1/32	.220	.004	.0015	.165	.004

[1] It is not commercial practice to grind the threads of taps smaller than No. 6 nor with more than 32 threads per inch.

TABLE 100.—*Dimensions of hand taps, cut and ground threads, American National coarse and fine thread series*

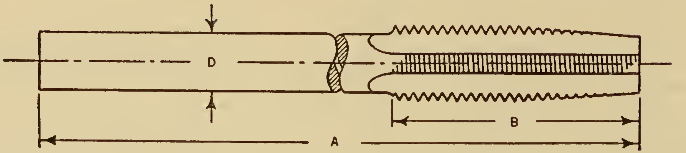


Sizes and threads per inch	Thread dimensions: Pitch diameter, Basic	Pitch diameter, Minimum	Pitch diameter, Maximum, cut thread	Pitch diameter, Maximum, ground thread	Major diameter, Basic	Major diameter, Cut thread, Minimum	Major diameter, Cut thread, Maximum	Major diameter, Ground thread, Minimum	Major diameter, Ground thread, Maximum	Tolerance on half angle of thread, Cut thread	Tolerance on half angle of thread, Ground thread	Tolerance on full angle of thread, cut thread	General dimensions: Over-all length, Basic A	Over-all length, Tolerance	Length of thread, Basic B	Length of thread, Tolerance	Length of square, Basic C	Length of square, Tolerance	Diameter of shank, Maximum D	Diameter of shank, Tolerance, cut thread	Diameter of shank, Tolerance, ground thread	Size of square, Maximum E	Size of square, Tolerance
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Minutes* ±	*Minutes* ±	*Minutes* ±	*Inches*	*Inch* ±	*Inches*	*Inch* ±	*Inches*	*Inch* ±	*Inches*	*Inch* —	*Inch* —	*Inches*	*Inch* —
1/4-20	0.2175	0.2180	0.2200	0.2185	0.2500	0.2525	0.2550	0.2535	0.2550	45	30	68	2 1/2	1/32	1	1/16	9/32	1/32	0.255	0.005	.0015	0.191	0.004
1/4-28	.2268	.2273	.2288	.2278	.2500	.2525	.2550	.2520	.2535	45	30	68	2 1/2	1/32	1	1/16	9/32	1/32	.255	.005	.0015	.191	.004
5/16-18	.2764	.2769	.2789	.2774	.3125	.3155	.3180	.3165	.3180	45	30	68	2 23/32	1/32	1 1/8	1/16	5/16	1/32	.318	.005	.0015	.238	.004
5/16-24	.2854	.2859	.2874	.2864	.3125	.3155	.3180	.3150	.3165	45	30	68	2 23/32	1/32	1 1/8	1/16	5/16	1/32	.318	.005	.0015	.238	.004
3/8-16	.3344	.3349	.3369	.3354	.3750	.3785	.3810	.3795	.3810	45	30	68	2 15/16	1/32	1 1/4	1/16	3/8	1/32	[1].381	.005	.0015	[1].286	.004
3/8-24	.3479	.3484	.3499	.3489	.3750	.3785	.3810	.3775	.3790	45	30	68	2 15/16	1/32	1 1/4	1/16	3/8	1/32	[1].275	.005	.0015	[1].206	.004
7/16-14	.3911	.3916	.3941	.3921	.4375	.4410	.4440	.4425	.4440	45	30	68	3 5/32	1/32	1 7/16	1/16	13/32	1/32	.323	.005	.0015	.242	.004
7/16-20	.4050	.4055	.4075	.4060	.4375	.4410	.4440	.4410	.4425	45	30	68	3 5/32	1/32	1 7/16	1/16	13/32	1/32	.323	.005	.0015	.242	.004
1/2-13	.4500	.4505	.4530	.4510	.5000	.5040	.5070	.5055	.5070	45	30	68	3 3/8	1/32	1 21/32	1/16	7/16	1/32	.367	.005	.0015	.275	.004
1/2-20	.4675	.4680	.4700	.4685	.5000	.5040	.5070	.5035	.5050	45	30	68	3 3/8	1/32	1 21/32	1/16	7/16	1/32	.367	.005	.0015	.275	.004
9/16-12	.5084	.5089	.5114	.5094	.5625	.5670	.5700	.5685	.5700	45	30	68	3 19/32	1/32	1 21/32	3/32	1/2	1/32	.429	.005	.0015	.322	.006
9/16-18	.5264	.5269	.5289	.5274	.5625	.5670	.5700	.5665	.5680	45	30	68	3 19/32	1/32	1 21/32	3/32	1/2	1/32	.429	.005	.0015	.322	.006

5/8-11	.5660	.5665	.5690	.5676	.6250	.6300	.6330	.6315	.6330	45	30	68	3 13/16	1/32	1 13/16	3/32	9/16	1/32	.480	.005	.0015	.360	.006
5/8-18	.5889	.5894	.5914	.5902	.6250	.6300	.6330	.6290	.6305	45	30	68	3 13/16	1/32	1 13/16	3/32	9/16	1/32	.480	.005	.0015	.360	.006
3/4-10	.6850	.6855	.6885	.6866	.7500	.7550	.7590	.7570	.7590	45	30	68	4 1/4	1/32	2	3/32	11/16	1/32	.590	.005	.0020	.442	.006
3/4-16	.7094	.7099	.7124	.7107	.7500	.7550	.7590	.7540	.7560	45	30	68	4 1/4	1/32	2	3/32	11/16	1/32	.590	.005	.0020	.442	.006
7/8-9	.8028	.8038	.8068	.8050	.8750	.8805	.8845	.8830	.8850	40	25	60	4 11/16	1/32	2 7/32	3/32	3/4	1/32	.697	.005	.0020	.523	.006
7/8-14	.8286	.8296	.8321	.8305	.8750	.8805	.8845	.8795	.8815	45	30	68	4 11/16	1/32	2 7/32	3/32	3/4	1/32	.697	.005	.0020	.523	.006
1-8	.9188	.9198	.9228	.9212	1.0000	1.0060	1.0100	1.0090	1.0110	40	25	60	5 1/8	1/32	2 1/2	3/32	13/16	1/32	.800	.005	.0020	.600	.006
1-14	.9536	.9546	.9571	.9555	1.0000	1.0060	1.0100	1.0045	1.0065	45	30	68	5 1/8	1/32	2 1/2	3/32	13/16	1/32	.800	.005	.0020	.600	.006
1 1/8-7	1.0322	1.0332	1.0367	1.0347	1.1250	1.1310	1.1355	1.1345	1.1370	40	25	60	5 7/16	1/16	2 9/16	3/32	7/8	1/16	.896	.007	.0020	.672	.008
1 1/8-12	1.0709	1.0719	1.0749	1.0729	1.1250	1.1310	1.1355	1.1300	1.1325	45	30	68	5 7/16	1/16	2 9/16	3/32	7/8	1/16	.896	.007	.0020	.672	.008
1 1/4-7	1.1572	1.1582	1.1617	1.1597	1.2500	1.2565	1.2610	1.2595	1.2620	40	25	60	5 3/4	1/16	2 9/16	3/32	1	1/16	1.021	.007	.0020	.766	.008
1 1/4-12	1.1959	1.1969	1.1999	1.1979	1.2500	1.2565	1.2610	1.2550	1.2575	45	30	68	5 3/4	1/16	2 9/16	3/32	1	1/16	1.021	.007	.0020	.766	.008
1 1/2-6	1.3917	1.3927	1.3962	1.3945	1.5000	1.5075	1.5120	1.5115	1.5140	40	25	60	6 3/8	1/16	3	3/32	1 1/8	1/16	1.233	.007	.0020	.925	.008
1 1/2-12	1.4459	1.4469	1.4499	1.4479	1.5000	1.5075	1.5120	1.5050	1.5075	45	30	68	6 3/8	1/16	3	3/32	1 1/8	1/16	1.233	.007	.0020	.925	.008
1 3/4-5	1.6201	1.6216	1.6256	1.6236	1.7500	1.7575	1.7630	1.7620	1.7650	35	20	53	7	1/16	3 3/16	1/8	1 1/4	1/16	1.430	.007	.0030	1.072	.008
2-4 1/2	1.8557	1.8572	1.8612	1.8592	2.0000	2.0085	2.0140	2.0130	2.0160	35	20	53	7 5/8	1/16	3 9/16	1/8	1 3/8	1/16	1.644	.007	.0030	1.233	.008
2 1/4-4 1/2	2.1057	2.1072	2.1117	2.1092	2.2500	2.2590	2.2650	2.2630	2.2660	35	20	53	8 1/4	1/16	3 9/16	1/8	1 7/16	1/16	1.894	.009	.0030	1.420	.010
2 1/2-4	2.3376	2.3396	2.3441	2.3416	2.5000	2.5100	2.5160	2.5140	2.5170	30	20	45	8 3/4	1/16	4	1/8	1 1/2	1/16	2.100	.009	.0030	1.575	.010
2 3/4-4	2.5876	2.5896	2.5946	2.5916	2.7500	2.7600	2.7670	2.7640	2.7670	30	20	45	9 1/4	1/16	4	1/8	1 9/16	1/16	2.350	.009	.0030	1.762	.010
3-3 1/2	2.8144	2.8164	2.8214	2.8184	3.0000	3.0105	3.0175	3.0150	3.0180	30	20	45	9 3/4	1/16	4 9/16	1/8	1 5/8	1/16	2.543	.009	.0030	1.907	.010

[1] Applicable optionally either to the 3/8-16 or the 3/8-24 sizes.

TABLE 101.—*Dimensions of tapper taps, cut and ground threads, American National coarse and fine thread series*

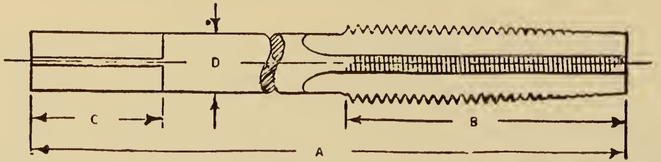


Sizes and threads per inch	Thread dimensions													General dimensions					
	Pitch diameter					Major diameter					Tolerance on half angle of thread		Tolerance on full angle of thread, cut thread	Over-all length		Length of thread		Diameter of shank [1]	
	Basic	Cut thread		Ground thread		Basic	Cut thread		Ground thread										
		Minimum	Maximum	Minimum	Maximum		Minimum	Maximum	Minimum	Maximum	Cut thread	Ground thread		Basic *A*	Tolerance	Basic *B*	Tolerance	Maximum *D*	Tolerance
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Minutes* ±	*Minutes* ±	*Minutes* ±	*Inches*	*Inch* ±	*Inches*	*Inch* ±	*Inches*	*Inch* −
¼—20	0.2175	0.2190	0.2215	0.2180	0.2185	0.2500	0.2535	0.2565	0.2535	0.2550	45	30	68	12, 15	⅛	1¼	1/16	0.185	0.005
¼—28	.2268	.2273	.2288	.2273	.2278	.2500	.2525	.2550	.2520	.2535	45	30	68	12, 15	⅛	1	1/16	.185	.005
5/16—18	.2764	.2779	.2804	.2769	.2774	.3125	.3165	.3195	.3165	.3180	45	30	68	12, 15	⅛	1⅜	1/16	.240	.005
5/16—24	.2854	.2859	.2874	.2859	.2864	.3125	.3155	.3180	.3150	.3165	45	30	68	12, 15	⅛	1 1/16	1/16	.240	.005
⅜—16	.3344	.3359	.3384	.3349	.3354	.3750	.3795	.3825	.3795	.3810	45	30	68	12, 15	⅛	1 9/16	1/16	.294	.005
⅜—24	.3479	.3484	.3499	.3484	.3489	.3750	.3785	.3810	.3775	.3790	45	30	68	12, 15	⅛	1 3/16	1/16	.294	.005
7/16—14	.3911	.3926	.3956	.3916	.3921	.4375	.4420	.4460	.4425	.4440	45	30	68	12, 15	⅛	1 13/16	1/16	.345	.005
7/16—20	.4050	.4055	.4075	.4055	.4060	.4375	.4410	.4440	.4410	.4425	45	30	68	12, 15	⅛	1⅜	1/16	.345	.005
½—13	.4500	.4515	.4545	.4505	.4510	.5000	.5045	.5085	.5055	.5070	45	30	68	12, 15	⅛	1⅞	1/16	.400	.005
½—20	.4675	.4680	.4700	.4680	.4685	.5000	.5040	.5070	.5035	.5050	45	30	68	12, 15	⅛	1⅜	1/16	.400	.005

9/16—12	.5084	.5104	.5134	.5089	.5094	.5625	.5680	.5720	.5685	.5700	45	30	68	12, 15	1/8	2 1/8	3/32	.450	.006
9/16—18	.5264	.5269	.5289	.5269	.5274	.5625	.5670	.5700	.5665	.5680	45	30	68	12, 15	1/8	1 9/16	3/32	.450	.006
5/8—11	.5660	.5680	.5710	.5665	.5676	.6250	.6310	.6350	.6315	.6330	45	30	68	12, 15	1/8	2 5/16	3/32	.503	.006
5/8—18	.5889	.5894	.5914	.5894	.5902	.6250	.6300	.6330	.6290	.6305	45	30	68	12, 15	1/8	1 11/16	3/32	.503	.006
3/4—10	.6850	.6870	.6905	.6855	.6866	.7500	.7560	.7605	.7570	.7590	45	30	68	12, 15	1/8	2 1/2	3/32	.616	.006
3/4—16	.7094	.7099	.7124	.7099	.7107	.7500	.7550	.7590	.7540	.7560	45	30	68	12, 15	1/8	1 3/4	3/32	.616	.006
7/8—9	.8028	.8048	.8083	.8038	.8050	.8750	.8815	.8860	.8830	.8850	40	25	60	12, 15	1/8	2 3/4	3/32	.727	.006
7/8—14	.8286	.8296	.8321	.8296	.8305	.8750	.8805	.8845	.8795	.8815	45	30	68	12, 15	1/8	1 7/8	3/32	.727	.006
1—8	.9188	.9208	.9243	.9198	.9212	1.0000	1.0070	1.0115	1.0090	1.0110	40	25	60	12, 15	1/8	3 1/8	3/32	.834	.006
1—14	.9536	.9546	.9571	.9546	.9555	1.0000	1.0060	1.0100	1.0045	1.0065	45	30	68	12, 15	1/8	2 1/8	3/32	.834	.006
1 1/8—7	1.0322	1.0347	1.0387	1.0332	1.0347	1.1250	1.1325	1.1375	1.1345	1.1370	40	25	60	15	3/16	3 1/2	3/32	.933	.008
1 1/8—12	1.0709	1.0719	1.0749	1.0719	1.0729	1.1250	1.1310	1.1355	1.1300	1.1325	45	30	68	15	3/16	2 3/8	3/32	.933	.008
1 1/4—7	1.1572	1.1597	1.1637	1.1582	1.1597	1.2500	1.2580	1.2630	1.2595	1.2620	40	25	60	15	3/16	3 1/2	3/32	1.058	.008
1 1/4—12	1.1959	1.1969	1.1999	1.1969	1.1979	1.2500	1.2565	1.2610	1.2550	1.2575	45	30	68	15	3/16	2 3/8	3/32	1.058	.008
1 1/2—6	1.3917	1.3942	1.3982	1.3927	1.3945	1.5000	1.5090	1.5140	1.5115	1.5140	40	25	60	15	3/16	4	3/32	1.278	.008
1 1/2—12	1.4459	1.4469	1.4499	1.4469	1.4479	1.5000	1.5075	1.5120	1.5050	1.5075	45	30	68	15	3/16	2 5/8	3/32	1.278	.008
1 3/4—5	1.6201	1.6226	1.6271	1.6216	1.6236	1.7500	1.7590	1.7650	1.7620	1.7650	35	20	53	15	3/16	4 1/2	1/8	1.484	.008
2—4 1/2	1.8557	1.8582	1.8627	1.8572	1.8592	2.0000	2.0095	2.0155	2.0130	2.0160	35	20	53	15	3/16	4 1/2	1/8	1.705	.008

[1] A nut guide back of the thread on fine thread sizes, equal in length to the basic diameter, is optional.

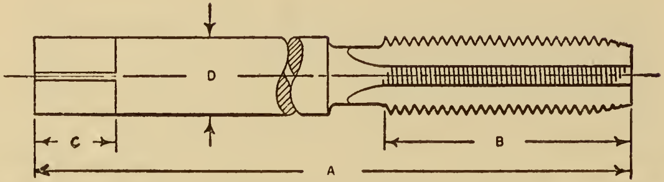
TABLE 102.—*Dimensions of nut taps, cut and ground threads, American National coarse and fine thread series*



Sizes and threads per inch	Thread dimensions													General dimensions									
	Pitch diameter					Major diameter					Tolerance on half angle of thread		Tolerance on full angle of thread, cut thread	Over-all length		Length of thread		Length of square		Diameter of shank		Size of square	
	Basic	Cut thread		Ground thread		Basic	Cut thread		Ground thread														
		Minimum	Maximum	Minimum	Maximum		Minimum	Maximum	Minimum	Maximum	Cut thread	Ground thread		Basic *A*	Tolerance	Basic *B*	Tolerance	Basic *C*	Tolerance	Maximum *D*	Tolerance	Maximum *E*	Tolerance
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Minutes* ±	*Minutes* ±	*Minutes* ±	*Inches*	*Inch* ±	*Inches*	*Inch* ±	*Inches*	*Inch* ±	*Inches*	*Inch* —	*Inches*	*Inch* —
¼-20	0.2175	0.2190	0.2215	0.2180	0.2185	0.2500	0.2535	0.2565	0.2535	0.2550	45	30	68	5	1/16	1⅝	1/16	9/16	1/32	0.185	0.005	0.139	0.004
¼-28	.2268	.2273	.2288	.2273	.2278	.2500	.2525	.2550	.2520	.2535	45	30	68	5	1/16	1¼	1/16	9/16	1/32	.185	.005	.139	.004
5/16-18	.2764	.2779	.2804	.2769	.2774	.3125	.3165	.3195	.3165	.3180	45	30	68	5½	1/16	1 13/16	1/16	⅝	1/32	.240	.005	.180	.004
5/16-24	.2854	.2859	.2874	.2859	.2864	.3125	.3155	.3180	.3150	.3165	45	30	68	5½	1/16	1⅜	1/16	⅝	1/32	.240	.005	.180	.004
⅜-16	.3344	.3359	.3384	.3349	.3354	.3750	.3795	.3825	.3795	.3810	45	30	68	6	1/16	2	1/16	11/16	1/32	.294	.005	.220	.004
⅜-24	.3479	.3484	.3499	.3484	.3489	.3750	.3785	.3810	.3775	.3790	45	30	68	6	1/16	1½	1/16	11/16	1/32	.294	.005	.220	.004
7/16-14	.3911	.3926	.3956	.3916	.3921	.4375	.4420	.4460	.4425	.4440	45	30	68	6½	1/16	2⅜	1/16	¾	1/32	.345	.005	.259	.004
7/16-20	.4050	.4055	.4075	.4055	.4060	.4375	.4410	.4440	.4410	.4425	45	30	68	6½	1/16	1¾	1/16	¾	1/32	.345	.005	.259	.004
½-13	.4500	.4515	.4545	.4505	.4510	.5000	.5045	.5085	.5055	.5070	45	30	68	7	1/16	2½	1/16	⅞	1/32	.400	.005	.300	.004
½-20	.4675	.4680	.4700	.4680	.4685	.5000	.5040	.5070	.5035	.5050	45	30	68	7	1/16	1⅞	1/16	⅞	1/32	.400	.005	.300	.004
9/16-12	.5084	.5104	.5134	.5089	.5094	.5625	.5680	.5720	.5685	.5700	45	30	68	7½	1/16	2¾	3/32	⅞	1/32	.450	.006	.337	.006
9/16-18	.5264	.5269	.5289	.5269	.5274	.5625	.5670	.5700	.5665	.5680	45	30	68	7½	1/16	2	3/32	⅞	1/32	.450	.006	.337	.006

⅝-11	.5660	.5680	.5710	.5665	.5676	.6250	.6310	.6350	.6315	.6330	45	30	68	8	1/16	3	3/32	15/16	1/32	.503	.006	.377	.006
⅝-18	.5889	.5894	.5914	.5894	.5902	.6250	.6300	.6330	.6290	.6305	45	30	68	8	1/16	2¼	3/32	15/16	1/32	.503	.006	.377	.006
¾-10	.6850	.6870	.6905	.6855	.6866	.7500	.7560	.7605	.7570	.7590	45	30	68	9	1/16	3¼	3/32	1	3/64	.616	.006	.462	.006
¾-16	.7094	.7099	.7124	.7099	.7107	.7500	.7550	.7590	.7540	.7560	45	30	68	9	1/16	2½	3/32	1	3/64	.616	.006	.462	.006
⅞-9	.8028	.8048	.8083	.8038	.8050	.8750	.8815	.8860	.8830	.8850	40	25	60	10	1/16	3⅝	3/32	1 1/16	3/64	.727	.006	.545	.006
⅞-14	.8286	.8296	.8321	.8296	.8305	.8750	.8805	.8845	.8795	.8815	45	30	68	10	1/16	2¾	3/32	1 1/16	3/64	.727	.006	.545	.006
1-8	.9188	.9208	.9243	.9198	.9212	1.0000	1.0070	1.0115	1.0090	1.0110	40	25	60	11	1/16	4	3/32	1⅛	3/64	.834	.006	.625	.006
1-14	.9536	.9546	.9571	.9546	.9555	1.0000	1.0060	1.0100	1.0045	1.0065	45	30	68	11	1/16	3	3/32	1⅛	3/64	.834	.006	.625	.006
1⅛-7	1.0322	1.0347	1.0387	1.0332	1.0347	1.1250	1.1325	1.1375	1.1345	1.1370	40	25	60	11½	3/32	4¾	3/32	1¼	3/64	.933	.008	.700	.008
1⅛-12	1.0709	1.0719	1.0749	1.0719	1.0729	1.1250	1.1310	1.1355	1.1300	1.1325	45	30	68	11½	3/32	3½	3/32	1¼	3/64	.933	.008	.700	.008
1¼-7	1.1572	1.1597	1.1637	1.1582	1.1597	1.2500	1.2580	1.2630	1.2595	1.2620	40	25	60	12	3/32	4¾	3/32	1 5/16	3/64	1.058	.008	.793	.008
1¼-12	1.1959	1.1969	1.1999	1.1969	1.1979	1.2500	1.2565	1.2610	1.2550	1.2575	45	30	68	12	3/32	3½	3/32	1 5/16	3/64	1.058	.008	.793	.008
1½-6	1.3917	1.3942	1.3982	1.3927	1.3945	1.5000	1.5090	1.5140	1.5115	1.5140	40	25	60	13	3/32	5⅜	3/32	1½	3/64	1.278	.008	.958	.008
1½-12	1.4459	1.4469	1.4499	1.4469	1.4479	1.5000	1.5075	1.5120	1.5050	1.5075	45	30	68	13	3/32	4	3/32	1½	3/64	1.278	.008	958	.008
1¾-5	1.6201	1.6226	1.6271	1.6216	1.6236	1.7500	1.7590	1.7650	1.7620	1.7650	35	20	53	14	3/32	5½	⅛	1⅝	1/16	1.484	.008	1.113	.008
2-4½	1.8557	1.8582	1.8627	1.8572	1.8592	2.0000	2.0095	2.0155	2.0130	2.0160	35	20	53	15	3/32	6⅛	⅛	1¾	1/16	1.705	.008	1.279	.008
2¼-4½	2.1057	2.1087	2.1137	2.1072	2.1092	2.2500	2.2600	2.2670	2.2630	2.2660	35	20	53	16	3/32	6⅛	⅛	1⅞	1/16	1.953	.010	1.465	.010
2½-4	2.3376	2.3406	2.3456	2.3396	2.3416	2.5000	2.5105	2.5175	2.5140	2.5170	30	20	45	17	3/32	6⅞	⅛	2	1/16	2.167	.010	1.625	.010

TABLE 103.—*Dimensions of pulley taps, cut threads, American National coarse and fine thread series*



Sizes and threads per inch	Thread dimensions								General dimensions									
	Pitch diameter			Major diameter			Tolerance on half angle of thread	Tolerance on full angle of thread	Over-all length		Length of thread		Length of square		Diameter of shank		Size of square	
	Basic	Minimum	Maximum	Basic	Minimum	Maximum			Basic *A*	Tolerance	Basic *B*	Tolerance	Basic *C*	Tolerance	Maximum *D*	Tolerance	Maximum *E*	Tolerance
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Minutes* ±	*Minutes* ±	*Inches*	*Inch* ±	*Inches*	*Inch* ±	*Inch*	*Inch* ±	*Inch*	*Inch* —	*Inch*	*Inch* —
1/4–20	0.2175	0.2180	0.2200	0.2500	0.2525	0.2550	45	68	6, 8	1/16	1	1/16	5/16	1/32	0.255	0.005	0.191	0.004
5/16–18	.2764	.2769	.2789	.3125	.3155	.3180	45	68	6, 8	1/16	1 1/8	1/16	3/8	1/32	.318	.005	.238	.004
3/8–16	.3344	.3349	.3369	.3750	.3785	.3810	45	68	6, 8, 10, 12, 14	1/16	1 1/4	1/16	7/16	1/32	.381	.005	.286	.004
7/16–14	.3911	.3916	.3941	.4375	.4410	.4440	45	68	6, 8, 10, 12, 14	1/16	1 7/16	1/16	1/2	1/32	.444	.005	.333	.004
1/2–13	.4500	.4505	.4530	.5000	.5040	.5070	45	68	6, 8, 10, 12, 14	1/16	1 21/32	1/16	9/16	1/32	.507	.005	.380	.004
9/16–12	.5084	.5089	.5114	.5625	.5670	.5700	45	68	6, 8, 10, 12, 14	1/16	1 21/32	1/16	5/8	1/32	.570	.005	.427	.006
5/8–11	.5660	.5665	.5690	.6250	.6300	.6330	45	68	6, 8, 10, 12, 14	1/16	1 13/16	1/16	11/16	1/32	.633	.005	.475	.006
3/4–10	.6850	.6855	.6885	.7500	.7550	.7590	45	68	10, 12, 14	1/16	2	1/16	3/4	1/32	.759	.005	.569	.006

2. Tolerances for Taps for Special Threads.—Tables of tolerances for two classes of taps for threads of special diameter and pitch are given, namely, cut thread taps and ground thread taps. (See Tables 104 and 105.)

The selection of the tap will depend upon the pitch diameter tolerance on the tapped hole. A tap should be selected whose tolerance does not exceed 75 per cent of the pitch diameter tolerance on the tapped hole.

Table 104.—*Tolerances for cut thread taps, special diameters and pitches*

Sizes		Coarser pitches than American National fine thread series				Finer pitches than American National fine thread series			
		Major diameter	Pitch diameter			Major diameter	Pitch diameter		
From—	To—	Minimum = basic major diameter plus	Minimum = minimum pitch diameter of hole plus	Tolerance, plus	Maximum = minimum pitch diameter of hole plus	Minimum = basic major diameter plus	Minimum = minimum pitch diameter of hole plus	Tolerance, plus	Maximum = minimum pitch diameter of hole plus
1		2	3	4	5	6	7	8	9
		Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1/4	3/8	0.0030	0.0005	0.0020	0.0025	0.0020	0.0005	0.0015	0.0020
7/16	5/8	.0040	.0005	.0025	.0030	.0025	.0005	.0020	.0025
3/4	1	.0055	.0010	.0030	.0040	.0025	.0005	.0025	.0030
1 1/8	1 1/2	.0070	.0010	.0035	.0045	.0035	.0010	.0030	.0040
1 5/8	2	.0085	.0015	.0040	.0055	.0035	.0010	.0030	.0040
2 1/8	2 1/2	.0100	.0015	.0045	.0060	.0045	.0010	.0035	.0045
2 5/8	3	.0100	.0020	.0050	.0070	.0045	.0010	.0035	.0045
3 1/8	4	.0100	.0020	.0055	.0075	.0055	.0010	.0045	.0055

Note.—Maximum lead error=±0.003 inch in 1 inch of thread. Tolerance on half angle of thread=±40 minutes.

Table 105.—*Tolerances for ground thread taps, special diameters and pitches*

Sizes		Coarser pitches than American National fine thread series				Finer pitches than American National fine thread series			
		Major diameter	Pitch diameter			Major diameter	Pitch diameter		
From—	To—	Minimum = basic major diameter plus	Minimum = minimum pitch diameter of hole plus	Tolerance, plus	Maximum = minimum pitch diameter of hole plus	Minimum = basic major diameter plus	Minimum = minimum pitch diameter of hole plus	Tolerance, plus	Maximum = minimum pitch diameter of hole plus
1		2	3	4	5	6	7	8	9
		Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1/4	3/8	0.0025	0.0006	0.0005	0.0011	0.0015	0.0005	0.0005	0.0010
7/16	1/2	.0030	.0007	.0005	.0012	.0020	.0005	.0005	.0010
9/16	5/8	.0035	.0008	.0010	.0018	.0020	.0006	.0008	.0014
3/4	1	.0040	.0010	.0010	.0020	.0025	.0007	.0008	.0015
1 1/8	1 1/2	.0050	.0012	.0015	.0027	.0025	.0008	.0010	.0018
1 5/8	2	.0065	.0015	.0020	.0035	.0030	.0010	.0015	.0025
2 1/8	2 1/2	.0080	.0020	.0020	.0040	.0030	.0010	.0015	.0025
2 5/8	3	.0080	.0020	.0020	.0040	.0035	.0015	.0015	.0030
3 1/8	4	.0080	.0020	.0025	.0045	.0035	.0015	.0020	.0035

Note.—Maximum lead error=±0.0005 inch in 1 inch of thread. Tolerance of half angle of thread=±20 minutes.

18415°—29——15

3. Shape of Cutting Edge for Taps (and Other Internal Threading Tools).—In Figure 66 is shown the form of outline, measured on an axial section of the work, required for a tap or other internal threading tool intended for cutting threads of American National form. These outlines are alike for all pitches and classes of fit. Such a diagram, if drawn to a magnification of one hundred or two hundred times, will serve as a chart for projection testing. Note the shaded area at the point of the tool, within which a tool point of any shape is permissible. Also note the shaded area at the root of the thread which shows permissible variations in tooth outline at this point.

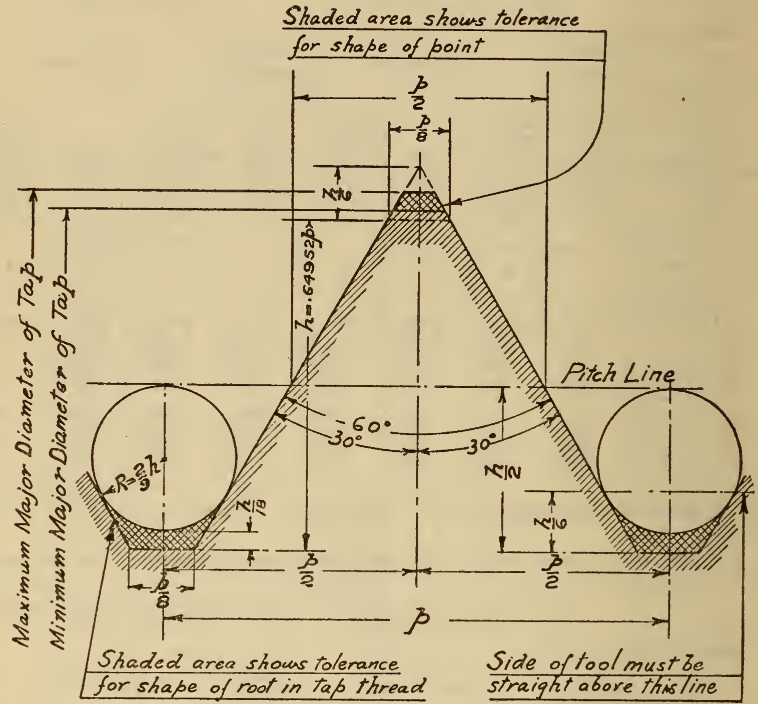


Fig. 66.—*Shape for teeth of top or internal thread-chasing tool*

While sharp-cornered tools are easier to make, one with a permissible round at the point might be more durable. In any event, the maker of the tap or other tool should keep the outline well away from the lower part of the permissible area, represented by the basic flat of $\frac{1}{8} \times p$. The danger here is that after a few holes have been tapped the corners will be rounded over so that the tapped hole rejects the "go" gage.

Tables 98 to 103, inclusive, give the necessary dimensions for drawing the diagram shown in Figure 66 for any standard pitch.

4. Marking of Taps.—It is recommended that taps be marked to indicate the diameter, pitch, and thread series or thread form, as, for example (see Section II, division 2, "Symbols"):

A 1-inch, 8-pitch cut thread tap will be marked............. 1″–8–NC.
A 1-inch, 14-pitch ground thread tap will be marked......... 1″–14–NF–G.
A 1-inch tap, 16 threads per inch, American National form of thread, will be marked............................ 1″–16–NS.
A 1-inch tap, 16 threads per inch, left hand, American National form of thread, will be marked.......................... 1″–16 L.H.–NS

A multiple threaded tap will be marked as above, and also with the number of starts. Where the size of the shank is large enough, the lead should also be given. Thus a double-threaded tap, 1 inch in diameter, 16 threads per inch, American National form of thread, with a lead of 0.125 inch will be marked .... 1″–16–NS–Double,Lead–0.125.

(c) DIE-HEAD CHASERS

There are given in Table 106 the simplified list of sizes and varieties, for threads of American National form, of die-head chasers for self-opening and adjustable die heads, as adopted December 4, 1925, at a general conference of representative manufacturers, distributors, and users, and promulgated in United States Department of Commerce Simplified Practice Recommendation No. 51.

TABLE 106.—*Die-head chasers, stock sizes for threads of American National form*

Sizes [1]	Threads per inch				Sizes [1]	Threads per inch			
	American National coarse thread seiies	American National fine thread series	Fine threads for lighting-fixture tubing	American National 12-pitch thread series (railway sizes)		American National coarse thread series	American National fine thread series	Fine threads for lighting-fixture tubing	American National 12-pitch thread series (railway sizes)
1	2	3	4	5	1	2	3	4	5
5	40				7/8	9	[3] 14(18)	27	12
6	32				15/16				12
8	32	36			1	8	14	27	12
10	24	32			1 1/16				12
12	24	28			1 1/8	7	12		12
1/4	20	28	27		1 3/16				12
5/16	18	24	27		1 1/4	7	12		12
3/8	16	24	27		1 5/16				12
7/16	14	20	27		1 3/8				12
1/2	13	20	27	12	1 1/2	6	12		12
9/16	12	18	27	12	1 3/4	5			12
5/8	11	18	27	12	2	4 1/2			
11/16				12					
3/4	10	16	27	12					
13/16		[2] (24)		12					

[1] Although self-opening die heads have a diameter adjustment, all chasers not stamped with these sizes will be regarded as specials.
[2] Spark plug bushing, 13/16 inch—24.
[3] Spark plug shell, 7/8 inch—18.

(d) TAP-DRILL SIZES

(Classes 1 to 4, inclusive)

The essential requirement of a tap drill is that the hole produced by it shall be such that, when tapped with a screw thread, the minor diameter of the tapped hole shall be within the specified limits shown in Tables 7 to 14, inclusive, of Section III. It should be noted that the minor diameters of the tapped holes are the same for classes 1 to 4, inclusive. This condition results from the requirement on page 18, Section III, with reference to clearance on minor diameter:

> "4. CLEARANCE ON 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 equal to not less than 62 to 75 per cent (depending on the size), and not more than 83⅓ per cent of the basic thread depth. (See fig. 17.)"

If the drill is too large, the minor diameter of the tapped hole will also be too large and the thread in the nut will be too shallow; that is, too small a percentage of a full thread. As an extreme case the threads in the nut will engage only the tops of the threads on a bolt of correct size, and under stress the threads of the screw will strip and the full strength of the fastening will not be developed.

If, on the other hand, the tap drill is too small, the tap will be forced to cut a thread of full depth, and in the extreme case to act as a reamer also. This will result in excessive power consumption and tap breakage, and will also make the minor diameter of the tapped hole dependent upon the minor diameter of the tap. This is undesirable, since the minor diameter of the tap is not, in general, held to the same close limits as the other tap elements, and as a result the minor diameter of a hole tapped under these conditions may be in error even though the tap is otherwise correct.

It is a well-known fact that the size of the hole produced by a tap drill depends to some extent upon the method of grinding the drill, the material drilled, the lubricant used, and the speed and feed of operation. This being true, it is apparent that fixing the diameter of the tap drill does not completely fix the diameter of the drilled hole. The most that can be accomplished is to fix the drill diameters between certain limits and to depend upon correct grinding, lubrication, and operation to keep the diameter of the holes within prescribed limits.

There are given in Tables 107, 108, and 109 all drills regularly carried in stock, both English and metric, which fall between the limiting dimensions of the minor diameter of the threaded hole for the American National coarse, fine, and 12-pitch thread series. A drill near the larger limits may be selected when it is desired to minimize tapping difficulties or provide for considerable wear of the drill; thus the drill may be allowed to wear undersize until the holes produced reach the lower limit on minor diameter, but the unworn drill can be allowed to cut only a very small amount oversize. On the other hand, a drill near the smaller limit may be selected when conditions of lubrication, operation, physical properties of material, etc., cause the drill to cut oversize, but such selection permits less wear of the drill.

TABLE 107.—*Sizes of tap drills, American National coarse-thread series*

Size of thread	Threads per inch	Minor diameter of nut			Stock drills within limits on minor diameter of nut					
					Numbered and fractional inch sizes			Metric sizes		
		Basic	Maximum	Minimum	Nominal size	Diameter	Per cent of depth of basic thread	Nominal size	Diameter	Per cent of depth of basic thread
1	2	3	4	5	6	7	8	9	10	11
		Inch	*Inch*	*Inch*		*Inch*		*mm*	*Inch*	
1	64	0.0527	0.0604	0.0561	No. 53	0.0595	67	1.5	0.0591	68
2	56	.0628	.0715	.0667	No. 51	.0670	82	1.7	.0669	82
					No. 50	.0700	69	1.75	.0689	74
								1.8	.0709	65
3	48	.0719	.0820	.0764	5/64 inch	.0781	77	2.0	.0787	75
					No. 47	.0785	76			
					No. 46	.0810	67			
					No. 45	.0820	63			
4	40	.0795	.0913	0849	No. 44	.0860	80	2.2	.0866	78
					No. 43	.0890	71	2.25	.0886	72
								2.3	.0906	66
5	40	.0925	.1043	.0979	No. 40	.0980	83	2.5	.0984	82
					No. 39	.0995	79	2.6	.1024	70
					No. 38	.1015	72			
					No. 37	.1040	65			

TABLE 107.—*Sizes of tap drills, American National coarse-thread series*—Contd.

Size of thread	Threads per inch	Minor diameter of nut			Stock drills within limits on minor diameter of nut					
					Numbered and fractional inch sizes			Metric sizes		
		Basic	Maximum	Minimum	Nominal size	Diameter	Per cent of depth of basic thread	Nominal size	Diameter	Per cent of depth of basic thread
1	2	3	4	5	6	7	8	9	10	11
		Inches	*Inches*	*Inches*		*Inches*		*mm*	*Inches*	
6	32	0.0974	0.1118	0.1042	No. 36	0.1065	78	2.7	0.1063	78
					7/64 inch	.1094	70	2.75	.1083	73
					No. 35	.1100	69	2.8	.1102	68
					No. 34	.1110	67	-----	-----	-----
8	32	.1234	.1378	.1302	No. 29	.1360	69	3.4	.1339	74
					-----	-----	-----	3.5	.1378	65
10	24	.1359	.1541	.1449	No. 26	.1470	79	3.7	.1457	82
					No. 25	.1495	75	3.75	.1476	78
					No. 24	.1520	70	3.8	.1496	75
					No. 23	.1540	67	3.9	.1535	67
12	24	.1619	.1801	.1709	11/64 inch	.1719	81	4.4	.1732	79
					No. 17	.1730	79	4.5	.1772	72
					No. 16	.1770	72	-----	-----	-----
					No. 15	.1800	67	-----	-----	-----
1/4	20	.1850	.2060	.1959	No. 9	.1960	83	5.0	.1968	82
					No. 8	.1990	79	5.1	.2008	76
					No. 7	.2010	75	5.2	.2047	70
					13/64 inch	.2031	72	-----	-----	-----
					No. 6	.2040	71	-----	-----	-----
					No. 5	.2055	69	-----	-----	-----
5/16	18	.2403	.2630	.2524	F	.2570	77	6.5	.2559	78
					G	.2610	71	6.6	.2598	73
3/8	16	.2938	.3184	.3073	5/16 inch	.3125	77	7.9	.3110	79
					O	.3160	73	8.0	.3150	74
7/16	14	.3447	.3721	.3602	U	.3680	75	9.2	.3622	81
					-----	-----	-----	9.25	.3642	79
					-----	-----	-----	9.3	.3661	77
					-----	-----	-----	9.4	.3701	73
1/2	13	.4001	.4290	.4167	27/64 inch	.4219	78	-----	-----	-----
9/16	12	.4542	.4850	.4723	31/64 inch	.4844	72	12.0	.4724	83
5/8	11	.5069	.5397	.5266	17/32 inch	.5312	79	13.5	.5315	79
3/4	10	.6201	.6553	.6417	-----	-----	-----	16.5	.6496	77
7/8	9	.7307	.7689	.7547	49/64 inch	.7656	76	19.5	.7677	74
1	8	.8376	.8795	.8647	7/8 inch	.8750	77	22.0	.8661	82
1 1/8	7	.9394	.9858	.9704	63/64 inch	.9844	76	25.0	.9842	76
1 1/4	7	1.0644	1.1108	1.0954	1 7/64 inches	1.1094	76	28.0	1.1024	80
1 1/2	6	1.2835	1.3376	1.3196	1 21/64 inches	1.3281	79	-----	-----	-----
1 3/4	5	1.4902	1.5551	1.5335	1 35/64 inches	1.5469	78	39.0	1.5354	83
					-----	-----	-----	39.5	1.5551	75
2	4½	1.7113	1.7835	1.7594	1 49/64 inches	1.7656	81	45.0	1.7716	79
					1 25/32 inches	1.7812	76	-----	-----	-----
2 1/4	4½	1.9613	2.0335	2.0094	2 1/64 inches	2.0156	81	51.5	2.0276	77
					2 1/32 inches	2.0312	76	-----	-----	-----
2 1/2	4	2.1752	2.2564	2.2294	2 15/64 inches	2.2344	82	57.0	2.2441	79
					2 1/4 inhces	2.2500	77	-----	-----	-----
2 3/4	4	2.4252	2.5064	2.4794	2 31/64 inches	2.4844	82	63.0	2.4803	83
					2 1/2 inches	2.5000	77	63.5	2.5000	77
3	4	2.6752	2.7564	2.7294	2 47/64 inches	2.7344	82	69.5	2.7362	81
					2 3/4 inches	2.7500	77	70.0	2.7559	75
3	3½	2.6288	2.7216	2.6907	2 45/64 inches	2.7031	80	68.5	2.6968	82
					2 23/32 inches	2.7188	76	69.0	2.7165	76

TABLE 108.—*Sizes of tap drills, American National fine-thread series*

Size of thread	Threads per inch	Minor diameter of nut			Stock drills within limits on minor diameter of nut					
					Numbered and fractional inch sizes			Metric sizes		
		Basic	Maximum	Minimum	Nominal size	Diameter	Per cent of depth of basic thread	Nominal size	Diameter	Per cent of depth of basic thread
1	2	3	4	5	6	7	8	9	10	11
		Inches	*Inches*	*Inches*		*Inches*		*mm*	*Inches*	
0	80	0.0438	0.0492	0.0465	No. 56 3/64 inch	0.0465 .0469	83 81	1.2 1.25	0.0472 .0492	79 67
1	72	.0550	.0610	.0580	No. 53	.0595	75	1.5	.0591	77
2	64	.0657	.0724	.0691	No. 50	.0700	79	1.8	.0709	74
3	56	.0758	.0834	.0797	No. 46 No. 45	.0810 .0820	78 73	2.1	.0827	70
4	48	.0849	.0937	.0894	3/32 inch No. 42	.0938 .0935	67 68	2.3	.0906	79
5	44	.0955	.1049	.1004	No. 38 No. 37	.1015 .1040	80 71	2.6	.1024	77
6	40	.1055	.1158	.1109	No. 34 No. 33	.1110 .1130	83 77	2.9	.1142	73
8	36	.1279	.1391	.1339	No. 29	.1360	78	3.4 3.5	.1339 .1378	83 73
10	32	.1494	.1618	.1562	5/32 inch No. 22 No. 21 No. 20	.1562 .1570 .1590 .1610	83 81 76 71	4.0 4.1	.1575 .1614	80 70
12	28	.1696	.1833	.1773	No. 15 No. 14	.1800 .1820	78 73	4.6	.1811	75
1/4	28	.2036	.2173	.2113	No. 3	.2130	80	5.4 5.5	.2126 .2165	81 72
5/16	24	.2584	.2739	.2647	I	.2720	75	6.8 6.9	.2677 .2717	83 75
3/8	24	.3209	.3364	.3299	Q	.3320	79	8.4 8.5	.3307 .3346	82 75
7/16	20	.3725	.3906	.3834	W 25/64 inch	.3860 .3906	79 72	9.75 9.8 9.9	.3839 .3858 .3898	83 80 73
1/2	20	.4350	.4531	.4459	29/64 inch	.4531	72	11.5	.4528	73
9/16	18	.4903	.5100	.5024		.5062	78			
5/8	18	.5528	.5725	.5649				14.5	.5709	75
3/4	16	.6688	.6903	.6823	11/16 inch	.6875	77	17.5	.6890	75
7/8	14	.7822	.8062	.7977	[1]	[1]	[1]	[1]	[1]	[1]
1	14	.9072	.9312	.9227				23.5	.9252	81
1 1/8	12	1.0167	1.0438	1.0348				26.5	1.0433	75
1 1/4	12	1.1417	1.1688	1.1598				29.5	1.1614	82
1 1/2	12	1.3917	1.4188	1.4098				36.0	1.4173	76
1 3/4	10	1.6201	1.6525	1.6417	[1]	[1]	[1]	[1]	[1]	[1]
2	10	1.8701	1.9025	1.8917	[1]	[1]	[1]	[1]	[1]	[1]
2 1/4	8	2.0876	2.1282	2.1147	2 1/8 inches	2.1250	77	54.0	2.1260	76
2 1/2	8	2.3376	2.3782	2.3647	2 3/8 inches	2.3750	77			
2 3/4	8	2.5876	2.6282	2.6147	2 5/8 inches	2.6250	77	66.5	2.6181	81
3	8	2.8376	2.8782	2.8647	2 7/8 inches	2.8750	77	73.0	2.8740	78

[1] No standard size.

TABLE 109.—*Sizes of tap drills, American National 12-pitch thread series*

Size of thread	Threads per inch	Minor diameter of nut			Stock drills within limits on minor diameter of nut					
					Numbered and fractional inch sizes			Metric sizes		
		Basic	Maximum	Minimum	Nominal size	Diameter	Per cent of depth of basic thread	Nominal size	Diameter	Per cent of depth of basic thread
1	2	3	4	5	6	7	8	9	10	11
		Inches	*Inches*	*Inches*		*Inch*		*mm*	*Inches*	
1/2	12	0.3917	0.4221	0.4098	Z 27/64 inch	0.4130 .4219	80 72	10.5	0.4134	80
9/16	12	.4542	.4850	.4723	31/64 inch	.4844	72	12.0	.4724	83
5/8	12	.5167	.5438	.5348	[1]	[1]	[1]	[1]	[1]	[1]
11/16	12	.5792	.6063	.5973	[1]	[1]	[1]	[1]	[1]	[1]
3/4	12	.6417	.6688	.6598	[1]	[1]	[1]	[1]	[1]	[1]
13/16	12	.7042	.7313	.7223				18.5	.7283	78
7/8	12	.7667	.7938	.7848				20.0	.7874	81
15/16	12	.8292	.8563	.8473	[1]	[1]	[1]	[1]	[1]	[1]
1	12	.8917	.9188	.9098	[1]	[1]	[1]	[1]	[1]	[1]
1 1/16	12	.9542	.9813	.9723	[1]	[1]	[1]	[1]	[1]	[1]
1 1/8	12	1.0167	1.0438	1.0348				26.5	1.0433	75
1 3/16	12	1.0792	1.1063	1.0973				28.0	1.1024	79
1 1/4	12	1.1417	1.1688	1.1598				29.5	1.1614	82
1 5/16	12	1.2042	1.2313	1.2223	[1]	[1]	[1]	[1]	[1]	[1]
1 3/8	12	1.2667	1.2938	1.2848	[1]	[1]	[1]	[1]	[1]	[1]
1 1/2	12	1.3917	1.4188	1.4098				36.0	1.4173	76
1 3/4	12	1.6417	1.6688	1.6598	[1]	[1]	[1]	[1]	[1]	[1]
2	12	1.8917	1.9188	1.9098	[1]	[1]	[1]	[1]	[1]	[1]
2 1/4	12	2.1417	2.1688	2.1598				55.0	2.1654	78
2 1/2	12	2.3917	2.4188	2.4098	[1]	[1]	[1]	[1]	[1]	[1]
2 3/4	12	2.6417	2.6688	2.6598	[1]	[1]	[1]	[1]	[1]	[1]
3	12	2.8917	2.9188	2.9098				74.0	2.9134	80

[1] No standard size.

2. RETHREADING TOOLS FOR AMERICAN NATIONAL FIRE-HOSE THREADS

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.

3. TOOLS FOR AMERICAN NATIONAL PIPE THREADS (60°)

(a) TAPS

Recommended dimensions of standard taps for American National taper pipe threads are given in Table 110.

TABLE 110.—*Dimensions of standard taps for American National taper pipe threads*

Nominal sizes, in inches	Length over all		Length of thread		Diameter of shank		Size of square		Projection of small end through taper gage	
	Nominal	Tolerance	Nominal	Tolerance	Nominal (maximum)	Tolerance	Nominal (maximum)	Tolerance	Nominal	Tolerance
1	2	3	4	5	6	7	8	9	10	11
	Inches	*Inch*	*Inches*	*Inch*	*Inches*	*Inch*	*Inches*	*Inch*	*Inch*	*Inch*
1/8	2 1/8	±1/32	3/4	±3/64	0.4375	−0.007	0.328	−0.006	0.312	±0.0625
1/4	2 7/16	±1/32	1 1/16	±3/64	.5625	−.007	.421	−.006	.459	±.0625
3/8	2 9/16	±1/32	1 1/16	±3/64	.7000	−.007	.531	−.006	.454	±.0625
1/2	3 1/8	±1/32	1 3/8	±3/64	.8650	−.007	.640	−.006	.579	±.0625
3/4	3 1/4	±1/32	1 3/8	±3/64	1.0750	−.009	.812	−.010	.565	±.0625
1	3 3/4	±1/16	1 3/4	±3/64	1.1250	−.009	.843	−.010	.678	±.0938
1 1/4	4	±1/16	1 3/4	±3/64	1.3125	−.009	.984	−.010	.686	±.0938
1 1/2	4 1/4	±1/16	1 3/4	±3/64	1.5000	−.009	1.125	−.010	.699	±.0938
2	4 1/2	±1/16	1 3/4	±3/64	1.8750	−.009	1.406	−.010	.667	±.0938
2 1/2	5 1/2	±1/16	2 9/16	±3/64	2.2500	−.009	1.687	−.010	.925	±.0938
3	6	±1/16	2 5/8	±3/64	2.6250	−.009	1.968	−.010	.925	±.0938
3 1/2	6 1/2	±1/16	2 11/16	±3/64	2.8125	−.009	2.108	−.010	.938	±.1250
4	6 3/4	±1/16	2 3/4	±3/64	3.0000	−.009	2.250	−.010	.950	±.1250

(b) DIE-HEAD CHASERS

There is given in Table 111 the simplified list of sizes and varieties, for American National straight and taper pipe threads, of die-head chasers for self-opening and adjustable die heads, as adopted December 4, 1925, at a general conference of representative manufacturers, distributers, and users, and promulgated in United States Department of Commerce Simplified Practice Recommendation No. 51.

TABLE 111.—*Die-head chasers, stock sizes for American National straight and taper pipe threads*

Size	Threads per inch	Size	Threads per inch
1	2	1	2
1/8	27	1	11 1/2
1/4	18	1 1/4	11 1/2
3/8	18	1 1/2	11 1/2
1/2	14	2	11 1/2
3/4	14	2 1/2	8

(c) TAP DRILL SIZES

Sizes of tap drills recommended for American National taper pipe threads are given in Table 112.

Sizes of tap drills recommended for American National straight pipe threads are given in Table 113.

TABLE 112.—*Sizes of tap drills, American National taper pipe threads*

Nominal sizes, in inches	Threads per inch	Minor diameter at small end of pipe	Tap drill	Nominal sizes, in inches	Threads per inch	Minor diameter at small end of pipe	Tap drill
1	2	3	4	1	2	3	4
		Inches	*Inches*			*Inches*	*Inches*
$\frac{1}{8}$	27	0.33388	$\frac{21}{64}$	2	$11\frac{1}{2}$	2.19946	$2\frac{3}{16}$
$\frac{1}{4}$	18	.43294	$\frac{7}{16}$	$2\frac{1}{2}$	8	2.61953	$2\frac{5}{8}$
$\frac{3}{8}$	18	.56757	$\frac{9}{16}$	3	8	3.24063	$3\frac{1}{4}$
$\frac{1}{2}$	14	.70129	$\frac{45}{64}$	$3\frac{1}{2}$	8	3.73750	$3\frac{3}{4}$
$\frac{3}{4}$	14	.91054	$\frac{29}{32}$	4	8	4.23438	$4\frac{1}{4}$
1	$11\frac{1}{2}$	1.14407	$1\frac{9}{64}$	$4\frac{1}{2}$	8	4.73125	$4\frac{3}{4}$
$1\frac{1}{4}$	$11\frac{1}{2}$	1.48757	$1\frac{31}{64}$	5	8	5.29073	$5\frac{9}{32}$
$1\frac{1}{2}$	$11\frac{1}{2}$	1.72652	$1\frac{23}{32}$	6	8	6.34609	$6\frac{11}{32}$

TABLE 113.—*Sizes of tap drills, American National straight pipe threads*

Nominal sizes, in inches	Threads per inch	Minor diameter, basic	Tap drill	Nominal sizes, in inches	Threads per inch	Minor diameter, basic	Tap drill
1	2	3	4	1	2	3	4
		Inches	*Inches*			*Inches*	*Inches*
$\frac{1}{8}$	27	0.34513	$\frac{11}{32}$	2	$11\frac{1}{2}$	2.22671	$2\frac{7}{32}$
$\frac{1}{4}$	18	.44544	$\frac{7}{16}$	$2\frac{1}{2}$	8	2.66216	$2\frac{21}{32}$
$\frac{3}{8}$	18	.58257	$\frac{37}{64}$	3	8	3.28850	$3\frac{9}{32}$
$\frac{1}{2}$	14	.72129	$\frac{23}{32}$	$3\frac{1}{2}$	8	3.78881	$3\frac{25}{32}$
$\frac{3}{4}$	14	.93172	$\frac{15}{16}$	4	8	4.28713	$4\frac{9}{32}$
1	$11\frac{1}{2}$	1.16907	$1\frac{5}{32}$	$4\frac{1}{2}$	8	4.78594	$4\frac{25}{32}$
$1\frac{1}{4}$	$11\frac{1}{2}$	1.51382	$1\frac{33}{64}$	5	8	5.34929	$5\frac{11}{32}$
$1\frac{1}{2}$	$11\frac{1}{2}$	1.75277	$1\frac{3}{4}$	6	8	6.40597	$6\frac{13}{32}$

4. TOOLS FOR AMERICAN NATIONAL ACME SCREW THREADS

The methods of producing Acme threads are subject to greater limitations than those for fastening screws on account of the larger amount of metal to be removed, the small thread angle, and the usually larger helix angles, the last two being conducive to side-cutting. Further limiting conditions are the necessity for accurate control of the minor diameter of the screw and for rounding or beveling the corners at the minor diameter of the nut. Consequently the matters of clearances on cutting tools and of proper tooth outlines require careful consideration.

The tool specifications here given are intended as an aid in meeting the specifications laid down for the threaded product, and in practical application may be modified as variations in the nature of the material threaded, the lubrication, the methods involved, and other varying factors may require; the essential requirement being that the specified limiting dimensions of the threaded product be maintained.

(a) FORM OF TOOLS FOR PRODUCING SCREW

All threading tools, whether for use in a lathe, die head, or thread miller, and whether single or multiple pointed, must produce the standard 29° thread profile on an axial section of the work when the helix angle is less than 5°. Most cutting tools for standard 60° fastening screw threads have their cutting edges in an axial plane of the work, and the shape of those edges is practically reproduced on the work for the reason that the helix angle of a 60° thread is seldom over 5°. In producing Acme threads, however, particularly if the helix angle is larger than 5°, it is necessary that the tool be set at an angle corresponding to the helix angle of the thread at a diameter less than the diameter at the pitch line. This necessitates a modification of the tool shape, such that its included angle is less than 29°, in order to produce in the work a thread angle of 29° in an axial plane. On threads having a small thread angle, such as Acme threads, a distortion of the thread profile becomes pronounced when the helix angle is large, and which is greater at the minor diameter of the screw than at the major diameter because of the greater rate of increase of the helix angle as the center of the work is approached. In order to reduce such distortion to a minimum, when the helix angle at the minor diameter is greater than 5°, the tool should be set at an angle corresponding to the helix angle at a diameter less than the diameter at the pitch line.

In Figure 67 is shown, for example, the modification of shape required for a single-point lathe tool to be set to a helix angle *s*. The tool has an included angle 2 a', which is less than 29°, a radial clearance V, and a side clearance s'.

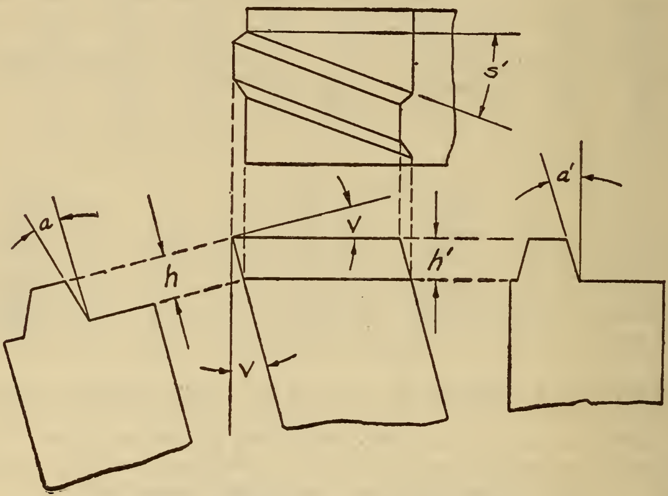


Fig. 67.—*Clearances for single point cutting tool*

s = helix angle of screw.
a = half angle of thread.
Tan V = tan s cot a.
Tan a' = tan a sec. V.
$h' = h \cos V$.
Tan s' = tan s cos V.

1. Outline for Single-Point Tool or Cutter.—In Figure 68 is shown the form of outline required for a single-point lathe tool or a milling cutter to produce directly a standard thread. Such a diagram, if drawn to a magnification of 50 or 100 diameters, will serve as a chart for projection testing. The shaded area at the point shows the permissible variation in outline at this point, but straightness of the cutting edge of the point, except for rounding at the corners, should be maintained.

2. Outline for Multiple-Tooth Chasers and Hobs.—In Figure 69 is shown a similar outline for multiple-toothed chasers or hobs. The tolerance at the point or crest of the tool is the same as in Figure 68. At the roots of the teeth, however, the depth of the thread space is carried far enough to clear the

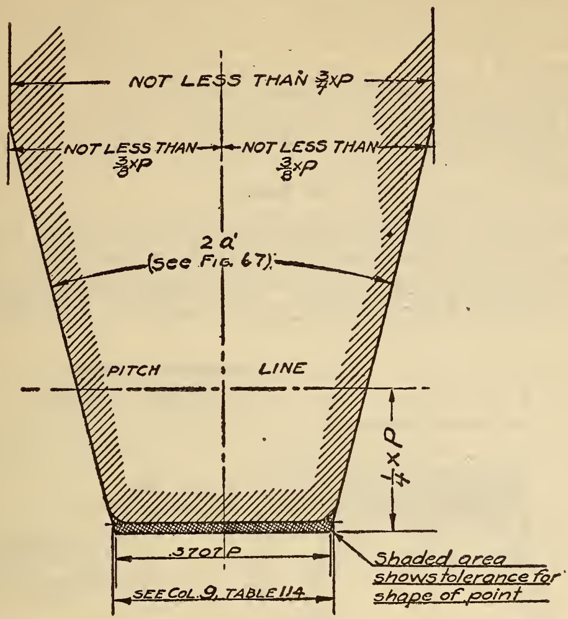


FIG. 68.—*Shape for cutter or single point lathe tool, Acme threads*

NOTE.—In cutting screws of classes 2, 3, or 4 Acme, with the permissible variation in width of point here shown, only a part of the thread thickness tolerance can be used when the width is a minimum, and all or most of it must be used when the width is a maximum, in order to produce the minor diameter of the screw within the specified limits.

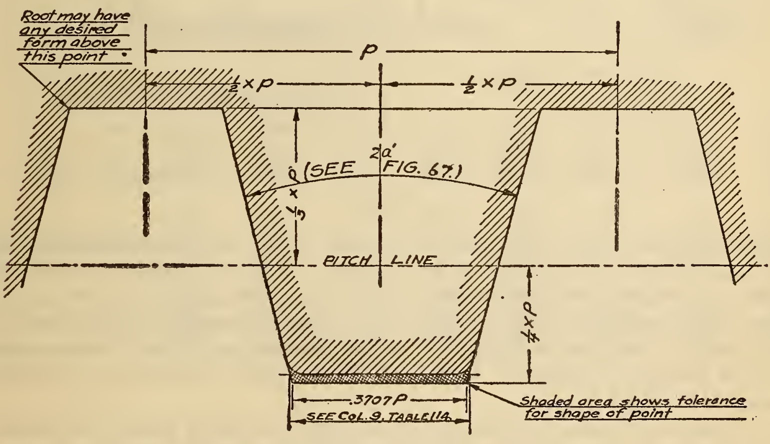


FIG. 69.—*Shape for teeth of chaser or hob*

NOTE.—In cutting screws of classes 2, 3, or 4 Acme, with the permissible variation in width of point here shown, only a part of the thread thickness tolerance can be used when the width is a minimum, and all or most of it must be used when the width is a maximum, in order to produce the minor diameter of the screw within the specified limits.

crests of the screw thread being cut. This is necessary, as it is practically impossible to trim the crests with the chaser or hob and maintain the tolerances on major and minor diameters and thread thickness, particularly when producing screws of classes 2, 3, or 4 fits. The shaded area at the point shows the permissible variation in outline at this point, but the straightness of the cutting edge of the point, except for rounding at the corners, should be maintained.

In Table 114 are given the required dimensions for drawing the charts of Figures 68 and 69.

(b) TAPS

1. Tap Dimensions.—Tap dimensions are given in Table 115, which are suitable for taps intended for producing Acme threads to specifications for classes 1, 2, 3, or 4, the nut dimensions of Acme threads being the same for all classes of fit with the exception of the maximum minor diameter. The values tabulated

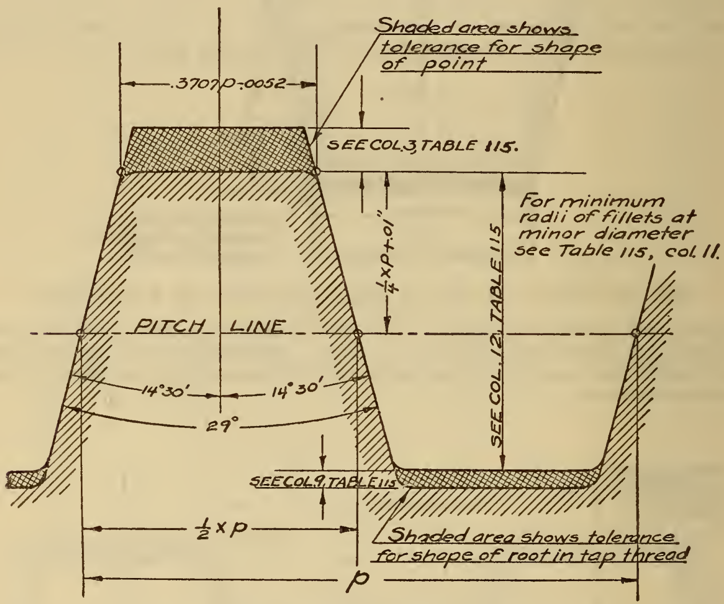


Fig. 70.—*Shape for teeth of tap or internal thread chasing tool, Acme threads*

for the maximum minor diameter of the tap correspond to the maximum minor diameter of the nut, classes 2, 3, or 4 Acme. As it is necessary for the tap to produce a radius or bevel at the minor diameter of the nut at the corners of the thread, this radius is also tabulated, and in order to insure that such a radius or bevel will be produced, the minimum minor diameter of the tap is also specified. This is taken to correspond to the maximum minor diameter of the screw, classes 2, 3, or 4 Acme.

2. Design of Taps.—On account of the large amount of metal to be removed in tapping an Acme thread, at least two taps are required, a roughing tap and a finishing tap. In fact, a common practice has been to furnish Acme thread taps in sets containing from two to five taps to produce a thread of a given size, but if properly designed and made, two taps should be sufficient except when the nut to be tapped is unusually long.

Spiral flutes are an essential feature of a properly designed Acme thread tap, the helix angle of which is such that the cutting faces are at 90° to the helix of the thread. Chip clearances on both the top and sides of the thread are also necessary for satisfactory cutting action.

The roughing tap is so made that the thread space cut is narrow, leaving sufficient metal to be removed by the finishing tap to assure efficient action of the latter, and that the major diameter be slightly small. The finishing tap is provided with a leader section having threads of the same thickness as the roughing tap. Behind the leader section the thickness of the threads gradually increases at such a rate as to cause the tap to produce chips of thicknesses which will assure good cutting action. Behind this second section the thread profile of the straight portion of the tap is such as to produce threads in the nut within the specified tolerances—that is, as specified below under "shape of cutting edge." The finishing tap is preferably a ground-thread tap, especially when a smooth finish is desired.

3. Shape of Cutting Edge for Finishing Taps (and Other Internal Threading Tools).—In Figure 70 is shown the form of outline, measured in an axial section of the work, required for a tap or other internal threading tool intended for cutting threads of Acme form. These outlines are alike for all classes of fit. Such a diagram, if drawn to a magnification of 50 or 100 diameters, will serve as a chart for projection testing. The shaded areas in Figure 70 at the major and minor diameters show the permissible variations in tooth outlines at these points; the fillets at the minor diameter and straightness of the cutting edge on the minor diameter should be maintained.

Table 114.—*Dimensions for determining shape of cutter, chaser, or hob teeth, American National Acme threads*

Number of threads per inch	Pitch, *p*	½×*p*	⅓×*p*	¼×*p*	Basic width of flat, 0.37069*p*	Width of point of single-point tool, chaser, or hob, all fits (see figs. 68 and 69)		
						Minimum	Tolerance	Maximum
1	2	3	4	5	6	7	8	9
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1	1.00000	0.50000	0.33333	0.25000	0.37069	0.3707	0.0040	0.3747
1⅓	.75000	.37500	.25000	.18750	.27802	.2780	.0034	.2814
1½	.66667	.33333	.22222	.16667	.24713	.2471	.0032	.2503
2	.50000	.25000	.16667	.12500	.18534	.1853	.0028	.1881
2½	.40000	.20000	.13333	.10000	.14828	.1483	.0025	.1508
3	.33333	.16667	.11111	.08333	.12356	.1236	.0023	.1259
4	.25000	.12500	.08333	.06250	.09267	.0927	.0020	.0947
5	.20000	.10000	.06667	.05000	.07414	.0741	.0018	.0759
6	.16667	.08333	.05556	.04167	.06178	.0618	.0016	.0634
8	.12500	.06250	.04167	.03125	.04634	.0463	.0014	.0477
10	.10000	.05000	.03333	.02500	.03707	.0371	.0012	.0383
12	.08333	.04167	.02778	.02083	.03089	.0309	.0011	.0320

TABLE 115.—*Dimensions and tolerances for taps for American National Acme screw threads*

Number of threads per inch	Major diameter			Width of thread space at basic pitch line			Minor diameter			Radius of fillet at minor diameter, minimum	Depth of thread, minimum
	Minimum equals basic major diameter plus	Tolerance, plus	Maximum equals basic major diameter plus	Maximum	Tolerance, minus	Minimum	Maximum equals basic major diameter minus	Tolerance, minus	Minimum equals basic major diameter minus		
1	2	3	4	5	6	7	8	9	10	11	12
	Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1	0.020	0.048	0.068	0.4980	0.0040	0.4940	0.9900	0.0150	1.0050	0.02	0.5100
1⅓	.020	.040	.060	.3733	.0034	.3699	.7413	.0130	.7543	.02	.3850
1½	.020	.037	.057	.3317	.0032	.3285	.6585	.0123	.6708	.02	.3433
2	.020	.030	.050	.2486	.0028	.2458	.4929	.0106	.5035	.02	.2600
2½	.020	.026	.046	.1988	.0025	.1963	.3937	.0095	.4032	.02	.2100
3	.020	.023	.043	.1655	.0023	.1632	.3275	.0087	.3362	.01	.1767
4	.020	.020	.040	.1240	.0020	.1220	.2450	.0075	.2525	.01	.1350
5	.020	.017	.037	.0991	.0018	.0973	.1955	.0067	.2022	.01	.1100
6	.020	.015	.035	.0825	.0016	.0809	.1626	.0061	.1687	.01	.0933
8	.020	.013	.033	.0618	.0014	.0604	.1215	.0053	.1268	.01	.0725
10	.020	.011	.031	.0494	.0012	.0482	.0968	.0048	.1016	.01	.0600
12	.020	.010	.030	.0411	.0011	.0400	.0804	.0044	.0848	.01	.0517

APPENDIX 5. 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.

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 per cent zinc dust, which has passed through a 200-mesh sieve, and 60 per cent 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 116. These tolerances necessitate the use of ground-thread taps.

(*e*) The pitch diameter tolerances for the stud are as given in Table 116. 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 nut.

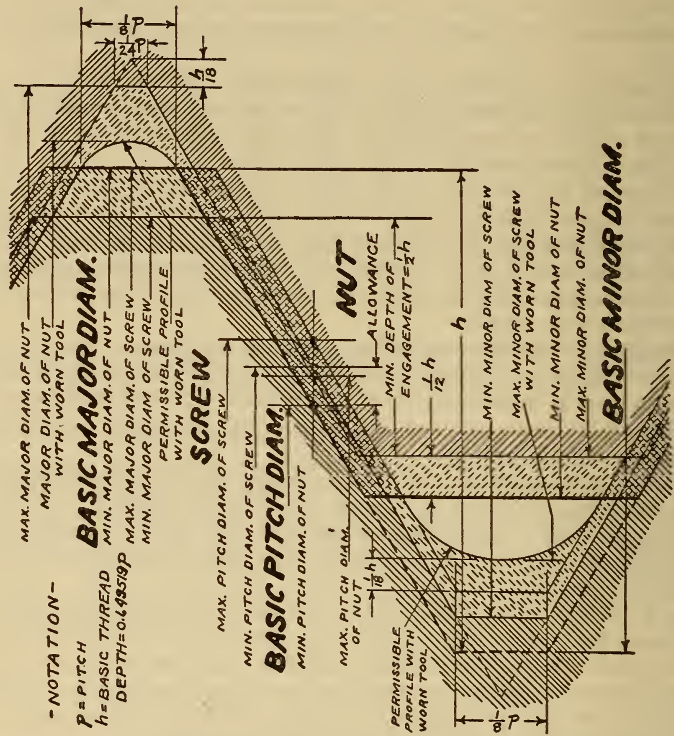


FIG. 71.—*Illustration of tolerances, allowance, and crest clearances for class 5, wrench fit for threaded studs*

(*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.

(*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 71, 72, and 73.

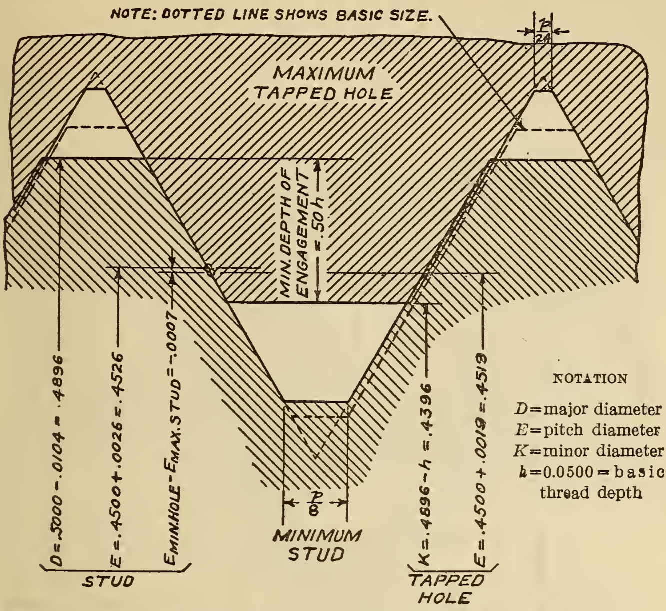


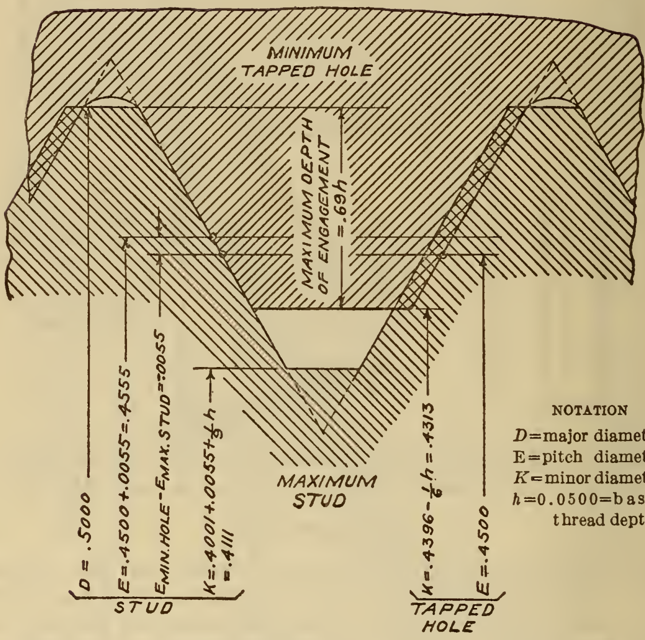
Fig. 72.—*Illustration of loosest condition for class 5, wrench fit for threaded studs, one-half inch, 13 threads, set in hard materials*

(b) CLASSIFICATION

1. Allowance and Tolerance Values.—Allowances and tolerances are specified in Tables 116 and 117, inclusive, for coarse-threaded and fine-threaded 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 118 and 119 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.



NOTATION
D=major diameter
E=pitch diameter
K=minor diameter
h=0.0500=basic thread depth

Fig. 73.—*Illustration of tightest condition for class 5, wrench fit for threaded studs, one-half inch, 13 threads, set in hard materials*

TABLE 116.—*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
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 "6. 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 tolerance 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 117.—*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
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 "6. 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 tolerance 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 118.—*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					Tapped-hole sizes					Recommended tap drill size		Approximate torque at full engagement of $1\frac{1}{2}D$	
		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 [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
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 119.—*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 1½D	
		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
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. SPECIFICATIONS FOR THREADING TOOLS

(a) FORM OF TOOLS FOR PRODUCING STUDS

The specifications given in Appendix 4 for tolerances on chasers, thread milling cutters, roller dies, threading hobs, etc., are also applicable to tools used for the production of threaded studs to the above specifications.

(b) TAPS

In order to produce tapped holes within the tolerances specified herein for class 5, wrench fit for threaded studs, the use of ground thread taps, for which specifications are given in Appendix 4, is necessary.

(c) TAP DRILLS

The essential requirement of a tap drill is that the hole produced by it shall be such that, after tapping, the minor diameter of the tapped hole shall be within the specified limits shown in Tables 118 and 119. Inasmuch as these limiting dimensions for the minor diameter of the tapped hole are greater than those specified in Section III for fits of classes 1 to 4, inclusive, the tap drills specified in Appendix 4 can not be used for class 5, wrench fit for threaded studs. In columns 13 and 14 of Tables 118 and 119 are given recommended sizes of tap drills which lie within the specified limits on minor diameter; wherever possible these consist of existing stock sizes of drills. However, the size of hole produced by a tap drill depends somewhat upon the method of grinding the drill, the material drilled, the lubricant used, and the speed and feed of operation, so that the fixing of the tap drill size does not completely determine the diameter of the drilled hole, and careful attention to these other factors is necessary.

6. 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" cone-pointed snap gages 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 can not 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 6. 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 120.

TABLE 120.—*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 7. (1) DESIGN OF GAGES AND (2) GAGING PRACTICES

1. REPORT OF THE AMERICAN GAGE DESIGN COMMITTEE[9] (ABRIDGED)

(a) HISTORY OF THE AMERICAN GAGE DESIGN COMMITTEE

The American Gage Design Committee was formed in December, 1926, to consolidate for the benefit of industry at large the independent efforts which were already in progress on the part of a number of large industrial concerns, repre-

[9] For complete specifications see American Gage Design Committee report published as Commercial Standard No. CS8–29 of the Department of Commerce.

sentatives of United States Government bureaus and several of the leading gage manufacturers to simplify gaging practice through the adoption of standard designs for gage blanks and component parts. The designs developed by the American Gage Design Committee are now available to everyone and will minimize the necessity for the manufacture of special gages of the simpler types. The committee was given full support and recognition by engineering societies, the American Standards Association, the Bureau of Standards, the War and Navy Departments, and this commission. It should be pointed out, however, that the major work of the committee was contributed by industry itself, many of the country's large industrial units in widely diversified fields being represented by active membership on the committee. Joint meetings were held with the commission throughout 1927 and 1928. Rapid progress was made in these meetings, and formal design standards were completed and adopted for plain and thread-plug gages of all sizes up to 4½ inches diameter, and for plain and thread-ring gages of all sizes up to 4½ inches diameter.

The meetings of the committee were open, and ideas and suggestions from all branches of industry were welcomed and given careful consideration, it being the earnest endeavor of the committee to crystallize the best design and construction of gage blanks, handles, and component parts for plain and thread gages.

The fullest cooperation was extended by all, proprietary patent rights being waived by individual gage manufacturers for the general benefit of industry.

In promulgating the new standards the committee has not intended to obsolete existing stocks of gages in the hands of manufacturers or users; rather, it has been its intention to provide a standard which could be gradually adopted through replacement of existing stocks. Representing the best ideas of industry at large, including gage makers and gage users, the American Gage Design Standards should have whole-hearted support and be accepted and used by gage purchasers, and should render obsolete the wasteful and costly practice of requisitioning gages to individual design standards, which has existed in many cases heretofore. Tool supervisors and standards departments of large industrial concerns are particularly urged to adopt, as soon as practicable, the American Gage Design Standards as a substitute for any individual standards which may now be employed. The result will inevitably be the elimination of confusion in gage departments, and advancement in the direction of economy and quality of product.

The following, among others, have participated in the work of the American Gage Design Committee:

Erik Aldeborgh, the Standard Gage Co., Poughkeepsie, N. Y.

J. Chester Bath, John Bath & Co., Worcester, Mass.

H. W. Bearce, secretary, Bureau of Standards, Washington, D. C.

*†F. S. Blackall, jr., chairman of editorial subcommittee, vice president and general manager, The Taft-Peirce Manufacturing Co., Woonsocket, R. I.

*‡E. J. Bryant, Greenfield Tap and Die Corporation, Greenfield, Mass.

*C. R. Burt, vice president, Pratt & Whitney Co., Hartford, Conn.

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Details of the American Gage Design Standards are explained by definitions, cuts, line drawings, and dimensional tables in the pages that follow.

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(b) TERMINOLOGY

The following glossary is intended to clarify the meaning of certain technical terms employed in this report. The definitions are not intended to be general; rather they are specific as to their application to the American Gage Design Standards.

American Gage Design Standard: The caption "American Gage Design Standard" has been adopted to designate gages made to the design specifications promulgated by the American Gage Design Committee.

1. *A plain cylindrical plug gage* is a complete unthreaded internal gage of single or double ended type for the size control of holes. It consists of handle and gaging member or members, with suitable locking means.

2. *A progressive cylindrical plug gage* is a complete unthreaded internal gage consisting of handle and gaging member in which the "go" and "not go" gaging sections are combined in a single unit secured to one end of the handle.

3. *A thread plug gage* is a complete internal thread gage of either single or double ended type, comprising handle and threaded gaging member or members, with suitable locking means.

4. *The gaging member* is that integral unit of a plug gage which is accurately finished to size and is employed for size control of the work. In taper-lock gages, the gaging member consists of a shank and a gaging section.

5. *The gaging section* is that portion of the gage which comes into physical contact with the work. In the 1.510 to 4.510 inch plug range, the gaging section is identical with the gaging member.

6. *The shank* (applied to taper-lock gages only) is that portion of the gaging member which is employed for fixing the gaging member to the handle.

7. The term "*taper-lock*" designates that construction in which the gaging member has a taper shank, which is forced into a taper hole in the handle. This design is standard for plug gages in the range above 0.059 inch to and including 1.510 inches, is optional for plain cylindrical and thread plug gages in the range above 1.510 inches to and including 2.510 inches, and is standard for pipe thread plug gages up to and including 2-inch nominal pipe size.

8. *Lightening holes* are unfinished drilled holes provided in the heavier sizes of gaging members for the sole purpose of reducing the weight of the gage.

9. The *handle* is that portion of a plug gage which is employed as supporting means for the gaging member or members.

10. The *drift hole* or *drift slot* is a small hole or slot provided in the side of a taper-lock gage handle near the "go" end through which a pin or drift may be inserted for the purpose of driving the gaging member out of the handle.

11. A *plain ring gage* is an unthreaded external gage employed for the size control of external diameters. In the smaller sizes it consists of a gage body into which is pressed a *bushing*, the latter being accurately finished to size for gaging purposes.

12. A *thread ring gage* is an external thread gage employed for the size control of threaded work, means of adjustment being provided integral with the gage body.

13. The *flange* is that external portion of a large ring gage which is reduced in section for the purpose of lightening the gage.

14. The *hub* is the mid-section of a flanged ring gage. It determines the length of the gaging section.

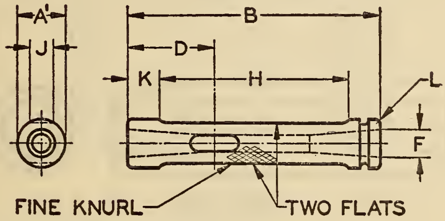
15. The *thread ring gage locking device* is a means of expanding and contracting the thread ring gage during the manufacturing or resizing process. It also provides an effectual lock. It comprises an *adjusting screw*, a *locking screw*, and a *sleeve*. For detailed description and illustration see pages 249 to 250.

16. *Adjusting slots* are radial slots provided in thread ring gages in order to facilitate expansion and contraction of gage size by means of the adjusting device. Adjusting slots always terminate in an *adjusting slot terminal hole.*

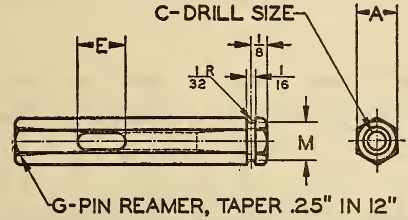
17. The *locking slot* is that slot which passes entirely through the wall of a thread ring gage. In conjunction with the thread ring gage locking device it permits expansion and contraction of gage size.

(c) AMERICAN GAGE DESIGN STANDARD SPECIFICATIONS

1. Plain Cylindrical Plug Gage Blanks and Handles.—Two separate designs have been adopted for plain cylindrical plug gages—a taper-lock design for the range from 0.059 to 1.510 inches, and the reversible type for the range from above 1.510 to 4.510 inches. Use of the taper-lock design is optional for the size range from above 1.510 to 2.510 inches.



OPTIONAL



STANDARD

Fig. 74.—*Plug gage handles, Nos. 000 to 0, inclusive*

The groove in the "not-go" end of the handle is to distinguish it from the "go" end. The dimension *M* is left to the discretion of the manufacturer.

(*a*) *Taper-lock design.*—It was felt that the taper-lock design was particularly well suited for the smaller sizes of plain plug gages. This type of gage is simple and economical of production. Gaging members are readily removable from the handle when replacement is necessary. Complete dimensional tolerances have been established for the mating parts of gaging members and handles, insuring absolute interchangeability of gaging members and handles wherever manufactured. General details of construction are shown in Figures 74 to 78, inclusive, and dimensions are given in Tables 121 and 122.

(*b*) *Reversible design.*—Consideration of simplicity and economy of manufacture and use will likewise dictate the choice of the reversible design in the larger size ranges. At this time this design is not completely developed.

(*c*) *Handles.*—Handles for both taper-lock and reversible gages are the hexagonal type. However, the use of round medium-knurled handles, while not recommended, is made optional in all sizes.

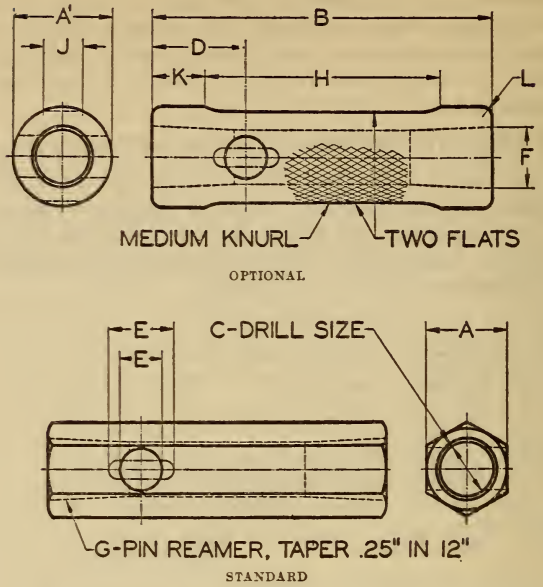


FIG. 75.—*Plug gage handles, Nos. 1 to 5, inclusive*

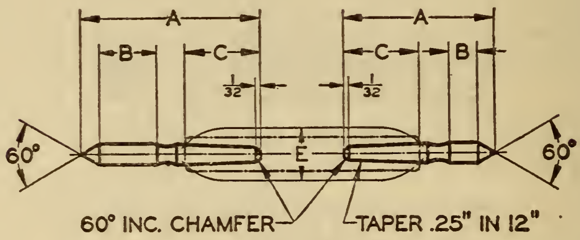


FIG. 76.—*Plain cylindrical plug gages, above 0.059 to 0.150 inch, inclusive*

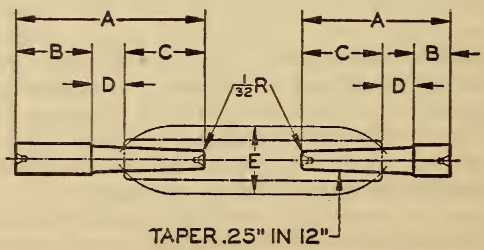


FIG. 77.—*Plain cylindrical plug gages, above 0.150 to 0.240 inch, inclusive*

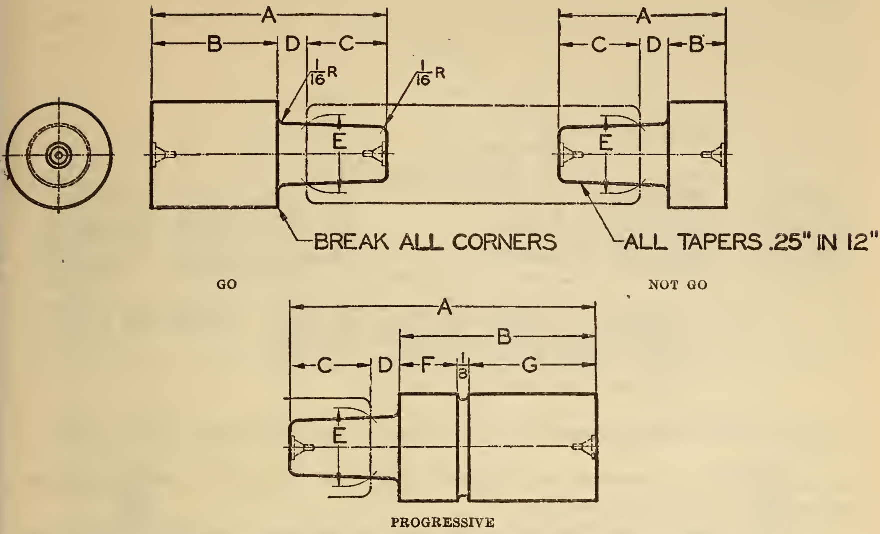


Fig. 78.—*Plain cylindrical plug gages, above 0.240 to 1.510 inches, inclusive (optional above 1.510 to 2.510 inches)*

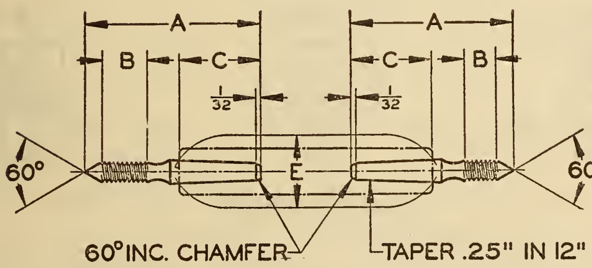


Fig. 79.—*Thread plug gages, No. 0 to No. 6 sizes, inclusive*

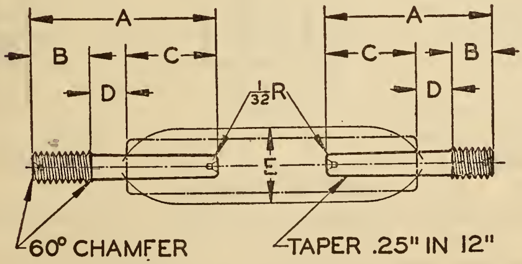


Fig. 80.—*Thread plug gages, No. 8 to No. 12 sizes, inclusive*

2. Thread Plug Gage Blanks and Handles.—The taper-lock and reversible designs have been adopted for thread plug gage blanks and handles and follow the plain plug gage standards with the exception that the length of thread-gaging members is slightly different in some instances. General details of con-

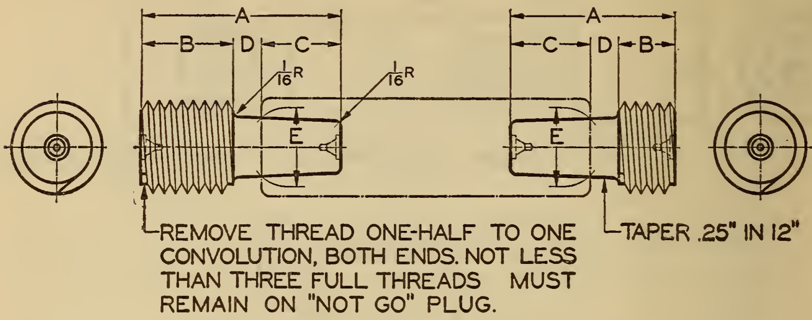


Fig. 81.—*Thread plug gages, ¼ to 1½ inches, inclusive (optional to 2½ inches)*

struction will be apparent from Figures 74, 75, 79, 80, and 81, and dimensions are given in Tables 121 and 123.

3. Plain Ring Gage Blanks.—The use of the solid ring gage design for external size control, being fairly well established, the committee's work on

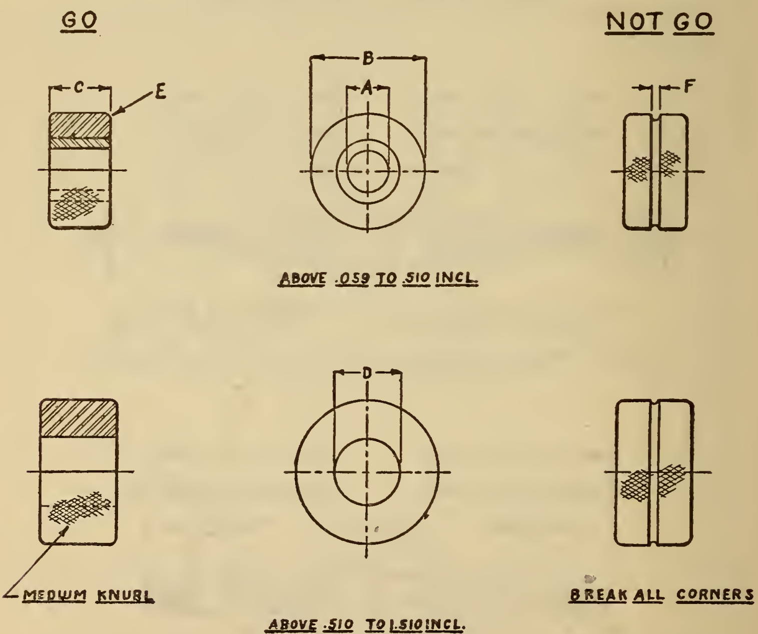


Fig. 82.—*Plain ring gages, above 0.059 to 1.510 inches, inclusive*

plain ring gages was concerned chiefly with matters of proportion. In the smaller sizes of plain ring gages it was felt desirable to employ a hardened bushing pressed into a soft gage body, in place of the one-piece ring gage, and this design has been adopted in the range from 0.059 to 0.510 inch. The single piece gage is employed in all cases above 0.510, but gages in diameters above 1.510 inches are flanged, in order to eliminate unnecessary weight and facilitate handling. No dimensional difference exists between "go" and "not go" blanks of identical size range, but an annular groove is provided in the periphery of "not go" blanks as a means of identification. General details of construction are shown in Figures 82 and 83, and dimensions are given in Tables 124 and 125.

4. Thread Ring Gage Blanks.—The committee found universal accord as to the superiority of the adjustable thread ring gage over the solid type, with the result that all American Gage Design Standard thread ring gage blanks are equipped with an effective device for adjusting and locking the gage in the manufacturing or resizing processes. Of the many locking devices considered the single-unit locking device was finally adopted as standard, as it permits a minimum diameter of blank for a given size range, and provides a simple adjustment and positive lock without introducing any mechanical stresses into the gage body which might tend to create distortion after setting. Referring to Figure 84, the construction and operation of this device is as follows: The adjusting screw is

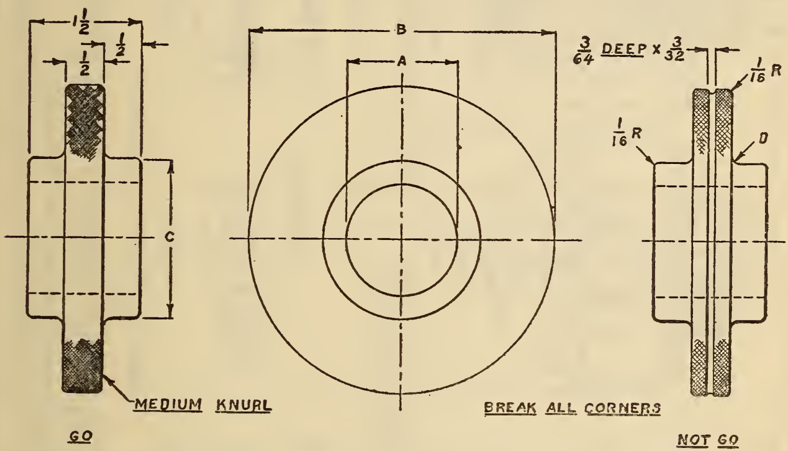


Fig. 83.—*Flanged plain ring gages, above 1.510 to 4.510 inches, inclusive*

threaded externally and internally and split longitudinally. Turning this screw to the right exerts pressure on the sleeve against the shoulder in the left-hand side of the gage here shown, thus spreading the ring. Once the ring has been properly adjusted by means of the adjusting screw, the adjustment is locked by tightening the locking screw. The tightening of the locking screw exerts a pull between the shoulder immediately under its head and the internal threads of the adjusting screw, which causes it to expand into the threads in the wall of the gage without exerting any extra pressure on the sleeve. Therefore, the clamping is accomplished by expansion of the adjusting screw equally in all directions and not by the application of any eccentric forces that tend to distort the gage or upset the adjustment. The locking pressure, it is seen, is taken up centrally in the locking screw itself, as the reacting support is directly under the head of the locking screw in the form of a shoulder in the gage. The sleeve, being accurately fitted, serves as a large dowel to maintain the alinement of the gage.

Three types of thread ring gage blanks have been provided, as illustrated in Figure 84: A thin flat disk type with one adjusting slot for all pitches and sizes, both "go" and "not go," up to and including 5/16 inch; a thin flat disk type with two adjusting slots for all sizes and pitches of both "go" and "not go" gages above $\frac{5}{16}$ inch up to and including ½ inch, all fine pitches of both "go" and "not go" gages above ½ inch up to and including 4½ inches, and all coarse pitch "not go" gages above ½ inch up to and including 4½ inches; and a thick flanged type

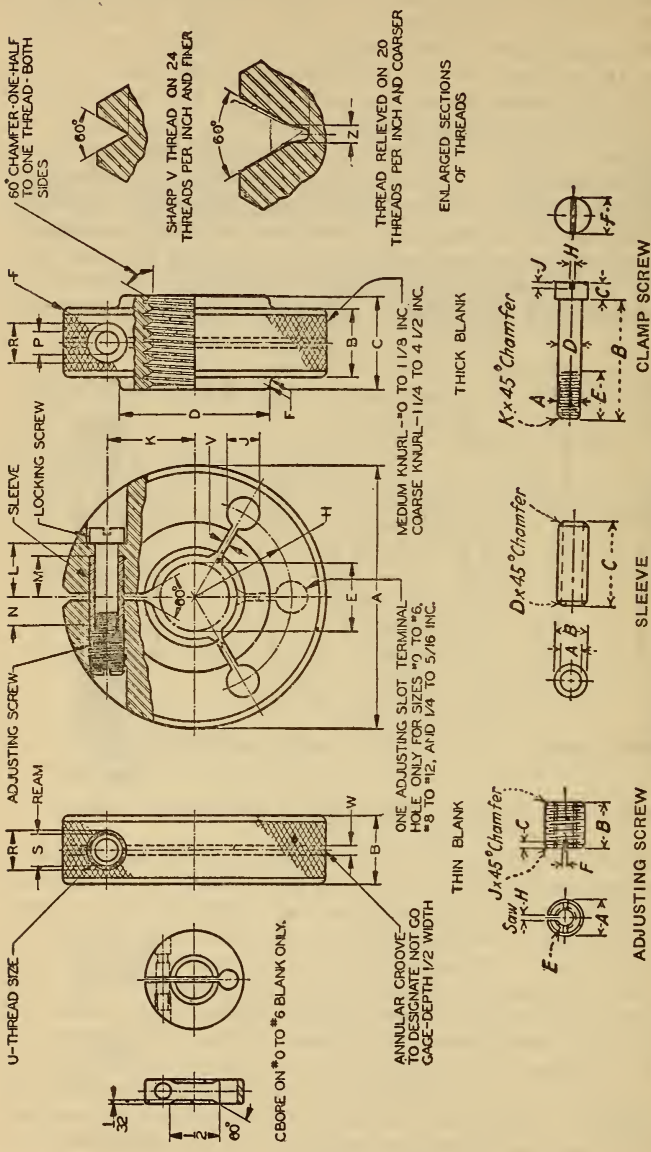


FIG. 84.—*Thread ring gage blanks*

NOTE.—Thin gage blanks are to be used for all "not go" thread ring gages, all American National fine-thread "go" ring gages, and American National coarse-thread "go" ring gages up to and including the one-half-inch size. Thick blanks are to be used for all American National coarse-thread "go" ring gages above the one-half-inch size.

It is recommended that standard thread ring gage blanks be used for special pitches as follows:

Less than one-half-inch, inclusive, thin blanks for all pitches.

Nine-sixteenths to 1⅛ inches, inclusive, thin blanks for 12 threads per inch and finer, and thick blanks for pitches coarser than 12 threads per inch.

Above 1⅛ inches, thin blanks for 10 threads per inch and finer, and thick blanks for pitches coarser than 10 threads per inch.

for all coarse pitch "go" gages above ½ inch up to and including 4½ inches. Dimensions for thread ring gage blanks covering the range from No. 0 to 4½ inches, inclusive, are given in Tables 126 and 127.

TABLE 121.—*Dimensions of taper-lock plug gage handles*

[For notation see figs. 74 and 75]

Handle size No.	A	B	Drill C	D	E	F	G	A′	J	K	L
1	2	3	4	5	6	7	8	9	10	11	12
	Inches	*Inches*		*Inches*	*Inch*	*Inch*	*No.*	*Inches*	*Inch*	*Inch*	*Inch*
000	3/16	1½	No. 34 (0.111)	9/16	5/64 by ¼	0.125 .126	000	¼	5/32	¼	1/32
00	¼	1¾	No. 29 (0.136)	⅝	3/32 by 5/16	.155 .156	0	5/16	3/16	¼	1/32
0	5/16	2	No. 20 (0.161)	11/16	⅛ by ⅜	.180 .181	2	⅜	3/16	¼	1/32
1	⅜	2¾	7/32	25/32	⅛ by ½	.239 .240	4	7/16	7/32	½	1/16
2	½	3	L (0.290)	25/32	15/64	.309 .310	6	⅝	⅜	½	1/16
3	11/16	3¼	25/64	27/32	11/32	.409 .410	7	13/16	7/16	½	3/32
4	⅞	3⅝	37/64	63/64	⅜	.609 .610	10	1 1/16	7/16	9/16	3/32
5	1⅛	4	25/32	1⅛	7/16	.809 .810	11	1 5/16	½	⅝	⅛
[1] 5	1⅛	4	25/32	1⅛	7/16	.809 .810	11	1 5/16	½	⅝	⅛

[1] Optional range.

TABLE 122.—*Dimensions of taper-lock plain cylindrical plug gages*

[For notation see figs. 76, 77, and 78]

Range		Handle size No.	Go		All			Not go		Progressive			
Above	Including		A	B	C	D	E	A	B	A	B	F	G
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Inches	*Inches*		*Inches*	*Inches*	*Inch*	*Inch*	*Inch*	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*	*Inches*
0.059	0.105	000	1 5/32	⅜	½	------	0.125 .126	3 1/32	3/16	------	------	------	------
.105	.150	00	1 11/32	7/16	9/16	------	.155 .156	1⅛	7/32	------	------	------	------
.150	.240	0	1 15/32	19/32	⅝	¼	.180 .181	1 5/32	9/32	------	------	------	------
.240	.365	1	1¾	¾	¾	¼	.239 .240	1 5/16	5/16	2 3/16	1 3/16	5/16	¾
.365	.510	2	2	1	¾	¼	.309 .310	1⅜	⅜	2½	1½	⅜	1
.510	.825	3	2¼	1¼	¾	¼	.408 .410	1½	½	2⅞	1⅞	½	1¼
.825	1.135	4	2 9/16	1⅜	⅞	5/16	.608 .610	1 13/16	⅝	3 5/16	2⅛	⅝	1⅜
1.135	1.510	5	2⅞	1½	1	⅜	.808 .810	2⅛	¾	3¾	2⅜	¾	1½
[1] 1.510	2.010	5	3¼	1⅞	1	⅜	.808 .810	2¼	⅞	4¼	2⅞	⅞	1⅞
[1] 2.010	2.510	5	3⅜	2	1	⅜	.808 .810	2¼	⅞	4⅜	2⅞	⅞	2

[1] Optional range.

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TABLE 123.—*Dimensions of taper-lock thread plug gages*[1]

[For notation see figs. 79, 80, and 81]

Thread sizes, inclusive	Handle size No.	Go		Both			Not go	
		A	*B*	*C*	*D*	*E*	*A*	*B*
1	2	3	4	5	6	7	8	9
		Inches	*Inches*	*Inch*	*Inch*	*Inch*	*Inches*	*Inch*
Nos. 0 to 3	000	1 1/32	1/4	1/2	-------	0.125 .126	3 1/32	3/16
Nos. 4 to 6	00	1 7/32	5/16	9/16	-------	.155 .156	1 1/8	7/32
Nos. 8 to 12	0	1 9/32	13/32	5/8	1/4	.180 .181	1 5/32	9/32
1/4 to 5/16	1	1 1/2	1/2	3/4	1/4	.239 .240	1 5/16	5/16
3/8 to 1/2	2	1 3/4	3/4	3/4	1/4	.309 .310	1 3/8	3/8
9/16 to 3/4	3	1 7/8	7/8	3/4	1/4	.408 .410	1 1/2	1/2
7/8 to 1 1/8	4	2 3/16	1	7/8	5/16	.608 .610	1 13/16	5/8
1 1/4–7	5	2 5/8	1 1/4	1	3/8	.808 .810	2 1/8	3/4
1 1/2–6	5	2 7/8	1 1/2	1	3/8	.808 .810	2 1/8	3/4
1 1/4–12 1 1/2–12	5	2 3/8	1	1	3/8	.808 .810	2 1/8	3/4

[1] The reversible type of design is recommended for thread plug gages in all sizes above 1 1/2 inches diameter.

TABLE 124.—*Dimensions of plain ring gages*[1]

[For notation see fig. 82]

Range *A*		Ring size No.	*B*	*C*	*D* hole[2]	*E*	*F*[3]	Length of bushing
Above	Including							
1	2	3	4	5	6	7	8	9
Inches	*Inches*		*Inches*	*Inches*	*Inch*	*Inch*	*Inch*	*Inch*
0.059	0.150	00	1 5/16±0.010	3/16±0.010	3/8+0.000 −.005	1/32	1/32	1/4
.150	.240	0	1 5/16± .010	3/8± .010	7/16+ .000 − .005	1/32	1/16	7/16
.240	.365	1	1 1/8 ± .010	9/16± .010	9/16+ .000 − .005	1/16	3/32	5/8
.365	.510	2	1 3/8 ± .010	3/4± .010	3/4+ .000 − .005	1/16	3/32	13/16
.510	.825	3	1 3/4 ± .010	1 5/16± .010	--------------	3/32	3/32	--------
.825	1.135	4	2 1/8 ± .010	1 1/8 ± .010	--------------	3/32	3/32	--------
1.135	1.510	5	2 1/2 ± .010	1 9/16± .010	--------------	3/32	3/32	--------

[1] Material:
To 0.510 inch, inclusive: Shell, cold rolled steel; bushing, tool steel, hardened.
Above 0.510 to 1.510: Tool steel, hardened.
[2] Bushing is +0.020 inch for fitting.
[3] Depth of groove to be 1/2 of width.

TABLE 125.—*Dimensions of plain ring gages (flanged)*

[For notation see fig. 83]

Range *A*		Ring size No.	*B*	*C*= *A*+	*D*
Above	Including				
1	2	3	4	5	6
Inches	*Inches*		*Inches*	*Inches*	*Inch*
1.510	2.010	6	4 1/8	7/8	1/8
2.010	2.510	7	4 5/8	7/8	1/8
2.510	3.010	8	5 1/2	1	3/16
3.010	3.510	9	6	1	3/16
3.510	4.010	10	6 7/8	1 1/8	1/4
4.010	4.510	11	7 3/8	1 1/8	1/4

TABLE 126.—*General dimensions of thread ring gage blanks*

[For notation, see fig. 84]

Thread sizes, inclusive	A	B	C	D	E	F	H	J	K	L	M	N	Drill P	Drill R	Ream S	U Size	U P.D.	V	W
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Inches	Inch	Inches	Inches	Inches	Inch	Inches	Inch	Inches	Inch	Inch	Inch			Inch		Inch	Inch	Inch
Nos. 0 to 6	1	1/4	----	----	----	1/32	5/16	5/32	5/16	7/32	5/32	1/16	No. 41 (0.0960)	11/64 (0.1719)	0.1370 .1373	No. 8-36	0.1460 .1478	0.010 ([1])	1/32
Nos. 8 to 12	1	1/4	----	----	----	1/32	5/16	5/32	5/16	7/32	5/32	1/16	No. 41 (0.0960)	11/64 (0.1719)	.1370 .1373	No. 8-36	.1460 .1478	1/64	1/32
1/4-5/16	1 3/8	11/32	----	----	5/32	1/32	7/16	3/16	3/8	11/32	1/4	1/8	No. 31 (0.1200)	7/32 (0.2187)	.1810 .1813	No. 12-28	.1928 .1950	1/32	1/16
3/8-1/2	1 3/4	7/16	----	----	3/16	3/64	19/32	1/4	15/32	1/2	3/8	3/16	No. 25 (0.1495)	17/64 (0.2656)	.2150 .2153	1/4-28	.2268 .2290	1/32	3/32
9/16-3/4	2 3/16	9/16	3/4	1 1/16	11/32	1/16	3/4	5/16	11/16	17/32	13/32	7/32	No. 7 (0.2010)	21/64 (0.3281)	.2720 .2723	5/16-24	.2854 .2878	1/16	3/32
7/8-1 1/8	2 5/8	11/16	15/16	1 1/2	9/16	1/16	31/32	5/16	7/8	17/32	13/32	9/32	No. 1 (0.2280)	25/64 (0.3906)	.3340 .3344	3/8-24	.3479 .3503	1/16	3/32
1 1/4-1 1/2	3 1/4	3/4	1 1/8	1 7/8	27/32	1/16	1 3/16	3/8	1 1/8	5/8	7/16	5/16	17/64 (0.2656)	29/64 (0.4531)	.3890 .3894	7/16-20	.4050 .4076	1/16	3/32
1 5/8-2	3 3/4	13/16	1 1/4	2 3/8	1 3/16	3/32	1 7/16	3/8	1 3/8	5/8	7/16	5/16	17/64 (0.2656)	29/64 (0.4531)	.3890 .3894	7/16-20	.4050 .4076	1/16	1/8
2 1/8-2 1/2	4 1/2	7/8	1 5/16	2 7/8	1 19/32	3/32	1 3/4	7/16	1 11/16	13/16	9/16	7/16	21/64 (0.3281)	33/64 (0.5156)	.4510 .4515	1/2-20	.4675 .4701	3/32	1/8
2 5/8-3	5	7/8	1 3/8	3 3/8	2	3/32	2	7/16	1 15/16	13/16	9/16	7/16	21/64 (0.3281)	33/64 (0.5156)	.4510 .4515	1/2-20	.4675 .4701	3/32	1/8
3 1/8-3 1/2	5 1/2	15/16	1 7/16	3 7/8	2 7/16	3/32	2 7/32	7/16	2 3/16	13/16	9/16	7/16	21/64 (0.3281)	33/64 (0.5156)	.4510 .4515	1/2-20	.4675 .4701	3/32	1/8
3 5/8-4	6 3/8	15/16	1 1/2	4 5/8	2 15/16	3/32	2 5/8	1/2	2 9/16	1	3/4	5/8	13/32 (0.4062)	41/64 (0.6406)	.5710 .5715	5/8-18	.5889 .5919	3/32	1/8
4 1/8-4 1/2	7 1/4	1	1 1/2	5 3/8	3 3/8	3/32	3 1/32	1/2	3	1	3/4	5/8	13/32 (0.4062)	41/64 (0.6406)	.5710 .5715	5/8-18	.5889 .5919	3/32	1/8

[1] Approximate.

TABLE 127.—*Dimensions of thread ring gage locking device*

[For notation see fig. 84]

Adjusting screw										
A		*K* Minor diam.	*B*	*C*	*E*			*F*	*H*	*J*
Size	P. D.				Size	P. D.	Drill			
1	2	3	4	5	6	7	8	9	10	11
	Inch	*Inch*	*Inch*	*Inch*		*Inch*		*Inch*	*Inch*	*Inch*
8-36	0.1442 .1460	0.1315 .1333	3/16	3/64	No. 2-64	0.0759 .0773	No. 50 (0.0700)	1/32	1/64	0.020
12-28	.1906 .1928	.1744 .1766	1/4	3/64	No. 4-48	.0985 .1001	No. 42 (0.0935)	1/32	1/64	.020
1/4-28	.2246 .2268	.2084 .2106	5/16	1/16	No. 6-40	.1218 .1235	No. 32 (0.1160)	3/64	1/32	.020
5/16-24	.2830 .2854	.2641 .2665	5/16	1/16	No. 10-32	.1697 .1716	No. 20 (0.1610)	3/64	1/32	1/32
3/8-24	.3455 .3479	.3266 .3290	3/8	5/64	No. 12-28	.1928 .1950	No. 14 (0.1820)	1/16	3/64	1/32
7/16-20	.4024 .4050	.3797 .3823	7/16	5/64	1/4-28	.2268 .2290	No. 3 (0.2130)	1/16	3/64	1/32
1/2-20	.4649 .4675	.4422 .4448	1/2	3/32	5/16-24	.2854 .2878	I (0.2720)	5/64	1/16	3/64
5/8-18	.5859 .5889	.5607 .5637	9/16	3/32	3/8-24	.3479 .3503	Q (0.3320)	5/64	1/16	3/64

Sleeve				Clamp screw									
Drill *A*	*B*	*C*	*D*	*A*		*B*	*C*	*D*	*E*	*F*	*H*	*J*	*K*
				Size	P. D.								
12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Inch	*Inches*	*Inch*			*Inches*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
No. 43 (0.0890)	0.1368 .1370	1/4	0.010	No. 2-64	0.0745 .0759	29/64	5/64	0.0840 .0860	3/16	5/32	1/32	3/64	0.010
No. 32 (0.1160)	.1808 .1810	7/16	.020	No. 4-48	.0969 .0985	23/32	3/32	.1100 .1120	5/16	3/16	1/32	3/64	.020
No. 27 (0.1440)	.2148 .2150	5/8	.020	No. 6-40	.1201 .1218	1	1/8	.1360 .1380	7/16	7/32	3/64	1/16	.020
No. 10 (0.1935)	.2718 .2720	1 1/16	1/32	No. 10-32	.1678 .1697	1 1/16	1/8	.1880 .1900	7/16	9/32	3/64	1/16	1/32
No. 2 (0.2210)	.3337 .3340	3/4	1/32	No. 12-28	.1906 .1928	1 3/16	5/32	.2140 .2160	1/2	11/32	1/16	1/16	1/32
F (0.2570)	.3887 .3890	13/16	1/32	1/4-28	.2246 .2268	1 23/64	3/16	.2480 .2500	9/16	13/32	1/16	5/64	1/32
P (0.3230)	.4507 .4510	1 1/16	3/64	5/16-24	.2830 .2854	1 23/32	1/4	.3105 .3125	5/8	15/32	5/64	3/32	3/64
25/64 (.3906)	.5707 .5710	1 1/2	3/64	3/8-24	.3455 .3479	2 3/16	5/16	.3730 .3750	3/4	19/32	5/64	3/32	3/64

2. 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.

A screw thread comprises several elements: First, the major diameter; second, the pitch diameter; third, the minor diameter; fourth, the angle of the thread; and fifth, the lead. 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 can not be taken as conclusive.

(*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.

The usual form of cone-pointed snap gage 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.

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. Such gages have been found suitable only for the less accurate classes of work, such as the loose and free fit classes.

Thread micrometers and thread snap gages are used for testing the product as it is produced. As these instruments do not test all elements of the screw thread, 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.

(c) Thread Ring Gages.—Thread ring gages are extensively used to measure 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 recent 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 are being developed by the Bureau of Standards, one known as an "optical coincidence thread gage," and the other as a "stereoscopic thread gage."[10]

(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 exceed the minimum dimensions specified.

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[10] Described in N. S. T. C. Communication No. 132, pp. 20–23; Mar. 6, 1928.

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 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 a combined "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 vernier or 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.[11]

[11] Methods of measuring pitch diameter of screw thread gages are described in Appendix 2, p. 184.

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