INCH-POUND

MIL-DTL-45910D
18 June 2015
SUPERSEDING
MIL-I-45910C
11 March 1985

DETAIL SPECIFICATION

INSERT, SCREW THREAD-LOCKED IN AND RING LOCKED, SERRATED GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the requirements for locked in inserts. The method of locking in the insert should be by means of a serrated collar and an accessory lock ring with matching serrations installed within the parent material to prevent rotation (see 6.1).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL STANDARDS

FED-STD-H28/2	Screw-Thread Standards for Federal Services Section 2 Unified Inch Screw Threads- UN and UNR Thread Forms
FED-STD-H28/20	Screw-Thread Standards for Federal Services Section 20 Inspection Methods for Acceptability of UN, UNR, UNJ, M, AND MJ Screw Threads

Comments, suggestions, or questions on this document should be addressed to DLA Troop Support - Industrial Hardware Division (ATTN: Code FHTE), 700 Robbins Avenue, Philadelphia, PA 19111-5096 or email trpsptspecspa@dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil .

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-DTL-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-PRF-46010	Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting NATO Code - S-1738

DEPARTMENT OF DEFENSE STANDARDS

MS51498	Insert, Screw Thread - Locked in, Ring Locked, Serrated, High Strength, Oversize Replacer
MS51991	Insert, Screw Thread - Locked in, Ring Locked, Serrated
MS51993	Insert, Screw Thread - Locked in, Ring Locked, Serrated, High Strength
MS51994	Hole Preparation - Ring Locked Inserts and Studs, Standard Dimensions for
MS51995	Fasteners, Ring Locked Inserts and Studs, Installation and Replacement of
MS51996	Hole Preparation - Ring Locked Inserts and Studs, High Strength, Standard Dimensions for

(Copies of these documents are available online at http://quicksearch.dla.mil/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ASME B46.1	Surface Texture (Surface Roughness, Waviness, and Lay)

(Copies of this document are available from www.asme.org American Society of Mechanical Engineers, Three Park Avenue, M/S 10E, New York, NY 10016-5990.)

AMERICAN SOCIETY FOR QUALITY (ASQ)

ASQ Z1.4	Sampling Procedures and Tables for Inspection by Attributes.

(Copies of this document are available from www.asq.org American Society for Quality Control, 600 North Plankinton Avenue, Milwaukee, WI 53203.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A108	Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A380/A380M	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM B928/B928M	Standard Specification for High Magnesium Aluminum-Alloy Sheet and Plate for Marine Service and Similar Environments
ASTM E1417/E1417M	Standard Practice for Liquid Penetrant Testing
ASTM E1444/E1444M	Standard Practice for Magnetic Particle Testing
ASTM E1742/E1742M	Standard Practice for Radiographic Examination

ASTM F1941	Standard Specification for Electrodeposited Coatings on Threaded Fasteners (Unified Inch Screw Threads (UN/UNR))

(Copies of these documents are available from www.astm.org or the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

NATIONAL AEROSPACE STANDARD (NAS)

NASM1312-6	Fastener Test Methods, Method 6, Hardness

(Copies of this document are available from www.aia-aerospace.org or the Aerospace Industries Association, 1250 Eye Street, N. W., Suite 1200, Washington DC, 20005-3924.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE AMS2411	Plating, Silver for High Temperature Applications
SAE AMS4967	Titanium Alloy, Bars, Wire, Forgings, and Rings 6.0Al - 4.0V Annealed, Heat Treatable - UNS R56400
SAE AMS5731	Steel, Corrosion and Heat-Resistant, Bars, Wire, Forgings, Tubing, and Rings 15Cr - 25.5Ni - 1.2Mo - 2.1Ti - 0.006B - 0.30V Consumable Electrode Melted, 1800 ºF (982 ºC) Solution Heat Treated - UNS S66286
SAE AMS5732	Steel, Corrosion and Heat-Resistant, Bars, Wire, Forgings, Tubing, and Rings 15Cr - 25.5Ni - 1.2Mo - 2.1Ti - 0.006B - 0.30V Consumable Electrode Melted, 1800 ºF (982 ºC) Solution and Precipitation Heat Treated - UNS S66286
SAE AMS5734	Steel, Corrosion and Heat-Resistant, Bars, Wire, Forgings, and Tubing 15Cr - 25.5Ni - 1.2Mo - 2.1Ti - 0.006B - 0.30V Consumable Electrode Melted, 1650 ºF (899 ºC) Solution Heat Treated - UNS S66286
SAE AMS5737	Steel, Corrosion and Heat-Resistant, Bars, Wire, Forgings, and Tubing 15Cr - 25.5Ni - 1.2Mo - 2.1Ti - 0.006B - 0.30V Consumable Electrode Melted, 1800 ºF (982 ºC) Solution and Precipitation Heat Treated - UNS S66286
SAE AMS6349	Steel Bars 0.95Cr - 0.20Mo (0.38 to 0.43C) (SAE 4140) Normalized - UNS G41400
SAE AMS6382	Steel, Bars, Forgings, and Rings 0.95Cr - 0.20Mo (0.38 – 0.43C) (SAE 4140) Annealed - UNS G41400
SAE AMS6931	Titanium Alloy Bars, Forgings and Forging Stock 6.0Al – 4.0V Annealed - UNS R56400
SAE AMS-C-8837	Coating, Cadmium (Vacuum Deposited)
SAE AMS-QQ-A-225/6	Aluminum Alloy, 2024, Bar, Rod, and Wire; Rolled, Drawn, or Cold Finished - UNS A92024
SAE AMS-QQ-P-416	Plating, Cadmium (Electrodeposited)
SAE AS8879	Screw Threads - UNJ Profile, Inch Controlled Radius Root with Increased Minor Diameter
SAE AS51990	Ring, Lock, Serrated
SAE AS51997	Ring, Locked, Serrated – High Strength

(Copies of these documents are available from www.sae.org or the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Part standards. The individual item requirements shall be as specified herein and in accordance with the applicable part standards. In the event of any conflict between requirements of this specification and the part standard, the latter shall govern.

3.2 Material. The insert shall be a one piece all metal unit. The insert and lock ring shall be made from the following materials as specified in the applicable part standard (see 3.1) when inspected in conformance with 4.6.2.

3.2.1 Carbon and alloy steel. Carbon steel shall be grade 1117 (UNS G11170) in accordance with ASTM A108. Alloy steel shall be grade 4140 (UNS G41400) in accordance with SAE AMS6349 or SAE AMS6382.

3.2.2 Corrosion-resistant steel. Corrosion-resistant steel shall be type A286 (UNS S66286) in accordance with SAE AMS5731, SAE AMS5732, SAE AMS5734 or SAE AMS5737.

3.2.3 Titanium alloy. Titanium alloy shall be type Ti-6-Al-4V (UNS R56400) in accordance with SAE AMS4967 or SAE AMS6931.

3.2.4 Recycled, recovered, environmentally preferable, or biobased materials. Recycled, recovered, environmentally preferable, or biobased materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.3 Protective plating or surface treatment. The insert and lock ring shall be furnished with a protective plating or surface treatment as specified in the applicable part standard (see 3.1) when inspected in conformance with 4.6.3.

3.3.1 Carbon and alloy steel. Inserts of carbon or alloy steel and lock rings of carbon steel shall be cadmium plated in accordance with SAE AMS-QQ-P-416, Type II, Class 3.

3.3.2 Corrosion-resistant steel. Corrosion-resistant steel inserts and lock rings shall be cleaned, descaled and passivated in accordance with ASTM A380/A380M. When specified in the applicable part standard (see 3.1), corrosion-resistant steel inserts shall be silver plated in accordance with SAE AMS2411, 0.0002 inch minimum thickness. When specified in the applicable part standard (see 3.1), corrosion-resistant steel inserts shall have a dry film lubricant applied in accordance with MIL-PRF-46010.

3.3.3 Titanium alloy. Titanium alloy inserts shall have an anodic coating.

3.3.4 Zinc Nickel plating. As an alternative to cadmium plating, carbon and alloy steel inserts may be ZnNi plated in accordance with ASTM F1941 Fe/Zn-Ni 5ET alkaline zinc nickel electroplate, 12%-16% mass percent nickel, with chemical conversion coating per MIL-DTL-5541 TYPE II CLASS 1A.

3.4 Design, dimensions and tolerances. Design, dimensions and tolerances shall be in accordance with the requirements of the applicable part standard (see 3.1) and shall apply after application of the protective finish or surface treatment specified in 3.3.

3.4.1 Threads. Threads shall be right hand in accordance with the applicable part standard (see 3.1).

3.4.1.1 External threads. External threads shall be in accordance with FED-STD-H28/2 with pitch and minor diameters as specified in the applicable part standard (see 3.1) for fine and coarse threads.

3.4.1.2 Internal threads. Internal threads shall be in accordance with SAE AS8879 as specified in the applicable part standard (see 3.1). Internal threads which include locking feature shall be displaced or deformed as specified in 3.4.2. The insert without lubricant shall allow the "go" gage to enter not less than one-half turn before engagement of locking feature. When an insert with lubricant prevents the use of standard gages, the insert shall permit a minimum free rotational bolt thread engagement of three-fourths turn before engagement of the locking feature.

3.4.1.3 Thread forming. Threads may be produced either by machining, grinding, or fully formed by a single rolling process. In the event the external threads are rolled, the grain flow in the threads shall follow the general thread contour with the maximum density at the bottom of the root radius as shown in Figure 1 in accordance with 4.7.6.

3.4.1.4 Incomplete and lead thread. Incomplete and lead threads, unless otherwise specified shall be in accordance with SAE AS8879.

3.4.1.5 Thread concentricity. The internal thread pitch diameter shall be concentric with the external thread pitch diameter within 0.006 FIM.

3.4.2 Internal thread locking feature. The internal thread of the insert shall be distorted to impose friction between the insert and the inserted item. The feature shall not operate by means of separate movement from the installation, nor depend upon axial load on the insert wall.

3.4.2.1 Self-locking torque. When the insert is properly installed in the parent material, the locking feature shall provide a locking torque with a mating screw or bolt that is within the limits specified in Table I when tested in accordance with 4.7.2. Inserts shall not be subjected to self-locking tests after testing as specified in 4.7.3, 4.7.4 or 4.7.5.

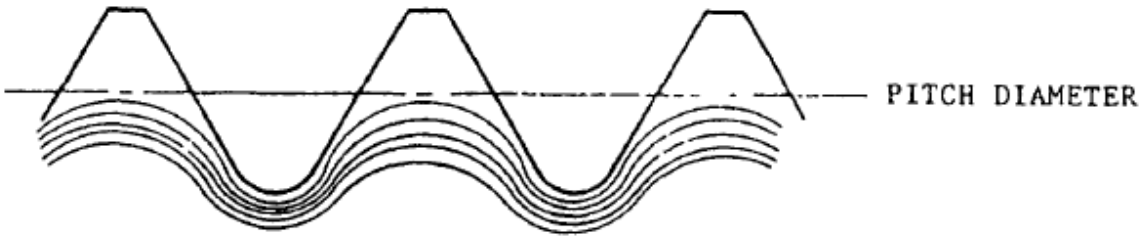


Figure 1. Thread Grain Flow.

TABLE I. Internal Thread, Self-Locking Torque.

Insert Internal Thread Nominal Size Fine or Coarse	MS51498, MS51991, MS51993	
	Max Locking Torque Inch-Lbs.	Min Breakaway Torque Inch-Lbs.
.112	5	1/
.138	10	1.0
.164	15	1.5
.190	18	2.0
.250	30	3.5
.3125	60	6.5
.375	80	9.5
.4375	100	14.0
.500	150	18.0
.5625	200	24.0
.625	300	32.0
.750	400	50.0
.875	600	70.0
1.000	800	90.0

1/ Some indication of torque

3.4.3 Locking serrations.

3.4.3.1 Insert Locking serrations. Insert locking serration dimensions shall conform in size to MS51498, MS51991 or MS51993 and applicable dash number and shall be of full form.

3.4.3.2 Lock ring serrations. Lock ring serration dimensions for both internal and external serrations shall conform in size to SAE AS51990 or SAE AS51997 and applicable dash number.

3.4.3.3 Serration concentricity. The internal serrations shall be concentric with the external serrations within 0.006 FIM.

3.4.4 Surface texture. Surface texture of the insert and lock ring prior to plating shall not exceed the values specified on the applicable part standard (see 3.1) and shall be in accordance with ASME B46.1 when tested in conformance with 4.6.6.

3.5 Mechanical properties. Inserts conforming to the design and dimensions specified in the applicable part standard (see 3.1) and having load ratings as specified in Table II shall be capable of developing a minimum tensile strength, a minimum proof strength and have shear engagement areas in accordance with Table II.

TABLE II. Mechanical Properties.

Load Rating KSI	Minimum Tensile Strength KSI	Minimum Proof Strength KSI	Shear Engagement Area (External Threads)		
			MS51991		
			-100 Numbers	-200 Numbers	-300 Numbers
125	125	125	Table V Col 1	Table V Col 1	Table V Col 2

Load Rating KSI	Minimum Tensile Strength KSI	Minimum Proof Strength KSI	Shear Engagement Area (External Threads)		
			MS51993		
			-500 Numbers	-640 Numbers	-800 Numbers
220	240	220	Table V Col 3	Table V Col 4	Table V Col 5

Load Rating KSI	Minimum Tensile Strength KSI	Minimum Proof Strength KSI	Shear Engagement Area (External Threads)		
			MS51498		
			-500 Numbers	-640 Numbers	-800 Numbers
220	240	220	Table V Col 6	Table V Col 7	Table V Col 8

3.5.1 Minimum applied axial load. The installed insert (with lock ring in place) shall develop the minimum axial load as specified in Table III. Axial values are based on the tensile stress area of the applicable test bolt and the minimum tensile strength specified in Table II when tested as specified in 4.7.3.

TABLE III. Axial Load at Specified Stress Level.

Nominal Size (Internal Thread)	Tensile 1/ Stress Area ($In.^2$) of Bolt		Minimum Applied Axial Load (Lbs.)		
			MS51991 125 KSI 2/		MS51498 & MS51993 240 KSI 3/
	Coarse Thread	Fine Thread	Coarse Thread (UNJC)	Fine Thread (UNJF)	Fine Thread (UNJF)
.112	.0060	.0066	750	825	------
.138	.0091	.0101	1,140	1,260	------
.164	.0140	.0147	1,750	1,840	------
.190	.0175	.0200	2,190	2,500	4,800
.250	.0318	.0364	4,000	4,550	8,750
.3125	.0524	.0580	6,600	7,300	13,900
.375	.0775	.0878	9,700	11,000	21,000
.4375	.1063	.1187	13,300	14,800	28,500
.500	.1419	.1599	17,700	20,000	38,400
.5625	----	.203	------	25,400	------
.625	----	.256	------	32,000	------
.750	----	.373	------	46,600	------
.875	----	.509	------	63,600	------
1.000	----	.663	------	82,900	------

1/ The tensile stress area used for the calculation of the axial load values are based on the stress area per formula specified in FED-STD-H28/2.

2/ The minimum applied axial loads shown are the product of the applicable tensile stress area times 125 KSI.

3/ The minimum applied axial loads shown are the product of the tensile stress area times 240 KSI.

3.5.2 Proof load. The installed insert shall be capable of withstanding proof loads as specified in Table IV when tested in conformance with 4.7.3.

TABLE IV. Proof Loads for Inserts Internal Threads.

Nominal Size (Internal Thread)	Tensile 1/ Stress Area ($In.^2$) of Bolt		Minimum Applied Axial Load (Lbs.)		
			MS51991 125 KSI 2/		MS51498 & MS51993 220 KSI 3/
	Coarse Thread	Fine Thread	Coarse Thread (UNJC)	Fine Thread (UNJF)	Fine Thread (UNJF)
.112	.0060	.0066	750	825	------
.138	.0091	.0101	1,140	1,260	------
.164	.0140	.0147	1,750	1,840	------
.190	.0175	.0200	2,190	2,500	4,400
.250	.0318	.0364	4,000	4,550	8,000
.3125	.0524	.0580	6,600	7,300	12,800
.375	.0775	.0878	9,700	11,000	19,300
.4375	.1063	.1187	13,300	14,800	26,100
.500	.1419	.1599	17,700	20,000	35,200
.5625	----	.203	------	25,400	------
.625	----	.256	------	32,000	------
.750	----	.373	------	46,600	------
.875	----	.509	------	63,600	------
1.000	----	.663	------	82,900	------

1/ The tensile stress area used for the calculation of the axial load values are based on the stress area per formula specified in FED-STD-H28/2.

2/ The minimum applied axial loads shown are the product of the applicable tensile stress area times 125 KSI.

3/ The minimum applied axial loads shown are the product of the tensile stress area times 220 KSI.

3.5.3 Resistance to pullout. The insert shall demonstrate minimum shear engagement areas as specified in Table V. The installed insert with lock ring in place as specified in 4.5.1 shall have a minimum resistance to pullout in accordance with Table VI. Values specified in Table VI are based on the minimum shear engagement areas of the insert (Table V) when installed in a test block of 25 KSI shear strength when tested as specified in 4.7.4.

TABLE V. Minimum Shear Engagement Area of Insert External Thread. 1/

Nominal Size (Internal Thread)	Minimum Shear Engagement Area (In.²) – Insert, Non Locked 1/							
	MS51991		MS51993			MS51498		
	-100 & -200 Numbers	-300 Numbers	-500 Numbers	-640 Numbers	-800 Numbers	-500 Numbers	-640 Numbers	-800 Numbers
	Col 1 Coarse Thread (NS)	Col 2 Fine Thread (NS)	Col 3 Fine Thread (NS)	Col 4 Fine Thread (NS)	Col 5 Coarse Thread (NS)	Col 6 Fine Thread (NS)	Col 7 Fine Thread (NS)	Col 8 Fine Thread (NS)
.112	.0312	----	----	----	----	----	----	----
.138	.0576	----	----	----	----	----	----	----
.164	.0976	----	----	----	----	----	----	----
.190	.1442	----	.1500	.1917	.2516	.1543	.2047	.2965
.250	.2034	----	.2788	.3550	.4484	.2917	.3790	.5265
.3125	.2663	----	.4521	.5678	.7165	.5546	.6987	.9281
.375	.3557	----	.6605	.8398	1.0690	.7826	.9992	1.2547
.4375	.4708	----	.8944	1.1340	1.4417	.9124	1.1938	1.6272
.500	.5872	----	1.1938	1.5126	1.9146	1.5757	1.7024	2.2785
.5625	----	.9983	----	----	----	----	----	----
.625	----	1.4120	----	----	----	----	----	----
.750	----	1.6990	----	----	----	----	----	----
.875	----	2.2641	----	----	----	----	----	----
1.000	----	2.8387	----	----	----	----	----	----
	Minimum Shear Engagement Area (In.²) – Insert, Locked 1/							
.112	.0270	----	----	----	----	----	----	----
.138	.0508	----	----	----	----	----	----	----
.164	.0941	----	----	----	----	----	----	----
.190	.1340	----	.1384	.1769	.2323	.1461	.1960	.2828
.250	.1896	----	.2607	.3319	.4249	.2669	.3542	.5017
.3125	.2547	----	.4146	.5303	.6790	.5212	.6653	.8947
.375	.3403	----	.6191	.7984	1.0276	.7436	.9602	1.2157
.4375	.4534	----	.8445	1.0831	1.3908	.8710	1.1524	1.5858
.500	.5678	----	1.1470	1.4658	1.8678	1.5254	1.6701	2.2282
.5625	----	.9748	----	----	----	----	----	----
.625	----	1.3766	----	----	----	----	----	----
.750	----	1.6623	----	----	----	----	----	----
.875	----	2.2283	----	----	----	----	----	----
1.000	----	2.7769	----	----	----	----	----	----

1/ Shear engagement area is the assembled dimensional value for the overall engaged area of mating thread members. It does not represent a dimension of either of the members in an unassembled condition.

TABLE VI. Resistance to Pullout, Insert External Threads.

Nominal Size (Internal Thread)	Minimum Resistant to Pullout (Lbs.) – Insert, Non Locked 1/							
	MS51991		MS51993			MS51498		
	-100 & -200 Numbers Coarse Thread (NS)	-300 Numbers Fine Thread (NS)	-500 Numbers Fine Thread (NS)	-640 Numbers Fine Thread (NS)	-800 Numbers Coarse Thread (NS)	-500 Numbers Fine Thread (NS)	-640 Numbers Fine Thread (NS)	-800 Numbers Fine Thread (NS)
.112	780	----	----	----	----	----	----	----
.138	1,420	----	----	----	----	----	----	----
.164	2,440	----	----	----	----	----	----	----
.190	3,600	----	3,750	4,790	6,290	3,860	5,120	7,410
.250	5,080	----	6,970	8,880	11,210	7,290	9,480	13,160
.3125	6,660	----	11,300	14,200	17,910	13,870	17,470	23,200
.375	8,890	----	16,510	21,000	26,720	19,560	24,980	31,370
.4375	11,770	----	22,360	28,350	36,040	22,800	29,850	40,680
.500	14,680	----	29,850	37,810	47,870	39,390	42,560	56,960
.5625	----	24,960	----	----	----	----	----	----
.625	----	35,300	----	----	----	----	----	----
.750	----	42,470	----	----	----	----	----	----
.875	----	56,600	----	----	----	----	----	----
1.000	----	70,970	----	----	----	----	----	----
	Minimum Resistant to Pullout (Lbs.) – Insert, Locked 1/							
.112	675	----	----	----	----	----	----	----
.138	1,270	----	----	----	----	----	----	----
.164	2,350	----	----	----	----	----	----	----
.190	3,350	----	3,460	4,420	5,810	3,650	4,900	7,070
.250	4,740	----	6,520	8,300	10,620	6,670	8,860	12,540
.3125	6,370	----	10,360	13,260	16,980	13,030	16,630	22,370
.375	8,510	----	15,480	19,960	25,690	18,590	24,000	30,390
.4375	11,340	----	21,110	27,080	34,770	21,780	28,810	39,640
.500	14,200	----	28,680	36,640	46,700	38,140	41,750	55,700
.5625	----	24,370	----	----	----	----	----	----
.625	----	34,420	----	----	----	----	----	----
.750	----	41,560	----	----	----	----	----	----
.875	----	55,710	----	----	----	----	----	----
1.000	----	69,420	----	----	----	----	----	----

1/ Installed in a test block with a shear strength as specified in 3.5.3.

3.5.4 Rotational resistance. The insert shall produce a minimum torque resistance value not less than that specified in Table VII when installed in conformance with MS51995 and the applicable part standard (see 3.1) and tested in accordance with 4.7.5.

TABLE VII. Rotational Resistance Strength.

Internal Thread Size	Minimum Rotational Resistance (Torque-Out in Inch Lbs.)		
	MS51991	MS51993	MS51498
.112	20	----	----
.138	30	----	----
.164	45	----	----
.190	65	120	400
.250	150	200	650
.3125	300	400	900
.375	550	650	1,300
.4375	850	900	2,300
.500	1,100	1,300	3,000
.5625	1,600	----	----
.625	2,300	----	----
.750	4,000	----	----
.875	6,000	----	----
1.000	8,000	----	----

3.5.4.1 Removal and replacement. The insert and lock ring shall meet the requirements of 3.5.4 when replacing an identical insert and lock ring (see 3.1) in an existing hole conforming to MS51994 and MS51996 and installed as specified in MS51995 provided the hole is undamaged by the insert removal operation.

3.5.5 Hardness.

3.5.5.1 Insert hardness. The insert shall meet the hardness as specified in the applicable part standard (see 3.1) when tested in accordance with 4.7.1.

3.5.5.2 Lock ring hardness. The lock ring of carbon steel shall be case hardened to the depth of 0.001 to 0.004 inch and be capable of developing a hardness as specified in the applicable part standard (see 3.1) when tested in accordance with 4.7.1. Corrosion-resistant steel lock rings shall not be case hardened.

3.6 Metallurgical properties.

3.6.1 Discontinuities. The insert and lock ring shall not exhibit discontinuities exceeding the following limitations when tested in accordance with 4.6.7.

3.6.1.1 Cracks. (see 6.3.1) The insert and lock ring shall be free of cracks in any direction or location.

3.6.1.2 Laps and seams. (see 6.3.2 and 6.3.3) The insert and lock ring may possess laps and seams except in locations specified in 3.6.2. Discontinuity depths shall not exceed 20 percent of the thread height (sharp V thread) for the insert and mating lock ring.

3.6.1.3 Inclusions. (see 6.3.4) The insert shall show no evidence of surface or subsurface inclusions at the thread root when examined in accordance with 4.6.7. Small inclusions in other parts of the insert or lock ring not indicative of unsatisfactory quality, shall not be cause for rejection.

3.6.2 Thread discontinuities. (laps, seams, and surface irregularities in rolled threads). Threads shall have no laps at the root or along the flanks as shown in Figure 2. Multiple laps on sides of threads are not permissible regardless of location. A single lap is permissible along the side of the thread above the pitch diameter on either the pressure or non-pressure side (one lap per thread) provided it extends toward the crest and generally parallel to the side as shown in Figure 3a. Crest craters, crest laps, or a crest lap in combination with a crest crater are permissible, provided the imperfection does not extend deeper than 20 percent of the basic thread height (see Table VIII) as measured from the thread crest when the thread major diameter is at minimum size (see Figure 3a). Slight deviation from the thread contour is permissible at the crest of the thread within the major diameter limits as shown in Figure 3b. The incomplete thread at each end of the thread max also deviate slightly from contour.

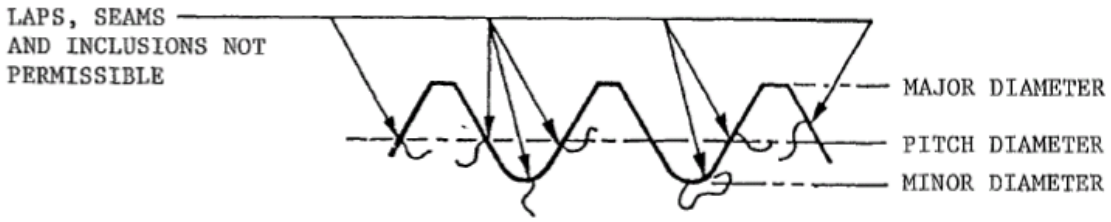


Figure 2. Laps, Seams and Surface Thread.

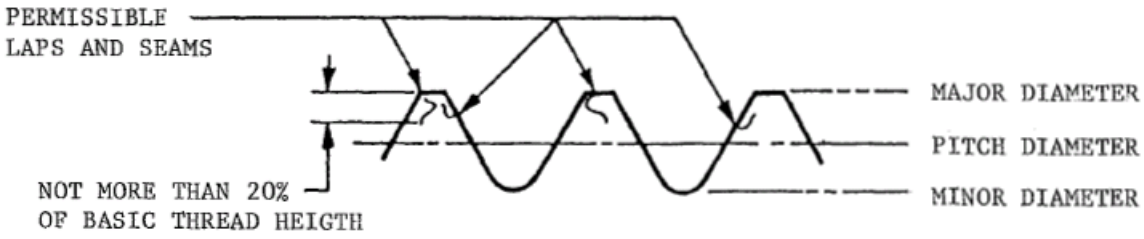


Figure 3a. Laps, Seams and Surface Thread.

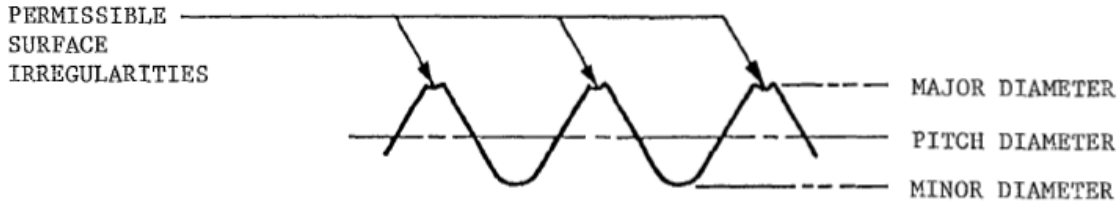


Figure 3b. Laps, Seems and Surface Thread.

TABLE VIII. Basic Thread Height, Unified Threads.

Threads Per Inch	Basic Thread Height (Ref)	20% Base Thread Height
48	0.0135	0.0027
40	0.0162	0.0032
36	0.0180	0.0036
32	0.0203	0.0041
28	0.0232	0.0046
24	0.0271	0.0054
20	0.0325	0.0065
18	0.0361	0.0072
16	0.0406	0.0081
14	0.0464	0.0093
13	0.0500	0.0100
12	0.0541	0.0108
11	0.0590	0.0118
10	0.0650	0.0130

3.6.3 Grinding burns. The insert or lock ring shall show no evidence of grinding burns.

3.7 Workmanship. Workmanship shall be consistent with the type of product, finish and class of thread fit specified. The insert and lock ring shall be of uniform quality free from laps, cracks, seems, inclusions, splits, or other defects which would be detrimental to the performance of the insert or lock ring in service use.

4. VERIFICATION

4.1 Conformance inspection. Conformance inspection shall be in as specified in Table IX.

4.1.1 Inspection lot. An inspection lot shall consist of all inserts and lock rings covered by a single applicable part standard (see 3.1) produced under essentially the same conditions and offered for inspections at one time.

4.2 Classification of defects. Classification of defects shall be in accordance with ASQ Z1.4 and Table X or XI as applicable.

4.2.1 Defect noncompliance. An insert or lock ring exhibiting one or more defects shall be considered defective.

4.3 Inspection sampling. Inspection sampling shall be in accordance with ASQ Z1.4 and the applicable inspection level specified in Table X or XI as applicable.

4.4 Inspection of packaging. The sampling and inspection of the preservation, packing and container marking shall be in accordance with requirements of 5.1.

4.5 Test block fabrication. Test blocks shall be fabricated in accordance with Figures 4 and 5 as applicable. Test blocks may exceed dimensions specified in Figures 4 and 5 to accommodate multiple testing of inserts and lock rings except for test of 4.7.3 and 4.7.4.

4.5.1 Test sample installation. Test sample inserts and lock rings shall be installed in accordance with MS51995 in test blocks as specified in 4.5.

4.5.1.1 Inspection of installed inserts and lock rings. The inserts and lock rings installed as specified in 4.5.1 shall be visually inspected under 10 diameters magnification. The presence of cracks in either test block, insert or lock rings as a result of installation shall be cause for rejection. When visual inspection discloses a condition which shows cause for further examination, the test specimen shall be penetrant inspected in accordance with ASTM E1417/E1417M.

4.5.1.2 Test bolts and screws. Bolts and screws for use in all tests shall have Class 3A threads in accordance with FED-STD-H28/2.

4.5.1.2.1 Bolts and screws used for testing as specified in 4.7.3, 4.7.4, and 4.7.5 shall be heat treated and plated as follows:

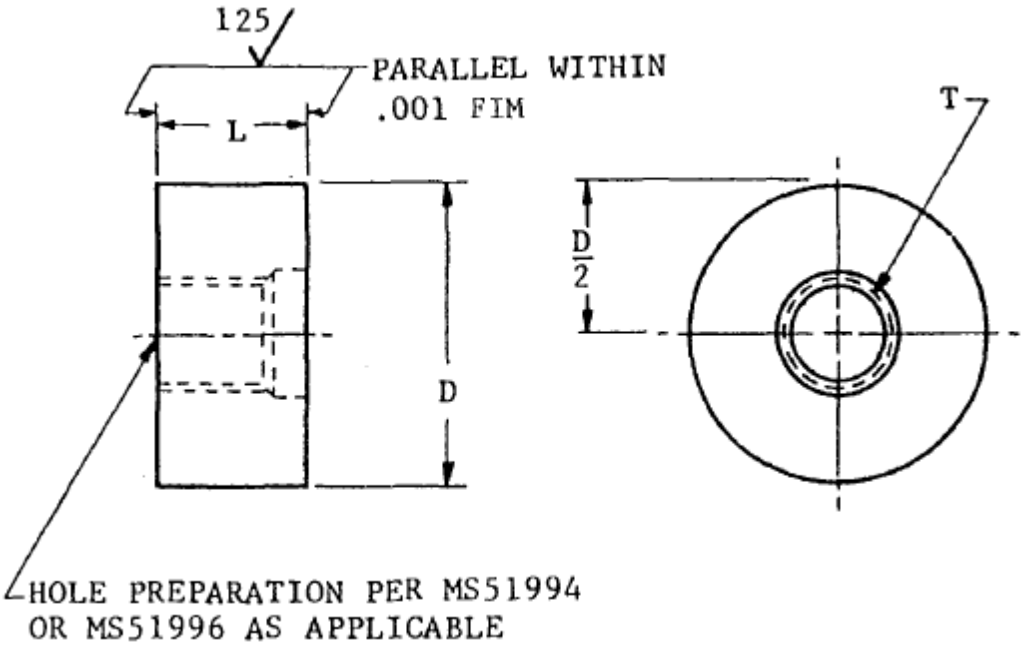
a. To test MS51991 inserts.
   Heat treat test bolts and screws 160 KSI minimum.
   Cadmium plate per SAE AMS-QQ-P-416, Type II, Class 3.

b. To test MS51993 and MS51498 insert.
   Heat treat test bolts and screws 260 KSI minimum.
   Cadmium plate per SAE AMS-C-8837, Type I, Class 2

4.5.1.2.2 Bolts and screws used for internal thread self-locking tests of inserts as specified in 4.7.2 shall be heat treated as follows:

a. For MS51991 Carbon steel inserts use test bolts heat treated to 125 KSI minimum with cadmium plate per SAE AMS- QQ-P-416, Type II, Class 3. For MS51991 corrosion-resistant steel inserts use corrosion-resistant steel bolts.

b. For MS51993 and MS 51498 Alloy steel inserts use test bolts heat treated to 160 KSI minimum with cadmium plate per SAE AMS- QQ-P-416, Type II, Class 3. For inserts of corrosion and heat resistant steel (A286) and silver plated use corrosion and heat resistant steel test bolts with minimum tensile tensile strength of 130 KSI cleaned, descaled and passivated in accordance with ASTM A380/A380M.



1. Dimensions:

   T = Nominal thread diameter of applicable insert external thread.

   D = 4 x T (For T thread sizes smaller than 0.500 Dia.).
   3 x T (For T thread sizes 0.500 Dia. and larger).

   L = Length of applicable insert plus 0.063.

2. Material:

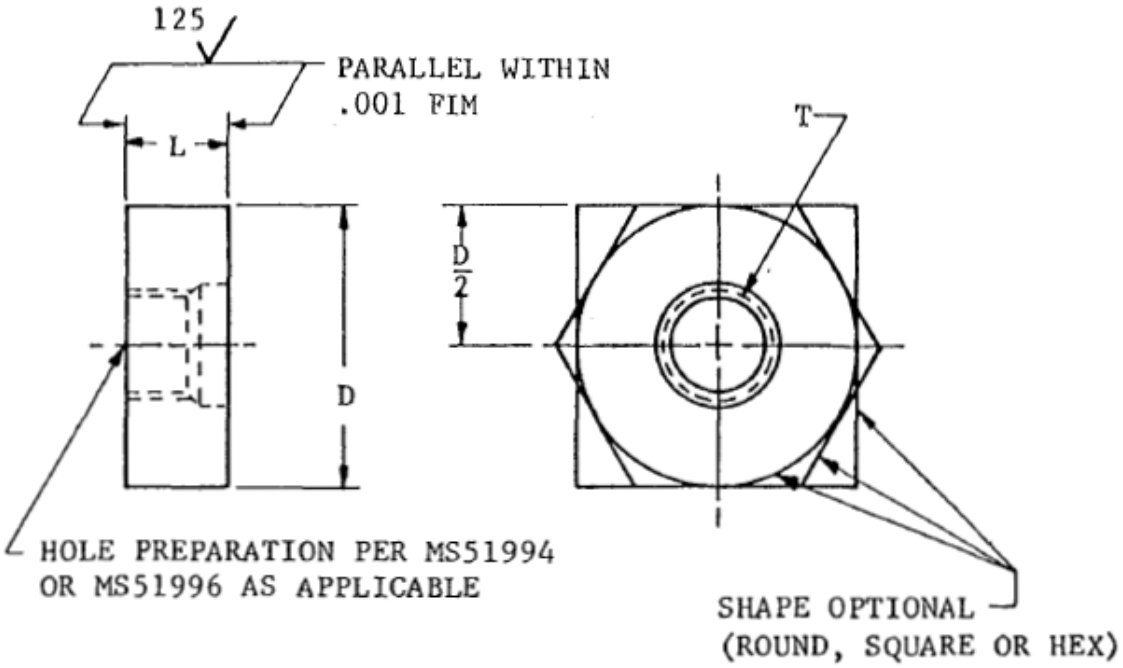
   (a) Axial tests (3.5.1 & 3.5.2) - Aluminum alloy, 2024-T4 per SAE AMS-QQ-A-225/6 (Bars and Rods).

   (b) Pullout test (3.5.3) - Aluminum alloy 5083-H321 per ASTM B928/B928M.

3. Anodize per MIL-A-8625, Type I, Class 1 or Class 2.

4. Penetrant inspect per ASTM E1417/E1417M: Discontinuities or cracks not acceptable.

FIGURE 4. Axial Load Test Blocks.



1. Dimensions:

   T = Nominal thread diameter of applicable insert external thread.

   D = 4 x T (For T thread sizes smaller than 0.500 Dia.).
   3 x T (For T thread sizes 0.500 Dia. and larger).

   (a) L = Length of applicable insert minus 0.063 for rotational resistance tests (3.5.4).

   (b) L = Length of applicable insert plus 0.063 for internal thread locking feature requirement (3.4.2).

2. Material:

   Aluminum alloy, 2024-T4 per SAE AMS-QQ-A-225/6 (Bars).

3. Anodize per MIL-A-8625, Type I, Class 1 or Class 2.

4. Penetrant inspect per ASTM E1417/E1417M: Discontinuities or cracks not acceptable.

FIGURE 5. Torque Test Blocks.

4.6 Method of inspection.

4.6.1 Visual and dimensional. The insert and lock ring shall be examined to verify that physical dimensions, locking serrations, surface texture, grinding burns and workmanship are in accordance with the applicable requirements of 3.4, 3.4.4 and 3.7.

4.6.2 Material inspection. Material inspection shall consist of certification supporting verifying data that the materials used in fabricating the insert and lock ring are in accordance with the applicable requirements of 3.2.

4.6.3 Treatment and finish inspection.

4.6.3.1 Protective finish inspection. Sample inserts and lock rings shall be inspected for minimum thickness and continuity of plating in accordance with SAE AMS-QQ-P-416 or SAE AMS2411 and requirements of 3.3.1, 3.3.2 and 3.3.3 as applicable.

TABLE IX. Quality Conformance Inspection.

Inspection	Requirement Paragraph	Test Method Paragraph
Group A		
Visual & Dimensional	3.4	4.6.1
Material	3.2	4.6.2
Protective finish and surface treatment	3.3 (as applicable)	4.6.3 (as applicable)
Grinding burns	3.6.3	4.6.1
Workmanship	3.7	4.6.1
Packaging	5.1	4.4
Group B		
Threads	3.4.1 thru 3.4.1.4	4.6.4 & 4.7.6
Thread concentricity	3.4.1.5	4.6.4.3
Locking serrations	3.4.3	4.6.5
Surface texture	3.4.4	4.6.6
Group C		
Self locking torque	3.4.2.1	4.7.2
Minimum applied axial load	3.5.1	4.7.3
Proof load	3.5.2	4.7.3
Resistance to pullout	3.5.3	4.7.4
Rotational resistance	3.5.4	4.7.5
Hardness	3.5.5	4.7.1
Cracks	3.6.1.1	4.6.7
Laps and seams	3.6.1.2	4.6.7
Inclusions	3.6.1.3	4.6.7
Thread discontinuities	3.6.2	4.6.7

TABLE X. Classification of Defects and Inspection Sampling for Inserts.

Category	Defect	Inspection Method
Critical	None defined	
Major		
101	Design and dimensions incorrect (3.4)	Standard Measuring and Test Equipment (SMTE)
102	Threads not as specified (3.4.1 thru 3.4.1.4 as applicable)	SMTE
103	Internal threads not concentric with external threads (3.4.1.5)	SMTE
104	Self-locking feature missing, when required (3.4.2)	Visual
105	Surface texture (3.4.4)	SMTE
106	Cracks (3.6.1.1) and thread discontinuities (3.6.2)	SMTE
107	Imperfect insert serrations (3.4.3.1)	Visual
108	Treatment and finish (3.3 as applicable)	Visual
109	Mechanical properties (3.5 as applicable to inserts)	SMTE
Minor		
201	Overall length (3.4)	SMTE
202	Workmanship (3.7)	Visual

TABLE XI. Classification of Defects and Inspection Sampling for Lock Ring.

Category	Defect	Inspection Method
Critical	None defined	
Major		
101	Design and dimensions incorrect (3.4)	SMTE
102	Imperfect lock ring serrations (3.4.3.2)	Visual
103	Concentricity between lock ring internal and external serrations (3.4.3.3)	SMTE
104	Surface texture (3.4.4)	SMTE
Minor		
201	Treatment and finish (3.3 as applicable)	Visual
202	Workmanship (3.7)	Visual

4.6.3.2 Cleaning, descaling and passivation inspection. Sample inserts and lock rings shall be inspected for cleaning, descaling and passivation in accordance with ASTM A380/A380M and requirements of 3.3.2.

4.6.4 Thread inspection.

4.6.4.1 External threads inspection. Sample inserts shall have their external threads inspected in accordance with FED-STD-H28/20, system 21, 3.4.1.1 and 3.4.1.3 requirements as applicable.

4.6.4.2 Internal threads inspection. Sample inserts shall have their internal threads inspected in accordance with FED-STD-H28/20, system 21, 3.4.1.2 and 3.4.1.3 requirements as applicable.

4.6.4.3 Thread concentricity inspection. Sample inserts shall have their internal thread pitch diameter concentric with the external thread pitch diameter in accordance with requirements of 3.4.1.5.

4.6.5 Locking serrations inspection. Sample insert and lock ring locking serrations of both internal and external of lock ring and external of insert shall be in accordance with requirements of 3.4.3 as applicable.

4.6.6 Surface texture inspection. Sample inserts and lock rings shall be inspected for surface texture with any of the surface examination and measurement methods specified in ASME B46.1 in accordance with requirements of 3.4.4.

4.6.7 Metallurgical properties inspection. Sample inserts and lock rings shall be inspected for discontinuities in accordance with 3.6. Any crack detected during visual examination shall be cause for rejection of the lot. When visual evidence of discontinuities show cause for further inspection, sample inserts and lock rings shall be subjected to magnetic particle inspection in accordance with ASTM E1444/E1444M for alloy steel, penetrant inspection in accordance with ASTM E1417/E1417M for corrosion resistant steel and radiographic inspection in accordance with ASTM E1742/E1742M for titanium alloy. Magnetic particle, penetrant or radiographic inspection alone shall not be cause for rejection. If indications are considered cause for rejection, representative samples shall be taken from those inserts and lock rings showing indications and these samples shall be further examined. Samples shall be sectioned and discontinuities measured under 10X magnification. The inspection shall be performed on finished inserts and lock rings free of lubrication and subsequent to any processing operation which could adversely affect the inserts and lock rings. Certification shall be required for identification marking.

4.7 Mechanical properties inspection. In lieu of the mechanical properties sampling inspection of 4.7, mechanical properties inspection may consist of certification supporting verifying data that the insert and lock ring have met the requirements of 3.5.

4.7.1 Hardness test. Sample inserts and lock rings shall be tested for hardness to meet the requirements of 3.5.5 in accordance with NASM1312-6.

4.7.2 Self-locking torque test. Sample inserts shall be installed in test blocks in accordance with Figure 5 and 4.5.1 to meet the requirements of 3.4.2.1. Bolts and screws shall be in accordance with 4.5.1.2 and shall have sufficient thread length to extend beyond the locking feature a minimum of two pitches (including thread chamfer). A new bolt or screw and a new sample insert shall be used for each complete fifteen cycle test. Bolts and screws shall assemble freely, with the fingers, up to the locking feature. The bolt and screw shall be engaged or disengaged from the assembled insert self-locking area for fifteen full installation and removal cycles without axial load on the insert. The test shall run at a rate slow enough to yield a dependable measure of torque and to avoid heating of the bolt or screw. A bolt or screw shall be considered fully installed when two threads extend past the end of the insert locking feature; the removal cycle shall be considered complete when the locking feature is disengaged.

4.7.2.1 Maximum locking torque test. Maximum locking torque shall be the maximum torque value encountered on any installation or removal cycle and shall not exceed the applicable values specified in Table I in accordance with the requirements of 3.4.2.1. Maximum locking torque readings shall be recorded on the first, seventh and fifteenth installation cycle.

4.7.2.2 Minimum breakaway torque test. Minimum breakaway torque shall be the minimum torque required to start removal of the bolt or screw from a fixed position located between the first 1/4 turn to 1 turn of the removal cycle. Minimum breakaway torque readings shall be recorded at the start of the first, seventh and fifteenth removal cycle. The torque for any cycle shall not be less than the applicable values specified in Table I in accordance with the requirements of 3.4.2.1.

4.7.3 Axial strength (tensile and proof test). Sample inserts and lock rings installed in test blocks in accordance with Figure 4 and 3.5.1 for tensile test and Figure 4 and 3.5.2 for proof test as specified in 4.5.1 shall meet installation requirements specified in 4.5.1.1. The test bolt shall assemble freely into the insert prior to engaging the self-locking devise, with finger torque. When testing MS51991 insert, the test bolt thread shall be of sufficient length to extend through the self-locking feature a minimum of two (2) pitches (including bolt thread chamfer). When testing MS51498 or MS51993 insert, the test bolt thread shall be of sufficient length to engage the full length of the internal thread. The bushing and test block clearance holes in the upper and lower yokes (see Figure 6) shall have a free fit not in excess of 0.06 inch greater than the bushing and test block diameters. The test bolt clearance hole in the upper bushing (see Figure 6) shall be 0.005 to 0.015 inch diameter larger than the nominal diameter of the test bolt. The bolt clearance hole in lower yoke shall have a diameter of 1½ x the nominal insert external thread diameter ±0.015. The axial tensile load values determined by Table II and specified in Table III, as applicable, shall be applied to the test assembly and failure of the insert shall not occur below these loads. Proof test load values determined by Table II and specified in Table IV as applicable, shall be applied to the test assembly and test may be terminated when proof load is reached. In the event of test bolt failure by fracture below the applicable load values specified in Table III or a test bolt failure by yielding (permanent set) below the applicable load values specified in Table IV, the test shall be repeated until the applicable load value of the insert is reached or exceeded. Rate of loading shall not exceed 100 KSI per minute per square inch based on the shank diameter area of the bolt. Sample inserts shall meet the requirements of 3.5.1 and 3.5.2 as specified.

4.7.4 Resistance to pull-out test. Sample inserts and lock rings shall be installed in test blocks in accordance with Figure 4 and 4.5.1 to meet the requirements of 3.5.3. The minimum single shear strength of the test block material shall be determined by means of double shear tests of coupons taken from the material from which the test blocks are fabricated. The procedure shall be the same as 4.7.3 except, to demonstrate the average shear engagement area, an axial load of sufficient magnitude to produce failure (pull-out) shall be applied to the assembly. The axial load test result shall be adjusted for test block shear strength as follows: The product of the axial load test result (pounds) and the ratio of the 25 KSI to the actual minimum shear strength shall be used as the resistance to pullout (pounds). The mean (arithmetical average) value as determined by five or more tests shall meet or exceed the values specified in Table VI in accordance with 3.5.3. In the event of bolt failure below the applicable strength rating, the test shall be repeated until the pull-out strength of the insert is reached or exceeded. Rate of loading shall not exceed 100 KSI per minute based on the shank diameter area of the bolt. Whenever the pull-out values exceed the tensile strength of the test bolt, or the test equipment, it is permissible to use lower shear strength materials (15 KSI approx.) in lieu of specified test block materials. Double shear tests on coupons taken from the lower shear strength test blocks shall be performed and the resultant shear strength used to adjust the test results as stated above.

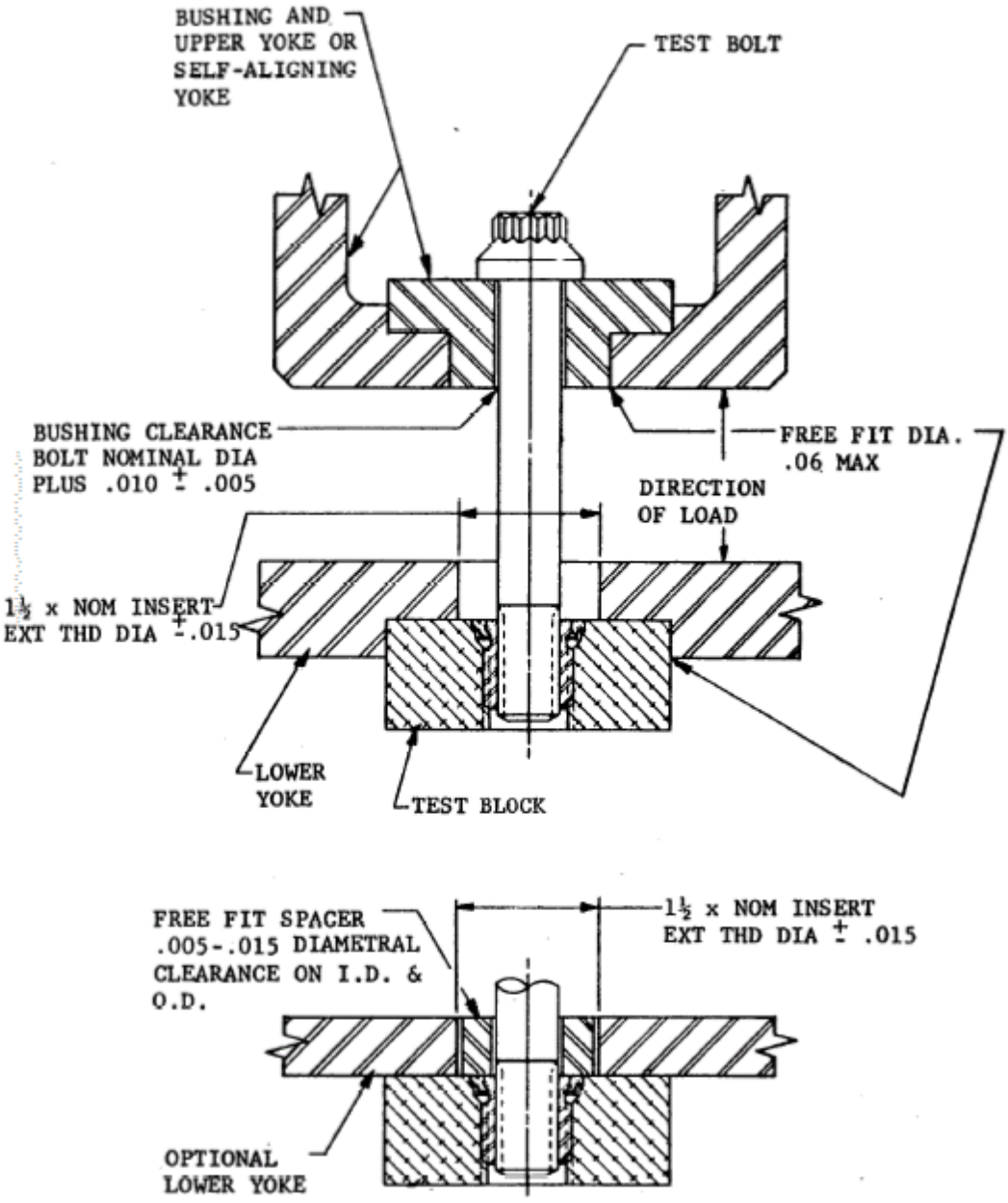
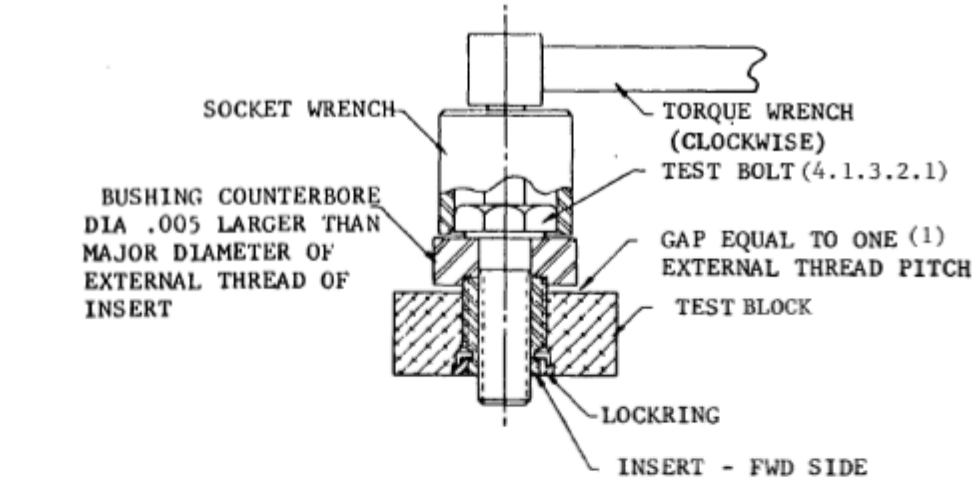
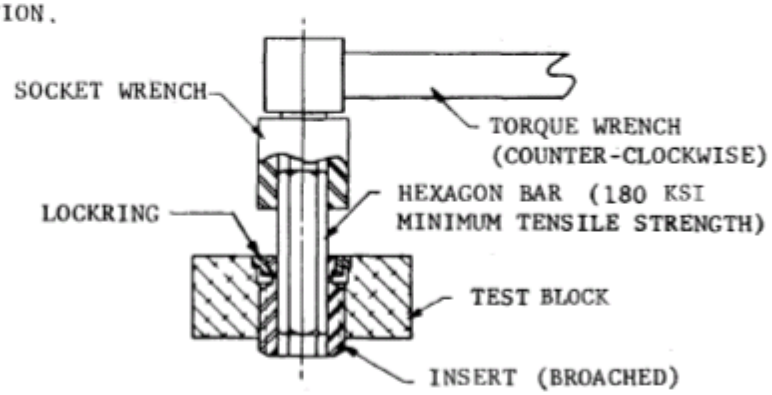


Figure 6. Axial Strength and Resistance to Pullout Test Fixtures.



NOTE: ABOVE TEST FIXTURE USED WITH INSERT IN THE AS RECEIVED CONDITION.



NOTE: ABOVE TEST FIXTURE USED WHEN PRODUCT IS INTERNALLY BROACHED WITH A HEXAGON WHOSE CROSS POINT DIMENSION DOES NOT EXCEED THE MAJOR DIAMETER OF THE INSERT INTERNAL THREAD. MORE ACCURATE RESULTS ARE OBTAINABLE WITH THIS METHOD AS THE INSERT WILL NOT TEND TO COLLAPSE OR TRANSMIT FRICTION INTO FINAL VALUES.

Figure 7. Rotational Resistance Test Fixture.

4.7.5 Rotational resistance test. Sample inserts and lock rings shall be installed in test blocks in accordance with Figure 5 and 4.5.1 and utilizing a test assembly as illustrated in Figure 7. With the forward side face of the insert installed in accordance with MS51995, the far side of the insert shall extend a distance approximately equal to one (1) external thread pitch past the far side of the test block allowing it to fit into the counterbore of the bushing. The insert shall fit into the bushing counterbore sufficiently close to prevent it from expanding under pressure. A test bolt or screw of 160 KSI minimum tensile strength as specified in 4.5.1.2.1 shall enter the insert from the back side (opposite normal entry). The test bolt or screw shall be torqued in a clockwise direction. Failure at applicable values below those specified in Table VII in accordance with the requirements of 3.5.4 shall be cause for rejection.

4.7.6 Grain flow inspection. Sample inserts shall be inspected for grain flow for rolled threads by microexamination or macroexamination in accordance with the requirements of 3.4.1.3 when applicable. Specimens shall be taken from the finished insert as shown in Figure 8. The inserts shall be etched in a suitable etchant sufficient time to reveal the macrostructure property.

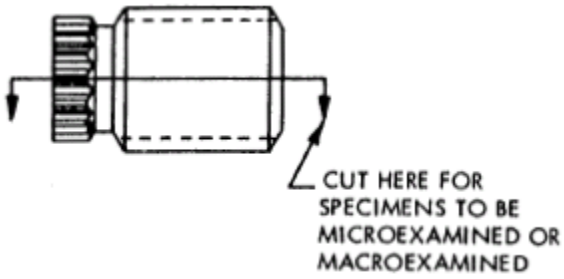


Figure 8. Metallurgical specimen.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Inserts and lock rings covered by this specification are intended as a general purpose fastener with a mechanical lock feature resist rotation. See MS51998 for design and usage limitations.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.
b. Title, number and date of applicable part standard (see 3.1).
c. Applicable part standard part number (see 3.1).
d. Material, if other than as specified in 3.2.
e. Packaging requirements (see 5.1).

6.3 Definitions.

6.3.1 Crack. A crack is a clean crystalline break passing through the grain or grain boundary without the inclusion of foreign elements.

6.3.2 Lap. A lap is a surface defect appearing as a seam, caused by the folding over of metal fins or sharp corners and then rolling or forging them into the surface, but not welding them.

6.3.3 Seam. A seam is an unwelded fold or lap which appears as an opening in the raw material as received from the source.

6.3.4 Inclusions. Inclusions are non-metallic materials in a solid metallic matrix.

6.4 Subject term (key word) listing.

Cadmium
Passivation
Titanium alloy

6.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

Custodian:
Army - AR
Navy - AS
Air Force - 99
DLA - IS

Preparing Activity:

DLA - IS

(Project 5325-2015-003)

NOTE: The activities listed above were interested in this document as of the date of document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.