

FED-STD-H28/20B
10 March 1994
SUPERSEDING
FED-STD-H28/20A
21 September 1987

FEDERAL STANDARD

SCREW-THREAD STANDARDS FOR FEDERAL SERVICES

SECTION 20

INSPECTION METHODS FOR ACCEPTABILITY
OF UN, UNR, UNJ, M, AND MJ SCREW-THREADS

This standard was approved by the Commissioner, Federal Supply Service, General Services Administration, for the use of all Federal agencies.

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New and revised pages will be issued under Change Notices which will be numbered consecutively and will bear the date of issuance. Change Notices should be retained and filed in front of the Standard until such time as they are superseded by a reissue of the entire Standard.

FOREWORD

This section was developed to provide inspection methods for acceptance of products, which use 60° symmetrical inch and metric screw threads, by the Federal Services. It was originally developed and widely circulated as Proposed Section 20 of the National Bureau of Standards (NBS) Handbook H28 by the Interdepartmental Screw-Thread Committee (ISTC) prior to its termination in November 1976. Responsibility for the standard was then transferred to the General Services Administration (GSA).

FED-STD-H28/20 was prepared by the Defense Industrial Supply Center (DLA-IS). It incorporated the American National Standard for Screw-Thread Gaging Systems for Unified (inch) Screw-Threads and applied this to both inch and metric thread gaging. In addition, guidelines for system selection and referee requirements were included.

FED-STD-H28/20A was an updated version of FED-STD-H28/20. In it, the requirements of ANSI/ASME B1.3M-1986 replaced those of ANSI B1.3-1979.

FED-STD-H28/20B is an updated version of FED-STD-H28/20A. In it, the requirements of ASME B1.3M-1992 replace those of ANSI/ASME B1.3M-1986. Significant changes include the following: (1) incorporated requirement of Change Notice 1 dated 22 February 1991; (2) deleted internal thread snap gages; (3) added permission to use unlisted gages or measuring devices if results correlate with those listed; (4) added evaluation of surfaces texture by visual or tactile comparison with texture specimens; (5) added linear and coordinate measuring machines for use in product thread evaluations; (6) noted that even and odd-lobed out-of-roundness variations may influence diameter measurements differently depending upon gage and measuring equipment design.

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SECTION 20 - INSPECTION METHODS FOR ACCEPTABILITY OF UN, UNR,
UNJ, M AND MJ SCREW-THREADS

1. Scope.

1.1 This standard establishes the Federal Services' approved inspection and referee methods for inch and metric module (UN, UNR, UNJ, M and MJ) screw threads. The standard may also be applied for Class 5 interference fit threads.

1.2 The inspection method selected to specify product threads' acceptability for the Federal Services shall be in accordance with this standard.

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-H28/6 - Gages and Gaging for Unified Screw Threads -
UN and UNR Thread Forms

FED-STD-H28/22 - Gages and Gaging for Metric Screw Threads -
M and MJ Thread Forms

FEDERAL SPECIFICATIONS

GGG-C-105 - Caliper, Micrometer (Inside, Outside, Tube) and
Gage, Depth Micrometer

(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, Federal Supply Service Bureau, Specifications Section, Suite 8100, 470 L'Enfant Plaza, S.W., Washington, DC 20407; telephone (202) 755-0325.

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(Federal Government activities may obtain copies of Federal specifications, standards, and commercial item descriptions, and the Index of Federal Specifications, Standards and Commercial Item Descriptions from established distribution points in their agencies.)

MILITARY STANDARD

MIL-STD-120 - Gage Inspection

(Copies of Federal and Military Specifications and Standards required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

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

ASME B1.3M-1992 - Screw Thread Gaging Systems for Dimensional Acceptability, Inch and Metric Screw Threads (UN, UNR, UNJ, M and MJ)

ANSI B1.18M - Metric Screw Threads for Commercial Mechanical Fasteners - Boundary Profile Defined

ASME/ANSI B47.1 - Gage Blanks

(Application for copies should be addressed to the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017-2392 or the American National Standards Institute, 11 West 42nd Street, New York, NY 10036-8002.)

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

NOTE: Some metric thread gages have been identified as Minimum Material (Mn/Mt) rather than HI, LO or NOT-GO. In this standard, requirements for HI, LO and NOT-GO gages apply to gages identified as Mn/Mt.

4. General requirements. An appropriate inspection method shall be specified for each application of UN, UNR, UNJ, M and MJ screw threads. The inspection method need not be indicated at each thread call-out if it is covered by a general note in any part of the procurement package for the threaded product (specification, drawing, invitation for bids, etc.). The inspection method may be either a standard gaging system, as provided herein, or a modification of a standard gaging system; selection will depend on engineering requirements and cost considerations. Detailed requirements and guidance are provided in the following sections.

5. Detailed requirements.

5.1 Inspection methods and their selection.

5.1.1 Established systems. Three gaging systems for inspection are established herein to provide a choice depending on the engineering requirement of the threaded product. These are identified as Systems 21, 22 and 23.

5.1.1.1 Systems 21, 22 and 23 are in accordance with ASME B1.3M-1992 for UN, UNR, UNJ, M and MJ threads. It is recommended that for System 23, size measurement values be required.

NOTE: System 21A in ASME B1.3M-1992 is used only for metric threads specified in accordance with ANSI B1.18M.

5.1.1.2 For special applications, the screw thread on a threaded product may require inspection not consistent with any of the standard gaging systems. In such cases, one of the standard gaging systems should be selected and modified by specifying the additional thread characteristics and gages from Tables 1 or 2 in ASME B1.3M-1992, as applicable.

5.1.2 Selection. Since most screw thread applications do not require that all of the features described in the applicable section of FED-STD-H28 be inspected, selection of the appropriate inspection method will be based on those features important to the end use. Consideration should be given to such factors as form, fit, function and fabrication of the threaded product. The cost of inspection should be compared to the possible costs resulting from uncertainties inherent in each inspection method. Guidance for selection of an inspection method from the three standard gaging systems is as follows:

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5.1.3 System 21.

5.1.3.1 System 21 provides for interchangeable assembly with functional size control at the maximum material limits within the length of standard gaging elements; and also control of characteristics identified as NOT-GO functional diameters or as HI (Internal) and LO (External) functional diameters. These functional gages provide some control at the minimum material limit when there is little variation in thread form characteristics such as lead, flank angle, taper and roundness.

5.1.3.2 System 21 is suggested for use under any one (or more) of the following conditions:

- a. Where the threads of the product do not need specific mechanical strength properties, or where mechanical strength requirements are not specified for the product threads by either material strength and dimensional limits or by testing strength of the threads.
- b. The threaded product has all the mechanical properties specified; mechanical property testing of the threads is required; and the testing requires that the screw threads be subject to shear and beam loading by matching threads (i.e., full size tensile testing of externally threaded product threads and full size proof-load testing of nuts). If the threads have a locking element incorporated, locking torque values and tests must be specified and run on matching threads inspected by either System 22 or System 23.
- c. For standard, off-the-shelf, general application fasteners when considered acceptable.
- d. Internal thread is less than 0.190 inch (5mm) nominal size.

5.1.4 System 22.

5.1.4.1 System 22 provides for interchangeable assembly with functional size control at the maximum material limits within the length of standard gaging elements; and also control of the minimum material size limits over the length of the full thread. Other thread characteristics such as lead, flank angle, taper and roundness variations are confined within these limits with no specific control of their magnitudes. For UNJ and MJ external threads, control is also provided for the thread root radius and rounded root minor diameter.

5.1.4.2 System 22 is suggested when none of the conditions specified in paragraphs 5.1.3.2 or 5.1.5.2 are applicable.

5.1.5 System 23.

5.1.5.1 System 23 provides for interchangeable assembly with functional size control at the maximum material limits within the length of standard gaging elements; and also control of the minimum material size limits over the length of the full thread. The magnitude of other thread characteristics such as lead, flank angle, taper and roundness are further controlled within these limits. For UNJ and MJ external threads, control is also provided for the thread root radius and rounded root minor diameter.

5.1.5.2 System 23 is suggested for use under any one (or more) of the following conditions:

- a. When thread element control is required to determine the extent of deviation in any of the elements of the thread; normally special applications.
- b. For threaded product used in research investigations and testing to determine the effect that a specific thread element variation has on the attributes of the threaded product or the attributes of the threaded product's application.
- c. The conducting of investigation and testing in analysis of thread failures.

5.1.6 Small lot and nonstandard size part considerations.

5.1.6.1 When gages and measuring equipment applicable to the specified inspection system are not economically feasible, as when small production lots or nonstandard size parts are being procured, other measuring equipment may be agreed upon by the parties involved.

NOTE: There is no measuring method exactly equivalent to a GO thread gage used to check maximum material. An approximate value may be calculated from single element measurements of pitch diameter, taper, roundness, flank angle, lead and helical path.

5.1.6.2 For small lots, where it is impractical to inspect threads by sampling and destructive strength testing, subject to provisions in the procurement document and agreement by the parties involved, 100% inspection of screw threads in accordance with System 22 or 23 may be substituted.

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5.2 Acceptability. Screw thread acceptability criteria are in accordance with Section 6 of ASME B1.3M-1992. Also see subsection 5.7 below.

5.3 Special inspection considerations.

5.3.1 Where product thread profile has been deformed or modified, it makes the gaging operation inconclusive. A performance test shall be conducted as required by the applicable specification for tensile strength or fatigue strength that loads the threads in shear.

5.3.2 If the shape of a component containing screw threads interferes with the physical shape of the specified gages, parties involved shall reach an agreement on the inspection method.

5.3.3 All references to runout, concentricity, perpendicularity and squareness of thread related surfaces shall be as follows:

- a. All references to the thread are to be from a cylinder with a diameter equal to the functional diameter of the thread unless otherwise specified.
- b. Runout and concentricity are full indicator movements for 360° rotation.

5.4 In-process controls. Various thread gages/manufacturing techniques may be used by the manufacturer for in-process control. However, the final product shall conform to the requirements of the specified gaging system.

5.5 Designation of inspection method. The inspection method for each threaded product shall be either: (1) covered by a general note in the procurement package (specification, drawing, invitation for bids, etc.); (2) indicated at the individual thread call-out; or (3) a combination of a general note to cover the majority of threads and individual thread call-out indicators for the exceptions. A general note shall designate a standard gaging system or a modification of a standard gaging system. An individual thread call-out shall show the standard gaging system number in parenthesis following the thread tolerance class designation; an "S" shall be added to the gaging system number if the standard gaging system is modified. Details of designation are in accordance with Section 7 of ASME B1.3M-1992 which includes examples. Exception: Reference in the standard notes shall be FED-STD-H28/20. Thus, a drawing note would read: "Acceptability of screw threads shall be in accordance with FED-STD-H28/20, System ____".

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5.6 Referee gaging.

5.6.1 Gaging Systems 21, 22 and 23 permit more than one type of gage to be used for the inspection of screw threads; however, in case of a dispute on acceptability, any gage which is permitted by the specified system may be used, provided that it is within tolerance. The gage or measuring instrument for referee purposes shall meet its calibration requirements as specified in Table XX.1 for external threads or Table XX.2 for internal threads. See paragraph 5.9. Also, the setting gage or standard used to verify the gage or measuring instrument shall meet its calibration requirements as specified Table XX.3.

5.6.2 Size measurement values provide the procurement agency with a method for judging acceptance or rejection of parts which depart from the specified limits of size. Use of equipment for size measurement is only mandatory when specifically required.

5.6.3 For optical projection, the following minimum magnification is required:

THREADS PER INCH	PITCH IN MM	MINIMUM MAGNIFICATION
Up to 14	More than 1.75	20X
14 up to 40	1.75 to 0.6	50X
40 and up	0.6 and less	100X

5.6.4 Excessive force shall not be applied to GO, NOT-GO, HI or LO gages or to hand-operated measuring instruments. Only light hand pressure shall be used.

5.6.5 Indicating gage and measuring instrument requirements shall be in accordance with subsection 5.7.

5.7 Indicating gages and measuring instruments - special requirements.

5.7.1 The smallest scale division on the indicating gage or the measuring instrument shall be no greater than 10% of the product feature tolerance and the accuracy of the indicating system or measuring instrument used on product threads shall be within $\pm 10\%$ of the product tolerance.

Example: For 1/4-28 UNF-3A, the pitch diameter product tolerance is 0.0025 inch. The smallest scale division on the indicator dial is 10% of this tolerance which is 0.00025 inch. Required accuracy is $\pm 10\%$ of the product tolerance which is ± 0.00025 inch within the actual measured distance.

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5.7.2 The accuracy of calibration of the setting gages used for settling disputes shall be the lesser of either $\pm W$ gage tolerance or ± 0.0002 inch (0.005 mm). The dimensional standards (usually tolerance Grade 3 gage blocks) used for referencing measuring instruments for the calibration of the setting and working gages shall be accurate to ± 10 microinches (0.00025 mm).

5.7.3 The vernier scale on angle measuring instruments shall be 1 minute of arc or less.

5.7.4 Test for repeatability of indicating gage or measuring instrument. The mechanical operation of the indicating gage or measuring instrument shall be tested by taking sufficient repeat measurements at the same place on the setting master. The range of measurements shall not exceed 10% of the product thread feature tolerance.

5.7.5 Measurement positions on product threads. For product thread measurement, whenever practicable, take sufficient measurements around the product thread axis near the front end, near the center and near the back end to ensure acceptance.

5.8 Workmanship requirements for gages.

5.8.1 Dimensions and tolerances for product inspection gages shall be in accordance with FED-STD-H28/6 for inch and FED-STD-H28/22 for metric threads. Tables XX.1 and XX.2 tabulate "Calibration Requirements for Gages and Measuring Equipment" to denote geometrical elements and relationships between geometrical elements which must be within specified tolerances for acceptable working gages. Also listed are traversing, amplification, magnification and geometrical requirements of the measuring instruments. Tabulation of "Setting Gages and Standards" denotes gages used to set or verify the working gages or measuring equipment. Also see subsection 5.7.

5.8.2 Dimensions and tolerances for setting thread and plain gages shall be in accordance with FED-STD-H28/6 for inch and FED-STD-H28/22 for metric threads. Calibration requirements for geometrical elements and relationships between geometrical elements which must be measured and within tolerance for acceptable setting gages are tabulated in Table XX.3.

5.8.3 Gaging surfaces of all gages shall not have geometric irregularities exceeding arithmetic average roughness R_a of 16 microinches (0.4 micrometer) for thread gage crests and 8 microinches (0.2 micrometer) for thread flanks and plain gaging contacts.

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5.8.4 All gages shall be supplied with gaging surfaces 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).

5.9 Calibration and inspection of gages and measuring instruments.

5.9.1 Thread inspection gages and measuring instruments shall be maintained within tolerance.

NOTE: Date of a gage calibration report is not necessarily a measure of the gage reliability, because wear on gages is determined by usage. Gages kept in a clean inspection area and carefully used may hold their calibration for many years. A new gage, just calibrated, may be worn out of tolerance in just a few hours when used improperly or in an abrasive or corrosive environment. Every characteristic listed in Tables XX.1, XX.2 and XX.3 is not subject to wear and, therefore, need not be checked each time gage is recalibrated.

5.9.2 Procedures for calibration and inspection of gages may be found in FED-STD-H28/6, MIL-STD-120 and manufacturer's procedures describing their instruments.

5.9.3 When satisfactory gage calibration records are not available, referee gages shall be calibrated and found within tolerance before using them to settle a dispute.

5.9.4 This standard does not require the manufacturer to add to existing Government requirements for gage record keeping.

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TABLE XX.1 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR EXTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 1)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS (k)
1. Thread rings (ASME/ ANSI B47.1 Split or Solid) 1.1 GO ring 1.2 LO and NOT-GO rings 2. Thread snap gages 2.1 GO segments 2.2 LO and NOT-GO segments 2.3 GO rolls (zero lead) 2.4 LO and NOT-GO rolls (zero lead)	Lead (also helical offset at split), flank angles, minor diameter, pitch dia- meter, taper of pitch cyl- inder, straightness, round- ness, clearance at root (f) Lead (also helical offset at split), flank angles, minor diameter, pitch diameter, taper of pitch cylinder, straightness, roundness, clearance at root (f) Lead, flank angles, minor diameter, pitch diameter, taper, straightness, clear- ance at root (c) (d) (f) Pitch, flank angles, minor diameter, pitch diameter, clearance at root (c) (d) (f) Pitch, flank angles, width of flat at crest, taper of pitch cylinder on each roll, parallelism of axes of rolls, clearance at root (c) (d) Pitch, flank angles, width of flat at crest, clearance at root (c) (d)	W thread setting plug for GO W thread setting plug for LO or NOT-GO W thread setting plug for GO (g) W thread setting plug for LO or NOT-GO (g) W thread setting plug for GO (g) (h) W thread setting plug for LO or or NOT-GO (g) (h)

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THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR EXTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 1)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS (k)
2.5 Minimum material - pitch diameter type - cone and vee	Pitch of vee, width of flat at crest, height of thread (c) (d)	W thread setting plug for LO or NOT-GO (g) (h)
2.6 Minimum material - thread groove diameter type - cone only - best wire size	Radius of contacts corres- ponding to best wire size (c) (d)	W thread setting plug for LO or NOT-GO (g) (h)
2.7 Minimum material - B and C NOT-GO rolls or seg- ments (System 21A only)	Vee gap at crest, cone flat width at crest, flank angles, contact height (c)	W thread setting plug for LO or NOT-GO
3. Plain diameter gages 3.1a Maximum plain cylindrical GO ring for major diameter	Taper, straightness, roundness, diameter	Series of plain plug gages in (0.0001 inch (0.0025 mm) steps or direct diameter measurement with internal measuring equipment using gage blocks equal to the maximum major diameter

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TABLE XX.1 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR EXTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 1)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS (k)
3.1b Minimum plain cylindrical NOT-GO ring for major diameter	Taper, straightness, roundness, diameter	Series of plain plug gages in 0.0001 inch (0.0025 mm) steps or direct diameter measurement with internal measuring equipment using gage blocks equal to the maximum major diameter
3.2 Major diameter snap type	Parallelism, flatness of contacts, distance between contacts	Plain Z tolerance plug gage or gage blocks with roll corresponding to maximum major diameter or direct measurement
3.3 Minor diameter snap type (55° max included angle)	Pitch, diameter, included angle of thread form, clearance form at tips of snap contacts	Plain Z tolerance plug gage or gage blocks equal to the maximum minor diameter or direct measurement
3.4 Maximum/minimum major diameter snap type	Parallelism, flatness of contacts, distance between contacts	Plain Z tolerance plug gage or gage blocks with roll corresponding to maximum or minimum major diameter or direct measurement

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TABLE XX.1 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR EXTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 1)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS (k)
3.5 Maximum/minimum minor diameter snap type (55° max included angle)	Pitch, diameter, included angle of thread form, clearance form at tips of snap contacts	Plain Z tolerance plug gage or gage blocks equal to the maximum or minimum minor diameter or direct measurement
4. Indicating thread gages having either two contacts at 180° or three contacts at 120°		
4.1.1 GO segments 4.1.2	Lead, flank angles, minor diameter, pitch diameter, taper, straightness, clearance at root, minor cylinder to pitch cylinder relationship of segments for coaxiality, see para- graphs 5.7.1 and 5.7.4 (c) (d) (f)	W thread setting plug for GO (g)
4.3.1 GO rolls 4.3.2 (zero lead)	Pitch, flank angles, minor diameter, taper, straight- ness, parallelism of axes of rolls to each other, runout of rolls to axis, clearance of root, see paragraphs 5.7.1 and 5.7.4 (c) (d)	W thread setting plug for GO (g) (h)
4.5.1 Minimum mate- 4.5.2 rial - pitch diameter type - cone and vee	Pitch, width of flat at crest, height of thread, runout of rolls to axis, see paragraphs 5.7.1 and 5.7.4 (c)	W thread setting plug for GO or for basic pitch diameter or for LO or NOT-GO (g) (h)

See page 25 for footnotes.

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TABLE XX.1 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR EXTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 1)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS (k)
4.6.1 Minimum mate- 4.6.2 rial - thread groove diam- eter type - cone or best wire size radius profile	Radius of contact, runout of rolls to axis, see paragraphs 5.7.1 and 5.7.4 (c)	W thread setting plug for LO or for NOT-GO (g) (h)
4.7 Major diam- eter/pitch diameter run- out gage	Pitch and flank angles of thread segments, straightness of plain gages, major cylinder to pitch cylinder relation- ship of segments for co- axiality, see paragraphs 5.7.1 and 5.7.4 (c) (d)	None
4.8 Differential segments or rolls; (GO profile for one pitch in length) used in combination with GO/mini- mum material indicating gages to yield a diameter equivalent for variations in lead (includ- ing uniformity of helix) and flank angle	GO profile of one pitch segment or roll requires flank angles checked GO full form segments; see 4.1.1/4.1.2 above GO full form rolls see 4.3.1/4.3.2 above Minimum material - pitch diameter type - cone and vee; see 4.5.1/4.5.2 above Minimum material - thread groove diameter type - cone only - best wire size; see 4.6.1/4.6.2 above See paragraphs 5.7.1 and 5.7.4. Use manufacturer's instructions for assessing the measurements for diam- eter equivalents for vari- ations in lead and flank angle (d)	(Following not required). Special lead standards and flank angle stand- ards with genera- ted variation portion and near perfect portion

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TABLE XX.1 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR EXTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 1)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS (k)
4.9. Minimum material - B and C NOT-GO rolls or segments (System 21A only)	Vee gap at crest, cone flat width at crest, flank angles, contact height (c)	W thread setting plug for LO or NOT-GO
5. Indicating plain diameter gages		
5.1 Major diameter type	Parallelism and flatness of contacts; see paragraphs 5.7.1 and 5.7.4 (d)	Plain Z tolerance plug gage for GO or basic major diameter or gage blocks
5.2 Minor diameter type (55° max included angle)	Pitch, included angle of thread form, width of flat on crests; see paragraphs 5.7.1 and 5.7.4	Plain Z tolerance plug gage for basic minor diam- eter at radiused root
6. Pitch micrometer w/standard contacts (approximately LO or NOT-GO profile) cone and vee	Pitch, flank angles; see GGG-C-105 for accuracy requirements and test pro- cedure; convert customary units to metric as required	W thread setting plug for basic pitch diameter, or GO, or LO, or NOT-GO (g)
7. Pitch micrometer w/modified contacts (approximately PD contact) cone and vee and vee	Pitch, flank angles; width of flat at crest, height of thread; see GGG-C-105 for accuracy requirements and test procedure; convert customary units to metric as required	W thread setting plug for basic pitch diameter, or GO, or LO, or NOT-GO (g)

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TABLE XX.1 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR EXTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 1)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS (k)
8. Thread measuring wires (best size) with suitable meas- uring means	Flatness and parallelism of spindle and anvil faces, screw calibration, measur- ing force; see paragraphs 5.7.1 and 5.7.4	Calibrated (best size) thread measuring wires and gage block
9. Optical comparator or toolmakers microscope w/suitable fixturing	Micrometer stage, magnifi- cation, radius chart, pro- tractor head; see para- graphs 5.7.1 and 5.7.4 (c)	Gage blocks, plug gages, sine bar
10. Profile tracing equipment w/suitable fixturing	Use manufacturer's instruc- tions to check out stylus traverse and electronic amplification	Special angle block supplied with instrument
11. Lead measuring machine w/suitable fixturing	Traversing system, straightness of ways, stylus radius; see para- graphs 5.7.1 and 5.7.4	Lead standard, gage blocks
12. Helical path attach- ment used w/GO type indicating gage	Lead, flank angles, taper, straightness, clearance at root; see paragraphs 5.7.1 and 5.7.4 (c) (d)	Lead standard
13. Helical path analyzer	Use manufacturer's instruc- tions to test the mechani- cal and electronic features	Lead standard
14. Plain micrometer/ calipers - modified as required	Meet requirements, in GGG-C-105 - convert custom- ary units to metric as required	Gage blocks, or calibrated plain plug gages

See page 25 for footnotes.

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TABLE XX.1 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR EXTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 1)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS (k)
15. Surface measuring equipment	Use manufacturer's instruc- tions for calibration procedures	Visual, tactile and precision tracer type roughness stand- ards
16. Roundness/Radial variation measure- ment equipment	Use manufacturer's instruc- tions for calibration procedures	Precision glass sphere, roundness magnification standard, gage blocks
17. Linear measuring machine with required accessories	Use manufacturer's instruc- tions for calibration procedures	As required in manufacturer's instructions
18. Coordinate measuring machine with required accessories	Use manufacturer's instruc- tions for calibration procedures	As required in manufacturer's instructions

See page 25 for footnotes.

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TABLE XX.2 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR INTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 2)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS
<p>1. Thread plug (ASME/ ANSI B47.1) 1.1 GO plug</p> <p>1.2 HI and NOT-GO plugs</p> <p>1.3 Full form gage GO plug (UNJ and MJ only)</p> <p>1.4 B and C NOT-GO plugs (System 21A only)</p> <p>2. Thread snap gages (Deleted)</p> <p>3. Plain diameter gages 3.1a Minimum plain cylindrical GO plug for minor diameter</p>	<p>Lead, flank angles, major diameter, pitch diameter, taper, straight- ness, roundness, clearance at root</p> <p>Lead, flank angles, major diameter, pitch diameter, taper, straight- ness, roundness, clearance at root</p> <p>Lead, flank angles, major diameter, pitch diameter, minor diameter at radiused root, taper, straightness, roundness, root radius</p> <p>Type B: Lead, flank angles, major diameter, width of flat at crest, contact height, measure- ment over three best size wires, taper, straightness, roundness, clearance at root Type C: Same as 1.2 above</p> <p>Taper, straightness, round- ness, diameter</p>	<p>Three best size wires</p> <p>Three best size wires</p> <p>Three best size wires</p> <p>Three best size wires</p> <p></p> <p>Gage blocks</p>

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TABLE XX.2 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR INTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 2)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS
3.1b Maximum plain cylindrical NOT-GO plug for minor diameter	Taper, straightness, round- ness, diameter	Gage blocks
3.2 Minimum major diameter snap type (55° max included angle)	Pitch, included angle, dimension over segments, width of flat at crests (c)	Plain Z tolerance ring gage for GO major diameter or gage blocks between jaws
3.3 Minimum minor diameter snap type	Taper, straightness, coaxi- ality of cylindrical seg- ments, dimension over segments (c) jaws	Plain Z tolerance ring gage for GO minor diameter or gage blocks between jaws
3.4 Maximum/minimum major diameter snap type (55° max included angle)	Pitch, included angle, dimension over segments, width of flat at crests (c)	Plain Z tolerance ring gage for GO major diameter Plain Z tolerance ring gage for HI or NOT-GO major diameter or gage blocks between jaws
3.5 Maximum/minimum minor diameter snap type	Taper, straightness, coaxi- ality of cylindrical seg- ments, dimension over segments (c)	Plain Z tolerance ring gage for GO minor diameter Plain Z tolerance ring gage for HI or NOT-GO minor diameter or gage blocks between jaws

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TABLE XX.2 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR INTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 2)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS
4. Indicating thread gages having either two contacts at 180° or three contacts at 120° 4.1.1 GO segments 4.1.2	Lead, flank angles, major diameter, pitch diameter, taper, straightness, clear- ance at root, major cylinder to pitch cylinder relation- ship of segments for coaxi- ality; see paragraphs 5.7.1 and 5.7.4 (c) (d)	Solid W thread setting ring for GO or basic pitch diameter (g)
4.3.1 GO rolls 4.3.2 (zero lead)	Pitch, flank angles, major diameter, taper, straight- ness, clearance at root, parallelism of axes of rolls to each other; see paragraphs 5.7.1 and 5.7.4 (c) (d)	Solid W thread setting ring for GO (g) (j)
4.5.1 Minimum mat- 4.5.2 erial - pitch diameter type - cone and vee	Pitch, width of flat at crest, height of thread, see paragraphs 5.7.1 and 5.7.4 (c) (d)	Solid W thread setting ring for GO or HI or NOT- GO or basic pitch diameter (g) (j)
4.5.1 Minimum mat- 4.6.2 erial - thread groove type - cone or best wire size radius profile or best size ball contacts	Radius of contacts or ball diameters, see paragraphs 5.7.1 and 5.7.4 (c)	W thread setting ring for HI or NOT-GO (g) (j) For ball con- tacts: Plain Z tolerance ring gage whose diameter is basic pitch diameter plus 1/2 the best ball size

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TABLE XX.2 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR INTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 2)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS
4.7 Minor diameter/ pitch diameter runout gage	Straightness of plain gage segment, pitch, flank angle, straightness of thread seg- ment, minor cylinder to pitch cylinder relationship of segments for coaxiality; see paragraphs 5.7.1 and 5.7.4 (c) (d)	None
4.8 Differential segments or rolls: (GO pro- file for one pitch in length) used in combina- tion with GO/ minimum material indicating gages to yield a diam- eter equivalent for variations in lead (includ- ing uniformity of helix) and flank angle	GO profile of one pitch in length, segment or roll, requires flank angles checked GO full form segment; see 4.1.1/4.1.2 above GO full form roll; see 4.3.1/4.3.2 above Minimum material - pitch diameter type - cone and vee; see 4.5.1/4.5.2 above Minimum material - thread groove type - cone only; see 4.6.1/4.6.2 above; See paragraphs 5.7.1 and 5.7.4. Use manufacturer's instructions	(Following not required). Spec- ial internal lead standard and in- ternal flank angle standard with generated errors portion and near perfect portion

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TABLE XX.2 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR INTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 2)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS
4.9 Minimum mate- rial - B and C NOT-GO rolls or segments (System 21A only)	Type B: Pitch, flank angles, width of flat, contact height (c) Type C: Pitch, flank angles, major diameter	Solid W setting ring for HI or NOT-GO (g) (i)
5. Indicating plain diameter gages 5.1 Major diameter type (55° max included angle)	Pitch, included angle of flanks, width of flat on crests; see paragraphs 5.7.1 and 5.7.4	Plain Z tolerance ring gage for basic major diam- eter or GO major diameter, gage blocks, direct measurement
5.2 Minor diameter type	Straightness, parallelism of contacts; see paragraphs 5.7.1 and 5.7.4 (d)	Plain Z tolerance ring gage for basic minor diam- eter, gage blocks, direct measurement
6. Internal pitch micro- meter w/standard con- tacts (approximately HI or NOT-GO profile) cone and vee	Pitch, flank angles, maximum error in indicated measure- ment in the micrometer head shall not exceed 0.0002 inch (0.005 mm)	Solid W thread setting ring gage for basic pitch diameter, meas- urement over wires (g)
7. Internal pitch micro- meter w/modified con- tacts (approximately PD contact) cone and vee	Pitch, flank angles, width of flat at crest, height of thread. Maximum error in indicated measurement in the micrometer head shall not exceed 0.0002 inch (0.005 mm)	Solid W thread setting ring gage for basic pitch diameter (g)

See page 25 for footnotes.

TABLE XX.2 CALIBRATION REQUIREMENTS AND STANDARDS FOR X TOLERANCE
THREAD GAGES, INDICATING GAGES, Z TOLERANCE PLAIN GAGES
AND MEASURING EQUIPMENT FOR INTERNAL PRODUCT THREADS (SEE
PARAGRAPH 5.8.1) - (Continued)

THREAD GAGES AND MEASURING EQUIPMENT (REF: ASME B1.3M-1992 TABLE 2)	CALIBRATION REQUIREMENTS FOR GAGES AND MEASURING EQUIPMENT (a) (b)	SETTING GAGES AND STANDARDS
8. Thread measuring ball w/suitable measuring means	Flatness and parallelism of internal anvils, screw calibration, measuring force; see paragraphs 5.7.1 and 5.7.4	Gage blocks, calibrated "best size" balls
9. Optical comparator or toolmakers micro- scope w/suitable fixturing and cast replica	Micrometer stage, magnifi- cation, radius chart, pro- tractor head; see paragraphs 5.7.1 and 5.7.4 (c)	Gage blocks, plug gages, sine bar, stage micrometer
10. Profile tracing equipment w/suitable fixturing	Use manufacturer's instruc- tions to check out stylus traverse and electronic amplification	Special angle block supplied with instrument
14. Surface measuring equipment	Use manufacturer's instruc- tions for calibration procedures	Visual, tactile and precision tracer type roughness stand- ards
15. Roundness/Radial variation measure- ment equipment	Use manufacturer's instruc- tions for calibration procedures	Precision glass sphere, roundness magnification standard, gage blocks
16. Linear measuring machine with re- quired accessories	Use manufacturer's instruc- tions for calibration procedures	As required in manufacturer's instructions
17. Coordinate measur- ing machine with re- quired accessories	Use manufacturer's instruc- tions for calibration procedures	As required in manufacturer's instructions

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TABLE XX.3 CALIBRATION REQUIREMENTS FOR THREAD AND PLAIN SETTING GAGES
(SEE PARAGRAPH 5.8.2)

SETTING GAGE	CALIBRATION REQUIREMENTS
GO, LO, NOT-GO W thread setting plug gage, truncated and full form	Lead, flank angles, major diameter, taper, straightness and roundness of major and pitch cylinders, clearance at root, coaxiality of major cylinder with pitch cylinder.
GO, HI, NOT-GO solid W thread setting ring gage	Lead, flank angles, minor diameter, pitch diameter (e), taper, straightness and roundness of minor and pitch cylinders, clearance at root, coaxiality of minor cylinder with pitch cylinder
Plain Z tolerance plug and ring gages	Diameter, taper, straightness, roundness

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Footnotes to Tables XX.1, XX.2 and XX.3

- (a) Use applicable X, W or Z gage tolerance.
- (b) Taper, straightness including bellmouth barrel shape and hour glass shape, roundness shall be within the X, W or Z tolerance depending on the element measured. In other words, if these features are measured at pitch cylinder, the tolerance for pitch diameter applies.
- (c) Use manufacturer's recommended procedures for his gage for checking the thread features and alignment of indicating gage components.
- (d) New rolls and segments shall be within X tolerance. Worn rolls or segments shall be replaced when a single thread element wears outside of X tolerance.
- (e) Pitch diameter of an internal thread, measured by best size ball contacts, will be 0.0001 to 0.0002 inch (0.0025 to 0.005 mm) larger than the pitch diameter, gaged indirectly by a snug fitting master thread plug gage or locked segments of an indicating gage which were measured by best size wire method. This difference is due to the functional size of the master thread plug gage or locked segments which unavoidably have small variations in lead, flank angle, taper and roundness.
- (f) Pitch diameter is usually transferred from thread setting gage.
- (g) When the gage is set by adjustment based upon actual measured pitch diameter of the setting master, the master shall meet all W tolerances except for pitch diameter, which may have a tolerance increased to X.
- (h) For external thread pitch diameter size, adjustable thread snap gages and indicating thread gages may be set from one or more of the following: threaded setting plug gage, Z tolerance plain cylindrical plug gage, gage blocks, direct measurement and specially designed transfer standards. Gaging elements must be qualified for setting from their outside diameters.
- (i) For internal thread pitch diameter size, some types of adjustable snap gages may be set from Z tolerance plain ring gage or direct measurement. Gaging elements must be qualified for setting from their outside diameters.
- (j) Pitch diameter size may be set by direct measurement over wires on 180° segments, with specially designed transfer standards or by Z tolerance plain ring gages when gaging elements are qualified for setting from their outside diameters.
- (k) W tolerance setting plug gages may be used until a single thread element wears outside the X gage tolerance.

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