INCH-POUND

MIL-STD-1891(AT)
10 January 1992
SUPERSEDING
(see 6.4)

MILITARY STANDARD

BOLTS AND SCREWS, INSPECTION OF

AMSC N/A
AREA NDTI

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

FOREWORD

1. This Military Standard is approved for use by U.S. Army Tank-Automotive Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Tank-Automotive Command, ATTN: AMSTA-GDS, Warren, MI 48397-5000, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

3. This military standard establishes the requirements for processing, inspecting, and testing bolts and screws.

CONTENTS

CONTENTS

TABLE

FIGURES

1. SCOPE

1.1 Scope. This standard covers processing procedures and operations for forming bolts and screws and inspection and test procedures for the finished product.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

MILITARY

MIL-STD-1312	- Fastener, Test Methods.
MIL-STD-1949	- Inspection, Magnetic Particle.
MIL-STD-6866	- Inspection, Liquid Penetrant.
MIL-STD-40002	- Heat Treatment Coding System, General.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Navy Publication and Printing Services Office, Standardization Document Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified here-in. Unless otherwise specified, the issues are those cited in the solicitation.

PURCHASE DESCRIPTIONS

MIPD-M3603	- Nickel Base Alloy, Corrosion and Heat Resistant, Solution Treated and Aged (D979).
MIPD-M3710	- Steel, Corrosion and Moderate Heat Resistant (AM 355).

(Application for copies should be addressed to the U.S. Army Tank-Automotive Command, ATTN: AMSTA-GDS, Warren, MI 48397-5000.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B117	- Standard Test Method of Salt Spray (Fog) Testing.
ASTM D4126	- Vapor-Degreasing Grade and General Solvent Grade 1,1,1 - Trichlorethane.

ASTM E8	- Standard Test Method of Tension Testing of Metallic Materials.
ASTM E112	- Standard Test Method of Determining Average Grain Size.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AS 478	- Identification Marking Methods.
AMS 5662	- Alloy Bars, Forgings, and Rings, Corrosion and Heat Resistant, 52.5Ni-19Cr-3.0Mo-.5.1(Cb+Ta)-0.90Ti-0.50Al-18Fe Consumable Electrode or Vacuum Induction Melted 1775°F (968°C) Solution Heat Treated.
AMS 7466	- Bolts and Screws, Nickel Alloy, Corrosion and Heat Resistant Upset Headed, Roll Threaded, Fatigue Resistant.
AMS 7467	- Bolts and Screws, Nickel Alloy, Corrosion and Heat Resistant Upset Headed, Roll Threaded, Stress-Rupture Resistant.

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents may also be available in or through libraries or other informational services.)

2.3 Order of precedence. 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. DEFINITIONS

3.1 Discontinuities. For the purpose of this standard, the following definitions for discontinuities shall apply.

3.1.1 Crack. A clean, crystalline break passing through the grain or grain boundary without inclusion of foreign elements.

3.1.2 Inclusions. Particles of nonmetallic impurities (usually oxides, sulfides, or silicates) which are mechanically held in the material during solidification.

3.1.3 Lap. An elongated discontinuity in the metal caused by rolling or forging a projection of metal (fin, flash, sharp edge or corner, etc.) mechanically into the surface.

3.1.4 Seam. An elongated discontinuity in the metal caused by rolling or forging a defect (burst, tear, etc.) closed but not fusing the edges together.

3.1.5 Nick, pit. A depression or indentation in the surface of the metal.

4. GENERAL REQUIREMENTS

4.1 Equipment.

4.1.1 Furnaces. Furnaces shall be suitable for the intended purpose and conform to MIL-STD-40002.

4.1.2 Stress corrosion fixture. The stress corrosion fixture shall meet the following requirements:

a. Material for the fixture shall be resistant to the stress corrosion solution specified in the following figures, as applicable:

Material	Figure
MIPD M3710	1
AMS 5662	2
MIPD M3603	3

b. The fixture shall be capable of maintaining the required load on the test bolt or screw.
c. The fixture shall permit free access of the stress corrosion solution to the stressed surfaces of the test bolt or screw.

4.2 Material.

4.2.1 Bolt and screw material. The material for bolts and screws shall be as specified in the applicable engineering drawing.

4.2.2 Vapor degreasing solvent. The vapor degreasing solvent shall be stabilized 1-1-1 trichloroethane conforming to ASTM D4126 or equivalent.

5. DETAILED REQUIREMENTS

5.1 Processing procedures and operations. The processing procedures and operations shall include but not be limited to the following requirements in the specified sequence. The exact heat treating temperatures and forming requirements shall be as further delineated in the applicable figure.

5.1.1 Head forming. The final forming of bolt and screw heads shall be by the hot forming method.

5.1.2 Heat treatment. The headed and machined blanks shall be heat treated as specified in the applicable instruction sheet of MIL-STD-40002.

5.1.3 Surface preparation. After heat treatment, the blanks shall be cleaned of all surface oxides, oxide penetration, and surface alloy depletion. The cleaning process shall produce no intergranular attack or corrosion of the blanks. Metal removal from the bearing surface of the head and full body diameter of the shank shall be minimized and still obtain a clean, smooth surface. Metal removal shall never be great enough to produce excessive cutting of the flowlines as shown in figure 4.

5.1.4 Fillet radius rolling. When specified in the applicable figure, the head-to-shank fillet radius of bolts and screws having the radius circumscribing the part shall be cold worked sufficiently to remove all visual evidence of grading or tool marks. The head-to-shank fillet distortion shall be within the limits specified in figure 5.

5.1.5 Thread rolling. Threads shall be formed by a single rolling process.

5.1.6 Cleaning. The finished bolt or screw shall be cleaned by vapor degreasing (see 4.2.2).

5.1.7 Surface treatment. Bolts and screws requiring surface treatment (e.g., passivation, silver plate, etc.) shall be processed as specified in the applicable engineering drawing.

5.1.8 Identification. Unless otherwise specified in the engineering drawing, the parts shall be marked on the part head with the mill heat number, heat treat lot number, and manufacturer's identification in accordance with AS 478, method 2C1.

NOTE: Due to the limited space available, a combination symbol may be used to provide traceability to the mill heat and heat treat lot.

5.2 Test methods.

5.2.1 Visual and fluorescent penetrant or magnetic particle. The parts shall be visual and fluorescent penetrant or magnetic particle inspected as specified in the applicable figure to verify conformance to the following:

a. Cracking. The part shall be devoid of cracking in all areas (see 3.1.1).

b. Imperfections. Indications of seams, inclusions, laps, nicks, or pits (see 3.1.2 thru 3.1.5) shall not be cause for rejection until after performing the macrostructure test (see 5.2.2.4).

5.2.2 Destructive analysis. Destructive analysis shall be performed in accordance with the requirements of the applicable figure and the following requirements.

5.2.2.1 Tensile properties. Tensile properties shall be determined as follows:

a. Parts shall be tested in accordance with MIL-STD-1312, test no. 8.
b. When the size or shape of the part makes it impractical to test as specified in 5.2.2.1.a, a specimen shall be machined from the part and tested in accordance with ASTM E8.

5.2.2.2 Shear test. The shear test shall be performed in accordance with MIL-STD-1312, test no. 13.

5.2.2.3 Hardness. The hardness of the part shall be uniform and within the range specified in the engineering drawing. The hardness of the threaded section and the head-to-shank fillet area when cold working of this area is specified, may be higher as a result of cold working. The hardness values shall be obtained by testing in accordance with MIL-STD-1312, test no. 6.

5.2.2.4 Macrostructure. Parts shall be sectioned as shown in figure 6, polished, etched with an approved etchant, and meet the following requirements when examined at a magnification of not less than 6X:

a. Flow lines (grain flow). Parts with upset heads shall show flow lines in the shank, head-to-shank, and head which show the contour of the part as shown in figure 4. Flow lines in the thread area shall follow the general thread contour and shall be of maximum density at the root of the thread as shown in figure 7.

b. Imperfections:

(1) Internal. There shall be no cracks, laps, or porosity in excess of that specified in table I.

(2) Threads.

(a) Root imperfections (notches, slivers, folds, roughness, oxide scale, etc.) shall not be acceptable.
(b) Multiple laps on the flanks of threads shall not be acceptable. Single laps on the flanks of threads that extend toward the root shall not be acceptable.
(c) A single lap shall be permissible along the flank of the thread above the pitch diameter on either the pressure or nonpressure flank provided the lap extends toward the crest and runs generally parallel to the flank.

(d) Crest craters, crest laps, or combination crest crater and crest laps shall be permissible provided the imperfection does not exceed the sizes specified in figure 8 and table I.

5.2.2.5 Microstructure. The specimen for microstructure examination shall be prepared in accordance with figure 6, etched with an approved etchant, and examined for microstructure.

5.2.2.6 Grain size. The specimen for grain size shall be prepared in accordance with figure 6 and analyzed in accordance with ASTM E112.

5.2.2.7 Stress rupture. The stress rupture test shall be performed in accordance with MIL-STD-1312, test no. 10.

5.2.3 Stress corrosion. The parts shall be stress corrosion tested in accordance with the requirements of the applicable figure and the following:

a. Testing. The parts shall be placed in the test fixture (see 4.1.2), loaded in tension as specified, and immersed in the stress corrosion solution.
b. Examination. After completion of the exposure to the stress corrosion solution, the parts shall be examined as follows:

(1) Visual. Inspected visually for unacceptable cracking.
(2) Tensile. Tensile tested to the requirements specified in the applicable figure.
(3) Microscopic. The rupture surface shall be examined microscopically at 100X magnification for the presence of unacceptable intergranular cracking.

5.2.3.1 Salt spray (fog) test. If the parts fail the stress corrosion test or in the event of a dispute between purchaser and vendor, the referenced test shall be a salt spray (fog) test performed in accordance with ASTM B117 and the following:

a. Testing. Unless otherwise specified in the applicable instruction sheet, the parts shall be placed in the test fixture (same fixture as used for the stress corrosion test, see 4.1.2), loaded in tension to 130,000 pounds per square inch (psi), and placed in the salt spray cabinet. The test shall be run for 500 hours.
b. Examination. After completion of exposure to the salt spray solution, the parts shall be examined as follows:

(1) Cleaning. Parts shall be rinsed thoroughly in clean warm water followed by a rinse in alcohol (ethyl) and then air dried.
(2) Visual. Parts shall be visually inspected for unacceptable cracks.
(3) Tensile. Parts shall be tensile tested in the manner specified in the applicable instruction sheet.

5.3 Substantiation. Samples of bolts and screws having indications shall be sectioned and examined in accordance with 5.2.2.4 to determine the extent of the imperfections.

5.4 Responsibility for approval. The contractor is responsible to ensure that sources, materials, equipment, facilities, and any changes thereto are in conformance with the provisions of this standard. Each supplier facility shall require separate approval for any given configuration from the contractor. The Government reserves the right to review for compliance to this standard any approvals granted by the contractor.

5.4.1 Process data. The contractor is responsible to review for approval supplier specific work instructions (process procedures) and any revision or change to such work instructions prior to their use. The Government reserves the right to review the contractor's approval/disapproval of these instructions as may be required to verify conformance to this standard and the applicable engineering drawings for the parts (see 6.3).

6. NOTES

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

6.1 Intended use. The procedures covered in this standard are intended to be used to ensure bolts and screws meet prescribed requirements detailed herein.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.3 Data requirements. Although this standard does not include any Government requirements for data, it does not exclude contractors from obtaining data from its suppliers as required to ensure compliance to this standard and to verify conformance to the applicable engineering drawings.

6.4 Supersession data. This standard supersedes Textron Lycoming Division, Stratford, Connecticut, Specification P8023D, dated 26 April 1982.

6.5 Subject term (key word) listing.

Bolts
Discontinuities
Head forming
Inspection
Processing
Screws
Thread rolling

TABLE I. Acceptable discontinuities.

Area	Permissible discontinuities 1/	Maximum depth normal to surface					
		Nominal fastener diameter 2/					
		0.190	0.250	0.3125	0.375	0.4375	0.500 & over
Head-to-shank fillet	No discontinuities	.000	.000	.000	.000	.000	.000
Root or threads	No discontinuities	.000	.000	.000	.000	.000	.000
Thread locations per figure 5	Laps and surface irregularities	.004	.005	.005	.006	.007	.008
Grip or shank diameter bearing surface of head	Seam not extending into fillet or root of threads	.004	.005	.005	.006	.007	.008
Nonbearing surface of head	Laps, seams, and nicks or gouges	.008	.010	.010	.012	.014	.016
Recess		.002	.002	.002	.002	.002	.002
Any location not specified above	Inclusions not indicative of unsatisfactory quality	Not applicable					

1/ See 3.1 for definitions of discontinuities.
2/ For a fastener diameter not listed, use the next larger size.

NOTE: Dimensions are in inches.

A. Processing:

1. Head forming - As specified in 5.1.1.
2. Heat treatment - Unless otherwise approved by the acquisitioning activity, heat treatment shall be performed as follows:

   a. Solution anneal:

      (1) Heat to 1900 ± 25 degrees Fahrenheit (°F).
      (2) Hold at heat for 1 hour.
      (3) Quench in agitated water or oil.
      (4) Subzero cool to minus 100°F maximum.
      (5) Hold at temperature for 3 hours maximum.
      (6) Warm in air to room temperature.

   b. Harden and temper:

      (1) Heat to 1750 ± 25°F.
      (2) Hold at heat for 30 to 90 minutes.
      (3) Water or oil quench.
      (4) Subzero cool to minus 100°F maximum.
      (5) Hold at temperature for 3 hours minimum.
      (6) Warm in air to room temperature.
      (7) Heat to 1015 ± 15°F.
      (8) Hold at heat for 3 hours minimum.
      (9) Cool in air to room temperature.

3. Head-to-shank fillet - Cold rolled.
4. Threads - Cold rolled.

B. Inspection:

1. Visual - Frequency 100 percent (%).
2. Magnetic particle - 100% inspection in accordance with MIL-STD-1949.
3. Hardness - Frequency 100% (see B.5.d).
4. Stress corrosion test:

   a. Stress corrosion - Hydrochloric acid-selenium dioxide solution (HCl-ScO_2) - The solution shall be used at room temperature and formulated as follows:

      (1) Selenium dioxide (SeO_2) - 10 grams.
      (2) Hydrochloric acid (HCl, 37%) - 250 milliliters (ml).
      (3) Water - 750 ml.

      NOTE: Only fresh solution shall be used. The solution shall be discarded after each use.

   b. Tension load - 90,000 psi.

FIGURE 1. MIPD-3710 material.

c. Duration of immersion - 18 hours.
d. Cleaning - After immersion, the bolts or screws shall be cleaned by thoroughly wiping with a clean wiper, then rinsed and scrubbed in acetone, and carefully wiped dry.

5. Destructive analysis - In accordance with 5.2.2 and the following:

a. Tensile properties:

(1) Ultimate strength, psi	170,000 minimum
(2) Yield at 0.2% offset, psi	155,000 minimum
(3) Elongation, % in 4D	12 minimum
(4) Reduction of area, %	25 minimum

b. Shear test - Not required.
c. Fatigue test - Not required.
d. Hardness - As specified in the engineering drawing.
e. Macrostructure - As specified in 5.2.2.4.
f. Grain size - ASTM #4 per ASTM E112 or finer.
g. Microstructure - As specified in MIPD-3710.
h. Stress rupture test - Not required.

FIGURE 1. MIPD-3710 material - Continued.

1. For applications where optimum properties up to 800°F are desired, process in accordance with AMS 7466.
2. For applications where optimum resistance to relaxation up to 1200°F is desired, process in accordance with AMS 7467.

NOTE: For applications where stress rupture is the limiting criteria, the following note shall be specified in the engineering drawing: Roll threads before precipitation heat treatment.

FIGURE 2. AMS 5662 material.

A. Processing:

1. Head forming - As specified in 5.1.1.
2. Solution heat treatment (see C.1 and C.3):

   a. Heat parts to 1850 to 1900°F (see C.2).
   b. Hold at heat for 1 to 4 hours.
   c. Rapid quench in agitated water maintained at 120°F maximum.

3. Head-to-shank fillet - Cold rolled.
4. Threads - Cold rolled.
5. Precipitation heat treatment (see C.3).

   a. Heat parts to 1550 ± 15°F.
   b. Hold at heat 6 to 12 hours.
   c. Air cool to room temperature.
   d. Heat to 1300 ± 15°F.
   e. Hold at heat for 16 hours.
   f. Air cool.

B. Inspection:

1. Visual - Frequency 100%.
2. Fluorescent penetrant - 100% inspected in accordance with MIL-STD-6866.
3. Hardness - Frequency 100% (see B.5.d).
4. Stress corrosion test - Not required.
5. Destructive analysis - In accordance with 5.2.2 and the following:

   a. Tensile properties:

(1)	Ultimate strength, psi	190,000 minimum
(2)	Yield at 0.2% offset, psi	125,000 minimum
(3)	Elongation, % in 4D	12 minimum
(4)	Reduction of area, %	15 minimum

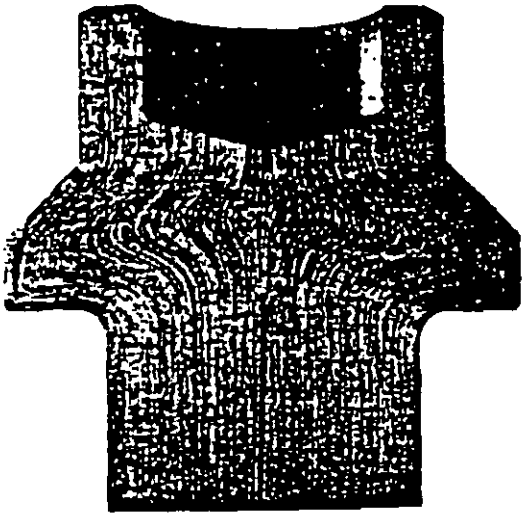
   b. Shear test - Not required.
   c. Fatigue test - Not required.
   d. Hardness - As specified in the engineering drawing.
   e. Macrostructure - As specified in MIPD-3603.
   f. Microstructure - As specified in MIPD-3603.
   g. Grain size - ASTM #4 per ASTM E112 or finer.
   h. Stress rupture test - Not required.

FIGURE 3. MIPD-3603 material.

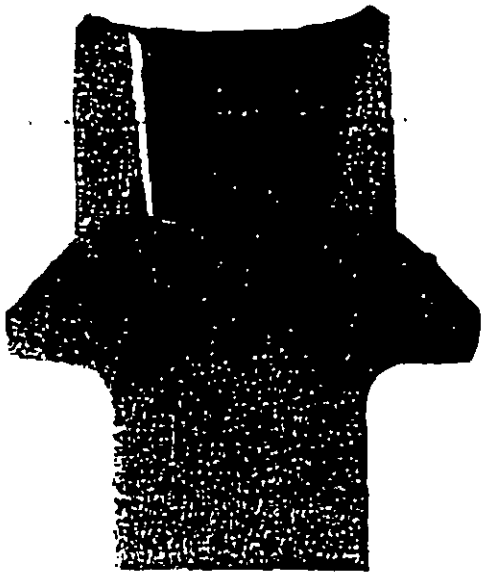
C. Notes:

1. Furnaces for solution heat treatment shall be capable of maintaining the temperature within the furnace work-load zone within ±10°F of the temperature controller.
2. Exact solution treating temperature and aging time within these ranges shall be specified by the contractor.
3. This heat treatment may only be performed by qualified heat treating sources acceptable to the contractor.

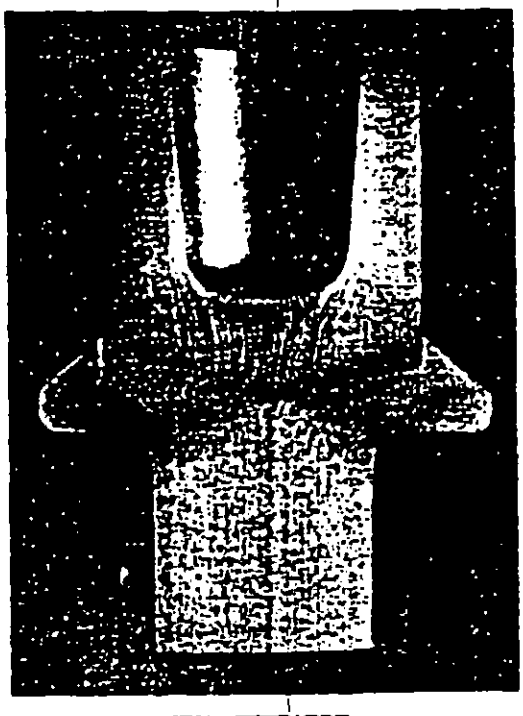
FIGURE 3. MIPD-3803 material - Continued.



ACCEPTABLE

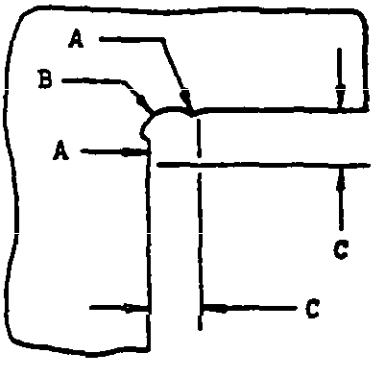


MARGINAL
ACCEPTABLE

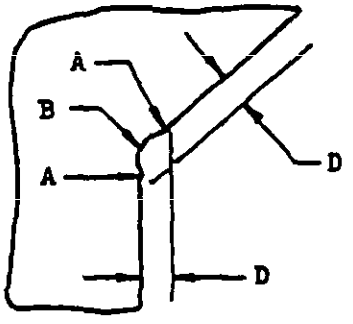


UNACCEPTABLE

FIGURE 4. Typical grain flow in formed heads.



PROTRUDING HEAD



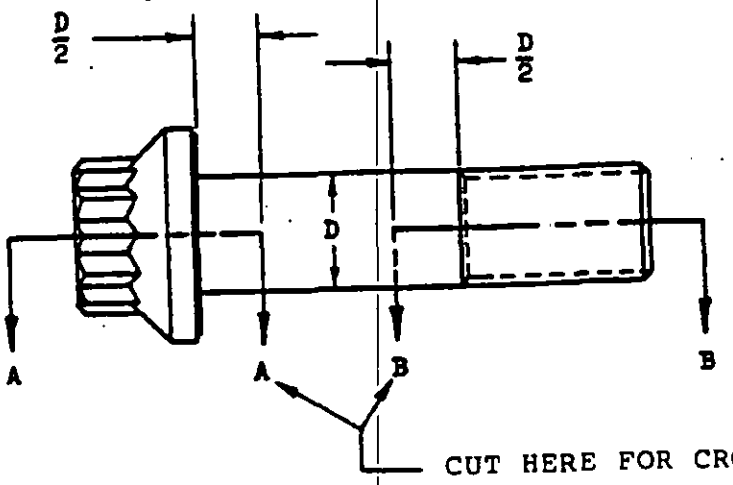
FLUSH HEAD

MAXIMUM DISTORTION	NOMINAL FASTENER DIAMETER (INCHES)				
	UNDER 0.3125	0.3125 and 0.375	0.4375 thru 0.625	0.750 thru 1.00	OVER 1.00
C	0.062	0.094	0.125	0.156	0.188
D	0.031	0.047	0.062	0.078	0.094

Notes:

1. Cold working of head-to-shank fillet may cause distortion of fillet area. Distortion shall not exceed 0.002 inch above A or below B contour. Distorted area shall not extend beyond C or D.

FIGURE 5. Head-to-shank fillet distortion.



NOTE:

1. If length of shank area of part is D or less, the entire bolt shall be cross-sectioned.

FIGURE 6. Metallurgical specimen.

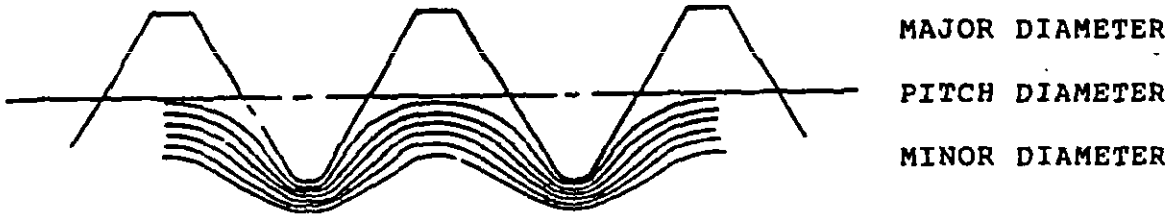
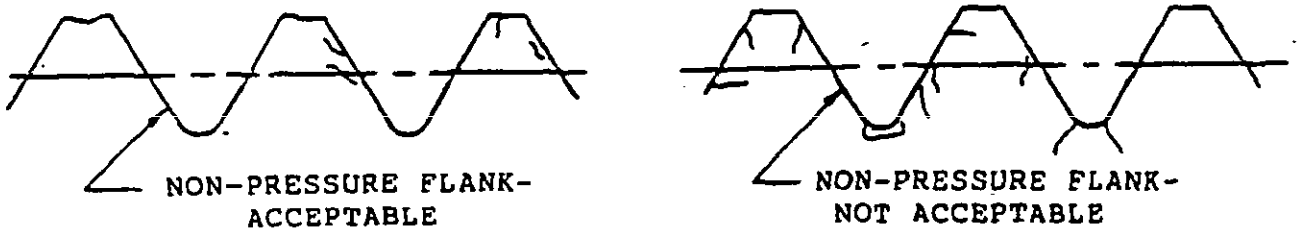


FIGURE 7. Typical flow lines.



NOTE:

1. Acceptable laps shall not exceed sizes specified in table I.

FIGURE 8. Thread discontinuities.

FOLD

U.S. ARMY TANK - AUTOMOTIVE COMMAND
ATTN: AMSTA-GDS
WARREN, MICHIGAN 48397-5000

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

POSTAGE AND FEES PAID

U.S. MAIL

COMMANDER
U.S. ARMY TANK - AUTOMOTIVE COMMAND
ATTN: AMSTA-GDS
WARREN, MICHIGAN 48397-5000

FOLD

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS: This form is provided to solicit beneficial comments which may improve this document and enhance its use. DoD contractors, government activities, manufacturers, vendors, or other prospective users of the document are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity. A response will be provided to the submitter, when name and address is provided, within 30 days indicating that the 1426 was received and when any appropriate action on it will be completed.

NOTE: This form shall not be used to submit requests for waivers, deviations or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. AREA NDTI

DOCUMENT IDENTIFIER (Number) AND TITLE

MIL-STD-1891(AT); Bolts and Screws, Inspection of

NAME OF ORGANIZATION AND ADDRESS OF SUBMITTER

☐ VENDOR ☐ USER ☐ MANUFACTURER

1. ☐ HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE? ☐ IS ANY PART OF IT TOO RIGID, RESTRICTIVE, LOOSE OR AMBIGUOUS? PLEASE EXPLAIN BELOW.

A. GIVE PARAGRAPH NUMBER AND WORDING

B. RECOMMENDED WORDING CHANGE

C. REASON FOR RECOMMENDED CHANGE(S)

2. REMARKS

SUBMITTED BY (Printed or typed name and address — Optional)

TELEPHONE NO.

DATE

DD FORM 1 OCT 76 1426

EDITION OF 1 JAN 72 WILL BE USED UNTIL EXHAUSTED.