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FEDERAL STANDARD

SCREW-THREAD STANDARDS FOR FEDERAL SERVICES

SECTION 22

GAGES AND GAGING FOR METRIC SCREW THREADS M AND MJ THREAD FORMS

This standard was approved by the Assistant Administrator, Office of Federal Supply and Services, General Services Administration, for the use of all Federal Agencies.

AMSC N/A

THDS

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FOREWORD

This section was developed to provide Gages and Gaging for Metric Screw Threads for the Federal Services. The present issue is a complete revision of FED-STD-H28/22 dated 13 February 1981 and titled "Metric Screw-Thread Gages".

FED-STD-H28/22A was prepared by the Defense Industrial Supply Center (DLA-IS) and incorporates the American National Standard for Gages and Gaging for Metric M Screw Threads, ANSI/ASME B1.16M-1984, and for MJ Series Metric Screw Threads, ANSI/ASME B1.22M-1985. Significant changes from the previous issue include the following:

(1) Design details and specifications are given for a larger variety of thread gages.
(2) Calibration requirements and standards for X tolerance thread gages, indicator gages, plain gages and measuring equipment have been added. Calibration requirements for thread and plain setting gages have also been added.
(3) Details on calibration and inspection of limit gages, snap gages, indicating gages and measuring instruments have been provided.
(4) For M threads only, NOT GO gages are reapplied as HI and LO gages. These gages are now permitted to enter beyond two (2) turns if a definite drag is present. The change was made to more closely approximate ISO 1502 NOT GO functional sizes.

SECTION 22 - GAGES AND GAGING FOR METRIC SCREW THREADS - M AND MJ THREAD FORMS

1. Scope. This section provides the standards for basic gaging principles, gaging practice, gage specifications, gage dimensions, gage measurements, measuring equipment, and calibration requirements for metric screw threads (M and MJ thread forms).

1.1 Limitations. Information and requirements for gaging systems, their selection, and referee gaging used to determine product thread acceptability are found in FED-STD-H28/20 and are not repeated in this section.

1.2 Application. This section applies to gages and measuring instruments used for inspection of product screw threads, conforming to FED-STD-H28/20, and to their setting gages.

1.3 Classification. The following classes of gages are included in this section:

(1) Working gages - used during product manufacture.
(2) Inspection gages - used as final conformance gages in the acceptance of product.
(3) Setting gages - used for setting and for checking the above gages.

2. Referenced documents.

2.1 Government publications. The issues of the following documents in effect on the date of invitation for bids or request for proposal form a part of this standard to the extent specified herein.

Federal standards.

FED-STD-H28/1	Nomenclature, Definitions and Letter Symbols for Screw Threads
FED-STD-H28/20	Inspection Methods for Acceptability of UN, UNR, UNJ, M and MJ Screw Threads
FED-STD-H28/21	Metric Screw Threads

(Activities outside the Federal Government may obtain copies of Federal specifications, standards and commercial item descriptions as outlined under General Information in the Index of Federal Specifications, Standards and Commercial Item Descriptions. The Index, which includes cumulative bi-monthly supplements as issued, is for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.)

(Single copies of this standard and other Federal specifications, standards and commercial item descriptions required by activities outside the Federal Government for bidding purposes are available from the General Services Administration Specification Section, Room 6662, 7th and D Streets, S.W., Washington, DC 20407; telephone (202) 472-2205.

(Federal Government activities may obtain copies of Federal standardization documents, and the Index of Federal Specifications, Standards, and Commercial Item Descriptions from established distribution points in their agencies.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless a specific issue is identified, the issue in effect on date of invitation for bids or request for proposal shall apply.

American National Standards.

ANSI/ASME B1.16M-1984	- Gages and Gaging for Metric M Screw Threads
ANSI/ASME B1.22M-1985	- Gages and Gaging for MJ Series Metric Screw Threads
ANSI B47.1	- Gage Blanks
ANSI/ASME B47.1aM	- Gage Blanks (Metric Translation of ANSI B47.1)

(Application for copies should be addressed to the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017 or the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

3. Definitions. The terms applicable to this standard are defined in FED-STD-H28/1.

4. General requirements.

4.1 Types of gaging practice. There are two distinct types of gaging practice for product screw threads. They are gaging by limit gages (attributes gaging) and gaging by size indicating gages (variables gaging).

4.1.1 Limit gaging. Limit gaging is a method to determine whether a specific screw thread characteristic is within the prescribed limits as governed by the gages. Limit gages consist of GO and NOT GO or HI/LO sets. Gaging decisions are based on unquantified operator or inspector feel when assembling the gage to the product thread and the accuracy of the gage geometry.

4.1.1.1 Maximum-material-limit gages. These gages, designated GO gages, inspect the GO maximum limit of external threads and the GO minimum limit of internal threads. The ideal maximum-material-limit or GO gage is a threaded counterpart of the thread, made exactly to its prescribed maximum-material-limits and, in length, equal to the length of engagement of the thread with its mating thread. GO gages inspect the functional diameter at the maximum-material-limit.

4.1.1.1.1 Use of GO thread snap and indicating gages. These gages have several advantages over GO thread plug and ring gages such as: (1) threads are inspected by applying the gage contacts over the external thread or within the internal threads at various positions which is faster, once initial set-up is complete, than the process of screwing the gage onto or into the full length of the product thread, and (2) threads can be inspected for roundness by making additional checks around product threads. GO thread plug and ring gages, however, are more positive in assuring assembleability of the product due to their 100% contact with the product threads.

4.1.1.2 Minimum-material-limit gages. Gages designated NOT GO or LO/HI are made to the limits of minimum material and represent the low limit of external threads and the high limit of internal threads. Within their engaged lengths, they inspect the NOT GO or LO/HI functional diameters. The minimum - material pitch diameter limits are necessarily a limitation of the pitch diameter as a single thread element. Also, it is a principle of limit gaging that each element or dimension can be checked only singly by a minimum-material-limit gage. Accordingly, separate gages are required to check pitch, major, and minor diameters at minimum-material limits. That is, for external threads two gages are necessary: one to check the major diameter and another to check the pitch diameter; internal threads require a gage to check the pitch diameter and another to check the minor diameter. Also, in minimum-material-limit gaging, a thorough checking of a thread requires several individual gaging operations along and around the thread.

4.1.1.2.1 NOT GO or LO/HI functional diameter gaging. The use of NOT GO or LO/HI gages provides a means of gaging when proper functioning of the thread assembly only requires control of the functional diameter of the threads at the NOT GO or LO/HI functional diameter limits. NOT GO plug and ring gages accept product threads based upon engagement with no more than three threads in accordance with ANSI/ASME B1.22M-1985 for MJ threads. HI plug and LO ring gages generally accept product threads based upon engagement of no more than two threads, although these gages may engage the full thread length if a definite drag is present in accordance with ANSI/ASME B1.16M-1984 for M threads. Snap and indicating gages are applied at several locations along the length of the thread. A NOT GO, LO, or HI functional diameter within the pitch diameter tolerance does not guarantee that the pitch diameter is within tolerance.

4.1.1.2.2 Single element gaging. The use of minimum-material-limit thread snap or indicating gages conforming to the thread length requirements controls to a close degree the pitch diameter at the minimum-material-limit as a single element. Thus, without further checking, their use provides a practical means of control over such other variables as lead, uniformity of helix, flank angle, taper, roundness, and surface condition. Since indicating gages give size value on product threads, they permit rapid input for adjustments on the screw thread production line. Size values also are very useful in decision making on borderline product threads.

4.1.2 Size indicating gaging. Size indicating gaging is a method for measuring screw thread dimensions. The measured values must be compared to the tabulated sizes to determine if the screw thread is within the specified limits of size. Gaging decisions are based on the mechanical measuring force of the indicating gage, the exactness of the gage geometry, gage linkage and the accuracy of the gages.

4.2 Gaging system approaches. There are two general methods of approach to dimensional inspection of product threads, namely, inspection by attributes and inspection by variables.

4.2.1 Attributes. Inspection by attributes involves the application of limit gages to assure that the product threads will assemble. Attribute gaging of threads determines only if characteristics conform to GO and NOT GO or LO/HI functional diameter requirements.

4.2.2 Variables. Inspection by variables involves the application of indicating gages or measuring instruments (optical, mechanical, pneumatic, or electrical) to determine the extent of variations of product thread elements relative to prescribed limits. Dimensional inspection by variables is most useful in the control of manufacturing tools and processes and to collect manufacturing data for the analysis of product thread variations.

4.3 Setting gages for reference. The setting gage represents the limiting physical dimension of the part. It clearly establishes the maximum or minimum size. The setting gage shall be accompanied by a record of its measurements.

4.3.1 Thread setting plug gages. A setting plug gage is a thread plug gage to which adjustable thread ring gages, thread snap gages, and other thread comparators are set to size. Threaded setting plug gages are of two standard designs which are designated as "full-form setting plugs" and "truncated setting plugs."

4.3.1.1 Full-form setting plug. The full-form setting plug is one having a width of flat at the crest equal to 0.125P. It is frequently used for setting thread snap gages and indicating type gages.

4.3.1.2 Truncated setting plug of standard design. The truncated setting plug of standard design, as shown in ANSI B47.1, is similar to the full-form setting plug except that the crest of the thread is truncated for half the length of the gage, giving a full-form portion and a truncated portion. In setting thread gages to size, the truncated portion controls the pitch diameter, and the full-form portion assures that proper clearance is provided at the major diameter of the ring gage. Also, the use of the full-form portion in conjunction with the truncated portion checks, to some degree, the flank angle of the thread gage.

4.3.2 Thread setting ring gages. Solid thread setting ring gages are used in setting snap and indicating gages for internal threaded product.

4.3.3 Plain cylindrical plug acceptance check gages. GO and NOT GO plain cylindrical plug gages are required to check the minor diameter limits of thread ring gages of the smaller sizes, after the gage has been properly set to the thread setting plug gage. Standard measuring equipment is usually employed in lieu of plain cylindrical plug gages for minor diameters larger than 10 mm.

5. Detailed requirements.

5.1 Inspection and setting gages.

5.1.1 M thread gage requirements.

5.1.1.1 American National Standard gaging. Gages and gaging practice shall be in accordance with ANSI/ASME B1.16M-1984. Paragraphs 5.1.3 through 5.1.6 below, also apply.

5.1.1.2 M thread gage limits of size. Use ANSI/ASME B1.16M-1984 Tables 10, 11, 12 and 13. When nominal size, pitch and tolerance class combination is not included in these tables, the following are applied:

a. Basic formulas for gage size limits in ANSI/ASME B1.16M-1984 Tables 4 and 5.

b. Thread size limits in accordance with FED-STD-H28/21.

c. Constants for computing dimensions in ANSI/ASME B1.16M-1984 Table 9.

d. X gage tolerances for working thread gages in ANSI/ASME B1.16M-1984 Table 6.

e. W gage tolerances for setting thread gages in ANSI/ASME B1.16M-1984 Table 7.

f. Z cylindrical gage tolerances for plain gages in ANSI/ASME B1.16M-1984 Table 8.

5.1.1.3 International Standard gaging. Requirements in 5.1.1.1 above are USA industry practice. Threaded ring and plug gages, together with their setting and checking gages which conform to ISO 1502 profiles and dimensions, are acceptable for the inspection of M profile screw threads only when agreed upon by the supplier and the contracting authority. These ISO gages differ from those specified herein in the amount and configuration of gage crest clearances and NOT GO gage flank engagement. But of even greater significance, ISO 1502 gages often permit new or worn gages to be outside acceptable product screw thread limiting dimensions. In contrast, USA gage practice does not permit gages outside product thread limits generally, though unavoidably, functional size may be outside product limits due to permissible gage maker's tolerance on lead and flank angle. Therefore, the following notes apply:

a. ISO setting and checking gages shall never be used with gages produced in accordance with USA standard practice, nor shall USA setting gages be used with ISO gages.

b. ISO gages may accept marginal product screw threads which are rejectable by the USA gages specified and vice versa.

5.1.2 MJ thread gage requirements. Gages and gaging practice shall be in accordance with ANSI/ASME B1.22M-1985. Paragraphs 5.1.3 through 5.1.6 below, also apply.

5.1.2.1 MJ thread gage limits of size. Use ANSI/ASME B1.22M-1985 Tables 5 and 6. When nominal size, pitch and tolerance class combination is not included in these tables, the following are applied:

a. Basic formulas for gage size limits in ANSI/ASME B1.22M-1985 Tables 7 and 8.

b. Thread size limits in accordance with FED-STD-H28/21.

c. Constants for computing dimensions in ANSI/ASME B1.22M-1985 Table 12.

d. X gage tolerances for working thread gages in ANSI/ASME B1.22M-1985 Table 9.

e. W gage tolerances for setting thread gages in ANSI/ASME B1.22M-1985 Table 10.

f. Z cylindrical gage tolerances for plain gages in ANSI/ASME B1.22M-1985 Table 11.

5.1.3 Gaging functional depth limits of product internal threads.

5.1.3.1 Current practice. There are two types of specifications referring to depth of internal threads. One type specifies minimum depth only. To check conformance to this requirement, a standard GO thread plug gage, modified to include a depth limit step, may be used. For the other type, maximum and minimum thread depths are specified so that the GO thread gage must include two depth limit steps. As an alternate, GO thread gages are available in specially designed holders which provide micrometer measurements of functional thread depths. These gages are used in accordance with the manufacturer's instructions. When production lot sizes do not justify the acquisition of special gaging equipment, functional thread depth may be measured by counting turns for removal of a standard GO gage and multiplying the number of turns by thread pitch.

5.1.3.2 Use of gages with depth limit steps. The modified GO thread plug gage is applied to the product as far as it will go without the application of significant force which would tend to deform the product material. The position of the limit steps in relation to the face of the product is noted to determine conformance.

5.1.3.3 *Location of limit steps.* Limit steps shall be located with reference to the front end face of the gage as shown in figures 22.1a and 22.1b and at a point on the circumference that will approximately bisect the crest flat of the gage.

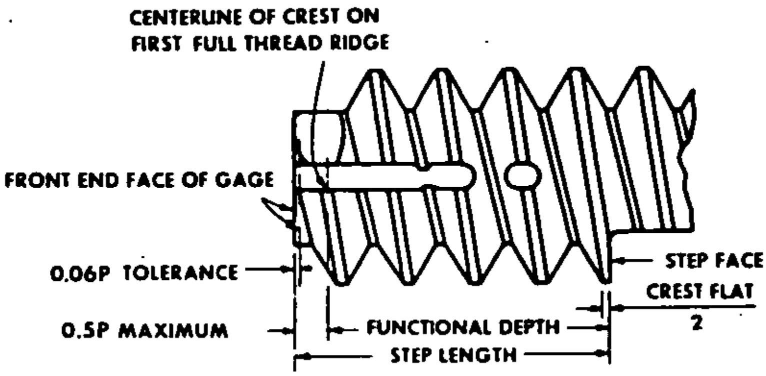
a. The first full crest of the GO thread plug gage with a depth limit step shall start at a location 0.5P from the front end face of the gage as shown in figures 22.1a and 22.1c.

b. The limit step face shall be straight for the depth of thread and shall be ground at 90 degrees to the axis of the gage.

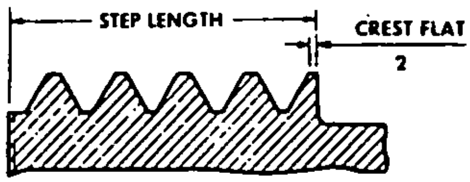
c. Reversible style thread gages are generally made with only one set of limit steps from one end of the gage in order to eliminate confusion and error from runout of one set of steps running into steps from the other end.

d. The design of the depth step is based on the length from the centerline of the crest on the first full thread ridge (which is untouched by removal of the thread convolution or chamfer at the end of the thread plug gage). The length from the end of the thread gage to the depth step is calculated by adding 0.5P to the functional depth of the full depth thread form required in the product.

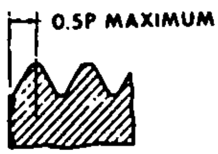
e. When measuring the step length over the end of the gage, the step length tolerance will apply only if the exact 0.5P length is held from the first full thread ridge centerline to the end. This dimension may vary without affecting the function, so long as the variation from 0.5P is taken into account, when measuring the step length over the end of the thread plug gage. Variation of the 0.5P dimension should be in a minus direction only and should not be of such magnitude as to infringe on the engaging flank of the first full thread ridge.



a. DEPTH LIMIT THREAD PLUG GAGE



b. LOCATION OF DEPTH STEP ON GAGE
(IN PLANE WHICH BISECTS CREST FLAT)



c. START OF PERFECT THREAD ON GAGE

FIGURE 22.1 DEPTH LIMIT GAGE FOR INTERNAL THREADS

5.1.4 Blunt Start End Threads, Tolerance on Location.

5.1.4.1 Plug gages. On plug gages with pitches coarser than 0.8 mm, remove one pitch ± one quarter turn of the partially formed thread on each end to obtain a blunt start on the thread.

5.1.4.2 Ring gages. On ring gages larger than 12mm nominal size or with a pitch coarser than 1.25 mm, remove one pitch ± one quarter turn of the partially formed thread at each end to obtain a blunt start on the thread.

5.1.5 Gage hardness. All gages shall be supplied with gaging surface of hardened steel or with contact surfaces of tungsten carbide, diamond, or similar material. Thermal treatments must provide maximum wear life and dimensional stability with hardness to be no less than 56HRC for steel. Steels suitable for this application include: 0-1 (UNS T31501), 0-2 (UNS T31502), 0-6 (UNS T31506), carborized 8620 (UNS G86200) and 52100 (UNS G52986).

5.1.6 Gage surfaces. Gaging surfaces of all gages shall not have geometric irregularities exceeding arithmetic average roughness R_a of 0.4 micrometer for thread gage crests and 0.2 micrometer for thread flanks and plain gaging contacts.

5.2 Working gages. It is the prerogative of the manufacturer to determine the in-process controls required to produce product threads which will be acceptable in accordance with the specified gaging system. Appendix A provides suggested applications of standard gages for use as working gages.

5.3 Final conformance gaging. Final dimensional acceptance of product threads shall be in accordance with the limits of size as determined by the gages listed under the gaging system designated in the procurement order, in accordance with FED-STD-H28/20. It is important that the method of final conformance gaging be understood by both the producer and user.

5.3.1 Temperature considerations. When inspection plug gages or setting gages and product are all made from iron or steel (not including corrosion resistant steels), departure from standard temperature need not be taken into consideration when checking product thread conformance. See ANSI/ASME B1.16M-1984 or ANSI/ASME B1.22M-1985, para. 2.4. For dissimilar materials, adjustments for thermal expansion may be required. See Appendix B.

NOTE: When product or gages are moved from areas of different ambient temperature, sufficient time must be allowed for temperatures to stabilize.

5.3.2 Gage setting procedures. For guidance, procedures for setting adjustable limit and indicating thread gages are presented in Appendix C.

5.3.3 Pitch diameter measurement of plug gages and solid ring gages. See Appendix D for information.

5.3.4 Surveillance of gages. All gages are subject to wear and damage from normal usage. Periodic rechecking and surveillance is a necessary precaution to assure product thread conformance.

MILITARY INTERESTS:

Custodians:

Army - AR
Navy - AS
Air Force - 11

Review Activities:

Army - AT, AV, ME
Navy - OS
Air Force - 99

User Activities:

Army - CR, ER
Navy - SH

CIVIL AGENCY COORDINATING ACTIVITIES:

Commerce - NBS
DOT - ACO, APM, FAA, FRA, NHT
GSA - 7FXE, PCD
HUD - BCC
Justice - FPI
NASA - JFK, LRC, MSF
USDA - AFS

PREPARING ACTIVITY:

DLA - IS

(DoD Project THDS-0061)

APPENDIX A

GAGES FOR USE IN MANUFACTURING

10. Scope. This appendix provides suggested applications of standard gages for in-process use during manufacturing. The information contained herein is for guidance only.

20. General. In the manufacture of product threads, it is necessary to control the limits of size and the various individual thread elements so that the threads produced will be acceptable to the gaging system specified. Production tooling techniques and use of specific manufacturing gages for in-process controls are the prerogatives of individual organizations. If the producer uses gages other than those described, he should evaluate the results obtained to assure correlation.

30. Limit gages.

30.1 Limit gages used in manufacturing checking may be of the same general design of thread plug and ring gages used in final conformance gaging. It is important, however, that thread plug and ring gages used in manufacturing checking have pitch diameter tolerances so applied as to be within the product limits of size, i.e., GO thread plugs with tolerance plus, NOT GO or HI thread plugs with tolerance minus, GO thread rings and GO setting plugs with tolerance minus, NOT GO or LO thread rings and NOT GO setting plugs with tolerance plus. Whereas final conformance gages should be as close as practical to the extreme limits of size of the product threads, gages for manufacturing checking should be as far removed from those extremes as is practicable while still within X gage tolerances; see 30.2 below. When X pitch diameter tolerance is specified for setting plugs and rings, it is recommended that W tolerances for lead and half-angle be required.

30.2 A practice sometimes utilized is to check the pitch diameter of new gages as received, to assign for final conformance gaging those closest to the extreme sizes of the product thread and to assign for manufacturing checking those farthest from the extreme limits of size of the product thread as follows:

	Final Conformance Gage	Manufacturing Gage
GO thread plug	Minimum size	Maximum size
NOT GO or HI thread plug	Maximum size	Minimum size
GO thread ring	Maximum size	Minimum size
NOT GO or LO thread ring	Minimum size	Maximum size

30.3 Periodic surveillance of gages will disclose when final conformance gages are best used as manufacturing gages and vice versa, due to wear, and when gages have worn outside permissible limits. Calibration requirements are given in Tables 14 and 15 of ANSI/ASME B1.16M-1984 and Tables 13 and 14 of ANSI/ASME B1.22M-1985, as applicable. Perhaps the most difficult point to reconcile in such a program is that of deviations resulting from normal use. Starting threads of both plugs and rings bear the brunt of use when making an inspection. Wear is seldom uniformly distributed over the gaging length and the thread flanks, resulting in inaccuracies of flank angle and pitch diameter. It is important for the success of such a program that inspection and manufacturing personnel agree on the position for the pitch diameter check and the degree of taper which may be tolerated before that gage should be taken out of service.

30.4 There are a number of other styles of limit thread gages utilized as manufacturing gages for technical or economic reasons. Among these are snap gages using gaging elements of various configurations. Included are those utilizing rolls, segments, and ball points. Whereas all of these would accept perfect threads with little or no appreciable difference, they may react quite differently on threads having variations in lead, flank angles, taper and roundness.

40. Indicating thread gages.

40.1 Indicating thread gaging provides a practical method of checking to verify conformance of thread elements of product complete threads. Indicating gages have been designed to meet specific needs in gaging both external and internal threads.

40.2 There were many factors which encouraged the development of indicating thread gages such as:

(1) A need for a numerical value for size to facilitate adjustments of manufacturing tools or processes.
(2) Means for a faster method of gaging with less reliance on inspector skills.
(3) Flexibility in application to accommodate the several tolerance classes both before and after coating.
(4) Ability to determine numerical values for deviations in the essential thread elements to serve more effectively the needs of statistical quality control techniques.
(5) Smaller gage inventory.
(6) A more reliable method for settling disputes on borderline product.
(7) Less gage wear and replacement costs.

40.3 Practically all indicating thread gages utilize mechanisms which facilitate application of the gage to the product thread or application of the product thread to the gage. Gages are set to thread setting plugs and rings of known sizes. Variations from these sizes are transmitted to a scale utilizing mechanical, electronic, or pneumatic amplification.

40.4 It is generally impracticable to determine precisely the pitch diameter of product threads as defined because of variations in form and lead. However, the result obtained with many types of gages in gaging product threads is a close approximation of either pitch diameter or functional diameter.

50. Differential gaging.

50.1 Cumulative thread form/element differential gaging. When the Cumulative Differential Reading is not greater than the allowable specified percentage of the pitch diameter tolerance, the product thread is verified as within the specification. When the Cumulative Differential Reading is greater than the allowable specified percentage of the pitch diameter tolerance, the product thread must be analyzed further to assure that the diameter equivalent of the variation of lead does not exceed the allowable percentage of the pitch diameter tolerance or the flank angles do not exceed tabulated tolerances. See ANSI/ASME B1.16M-1984 or ANSI/ASME B1.22M-1985 for determination of Cumulative Differential Reading.

50.2 Lead. Variation in lead is especially important since it affects pitch diameter in the ratio of 1 on lead to 1.732 on pitch diameter in a 60° thread. To check variation in lead:

(a) Set the indicating gage to the appropriate threaded setting gage and determine the taper of the product thread by checking diameters at different positions in the same axial plane along the thread using gaging elements illustrated in ANSI/ASME B1.16M-1984 Figure 30 (b) for external threads and Figure 16 (b) for internal threads or ANSI/ASME B1.22M-1985 Figure 31A (b) for external threads and Figure 17A (b) for internal threads. The difference between maximum and minimum diameter readings is the taper. Calculations show that one fourth of this taper should be included in the lead differential reading because lead variations may be compensated for by taper.

(b) When making the reading in (a) above, measure also the maximum diameter on the external thread or minimum diameter on the internal thread.

(c) Set the indicating gage to the setting gage used in (a) above and measure the maximum functional diameter of the external product thread or minimum functional diameter of the internal product thread over the length gaged in (a) above by using the gage illustrated in ANSI/ASME B1.16M-1984 Figure 30 (a) for external threads and Figure 16 (a) for internal threads or ANSI/ASME B1.22M-1985 Figure 31A (a) for external threads and Figure 17A (a) for internal threads.

(d) The Lead Differential Reading is the difference in the two measured diameters in (b) and (c) above plus one fourth of the taper measured in (a). If the Lead Differential Reading is greater than the allowable, it signifies that the lead variation is excessive.

50.3 Determining allowances on pitch diameter to compensate for lead variation in product threads with long length of engagement.

50.3.1 Follow procedure in 50.2 above to determine Lead Differential Reading for the product thread over a length equal to the length of the functional diameter gaging elements.

50.3.2 Divide the length of engagement of the product thread by the length of the functional diameter gaging elements. This result is the Length Factor.

50.3.3 Multiply the differential reading (para. 50.3.1) by the length factor (para. 50.3.2). This result is the amount by which the specified maximum-material functional diameter of that external product thread must be below the specified maximum-material limit. This will compensate for the lead variation in that product thread and will assure acceptance over full length engagement with a mating product thread made to its specified maximum-material size.

50.4 Flank angles. By subtracting Lead Differential Reading (see 50.2) from Cumulative Differential Reading (see 50.1) an approximate differential measurement of the diameter equivalent for variations in flank angles is obtained. This reading cannot be used to obtain angular values for the individual thread flanks as required for comparison to allowable variations in accordance with FED-STD-H28/21.

50.5 Direct Measurements.

50.5.1 There is an additional problem, primarily stemming from economics, where a relatively few parts with threads are involved, when neither limit nor indicating gages are available and it is economically impracticable to procure them. Such situations are daily problems in model shops, experimental and research departments, tool rooms, and job shops. A discussion of some commonly used practices follows.

50.5.2 Adequate means for determining accuracy of thread angle, thread form, and lead (both linear and helical) are essential. Optical projection or mechanical gages of a general nature are used frequently for such checking.

50.5.3 Numerical values for groove diameter may be determined by use of the three-wire method or for NOT GO minimum-material limit by the use of thread micrometers. The accuracy of these values is affected by the factors delineated in 50.5.4 through 50.5.7 below.

50.5.4 Values obtained from measuring systems, including three-wire measurement, are influenced by:

Variation in geometry and pitch of product thread.
Product thread characteristics (cleanliness, surface texture, hardness, etc.)
Measuring force.
Operating skill.
Shape of the threaded part.

50.5.5 Values obtained with thread micrometers are influenced by factors enumerated in 50.5.4, as applicable, and accuracy of the cone and vee contact elements.

50.5.6 To make use of the values covered in 50.5.3, (as applicable to the maximum-material limit, i.e., functional diameter), the diameter equivalent of variations in lead and the measured flank angles must be taken into account.

50.5.7 For use as a manufacturing check at minimum-material limit, the values covered in 50.5.3 may be used without change. However, one must realize that these values may be more restrictive of pitch diameter limits than would be experienced with limit gages.

50.5.8 A solid thread setting ring gage may not assemble with a thread plug gage with identical measured groove diameter. Each gage may have variations in lead and flank angles which makes the functional diameter of the ring smaller and the functional diameter of the plug larger. The interference could be 0.005 mm or greater.

APPENDIX B

THREAD DIAMETER ADJUSTMENT DUE TO TEMPERATURE VARIATION

60. Scope. This appendix provides guidance which may be used to determine the extent of correction to thread diameter measurement needed to adjust to the equivalent diameter at the standard temperature of $20^\circ \pm 1^\circ C$.

60.1 Limitations. The method presented is an approximation since diametral change is affected by temperature range and by complexity of gages and their components. Note must also be made that change in length of thread, due to temperature, will change the pitch, hence the functional diameter of the thread, in addition to that caused by diametral change.

60.2 Application. The method that follows is applicable where threaded product is made from material differing from gage material and where measurements are made at temperatures other than the standard. Every effort must be made to maintain stable product and gage temperature close to the standard in order to minimize uncertainties. See 60.1.

70. Thread diameter adjustment for temperatures above and below 20° C. Since product threads are checked in the manufacturing area at non-standard temperatures, the uncertainty in size (diameter correction C_T) between gage and dissimilar threaded materials should not exceed one tenth of the pitch diameter tolerance.

70.1 Thread diameter adjustment for size indicating gage measurements. C_T is equal to the sum of pitch diameter corrections due to thermal expansion or contraction in diameter (C_{TPD}) and lead (C_{TL}) or $C_T = C_{TPD} + C_{TL}$. By applying the value (C_T) to indicating gage measurement on the product thread, the threaded product size at 20° C is obtained. Plus (C_T) values are added to and minus (C_T) values are subtracted from the indicating gage reading on the product thread to obtain product size.

70.1.1 Pitch diameter correction (C_{TPD}) due to thermal expansion or contraction on diameter. By inserting the appropriate value in the following formula, the correction (C_{TPD}) is obtained.

$$C_{TPD} = -(e_p - e_g)\ (t_r - 20^\circ\ C)\ (PD)$$

where

C_{TPD} = pitch diameter correction in mm

e_p = linear thermal coefficient for threaded product material per degree C

e_g = linear thermal coefficient for gage material per degree C

t_r = room temperature in degrees Celsius

PD = basic pitch diameter of thread in mm

70.1.2 Pitch diameter correction (C_{TL}) due to thermal expansion or contraction of lead. Use the following formulas:

a. For external product thread compared to a setting gage at shop room temperature. C_{TL} is applied with a minus sign.

$$C_{TL} = -|1.732\ (e_p - e_g)\ (t_r - 20^\circ\ C)\ (LG)|$$

b. For internal product thread compared to a setting gage at shop room temperature. C_{TL} is applied with a plus sign.

$$C_{TL} = +|1.732\ (e_p - e_g)\ (t_r - 20^\circ\ C)\ (LG)|$$

c. For external product thread measured with thread segment type gage preset at standard temperature of 20° C $\pm 1^\circ$ C. C_{TL} is applied with a minus sign.

$$C_{TL} = -|1.732\ (e_p + e_g)\ (t_r - 20^\circ\ C)\ (LG)|$$

d. For internal product thread measured with thread segment type gage preset at standard temperature of 20° C $\pm 1^\circ$ C. C_{TL} is applied with a plus sign.

$$C_{TL} = +|1.732\ (e_p + e_g)\ (t_r - 20^\circ\ C)\ (LG)|$$

where

$|XXXXX|$ = plus value of bracketed term XXXXX regardless of sign

C_{TL} = diameter correction in mm

LG = length of gage thread engagement in mm

NOTE: For single element pitch diameter gaging, C_{TL} may be considered equal to zero.

70.2 Thread diameter evaluation for limit gaging. At non-standard temperature fixed limit gages, such as rings and plugs, do not accept threaded product at the tolerance limits. C_T is equal to the sum of pitch diameter corrections due to thermal expansion or contraction in diameter (C_{TPD}) and lead (C_{TL}) or $C_T = C_{TPD} + C_{TL}$. The C_T values are applied to the gages and thus define their modified limits. The C_T values help the inspector to make a decision on room temperatures.

NOTE: A negative value of C_T is the amount by which a product functional or pitch diameter appears to be too large when checked by a limit gage. A plus value is the opposite.

70.2.1 Pitch diameter correction (C_{TPD}) due to thermal expansion or contraction on diameter. By inserting the appropriate values in the following formula, the correction (C_{TPD}) is obtained.

$$C_{TPD} = -(e_p - e_g)\ (t_r - 20^{\circ}\ C)\ (PD)$$

70.2.2 Pitch diameter correction (C_{TL}) due to thermal expansion or contraction of lead. Use the following formulas:

a. For external product thread inspected with a fixed limit gage, e.g., a ring gage. C_{TL} is applied with a minus sign.

$$C_{TL} = -\left|1.732\ (e_p + e_g)\ (t_r - 20^{\circ}\ C)\ (LG)\right|$$

b. For internal product thread inspected with a fixed limit gage, e.g., a plug gage. C_{TL} is applied with a plus sign.

$$C_{TL} = +\left|1.732\ (e_p + e_g)\ (t_r - 20^{\circ}\ C)\ (LG)\right|$$

NOTE: For single element pitch diameter gaging, C_{TL} may be considered equal to zero.

70.3 Coefficient of linear thread expansion. Some useful coefficients of linear thermal expansion per degree Celsius are listed below. However, if the expansion correction is critical, the coefficient for the temperature range of the specific metal or alloy in use should be determined.

Aluminum alloy 7075	23.2×10^{-6}
Brass	18.7×10^{-6}
Bronze, Aluminum	16.2×10^{-6}
Chromium Carbide	8.5×10^{-6}
Copper	16.9×10^{-6}
Inconel 600	10.4×10^{-6}
Inconel X-750	10.3×10^{-6}
Iron	11.9×10^{-6}
Monel 400	11.5×10^{-6}
Monel K-500	11.2×10^{-6}
Steel 1020	12.1×10^{-6}
Steel, Corrosion resistant (18Cr - 8Ni Stainless)	17.3×10^{-6}
Steel, Corr. and heat resistant, A286	16.4×10^{-6}
Titanium Alloy, Ti-6Al-4V	8.8×10^{-6}
Tungsten Carbide	6.5×10^{-6}

APPENDIX C

GAGE SETTING PROCEDURES FOR ADJUSTABLE LIMIT AND INDICATING THREAD GAGES

80. Scope. The size of adjustable limit or indicating thread gages is controlled by utilizing the applicable W tolerance thread setting plugs. This appendix provides uniform setting procedures to aid in the proper setting and surveillance of the thread gages and facilitate correlation of gaging results. Information is for guidance.

90. Adjustable thread ring gages.

90.1 In setting an AGD adjustable thread ring gage, the sealing compound should be removed and the locking screw loosened. Turning the adjusting screw to the right enlarges the ring so that it turns freely onto the thread setting plug. Alternately adjusting the adjusting screw and tightening the locking screw, a firm fit on the smallest portion of the thread in the ring should result. While making the adjustment, the knurled outside diameter and both sides of the ring should be lightly tapped with a soft-tip or plastic hammer to permit the threads of the ring to wrap themselves around the threads of the setting plug.

90.2 Care should be taken to assure that there is no lateral displacement of the sectors comprising the ring gage that would produce a lead variation beyond the prescribed tolerance zone. After satisfactory adjustment has been obtained, the ring is to be removed from the plug and the same procedure of tapping is repeated with slightly greater emphasis to the sides. If the thread ring gage possesses proper rigidity, the same feel should be still there when the setting gage again is turned into the ring. A tighter fit or inability to reenter the setting gage denotes a fault of the locking device, that should then be taken apart and checked for dimensional conformity to ANSI/ASME B47.1a M. It is often advisable to do this before even attempting to adjust the thread ring gage. When proper adjustment has been obtained, the gage should be sealed.

90.3 In setting to a truncated setting plug, the ring gage may be set to either the full or the truncated portion. It is common practice to set slightly freer than a snug fit to the truncated portion and then to check the root clearance and wear of flank angle by screwing the ring onto the full portion. Extreme caution is required when this practice is followed to prevent damage to the thread crest of the setting plug. The opposite practice is to adjust and set the ring to the full portion and then determine the fit of the gage on the truncated portion. If the thread form of the ring gage is satisfactory, there will be a slight or no change of fit. In the case of a worn thread ring gage, the presence of shake or play when on the truncated portion indicates that the sides of the thread are no longer straight near the root and the gage should be relapped or discarded.

90.4 In order to provide maximum wear life of a setting plug, the plug should be threaded into a ring as few times as possible. This will prevent uneven wear and taper on the truncated end of the plug. When setting plugs are thus used properly, they do not wear unevenly. However, when setting plugs are applied repeatedly to check thread ring gages, the criteria for acceptability will vary with the type and application of the ring. A NOT GO or LO thread ring, for example, should be a snug fit at full engagement and provide some resistance to turning at one or two turns engagement. GO thread ring gages should also be a snug fit at full engagement. When the length of the product thread permits engagement with the full length of the GO ring, the requirement as to partial engagement may be relaxed to permit a slightly freer fit. However, there should be no relaxation in the requirements when short product threads, that only partly engage the GO ring, are being engaged.

90.5 The ring gage should be given further inspection to determine whether or not the minor diameter is within the specified limits. The minor diameter may be inspected by means of GO and NOT GO plain cylindrical plug acceptance check gages or by direct measurement.

90.6 If a full-form setting plug is used to set a thread ring gage, root clearance of the thread in the ring should be determined by the procedure outlined below.

90.6.1 Procedure for determining the clearance in thread ring gages. The roots of threads of ring gages, particularly NOT GO or LO ring gages, frequently do not clear the maximum major diameter of the external thread. To assist the gage maker and gage inspector, the recommended procedure for determining the clearance at root of thread of ring gages is given to supplement, or substitute for, the use of truncated setting plugs described in 90.3. For this purpose, an optical examination of a cast replica of the thread is made by means of a projection comparator, toolmaker's microscope, or universal measuring microscope. The actual magnification of the instrument as used must be known if size measurements are made. Additional details follow.

90.6.1.1 Casting mold. For materials which are poured, such as plaster of paris, the casting mold may be formed by holding the ring gage between thin plates or bars; metal, wood or heavy cardboard may be used. The top edge or one or both sides must be well below the thread axis to permit removal of the hardened casting without unscrewing. For small sizes of threads, a convenient arrangement is to use a taper mandrel that is provided with a lengthwise groove having smooth surfaces and an included angle of about 90°, into which the mixture is poured, and in which the cast is later mounted for examination. The bottom of the slot has a slight taper toward the axis at the small end. A square metal stop clamped in the groove serves as a wall in casting. Materials which are pressed into the thread, such as dental impression material, may not require a mold.

90.6.1.2 Method for making plaster of paris casts. A plaster of paris cast is usually made to determine errors in thread angle, and this cast can usually be used to determine clearance. Such a cast is made by mixing 5 parts (28 g) of a good grade of dental plaster of paris with from 4 to 5 (26 ml) parts by weight of potassium dichromate solution made by dissolving 40 g in 1 liter of water. The potassium dichromate inhibits rusting of the gage. This mixture is applied to the threads inside a mold as described in 90.6.1.1 above. It should be allowed to harden completely before removal. Plaster of paris casts have little shrinkage but do not retain dimensions over extended periods of time. They are difficult to remove from rough finish threads without damage.

90.6.1.3 Determining clearance of GO thread ring gages. The flat at the crest of the maximum external thread is 0.125P, therefore, if the root of thread of the GO ring is relieved to a width of 0.125P, the ring threads clear the maximum major diameter of the thread. If the roots of the GO ring gage threads are not relieved, they must be to a sharp enough V to clear a flat of 0.125P. The flanks of the thread should be straight to the point where the 0.125P flat will make contact with the flanks of the thread. The width of flat on the chart or template used should be 0.125P times the magnification of the comparator.

90.6.1.4 Determining clearance of NOT GO or LO thread ring gages. The flat at the crest of an external thread maximum major diameter and minimum pitch diameter is determined by the formula:

$$\text{Flat} = \frac{P}{2} - h' \tan 30^\circ = \frac{P}{2} - 0.57735\ h'$$

for the 60° form of thread, where h' = maximum major diameter minus minimum pitch diameter. If the NOT GO or LO ring gage has a relief of 0.25P as recommended, it is necessary to determine whether or not the relief is sufficient. To do this, make a chart or template representing a 60° thread with a flat at the crest equal to the flat, as determined by the above formula, times the magnification of the comparator. This chart or template should fit the image of the thread and contact the flanks of the thread image without contacting in the relief. If the ring threads are not relieved, they must be sharp enough to permit the chart or template to contact on the flanks of the image rather than in the root.

100. Thread snap gages.

100.1 The gaging elements of most types of thread snap gages are mounted on eccentric pins or studs which can be securely locked in position by means of locking screws or nuts. Since thread snap gages may be of different designs, the above description is used only to illustrate a general classification.

100.2 It is essential that proper setting procedures be utilized to assure uniform contact pressure between the gaging elements and their applicable thread setting plugs or rings. The gaging elements should be adjusted so that the thread setting gage will have a minimum perceptible drag when passing it through or over the gaging elements. One method is to adjust one of the thread roll gage elements so that the pressure between the gaging elements and the thread setting plug will just support the weight of the thread snap gage and, as the setting plug is slowly rotated, the thread snap gage will drop off by its own weight.

100.3 In setting large diameter thread snap gages, it may be desirable to support the thread snap gage in a vise or other holding means. Care should be taken to avoid deformation of the gage frame. Uniform gaging pressure can be attained by holding the gage frame in a vertical position and adjusting the gaging elements so that the thread setting plug will have perceptible drag and will just drop through the gaging elements by its own weight.

100.4 Care should be taken not to use too much force when checking or setting thread snap gages so that deformation, brinelling, or permanent damage to the gaging elements, gage frame, or thread setting plug does not occur.

100.5 Standard AGD truncated or full-form thread setting plugs may be used for setting thread snap gages used for external threads. Solid setting ring gages are used for adjusting snap gages for internal threads.

100.6 Large diameter thread snap and indicating gages whose gaging contacts are truncated to the pitch line are adjusted and set to the proper pitch diameter by direct measurement, size blocks, or various types of setting bars. The small diameter truncated gages may be set to plain pitch diameter size setting plugs and rings. Details of design and specific instructions covering the use of various types of setting means for large diameter thread snap gages are available directly from the gage manufacturer.

110. <u>Indicating thread gages.</u>

110.1 Indicating thread gages are of various designs but most of them are of the comparator type which compare and indicate the variation in size between a thread setting plug of known size and the size of the product thread being checked. Indicating thread gages provide an adjustable gaging force as an inherent part of the gage body construction. This gaging force may be varied according to the particular characteristics (i.e., weight, size, shape, etc.) of the product being checked. The accuracy of the setting and gaging is not normally influenced by variations in the gaging force as the gage is set and used with the same force applied in both instances. Care should be used in selecting the gaging force to be applied in relation to the deformability of product threads.

110.2 Usually the applicable GO and NOT GO or LO AGD truncated or full-form thread setting plugs are used to set the indicating thread gages for external product thread. Solid setting ring gages are used to set indicating thread gages for internal product threads. However, a thread setting gage of other than the applicable size is sometimes used and the tolerance zone for the product thread is established with reference to the size of the thread setting gage employed. This practice is advantageous as it eliminates the necessity for having applicable setting gages for each of the various classes of thread as well as special limits. Modification of limits of size to provide allowance for coating and limits of size after coating may be readily established with reference to the size of a thread setting gage.

110.3 Gage manufacturers usually offer specific information regarding the operation, checking, setting, and surveillance to cover their particular designs of indicating type thread gages.

110.4 For large diameter threads, see 100.6 above.

APPENDIX D

PITCH DIAMETER MEASUREMENT OF PLUG GAGES AND SOLID RING GAGES

120. Scope. The accurate measurement of pitch diameter of a thread, even though of perfect form and lead, presents certain difficulties which result in some uncertainty as to true value. This appendix provides a standard uniform practice for guidance, which will make consistant measurements of thread gage pitch diameters.

130. Thread plug gages. For standard 60° screw thread gages, pitch diameter measurements are made using the three-wire method in accordance with ANSI/ASME B1.16M-1984 or ANSI/ASME B1.22M-1985 Appendix B. For special long-lead single and multiple threads, information is provided as follows:

(a) For large lead angles $\left(\frac{w \tan^2 \lambda' \cos \alpha \cot \alpha}{2}\right)$ is greater than 0.0038 mm. In this expression, w is the mean measuring wire diameter; λ' is the angle between the wire axis and the plane perpendicular to the thread axis; is the thread flank angle. For the 60° thread, when using best size wires, the large lead angle criterion is applicable when $\frac{L\sqrt{P}}{d_2}$ is greater than 0.295 where d_2 is pitch diameter, P is pitch and L is lead with all characteristics in mm.

(b) When large lead angles are identified in accordance with item (a) above, wire size to be used shall be equal to w_1, from Table XXII.D.1, multiplied by pitch in mm. Use the following formula for pitch diameter:

$$d_2 = M_w - (C+c)$$

where

d_2 = pitch diameter

M_w = measurement over wires

$(C+c)$ = P $(C+c)_1$, with P being pitch in mm and $(C+c)_1$ read from Table XXII.D.1

140. Thread solid ring gages. Several basic methods are available for use in measuring the pitch diameter. Each has a limitation in size range for which it can be used. These methods include the following:

(a) A primary method uses three best size steel balls. The ring is placed on a flat horizontal surface. Two balls are placed in the threads on one side of the bore and the third is placed on a thread opposite the first two. Against these balls are placed blocks having parallel faces but with corners chamfered to clear the curvature of the ring. In the intervening space, a combination of precision gage blocks, together with a pair of tapered parallels, is inserted. The purpose of the tapered parallels is to secure a snug fit which will apply the force recommended to the balls in Tables B3 of ANSI/ASME B1.16M-1984 and ANSI/ASME B1.22M-1985. Adjustment should not exceed 0.025mm. A micrometer reading is taken over the combination and this reading converted to pitch diameter using the formula

$$D_2 = M - \left(\frac{\cot \alpha}{2}\right)(P) + W\ (1 + \operatorname{cosec} \alpha)$$

Where D_2 = pitch diameter of the ring gage
M = measurement between balls
α = thread half angle
P = pitch
W = mean diameter of balls

For a 60° thread of correct form, this formula simplifies to

$$D_2 = M - 0.866025P + 3W$$

(b) Measurements of pitch diameter may also be made using precision measuring machines with special fixturing and best ball size probes. These machines are calibrated using a standardized vee groove or thread cut on a cylindrical plug.

(c) Another method of measuring pitch diameter of a thread ring gage uses a specially controlled internal thread indicating gage with two special pitch diameter gaging segments. These segments have only 0.1P flank contact over 2 and 3 pitches respectively. The indicator is set with best size wires inserted in the segment grooves, to a gage block gap equal to the ideal measurement over wires.

(d) Other methods, such as use of a coordinate measuring machine with a single ball probe, have been and are being developed.

TABLE XXII.D.1 BEST WIRE DIAMETERS AND CONSTANTS FOR LARGE LEAD ANGLES, 1 mm AXIAL PITCH 60° THREADS

LEAD ANGLE, λ	1-START THREADS		2-START THREADS		LEAD ANGLE, λ	2-START THREADS		3-START THREADS	
	w_1	$(C+c)_1$	w_1	$(C+c)_1$		w_1	$(C+c)_1$	w_1	$(C+c)_1$
1	2	3	4	5	1	4	5	6	7
deg	*in.*	*in.*	*in.*	*in.*	*deg*	*in.*	*in.*	*in.*	*in.*
5.0	0.57493	0.86181	0.57477	0.86145	10.0	0.56767	0.84918	0.56728	0.84830
5.1	.57483	.86165	.57467	.86127	10.1	.56749	.84887	.56709	.84797
5.2	.57474	.86149	.57456	.86109	10.2	.56730	.84856	.56689	.84763
5.3	.57465	.86133	.57446	.86091	10.3	.56711	.84824	.56669	.84729
5.4	.57456	.86117	.57435	.86072	10.4	.56693	.84793	.56649	.84695
5.5	.57446	.86100	.57425	.86053	10.5	.56674	.84761	.56629	.84660
5.6	.57436	.86083	.57414	.86034	10.6	.56656	.84729	.56609	.84625
5.7	.57426	.86066	.57403	.86015	10.7	.56637	.84697	.56589	.84589
5.8	.57416	.86049	.57392	.85995	10.8	.56617	.84664	.56568	.84553
5.9	.57406	.86032	.57381	.85976	10.9	.56598	.84631	.56547	.84517
6.0	.57395	.86014	.57369	.85956	11.0	.56578	.84598	.56526	.84481
6.1	.57385	.85996	.57358	.85936	11.1	.56558	.84564	.56506	.84445
6.2	.57374	.85978	.57346	.85915	11.2	.56538	.84530	.56485	.84409
6.3	.57363	.85960	.57333	.85893	11.3	.56518	.84497	.56463	.84372
6.4	.57352	.85942	.57320	.85871	11.4	.56498	.84463	.56441	.84335
6.5	.57341	.85923	.57308	.85850	11.5	.56478	.84429	.56420	.84298
6.6	.57330	.85904	.57295	.85828	11.6	.56457	.84394	.56398	.84260
6.7	.57318	.85885	.57282	.85805	11.7	.56437	.84360	.56375	.84221
6.8	.57307	.85866	.57269	.85782	11.8	.56416	.84325	.56353	.84183
6.9	.57295	.85847	.57256	.85760	11.9	.56396	.84290	.56331	.84145
7.0	.57284	.85828	.57242	.85737	12.0	.56375	.84255	.56308	.84106
7.1	.57272	.85808	.57228	.85713	12.1	.56353	.84219	.56285	.84067
7.2	.57260	.85788	.57215	.85689	12.2	.56332	.84183	.56263	.84028
7.3	.57248	.85768	.57201	.85664	12.3	.56311	.84147	.56240	.83989
7.4	.57236	.85747	.57187	.85640	12.4	.56289	.84111	.56217	.83949
7.5	.57223	.85727	.57173	.85616	12.5	.56267	.84075	.56193	.83908
7.6	.57211	.85706	.57159	.85591	12.6	.56245	.84038	.56170	.83868
7.7	.57198	.85685	.57144	.85566	12.7	.56223	.84001	.56147	.83828
7.8	.57185	.85664	.57129	.85540	12.8	.56201	.83964	.56123	.83787
7.9	.57171	.85642	.57114	.85515	12.9	.56179	.83927	.56099	.83746
8.0	.57158	.85620	.57100	.85490	13.0	.56157	.83890	.56075	.83705
8.1	.57144	.85598	.57085	.85464	13.1	.56135	.83853	.56051	.83664
8.2	.57131	.85576	.57070	.85438	13.2	.56113	.83815	.56027	.83622
8.3	.57117	.85554	.57054	.85411	13.3	.56090	.83777	.56002	.83579
8.4	.57104	.85533	.57038	.85383	13.4	.56067	.83739	.55977	.83537
8.5	.57090	.85511	.57022	.85356	13.5	.56044	.83701	.55952	.83495
8.6	.57076	.85489	.57007	.85329	13.6	.56021	.83662	.55927	.83452
8.7	.57063	.85466	.56991	.85301	13.7	.55997	.83623	.55902	.83409
8.8	.57049	.85444	.56974	.85273	13.8	.55974	.83584	.55877	.83366
8.9	.57035	.85421	.56958	.85245	13.9	.55950	.83545	.55852	.83323
9.0	.57021	.85398	.56941	.85217	14.0	.55926	.83506	.55827	.83280
9.1	.57007	.85375	.56924	.85188	14.1	.55903	.83467	.558[illegible]	.83237
9.2	.56993	.85352	.56907	.85159	14.2	.55880	.83428	.55776	.83193
9.3	.56978	.85329	.56890	.85130	14.3	.55856	.83388	.55750	.83149
9.4	.56964	.85305	.56873	.85100	14.4	.55831	.83347	.55724	.83105
9.5	.56949	.85282	.56856	.85070	14.5	.55807	.83307	.55698	.83060
9.6	.56935	.85258	.56838	.85040	14.6	.55782	.83266	.55671	.83014
9.7	.56920	.85235	.56820	.85010	14.7	.55757	.83225	.55645	.82969
9.8	.56905	.85211	.56803	.84980	14.8	.55733	.83185	.55618	.82923
9.9	.56890	.85187	.56785	.84949	14.9	.55709	.83145	.55590	.82877
10.0	.56875	.85163	.56767	.84918	15.0	.55684	.83104	.55563	.82831

(CONTD)

TABLE XXII.D.1 BEST WIRE DIAMETERS AND CONSTANTS FOR LARGE LEAD ANGLES, 1 mm AXIAL PITCH 60° THREADS- CONTD

LEAD ANGLE, λ	3-START THREADS		4-START THREADS		LEAD ANGLE, λ	3-START THREADS		4-START THREADS	
	w_1	$(C+c)_1$	w_1	$(C+c)_1$		w_1	$(C+c)_1$	w_1	$(C+c)_1$
1	6	7	8	9	1	6	7	8	9
deg	*in.*	*in.*	*in.*	*in.*	*deg*	*in.*	*in.*	*in.*	*in.*
13.0	.56075	.83705	.56033	.83609	18.0	.54682	.81344	.54579	.81109
13.1	.56051	.83664	.56008	.83566	18.1	.54651	.81291	.54546	.81053
13.2	.56027	.83622	.55982	.83522	18.2	.54619	.81238	.54513	.80997
13.3	.56002	.83579	.55956	.83477	18.3	.54588	.81185	.54480	.80940
13.4	.55977	.83537	.55931	.83433	18.4	.54556	.81132	.54447	.80883
13.5	.55952	.83495	.55905	.83388	18.5	.54524	.81078	.54414	.80826
13.6	.55927	.83452	.55879	.83342	18.6	.54492	.81024	.54380	.80768
13.7	.55902	.83409	.55853	.83297	18.7	.54459	.80970	.54345	.80710
13.8	.55877	.83366	.55827	.83252	18.8	.54427	.80916	.54311	.80652
13.9	.55852	.83323	.55800	.83207	18.9	.54394	.80861	.54277	.80594
14.0	.55827	.83280	.55774	.83161	19.0	.54361	.80805	.54242	.80535
14.1	.55802	.83237	.55747	.83115	19.1	.54328	.80749	.54208	.80477
14.2	.55776	.83193	.55720	.83068	19.2	.54295	.80694	.54173	.80418
14.3	.55750	.83149	.55693	.83022	19.3	.54261	.80638	.54138	.80358
14.4	.55724	.83105	.55666	.82975	19.4	.54227	.80582	.54103	.80298
14.5	.55698	.83060	.55639	.82928	19.5	.54193	.80526	.54067	.80238
14.6	.55671	.83014	.55611	.82880	19.6	.54160	.80470	.54032	.80178
14.7	.55645	.82969	.55583	.82831	19.7	.54126	.80414	.53997	.80118
14.8	.55618	.82923	.55555	.82783	19.8	.54092	.80358	.53961	.80057
14.9	.55590	.82877	.55527	.82735	19.9	.54058	.80301	.53925	.79997
15.0	.55563	.82831	.55499	.82687	20.0	.54025	.80245	.53889	.79936
15.1	.55536	.82784	.55471	.82638	20.1	....	....	.53852	.79874
15.2	.55509	.82737	.55442	.82589	20.2	....	....	.53816	.79812
15.3	.55481	.82690	.55414	.82540	20.3	....	....	.53779	.79750
15.4	.55453	.82643	.55385	.82490	20.4	....	....	.53743	.79689
15.5	.55425	.82596	.55356	.82440	20.5	....	....	.53706	.79627
15.6	.55397	.82549	.55327	.82390	20.6	....	....	.53669	.79564
15.7	.55369	.82501	.55297	.82339	20.7	....	....	.53632	.79502
15.8	.55340	.82453	.55268	.82289	20.8	....	....	.53595	.79440
15.9	.55312	.82405	.55239	.82238	20.9	....	....	.53558	.79377
16.0	.55283	.82356	.55209	.82187	21.0	....	....	.53521	.79314
16.1	.55254	.82307	.55179	.82135	21.1	....	....	.53484	.79251
16.2	.55225	.82258	.55148	.82083	21.2	....	....	.53446	.79187
16.3	.55196	.82209	.55117	.82031	21.3	....	....	.53408	.79123
16.4	.55167	.82160	.55087	.81979	21.4	....	....	.53370	.79059
16.5	.55138	.82110	.55057	.81926	21.5	....	....	.53332	.78994
16.6	.55109	.82061	.55026	.81873	21.6	....	....	.53294	.78930
16.7	.55079	.82011	.54995	.81821	21.7	....	....	.53255	.78865
16.8	.55050	.81962	.54964	.81768	21.8	....	....	.53217	.78801
16.9	.55020	.81912	.54933	.81716	21.9	....	....	.53178	.78736
17.0	.54990	.81862	.54902	.81661	22.0	....	....	.53139	.78670
17.1	.54960	.81811	.54870	.81607	22.1	....	....	.53100	.78604
17.2	.54929	.81759	.54839	.81552	22.2	....	....	.53061	.78539
17.3	.54898	.81707	.54807	.81497	22.3	....	....	.53022	.78473
17.4	.54867	.81655	.54774	.81442	22.4	....	....	.52983	.78406
17.5	.54837	.81604	.54742	.81387	22.5	....	....	.52943	.78339
17.6	.54806	.81552	.54710	.81333	22.6	....	....	.52903	.78272
17.7	.54775	.81500	.54677	.81277	22.7	....	....	.52863	.78205
17.8	.54744	.81448	.54645	.81222	22.8	....	....	.52823	.78138
17.9	.54713	.81396	.54612	.81166	22.9	....	....	.52783	.78071
18.0	.54682	.81344	.54579	.81109	23.0	....	....	.52743	.78004

NOTE.—This table courtesy of the Van Keuren Co.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
FED-STD-H28/22A	GAGES AND GAGING FOR METRIC SCREW THREADS - M AND MJ

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)* ☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: ______
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 1426, 82 MAR

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